THE FIGHTER COLLECTION

EAGLE DYNAMICS

DCS SERIES

DCS: F-16C Viper

Early Access Guide

Updated 23 March 2026

DIGITAL COMBAT SIMULATOR

INTRODUCTION

Thank you for your purchase of DCS: F-16C Viper!

DCS: F-16C Viper brings to Digital Combat Simulator one of the most successful lightweight multirole fighters in modern history. This module features the most realistic PC simulation of the F-16C, which includes accurately simulated flight dynamics, avionics, sensors, and weapon systems. Although the F-16C has existed in many variants and configurations in its history, this module simulates the F-16C Block 50 as it existed in United States Air Force and Air National Guard service circa 2007.

The F-16C was the first operational U.S. fighter aircraft to utilize fly-by-wire controls; and designed for sustained 9G turn performance in close-range "dogfight" maneuvers. The F-16 has been in continuous production for over four decades, with well over 4,000 airframes produced, and continues to serve in the air forces of over 20 nations around the world. Known for its maneuverability and acceleration in close-range air-to-air combat, pilot-friendly cockpit design, and mission versatility, the F-16C Block 50 has also become one of the most successful SEAD (Suppression of Enemy Air Defenses) platforms in the United States Air Force, also known as "Wild Weasel".

As a Wild Weasel, the F-16 pilot uses a combination of sophisticated electronic sensors and clever tactics – and a little bit of crazy – to locate and attack hostile air defense batteries. This is often done while deliberately exposing themselves to engagement by those very same air defense weapons.

Be the first in, and the last out!

Key features:

- Detailed, fully-clickable, 6DOF cockpit along with a highly detailed external model.
- Detailed pilot model and animations.
- APG-68 Fire Control Radar (with air-to-air and air-to-ground modes), ASQ-213 HARM Targeting System, AAQ-33 targeting pod, and Joint Helmet Mounted Cueing System (JHMCS).
- Air-to-air weapons include the M61 20mm Vulcan cannon, AIM-9 Sidewinder heat-seeking missiles, and AIM-120 AMRAAM active radar-homing missiles.
- A large assortment of air-to-ground munitions, including (but not limited to) AGM-88 HARM anti-radar missiles, AGM-65 IR- and TV-guided Maverick anti-armor missiles, AGM-154 JSOW glide bombs, JDAM and WCMD inertially aided munitions, and Paveway laser-guided bombs.
- Tactical datalink, providing a high degree of situational awareness and teamwork between wingmen.
- ALR-56M radar warning receiver, ALE-47 countermeasure dispensers, and ALQ-131/184 jamming pods.
- Fly missions in the eastern Black Sea region, western Pacific Ocean around the Marianas Islands, or one of the many DLC maps like the Persian Gulf, Iraq, Afghanistan, and more.
- Multiplayer cooperative and head-to-head gameplay.
- Feature-rich Mission and Campaign editors facilitate user-created content.
- Huge array of land, air, and sea units to fight alongside and against.

Sincerely,
The DCS: F-16C Viper Team
2 October 2019

TABLE OF CONTENTS

LATEST CHANGES

Significant changes to the guide will be noted on this page.

15 Oct 2019 – Added IFF interrogation procedure to FCR chapter.

20 Oct 2019 – Updated AIM-9 diamond and uncage behavior description in AIM-9M/X employment sections.

22 Oct 2019 – Added FCR Track While Scan (TWS) sub-mode description to FCR chapter.

25 Oct 2019 – Added INS alignment procedures.

28 Oct 2019 – Added section on SMS MFD format and Selective Jettison (S-J).

05 Nov 2019 – Added air refueling procedures.

08 Nov 2019 – Added TNDL datalink information.

15 Nov 2019 – Added additional CMDS DED page descriptions.

24 Nov 2019 – Added information on the FCR Expand (EXP) field-of-view.

21 Jan 2020 – Added EEGS Level V gunsight information.

28 Jan 2020 – Added information on filtering datalink tracks on FCR MFD format.

11 Feb 2020 – Added slave/bore HOTAS functionality to AIM-9 employment section.

25 Feb 2020 – Updated TACAN band change procedure in the TACAN section.

15 Mar 2020 – Added M61A1 gun dispersion information to the Gun employment section.

31 Mar 2020 – Added TIME and ALOW DED page descriptions to the UFC section.

26 Aug 2020 – Substantially revised targeting pod sections to add new functionality. Added Stored Heading and In-flight INS alignment procedures.

27 Aug 2020 – Added procedures for kneeboard usage to the bomb seeker laser code section. Added missile DLZ to FCR MFD format in AIM-120 employment section. Added details on Dogfight and Missile Override modes.

28 Aug 2020 – Added new section describing Autopilot functions. Substantially revised section describing DED pages with many additional pages.

31 Oct 2020 – Added AGM-88 HARM section with HAS mode procedures.

3 Nov 2020 – Added AGM-65 Maverick section.

6 Dec 2020 – Added VIP/VRP/PUP section, and POS RUK sub-mode to AGM-88 HARM section.

15 Dec 2020 – Added a section on System-Point-of-Interest (SPI) and Cursor Zero (CZ) mechanics. Added section on TGP track modes.

14 Feb 2021 – Added Aircraft History and Weapons & Munitions sections.

20 Mar 2021 – Updated AGM-88 HARM with POS EOM and POS PB sub-modes.

16 May 2021 – Added JDAM section.

11 Jul 2021 – Added JSOW section.

1 Aug 2022 – Full review of existing manual initiated.

30 Nov 2022 – Revisions performed as necessary for accuracy and correct formatting; revised/updated DCS: World Fundamentals, Weapons & Munitions, Cockpit Overview, Hands-On Controls, Head-Up Display, Upfront Controls, Radio Communications (work-in-progress), Joint Helmet Mounted Cueing System, Defensive Systems, and ALIC Code Appendix. Added Tactical Employment chapter (work-in-progress), ASQ-213 HARM Targeting System chapter, Electronic Countermeasures, Appendix C – HAD/HAS Threat Tables, Appendix E – Glossary of Terms, and Appendix F – Formulas.

10 May 2023 – Revised/updated Procedures chapter. Updated Hands-On Controls section and added a consolidated HOTAS function table at the end. Updated Radar Warning Receiver section for new functionality and controls. Updated Appendix A with checklists from Procedures chapter. Updated Appendix B and Appendix C with latest ALIC codes and symbols. Added Appendix D – HOTAS Quick References. Corrected various typos.

13 Dec 2024 – Revised/updated Navigation, Radio Communications, Tactical Employment, and Datalink (WIP) chapters. Updated Appendix A with new checklists and added hyperlinks to all checklists for more efficient use on electronic devices such as tablets. Corrected various typos.

06 Jul 2025 – Added AAQ-33 Advanced Targeting Pod chapter. Updated Hands-On Controls section and Appendix D with new TGP commands for AAQ-33 and updated AGM-88 controls. Corrected various typos.

21 Mar 2026 – Added Data Transfer Equipment section. Revised/updated Fire Control Radar, Tactical Net Datalink, and ASQ-213 HARM Targeting System chapters. Updated Hands-On Controls section and Appendix D. Corrected various typos.

NOTE: The Air-to-Air Weapons Employment and Air-to-Ground Weapons Employment chapters will receive revisions/updates in the future.

DCS: WORLD FUNDAMENTALS

USAF Photo
by SrA Daniel Snider

HEALTH WARNING!

Please read before using this computer game or allowing your children to use it.

A very small proportion of people may experience a seizure or loss of consciousness when exposed to certain visual images, including flashing lights or light patterns that can occur in computer games. This may happen even with people who have no medical history of seizures, epilepsy, or "photosensitive epileptic seizures" while playing computer games.

These seizures have a variety of symptoms, including light-headedness, dizziness, disorientation, blurred vision, eye or face twitching, loss of consciousness or awareness even if momentarily.

Immediately stop playing and consult your doctor if you or your children experience any of the above symptoms.

The risk of seizures can be reduced if the following precautions are taken, (as well as a general health advice for playing computer games).

- Do not play when you are drowsy or tired.
- Play in a well-lit room.
- Rest for at least 10 minutes per hour when playing the computer game.

INSTALLATION AND LAUNCH

To install DCS World and the DCS: F-16C Viper module, you will need to be logged into Windows with Administrator rights.

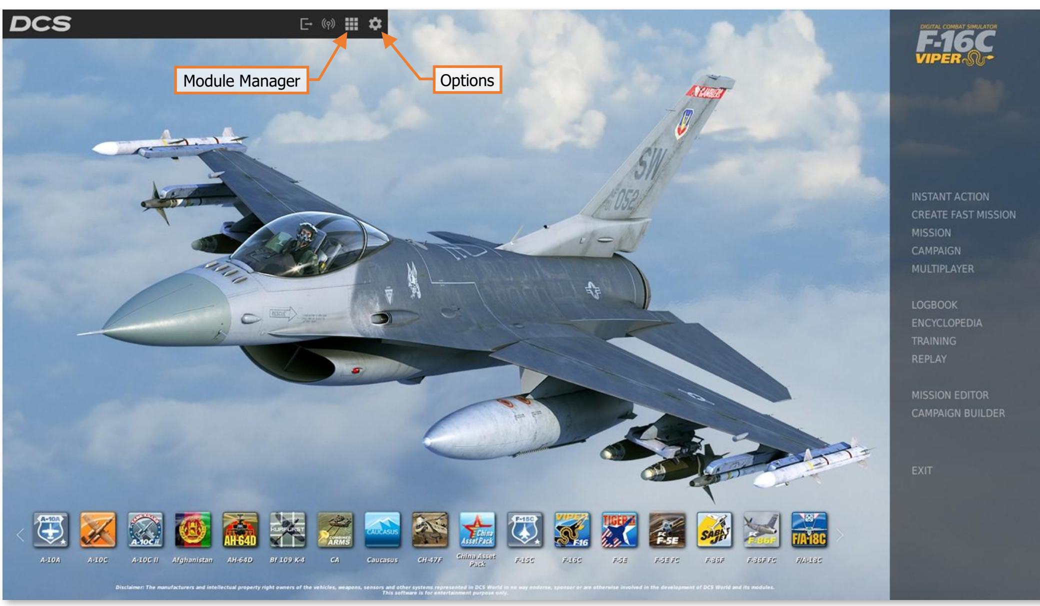
DCS World is the PC simulation environment that the DCS: F-16C Viper simulation operates within. When DCS World is launched, you in turn launch DCS: F-16C Viper.

As part of DCS World, a map of the Caucasus region, the Su-25T "Frogfoot" attack aircraft, and TF-51 training aircraft are also included for free.

After purchasing DCS: F-16C Viper from our e-Shop, start DCS World by executing the icon on your desktop. Upon initialization, the DCS World Main Menu page is opened. From the Main Menu, you can read DCS news, change your wallpaper by selecting any of the icons at the bottom of the page, or select any of the options along the right side of the page.

Select the Module Manager icon at the top of the Main Menu. Upon initial entry into the Module Manager, a pop-up window titled Install Modules should automatically display, listing any DCS products that you have purchased and have yet to install. Ensure DCS: F-16C Viper is checked, and then click OK. Alternatively, you can select the Modules tab, scroll down until you locate the DCS: F-16C Viper entry, and click Install. In either case, DCS World will close and automatically proceed with an update to download and install the necessary files. After the download and installation is complete, DCS World will automatically restart.

To get started quickly, you can select Instant Action and play any of the missions listed for the F-16C Viper.



Configure Your Game

Before jumping into the cockpit, the first thing we suggest is to configure your game. To do so, select the Options button at the top of the Main Menu screen. You can read a detailed description of all Options in the DCS User Manual. For this Early Access Guide, we will just cover the basics.

SYSTEM Tab

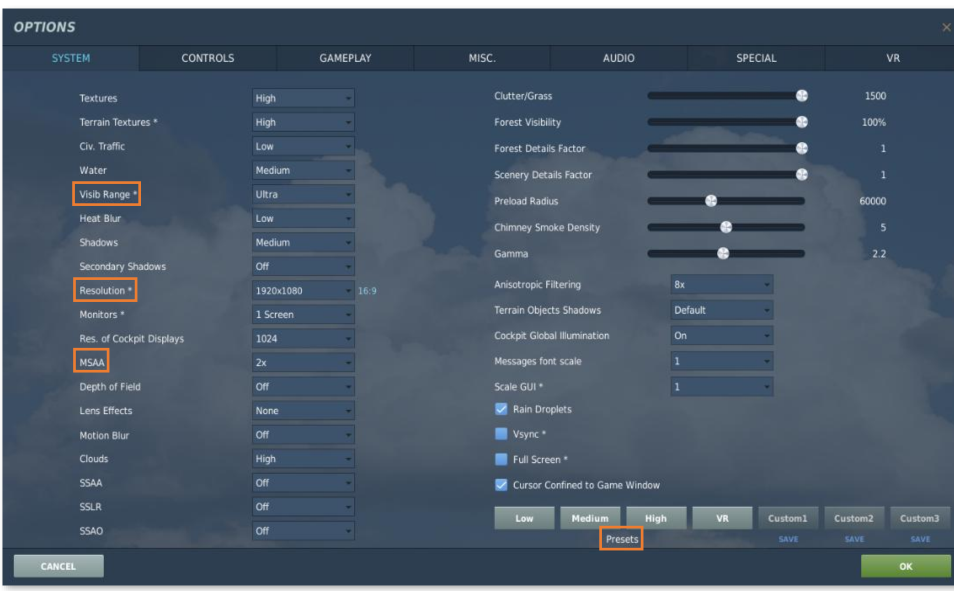
This tab allows you to configure your graphics options to best balance aesthetics with performance.

There are Presets options along the bottom of the page, but you can further adjust your graphics settings to best suit your computer. If you have lower performance, we suggest selecting the "Low" button and then increase graphics options to find your best balance.

Items that most affect performance include Visibility Range, Resolution, and MSAA. If you wish to improve performance, you may wish to first adjust these system options.

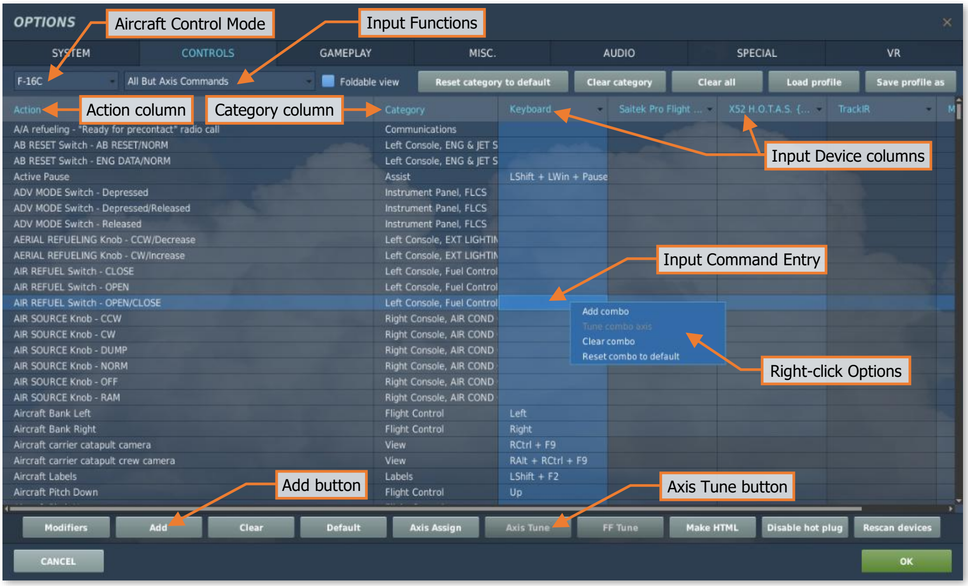
Items that have an asterisk (*) displayed next to them will require a restart of DCS World to take effect.

Note that some missions may enforce different Civ. Traffic settings that override the individual user selection on this tab. This may result in higher or lower levels of expected civilian traffic scenery, or none at all.



CONTROLS Tab

This tab provides an interface to set up your controls and functional bindings.



Aircraft Control Mode. From this drop-down menu, select "F-16C".

Input Functions. This displays various categories of input functions, such as axis devices, views, cockpit functions, etc. Additionally, "Search…" can be selected from the Input Functions drop-down to manually filter the Action column according to keyword matches.

Action column. This column along the left side of the screen displays the action associated with the corresponding input command entries.

Category column. This column to the right of the Action column displays the function group or cockpit panel each Action is grouped within.

Input Device columns. These columns display which input devices have been detected, including your keyboard, mouse, joysticks, throttle(s), or rudder pedals, and which input commands from the respective input devices will perform the corresponding Action.

Add button. To assign an input command to an Action, left-click the input command entry that corresponds with the desired Action under the desired input device column, then press the Add button along the bottom row. Alternatively, a double left-click on the desired command entry using mouse can be used, or right-clicking on the command entry and selecting "Add combo". Any of these methods will display the ASSIGNMENT PANEL.

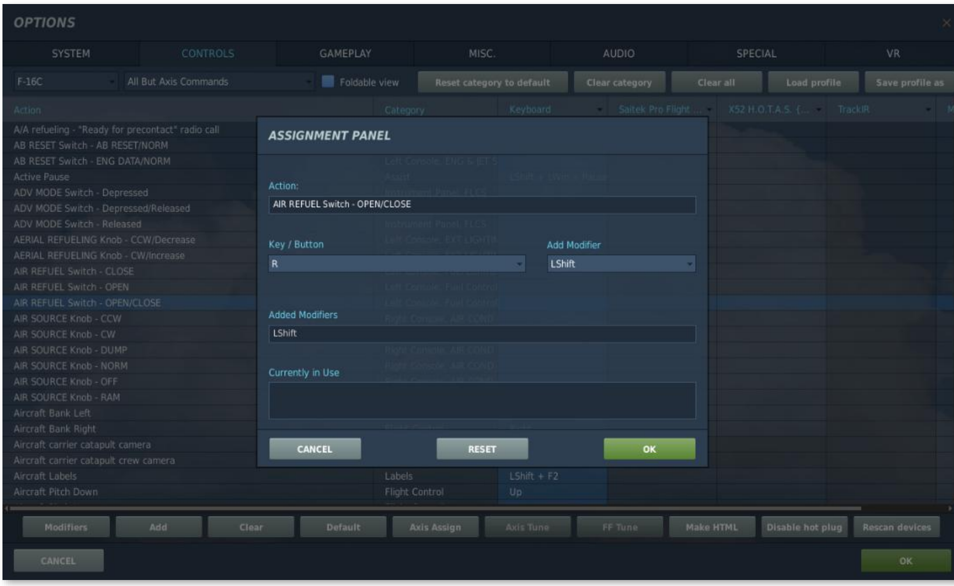
Default button. After assigning a command to an Action, you may revert to the default command assignment for that command entry by clicking on the corresponding entry to highlight, and then clicking the Default button. This can also be accomplished by right-clicking on the command entry and selecting "Reset combo to default".

Clear button. If you wish to remove all commands from an input device for that Action, click on the corresponding command entry to highlight, and then click the Clear button. This can also be accomplished by right-clicking on the command entry and selecting "Clear combo".

Axis Tune button. This button becomes available if an axis command entry is highlighted. When this button is clicked, the AXIS TUNE PANEL is displayed. This can also be accomplished by right-clicking on the command entry and selecting "Tune combo axis".

ASSIGNMENT PANEL

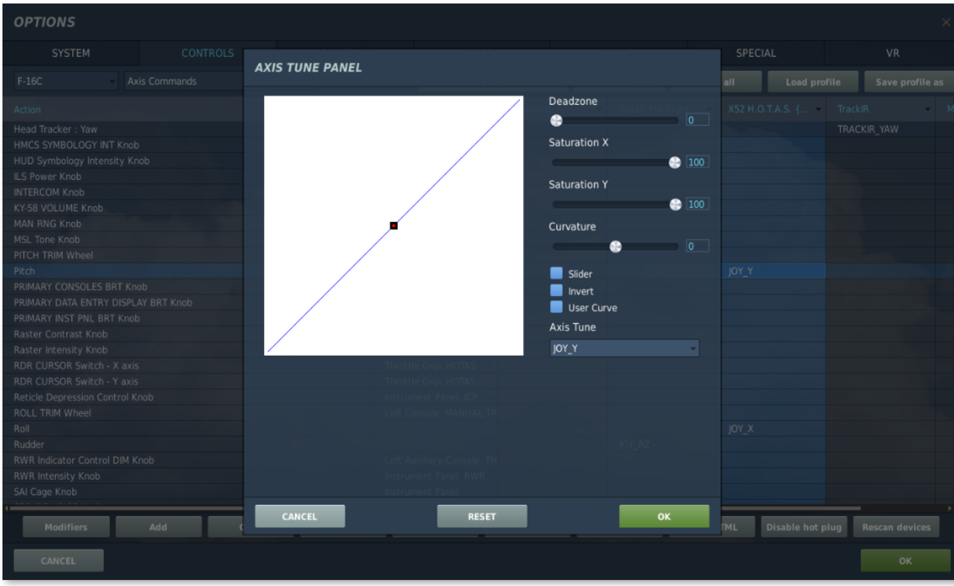
When this panel is displayed, simply press the button (or combination of buttons) or move the axis of the device to assign it to that Action.



- **Example 1:** If setting a pitch axis for a joystick, first select AXIS COMMANDS from the Input Functions drop down. Find the box where your joystick input device and the "Pitch" Action intersect and double-click the left mouse button in the box. In the ASSIGNMENT PANEL, move your joystick forward and back to assign the axis. Press OK when finished.
- **Example 2:** If setting a keyboard or controller device button, first select All But Axis Commands as the Input Function category, or the category that contains the desired Action you wish to edit. Find the box where your input device and the Action intersect, and double-click the left mouse button in the box. In the ASSIGNMENT PANEL, press the keyboard or controller device button you wish to assign to the Action. Press OK when finished.
- If you make a mistake during the assignment process, press the RESET button and try again.
- If another Action is already assigned to that button or button combination, that Action will be shown under Currently In Use.

AXIS TUNE PANEL

When this panel is displayed, the selected axis can be assigned a dead zone, different response curves, and other tuning.



GAMEPLAY Tab

This tab primarily allows you to adjust the game to be as realistic or casual as you want it to be. Choose from various difficulty settings like labels, tooltips, unlimited fuel and weapons, etc. You can also set your preferred language and units of measurement.

Turning Mirrors off can assist with improving performance.

Note that some missions may enforce different gameplay settings that override the individual user selection on this tab. This may result different gameplay behavior than the user expects, such as enforcing no labels or restricting information on the F10 map.

MISC Tab

This tab contains miscellaneous features to further tune the game to your preference.

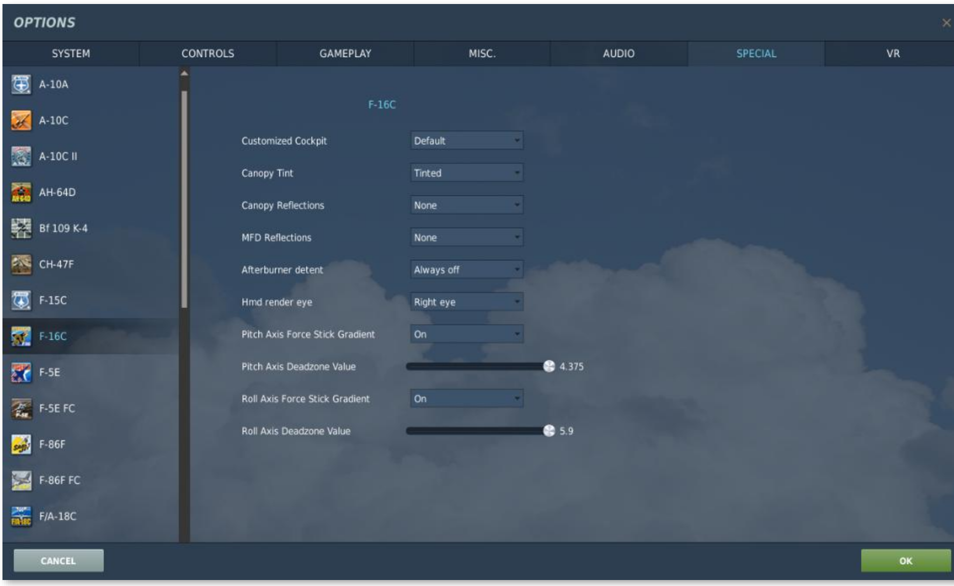
Note that some missions may enforce different gameplay settings that override the individual user selection on this tab. This may result different gameplay behavior than the user expects, such as enforcing no external views or Battle Damage Assessment overlays.

AUDIO Tab

This tab may be used to adjust the audio levels within the game, enable/disable various audio effects, or manage your Voice Chat settings.

SPECIAL Tab

Use this tab to modify module-specific options by selecting the F-16C from the module list along the left side of the screen.



Customized Cockpit. Only one option is available at this time, set to "Default".

Canopy Tint. May be set to "Transparent" or "Tinted".

Canopy Reflections. May be set to "None" or "Static".

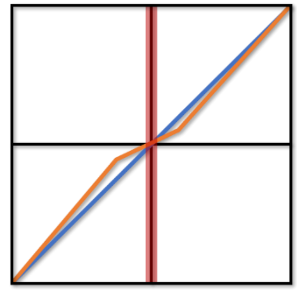
MFD Reflections. May be set to "None" or "Static".

Afterburner Detent. Determines when the throttle will go beyond the Afterburner detent within the game.

- Always off – In-game throttle will enter afterburner range based purely the user's throttle axis input.
- Always on – In-game throttle will only enter afterburner range based on the state of the Throttle Quadrant action "Cycle Afterburner Detent – ON/OFF".

HMD Render Eye. When a VR headset is in use, determines which eyepiece(s) render the JHMCS flight symbology. May be set to "Right eye", "Left eye", or "Both".

Pitch Axis Force Stick Gradient. Determines the pitch input gradient used within the pitch axis.

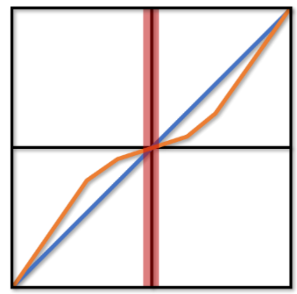


- On – Pitch inputs will use a realistic FLCS control scheme from the force-sensing side stick of the F-16 (Orange line). The graph pictured on the right approximates the gradient for illustration purposes only.
- Off – Pitch inputs will use a purely linear control scheme, which may be useful for non-force-sensing joysticks (Blue line).

Pitch Axis Deadzone Value. Sets the deadzone within the pitch axis, with 4.375% corresponding to a realistic FLCS control scheme from the force-sensing side stick of the F-16 (Red shading).

NOTE: Setting this value to 0 may cause erroneous autopilot behavior in the pitch axis.

Roll Axis Force Stick Gradient. Determines the roll input gradient used within the roll axis.



- On – Roll inputs will use a realistic FLCS control scheme from the force-sensing side stick of the F-16 (Orange line). The graph pictured on the right approximates the gradient for illustration purposes only.
- Off – Roll inputs will use a purely linear control scheme, which may be useful for non-force-sensing joysticks (Blue line).

Roll Axis Deadzone Value. Sets the deadzone within the roll axis, with 5.9% corresponding to a realistic FLCS control scheme from the force-sensing side stick of the F-16 (Red shading).

NOTE: Setting this value to 0 may cause erroneous autopilot behavior in the roll axis.

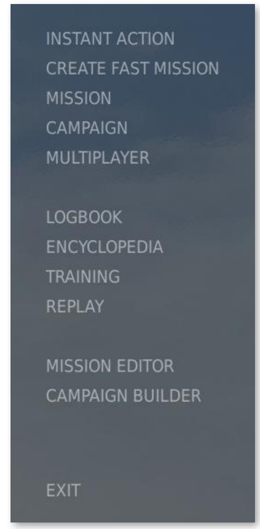
VR Tab

This tab allows you to enable support for a wide variety of VR Headsets and adjust their functionality. When using VR, be particularly aware of the Pixel Density setting as it can have a dramatic effect on game performance.

Fly a Mission

Now that you have configured your game, let's get to why you purchased DCS: F-16C Viper, to fly some missions! You have several options to fly a single or multi-player mission.

On the Main Menu page, you have the options to fly the Viper in an INSTANT ACTION mission, CREATE FAST MISSION, load a MISSION, play a CAMPAIGN, go through a TRAINING lesson, or create a mission in the MISSION EDITOR. You also have the option to jump online and fly with others in MULTIPLAYER.



INSTANT ACTION. Simple missions that place you in the task of your choice. These missions are grouped according to which map they take place in, so selecting a different map from the list along the right side of the Instant Action mission list may provide additional missions to choose from.

CREATE FAST MISSION. Set various mission criteria to allow a mission to be created for you.

MISSION. More in-depth, stand-alone combat missions.

CAMPAIGN. Linked missions to create a campaign narrative.

MULTIPLAYER. Create your own multiplayer session or join a multiplayer session already in progress.

TRAINING. Lessons that provide step-by-step instructions in tasks such as starting the F-16C, takeoff and landing, navigation, or employing weapons.

MISSION EDITOR. Use this very powerful tool to create your own missions.

To get started, we suggest one of the "Free Flight" INSTANT ACTION missions. Later, you can also use these missions to practice starting up the aircraft, takeoffs, landings, navigation, and sensor / weapon employment.

Game Problems

If you encounter a problem, particularly with controls, we suggest you back up and then delete the `Saved Games\DCS\Config` folder in your home directory, which is created by DCS on your operating system drive at first launch. Restart the game and this folder will be rebuilt automatically with default settings, including all the controller input profiles.

If problems persist, we suggest consulting our online technical support forums.

Useful Links

- DCS World homepage
- DCS: F-16C Viper forum

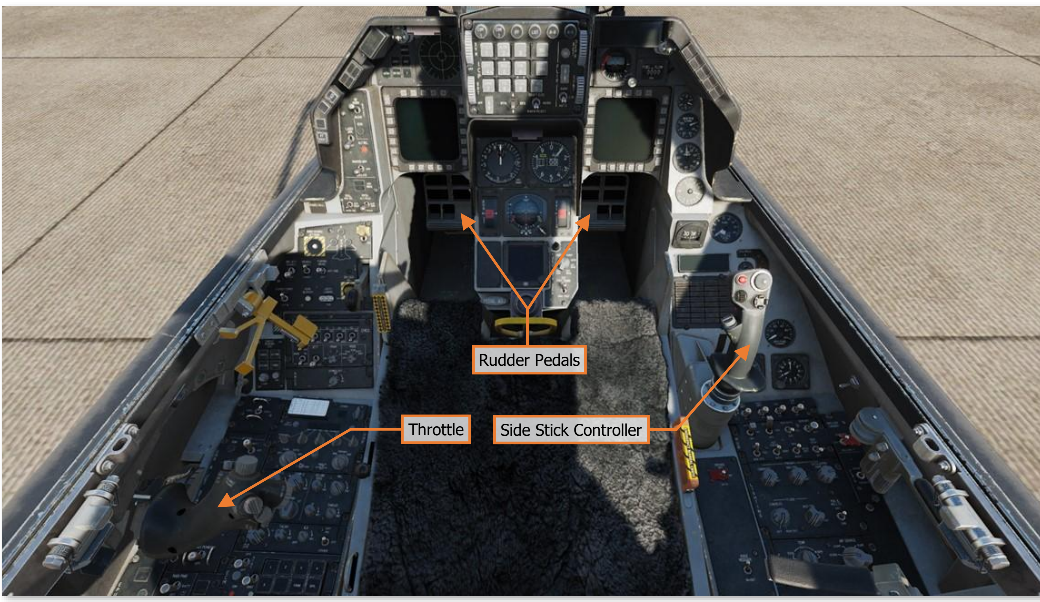
Note about this manual

(N/I). This denotes a system or function within this manual that is not implemented in DCS: F-16C Viper.

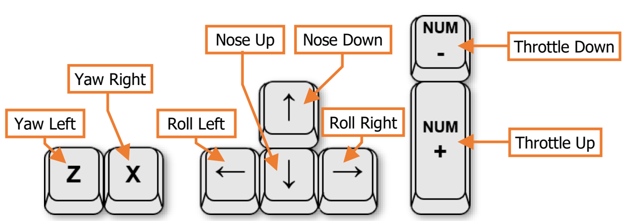
FLIGHT CONTROL

The primary aircraft flight controls include the **Side Stick Controller (SSC)**, **Throttle**, and **Rudder Pedals**.

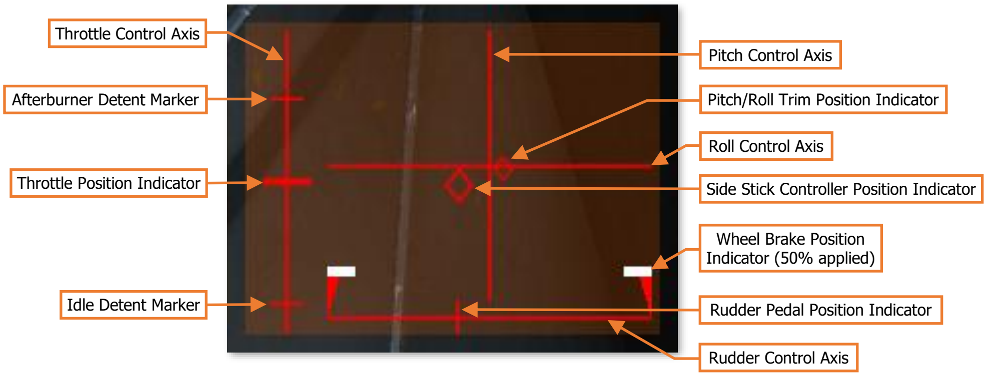
- The **Side Stick Controller (SSC)** is used to roll the aircraft left and right to perform turns, and pitch the nose up and down to climb or descend.
- The **Throttle** is used to control engine power and airspeed.
- The **Rudder Pedals** are used in flight to yaw the airplane left and right using the rudder (like a boat); and on the ground to turn the nose wheel when taxiing.



If you are flying with only a keyboard, the primary flight control keys will be the arrow keys to control roll and pitch, **[Numpad+]** and **[Numpad-]** to control throttle, and **[Z]** / **[X]** to control the rudder pedals. If you do have a joystick, it may be equipped with a throttle handle and/or a twist grip, which will allow you to control the rudder pedals.



When flying from the cockpit, the Controls Indicator display may be toggled by pressing **[RCtrl]+[Enter]** to see a visual reference of the positions of your flight controls.



Changing Airspeed

There are several methods to increase or decrease airspeed:

- **Aircraft engine power.** When advancing the throttle, the engine will produce more thrust. Likewise, retarding the throttle will produce less thrust.
- **Aircraft pitch angle and pitch rate.** Generally, pitching the nose up above the horizon will cause the aircraft to slow down; and pitching the nose down below the horizon will cause the aircraft to speed up. Rapid pitch changes can also affect speed, regardless of whether it is a pitch change in the horizontal plane or in the vertical plane. Higher pitch rates increase the Angle-of-Attack (AoA), which increases drag, leading to a loss in airspeed.
- **Speedbrakes.** Opening the speedbrakes will cause an increase in drag, which can cause a loss of speed, or reduce the rate the airspeed increases while in a dive.
- **Landing Gear.** Lowering the landing gear will produce additional drag like the speedbrakes, but they should only be lowered when below 300 knots to prevent damage.

The Airspeed & Velocity Scale on the HUD can be used to monitor airspeed, along with the Airspeed/Mach Indicator on the center section of the instrument panel.

Changing Altitude

Changing the pitch attitude of the aircraft can increase or decrease the altitude.

- **Increase altitude.** Pitching the nose up above the horizon will increase altitude, but this will cause a loss in airspeed unless engine power is increased to compensate. If the aircraft starts to stall, lower the nose and/or increase engine power.
- **Decrease altitude.** Pitching the nose down below the horizon will decrease altitude, but this will cause an increase in airspeed unless engine power is reduced to compensate. Additionally, the speedbrakes can be used to maintain current airspeed in shallow dives.

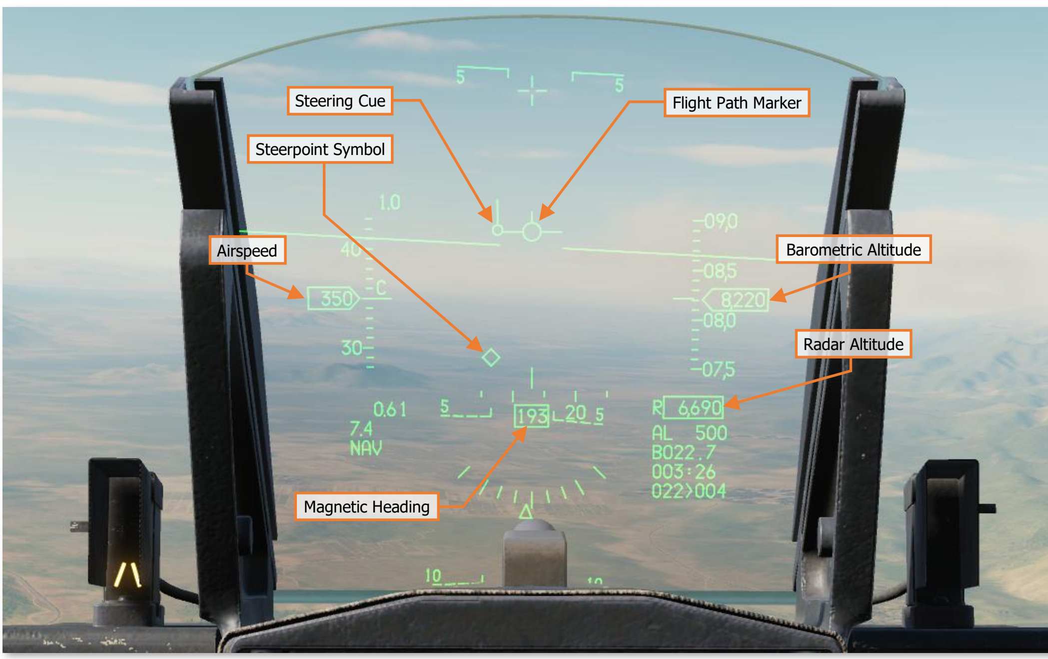
The Barometric Altitude & Altitude Scale and Radar Altimeter on the HUD can be used to monitor altitude, along with the Altimeter on the center portion of the instrument panel. Climb/descent rates can be monitored on the HUD Vertical Velocity Scale, along with the Vertical Velocity Indicator on the center instrument panel.

Changing Heading

Changing the heading of the aircraft in the horizontal plane is accomplished by rolling, or banking, the aircraft in the desired direction. As the bank angle is increased, the stick must be pulled back in pitch to prevent a loss in altitude. At steeper bank angles, pulling back on the stick can increase the turn rate by pitching the nose in the direction of the turn. Just prior to reaching the desired heading, the stick should be used to roll the aircraft back to level flight, so that the aircraft wings return to level just as the desired heading is reached.

Note the following:

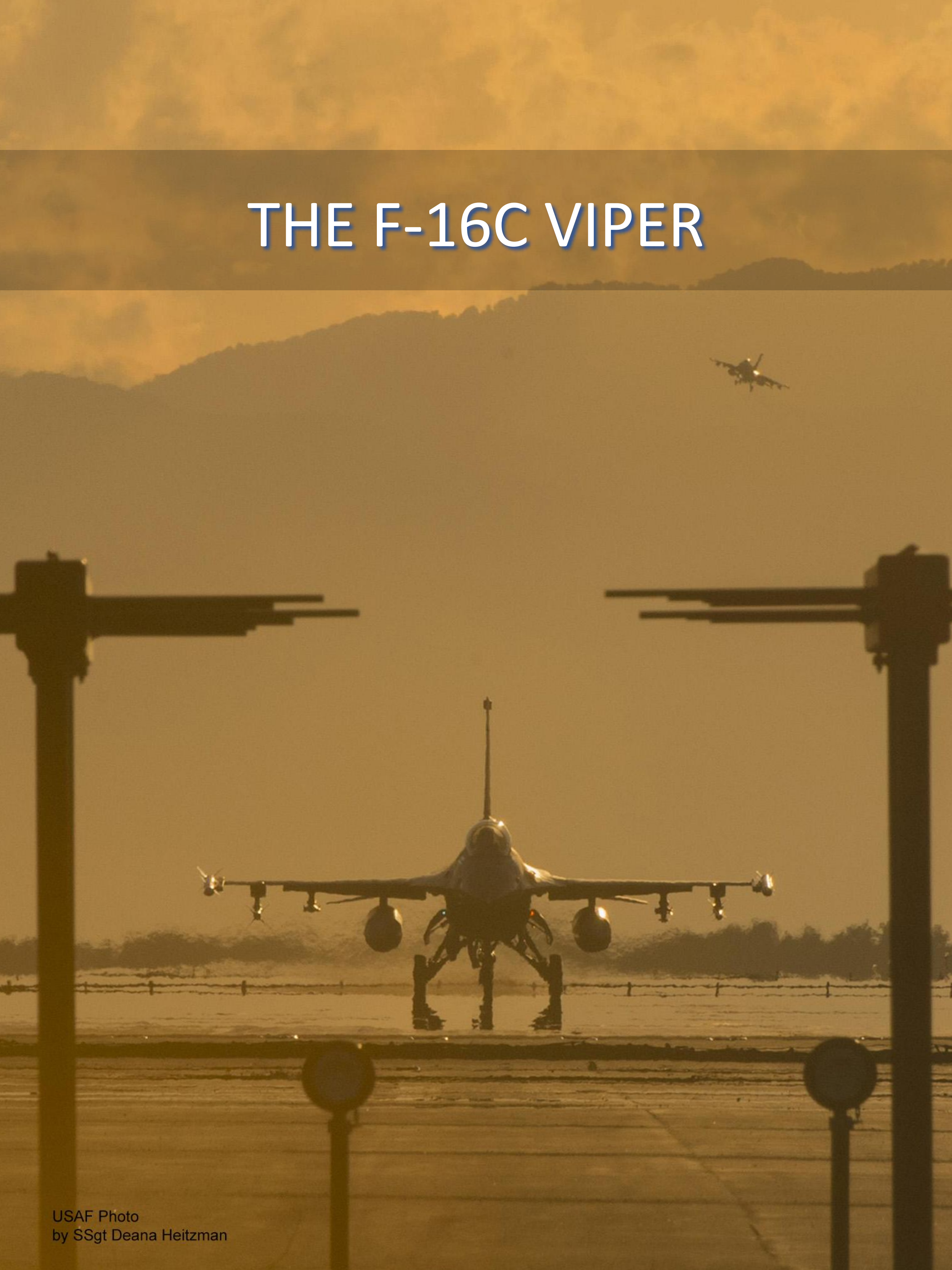
- Steep bank angles will require more pitch input to the stick to prevent altitude loss.
- During steep turns, higher pitch rates will increase the turn rate but will also increase the wings' angle-of-attack and cause the aircraft to slow down. If you lose too much speed, the aircraft may become uncontrollable. Increasing engine power or decreasing the turn rate will prevent speed loss.
- Keeping the Flight Path Marker on the Horizon Line throughout the turn will prevent altitude loss. A combination of pitch and roll inputs using the stick can be used to maintain altitude throughout the turn.



The Magnetic Heading Tape on the HUD can be used to monitor heading, which is displayed on either the top or bottom of the HUD, depending on the selected master mode. The Steering Cue shows the relative direction to your steerpoint. If you turn the aircraft to align the Flight Path Marker with the Steering Cue, you will be flying to your steerpoint.

The Electronic Horizontal Situation Indicator (EHSI) also provides the aircraft's heading. The top of the magnetic heading compass that is aligned with the lubber line at the top of instrument is the current heading.

THE F-16C VIPER



USAF Photo
by SSgt Deana Heitzman

AIRCRAFT HISTORY

The history of the F-16 is closely linked to the history of fly-by-wire. Fly-by-wire substitutes the traditional hydromechanical link between pilot and control surfaces for a computer. When the pilot moves the stick left, they are essentially telling the fly-by-wire computer that they wish to bank left; it's then up to the computer to decide how to translate that command into a series of control surface deflections. Fly-by-wire opened the door to aircraft designed with relaxed static stability: designs that would be too unstable for a human pilot to fly manually, but whose instability translated to improved maneuverability.

The F-16's pioneering fly-by-wire system is owed to a man named Harry Hillaker. In the 1940s, fresh out of college, Hillaker joined Consolidated Aircraft as an aircraft designer. There Hillaker contributed to the designs of the B-36 Peacemaker and the F-111, among others, and in doing so, he began to lament a trend among Air Force aircraft: Each new generation was becoming bigger, heavier, and less efficient. By the mid-1960s, Hillaker started contemplating a small, agile fighter that forsook contemporary Air Force dogma.

While Hillaker pondered his new fighter, NASA was breaking ground on fly-by-wire technology. Fly-by-wire was first used on the Gemini 2 capsule, and ultimately made its way to the Apollo lunar landers, where it impressed astronaut Neil Armstrong. Following the cancellation of the Apollo program, Armstrong was promoted to Deputy Associate Administrator for Aeronautics at NASA. Wanting to further investigate fly-by-wire technology, Armstrong acquired a lunar lander computer, and had it installed in an F-8 Crusader, to be used as a testbed for airborne fly-by-wire. This F-8, designated NASA 802, flew in May of 1972, thus becoming the United States's first fly-by-wire aircraft. NASA 802 caught the notice of Hillaker, who noted the drastic improvement in control responsiveness, a full 2.5 times that of an unmodified F-8.

NASA 802 (NASA)

The Fighter Mafia

Col. John Boyd (US)

Few fighter pilots are as well-known (or notorious) as Col. John Boyd. Following a 1953 tour in Korea as an F-86 Sabre pilot, Boyd attended the USAF Fighter Weapons School, where he quickly became a star pupil. His outstanding performance earned him an invite to return as an instructor, and through the 1960s, Boyd worked as teacher and tactician, conceiving of and developing his energy-maneuverability theory. E-M theory was an entirely novel analysis of aircraft combat, with a quantifiable underpinning contributed by mathematician Thomas Christie. Boyd and Christie crunched the numbers using Air Force computers, and the results led Boyd to the conclusion that a fighter with maximal thrust-to-weight ratio and minimal energy loss in turns would hold a competitive advantage over contemporary designs, which emphasized bigger, heavier engines and airframes.

In the late 1960s, in an effort to push his ideas, Boyd put together a team of likeminded experts: The "Fighter Mafia." Among them was Harry Hillaker of Consolidated Aircraft, which had since been sold to General Dynamics. The Fighter Mafia worked from inside the Air Force to advance the concept of a lightweight fighter.

In 1967, Boyd was recalled to USAF headquarters to apply his E-M theory to the flagging F-X project. The F-X project was to be the next generation USAF fighter aircraft, but it had stalled amidst doubts among USAF generals that it had become too large and costly. Boyd's analyses helped convince the Air Force to reduce the weight and complexity of the F-X. The lighter F-X proposal would be nicknamed the F-X "Blue Bird," but Boyd and the Fighter Mafia continued to push for an even smaller, even more nimble air superiority fighter, which they called the F-X "Red Bird."

The Fighter Mafia was a diverse group of fighter pilots and engineers, but they all had in common a desire to see the Air Force adopt a lightweight fighter design. This put them squarely at odds with the Air Force brass, most of whom leaned heavily on the upcoming "Blue Bird." The F-X program was seen as a sort of rebirth for the USAF fighter inventory, at this time comprised mostly of F-111s and F-4s. The F-111 had by then evolved into something ungainly and sluggish, and the F-4 was thought of as the Navy's bird, something the Air Force adopted only afterwards. The F-X represented a prideful Air Force future, embracing its "higher, faster, further" motto, and many in the USAF command ranks were emotionally invested in an aircraft that embodied those words.

F-15 Eagle (USAF)

The F-X program continued undeterred. In 1970, the Air Force announced that McDonnell-Douglas was selected to develop the F-X, now designated the F-15 Eagle.

Lightweight Fighter Program

Towards the end of the 1960s, the Deputy Secretary of Defense, David Packard (of Hewlett-Packard) had become concerned that the upcoming USAF and Navy frontline fighters — the F-15 and the F-14 Tomcat — represented future budget problems for the Armed Forces. The Fighter Mafia had continued to push the USAF towards their "Red Bird" concept, now also known as the F-XX. Their studies also helped convince manufacturers such as General Dynamics and Northrop to start investigating potential lightweight fighter designs. In late 1970, as the F-14 continued to experience budget and maintenance issues, Lockheed-Martin took the initiative and delivered to Packard an unsolicited proposal for a lightweight fighter. Other companies in the industry quickly followed suit, including General Dynamics.


David Packard (DoD)

Deputy SecDef Packard had been looking to implement a new "fly-before-you-buy" purchasing policy and had become recently enamored of competitive prototyping. He saw the new LWF proposals to advance his ideas. The Air Force was still lukewarm to the idea of a lightweight fighter, until the Fighter Mafia coined the "high/low mix" — the concept that the F-15 and F-XX would complement each other, occupying the high-cost and low-cost brackets of Air Force spending, respectively. The high/low mix idea reframed the LWF as an ally to the F-15, and lifted resistance among Air Force brass.

Packard's Lightweight Fighter RFP produced five proposals, among which two were selected for funding: The General Dynamics Model 401, and the Northrop P-600. Each company would be granted funding to build demonstrator aircraft, which would be tested against each other in a series of trials — the fingerprint of Deputy SecD Packard's influence. The P-600 would be redesignated the YF-17, and the Model 401 would become the YF-16.

Air Combat Fighter Competition

At General Dynamics, Robert. H Widmer became the chief engineer on the YF-16 project. At Harry Hillaker's insistence, the YF-16 was to incorporate a production fly-by-wire system — but as the engineers were still uncertain if fly-by-wire was feasible, the YF-16 program was designed with a contingency. Should it be necessary, the YF-16's wings could be shifted aftward to restore the airframe's static stability, and the analog fly-by-wire system was designed to be easily removable and replaced with traditional flight controls.

YF-16 Rollout, 1973 (GD)

Along with its revolutionary control system, the YF-16 became a testbed for other innovations: The aircraft would be capable of 9-g maneuvers, and the seat was reclined 30° to improve the pilot's g-tolerance. The reclined seat, and concern about the pilot's ability to manipulate systems during high-g maneuvering, guided the development of its HOTAS, which put more capability on the stick and throttle than prior aircraft. The small cockpit necessitated that the stick be moved to the side, so that it wouldn't obscure cockpit instruments.

In December 1973, the completed YF-16 prototype was unveiled at Edwards Air Force Flight Test Center, where it began flight trials. Its first flight on January 20, 1974 was unintended: During a fast-taxi run, a fault in the fly-by-wire system created a worsening control problem that forced the test pilot to lift off for a trip around the pattern. The actual, intended first flight occurred a few weeks later in February, following repairs of the prototype.

The Air Force had set the initial stakes of the LWF competition by committing to purchasing 650 aircraft of whichever model won. But by early 1974, interest in the Lightweight Fighter competition had grown, and as word spread to NATO allies, other countries began committing to purchases of the winner as well. In response to the heightened interest, the LWF competition was expanded into a new program called Air Combat Fighter (ACF). The ACF program specified a multirole lightweight fighter aircraft and required that any purchase of the winning model must also be in parallel to a purchase of F-15s. This requirement shut down the last of the resistance to the LWF program within the Air Force.

The expanded ACF program brought in foreign competitors, among them Dassault-Breguet, SEPECAT, and Saab. Ultimately, after flying 330 trial sorties spanning 417 flight hours, test pilots unanimously favored the YF-16. So it was January 13, 1975 when Secretary of the Air Force John L. McLucas announced that General Dynamics had won the ACF competition, and with it, hundreds of domestic and foreign orders for the F-16.

The F-16A and B

Through 1974 and 1975, General Dynamics developed the YF-16 into the F-16, making numerous structural modifications. What was originally envisioned as Boyd's lightweight fighter now had to become a multirole aircraft, per the ACF program requirements. The radome was enlarged to fit the AN/APG-68 radar, and two more pylons were added. These and other changes ultimately netted a 25% weight increase.

First production F-16A Block 10 (USAF)

So much was the Air Force's desire to keep the new fighter from impinging on the F-15's glory, that Air Force brass prohibited the F-16 from carrying AIM-7 Sparrows, the medium-range BVR missile of the day. (This requirement would impel one of the Fighter Mafia, General Mike Loh, to order the design of a medium-range missile that could be mounted on AIM-9 Sidewinder stations — a project that would ultimately produce the AIM-120 AMRAAM.)

In late 1975, the first F-16A FSD (full-scale development) was manufactured, and on October 20, 1978, the first production model rolled off the assembly line. The production F-16A first flew in November of that year, and the Air Force received its first delivery in January. The F-16 entered operational service with the 388th Tactical Fighter Squadron at Hill AFB, Utah in 1979. A year later, the F-16 was given the official moniker of "Fighting Falcon" — but of course, its pilots called it the "Viper."

In all, 475 F-16As and Bs (dual-seat variant) were produced. The model variants spanned Blocks 1, 5, 10, 15, and 20. Many Block 20 F-16As have since undergone the Mid-Life Upgrade (MLU), becoming functionally equivalent to F-16Cs.

The F-16C and D

On June 12, 1987, the Block 30 F-16 was introduced, designated the F-16C and D. Block 30 was the result of the Alternative Fighter Engine (AFE) program, a project to allow the F-16 to be configured with either the existing Pratt & Whitney F100-PW-220 engine, or with the General Electric F110-GE-100 as an alternative. The original plan was for the F-16 to have a common engine bay, allowing any aircraft to swap between the two engines. This idea was scrapped when it was discovered that the GE engine required widening the inlet. Due to the airframe change, beginning with Block 30, the blocks were split in two: Block 30, 40 and 50 were equipped with a General Electric engine; and Block 32, 42, and 52 were equipped with a Pratt & Whitney engine.

Along with the diversity of engine choices, the Block 30/32 F-16C received an upgraded mission computer with more storage, an AN/ALE-47 countermeasures dispenser, and the capability to employ AGM-45 Shrike and AIM-120 AMRAAM missiles.

Block 30/32 F-16Cs would be delivered to the USAF Thunderbirds demonstration squadron in 1986 and 1987; these aircraft are today some of the oldest still-operating F-16s. Other Block 30/32s were delivered to the U.S. Navy, re-designated the F-16N, and used as stripped-down aggressor aircraft in USN air combat training.

F-16C (MSGT Michael Ammons, USAF)

The Block 40/42 model, commonly called the "Night Falcon," was debuted in December 1988. As implied by its nickname, the Night Falcon introduced a suite of night attack technologies, including the LANTIRN navigation/terrain-following radar and targeting pods. The aircraft also got an upgraded fire control radar and RWR, a wide-angle holographic HUD capable of displaying FLIR video, and an improved mission computer. The aircraft got an exterior makeover as well: The hull was treated with radar-absorbent materials, and the iconic gold-tinted canopy debuted. Despite all these improvements, the USAF was in general disappointed with the increased weight and decreased performance of the Night Falcon series.

January 1991 saw the start of Operation Desert Storm in Iraq, and with it, the F-16's first combat deployment for the USAF. Following the Gulf War, on December 27, 1992, LTC Gary North of 33rd Tactical Fighter Squadron earned the first combat kill in a USAF F-16 after shooting down a Syrian MiG-25 that violated airspace restrictions. The MiG-25 was also the first aircraft destroyed by an AIM-120 AMRAAM.

In October of 1991, Block 50/52 rolled out, restoring the Viper's performance and maneuverability. The aircraft got an up-rated engine (the F110-GE-129 or the F100-PW-229), and with it a 20% increase in thrust. The radar was again upgraded, a secure modem-based datalink (SMDL) was added, and the Block 40's holographic HUD was replaced with the original Block 30 HUD. Some Block 50 F-16Cs were configured to carry the HARM Targeting System (HTS) pod; these SEAD aircraft were designated the F-16CJ and DJ.

The F-16C continues to see improvements and upgrades to keep it in step with technological innovations. Between 2003 and 2010, the Air Force's Common Configuration Implementation Program (CCIP) modernized and standardized the avionics and capabilities across the fleet of Block 40 and Block 50 F-16Cs. The FCC was upgraded, the MFDs were replaced with new color displays, support for JHMCS and MIDS-based datalink was added, and the IFF was modernized. F-16CJ and DJ SEAD models that underwent modernization through this program were redesignated the F-16CM or DM.

Today, while the USAF no longer purchases F-16s, it still operates a fleet of over 1,000 active-duty F-16Cs and Ds. F-16s have served in virtually every U.S. air combat action since Operation Desert Storm, and F-16s are scheduled to continue to remain in service until 2025, when they will be replaced with the F-35A Lightning II.

Aside from the United States, twenty-six other countries have purchased or leased F-16s, and all but one (Italy) continue to fly them as an integral part of their air forces. After purchasing General Dynamics, Lockheed-Martin continues to improve on the F-16 for foreign customers. The United Arab Emirates funded development of the F-16E and F models (Block 60), and many other countries have pledged to purchase the upcoming F-16V (Block 70/72). The F-16V is expected to be delivered to buyers starting in 2023.

F-16 from the 66th AGRS taking off from Nellis AFB (SRA Dylan Murakami, USAF)

WEAPONS & MUNITIONS

M61A1 Vulcan 20mm Cannon

A1C Kimberly Barrera (USAF)

The F-16 is equipped with an internal M61 Vulcan six-barreled rotary cannon. The M61 can employ M50- or PGU-series 20x102mm projectiles at 6,000 rounds per minute and is effective against both air and surface targets. PGU-series rounds provide increased range and decreased time of flight compared to M50-series ammunition. The ammunition drum carries 510 rounds, of which six different types can be chosen for loading:

M56 HEI. High-Explosive Incendiary rounds. HEI rounds have both explosive and incendiary effects, making them effective against aircraft, light vehicles, and personnel.

M56/M242 HEI-T. High-Explosive Incendiary rounds with Tracer mix. M242 tracer rounds are substituted for HEI rounds at regular intervals. The tracer rounds glow brightly when fired, allowing the pilot to visually see the ballistic path of the fired projectiles.

M53 API. Armor-Piercing Incendiary rounds. Armor-piercing rounds are made from solid steel with a combined incendiary effect, making them capable of penetrating armored vehicles. However, they have no explosive effects upon impact, which makes them less effective against personnel.

M55/M220 TP. Target Practice rounds. TP rounds are inert with only kinetic effects upon impact. TP mix always contains M220 tracer rounds at regular intervals.

PGU-28A/B SAPHEI. Semi-Armor-Piercing High-Explosive Incendiary rounds. These rounds have both incendiary/explosive effects and armor-piercing capability. The rounds are constructed such that the incendiary and explosive effects are triggered after penetration of the armor. SAPHEI rounds are effective against a wide range of vehicles but are not generally effective against personnel.

PGU-27A/B TP. Target Practice rounds. TP rounds are inert with only kinetic effects upon impact. TP mix always contains PGU-30A/B tracer rounds at regular intervals.

AIM-9 Sidewinder

SSgt Darnell T. Cannady (USAF)

The AIM-9 Sidewinder is an infrared-guided (heat-seeking) short-range air-to-air missile. It first entered service in 1956 and has since become one of the most successful missiles in the West. Its longevity is thanks to its versatility and continued improvement over multiple generations.

The AIM-9 uses an array of up to five scanning infrared sensors, cooled by an internal argon bottle (L and M models). The Sidewinder has a maximum speed of over Mach 2.5 and a maximum range of around 10 to 20 miles, depending on the variant. Minimum range is around 3,000 feet.

A single AIM-9 can be mounted on any of the F-16C's air-to-air stations.

AIM-9L Sidewinder. The "Lima" model was the first all-aspect Sidewinder fielded in 1977, meaning it no longer required the target to present a rear profile. The AIM-9L earned its first kill when it struck a Libyan Su-22, after being fired from an F-14 Tomcat, in the infamous Gulf of Sidra engagement of 1981.

AIM-9M Sidewinder. The "Mike" model introduced in 1982 improved on the Guidance Control Section (GCS). Susceptibility to flares was reduced, and background discrimination was improved, resulting in a greater chance of target acquisition. The rocket motor's smoke signature was reduced, making the missile less likely to be seen.

AIM-9X Sidewinder. The "X-ray" model introduced in 2003 is the latest iteration of the Sidewinder. The 9X adds high-angle off-boresight (HOB) capability and the ability to slave the seeker head to a helmet-mounted sight, such as the JHMCS. The missile's maneuverability was boosted with all-axis thrust-vectoring capability. These changes allow the pilot to simply "point their head and shoot" in nearly any direction, greatly increasing reaction time and lethality in air-to-air combat, even when in a defensive position. The infrared sensor was replaced with focal-plane arrays (FPAs) and counter-countermeasures capability was further improved. Electronic fuzing was added to reduce minimum range.

CAP-9M. Captive variant of the AIM-9M. The captive variant has the same size, weight, and drag characteristics as the AIM-9M, for training effectiveness. It also contains an integrated infrared sensor and will provide audio and visual guidance cues to the pilot, but it does not have a rocket motor and cannot be fired from the aircraft.

AIM-120 AMRAAM

The AIM-120 AMRAAM (Advanced Medium-Range Air-to-Air Missile) is an active radar-homing, medium-range air-to-air missile. First introduced in 1982, the AMRAAM was intended to replace the semi-active radar homing AIM-7 Sparrow, which was the medium-range BVR missile in the U.S. inventory at the time.

SSgt Sheila deVera (USAF)

The AIM-120 uses both command guidance and radar homing to reach its target. The AIM-120's integral radar has a comparatively short range and relies on steering signals transmitted automatically from the launching aircraft via a radio datalink. The AMRAAM has a maximum speed around Mach 4 and a maximum range of 30 to 40 miles.

AIM-120B AMRAAM. The B model was fielded in 1994 with improved guidance over the A-model.

AIM-120C AMRAAM. The C variant was fielded in 1996 and featured a slightly larger rocket motor, improved guidance, electronic counter-countermeasures (ECCM), and re-designed fins for carriage within the internal weapon bays of the F-22.

AGM-88 HARM

The AGM-88 HARM (High-speed Anti-Radiation Missile) is a passive radar homing air-to-ground missile used in the Suppression of Enemy Air Defenses (SEAD) role. The HARM has a radar receiver and processor that detects and identifies signals from enemy surface radars. When launched, it can guide to the target by homing on its specific radar emissions. The missile also has an inertial guidance system to provide mid-course guidance prior to detection of the radar signal (or if the signal is lost).

SSgt Scott Stewart (USAF)

The AGM-88 has a maximum speed of Mach 1.84 and an operational range of around 80 nautical miles. The missile can be employed using several different engagement profiles that can be selected prior to launch. It uses a laser proximity fuze for detonation to increase its area of weapons effects.

AGM-88C. This mid-1980s variant incorporates field-reprogrammable software and improved guidance and fuzing.

AGM-65 Maverick

SSgt Glenn B. Lindsey (USAF)

The AGM-65 Maverick is a medium-range air-to-ground missile designed for the close air support role. The AGM-65 family contains a diverse set of variants and guidance systems, including infrared, electro-optical, and laser guidance.

The AGM-65 has a maximum range of around 13 nautical miles. A single Maverick can be mounted to an LAU-117 rack, or up to 3 can be carried on an LAU-88 rack.

AGM-65D Maverick. The D model contains an imaging infrared sensor and guidance system. The sensor can locate and track targets during daylight and at night, in clear or restricted-visibility weather conditions. It contains a 125-pound shaped-charge warhead.

AGM-65G Maverick. The G model has the same guidance system as the D model, but with a larger 300-pound penetrating warhead, making it more effective against hardened targets.

AGM-65H Maverick. The H model uses a digital CCD sensor, making it effective in daylight only. The H model is capable of forced correlation and does not require a target centroid to track. It contains a 125-pound shaped-charge warhead.

AGM-65K Maverick. The K model has the same guidance system as the H model, but with a larger 300-pound penetrating warhead.

Mark 80-Series General-Purpose Bombs

SSgt Randy Mallard (USAF)

The Mark 80-series of general-purpose bombs is a series of unguided bombs dating back to the Vietnam War. The bombs come in nominal weights of 500, 1,000, and 2,000 pounds, and can be fitted with a variety of nose and tail fuzes or precision guidance kits.

The Mark 80-series bombs can be fitted to any air-to-ground pylon. The Mk-82 can also be mounted to a triple ejector rack (the TER-9A) in pairs or triples.

Mk-82. A 500-pound, general-purpose bomb.

Mk-82 Snakeye. A Mk-82 with Mk15 retarding petals that extend after release. The petals reduce the bomb's downrange speed after release, allowing aircraft to perform low-level straight-through deliveries at lower altitudes without risk of frag damage.

Mk-82 AIR. A Mk-82 with a BSU-49/B Air Inflatable Retarder (AIR). The AIR is a ballute that expands after release, performing the same retarding function as the Mk15. The BSU-49B is a newer technology and is more effective than the Mk15, making the bomb safe to use at higher speeds than the Snakeyes.

Mk-84. A 2,000-pound, general-purpose bomb.

Mk-84 AIR. A Mk-84 with a BSU-50 Air Inflatable Retarder (AIR). The Mk-84 AIR is available as a 2,000-poound general purpose bomb and a 2,000-pound inert training munition variant.

BDU-50 Training Munitions

SSgt Fernando Serna (USAF)

The BDU-50 is an inert, releasable training munition with the same mass and shape as the Mk-82 500-pound bomb but lacks a warhead.

The BDU-50 can be mounted directly to any air-to-ground pylon, or up to three can be mounted on a TER-9A triple ejector rack.

BDU-50LD. Simulates the low-drag or "slick" version of the Mk-82.

BDU-50HD. Simulates the high-drag, ballute-equipped Mk-82 AIR.

BDU-50LGB. Simulates the GBU-12, a Mk-82 equipped with a Paveway II laser-guided bomb kit.

BDU-33 Training Munitions

SSgt James R. Ferguson (USAF)

The BDU-33 is an inert, releasable training munition with a ballistic flight profile that simulates the Mk-82 500-pound bomb. Upon impact, the BDU-33 releases a smoke cloud that can be used to identify the impact point.

The BDU-33 can be loaded in sets of three on the TER-9A triple ejector rack.

CBU-87 Combined Effects Munition

SrA Edward Braly (USAF)

The CBU-87 Combined Effects Munition is an unguided cluster bomb that was developed in 1986. Each bomb contains an SUU-65/B canister and 202 BLU-97/B submunitions. These have both fragmentation and incendiary effects and are effective against vehicles and personnel.

After being released, the CBU-87 begins to spin at a pre-set speed. It falls to a preprogrammed burst altitude, at which point the canister separates and the submunitions are dispersed.

The CBU-87 can be mounted directly to any air-to-ground pylon, or up to three can be mounted on a TER-9A triple ejector rack.

CBU-97 Sensor-Fuzed Weapon

Cindy Farmer (US)

The CBU-97 Sensor-Fuzed Weapon is an unguided cluster bomb containing target-discriminating submunitions. Each bomb contains a SUU-66/B canister and 10 BLU-108 submunitions. When the bomb approaches its preprogrammed burst altitude, the canister opens and the submunitions are released. The submunitions deploy parachutes at preprogrammed intervals to increase lateral spacing. Once the submunitions reach the burst altitude, the parachute is separated, and a rocket motor spins the submunition and stops its descent. Each submunition releases four "Skeets," which are ejected in four different directions.

The Skeets have ground-facing laser and infrared sensors, both of which are used to detect the presence of a vehicle. When a vehicle is detected, the Skeet detonates, firing an explosively formed projectile (EFP) downward toward the vehicle. The EFP usually strikes the radiative part of the vehicle (usually the engine) as detected by the Skeet's infrared sensor and penetrates its armor, using pure kinetic energy to produce lethal effects.

If a vehicle is not detected, they will self-destruct before reaching the ground. This helps reduce collateral casualties associated with the use of cluster munitions.

The CBU-97 can be mounted directly to any air-to-ground pylon, or up to three can be mounted on a TER-9A triple ejector rack.

Paveway II Laser-Guided Bombs

SSgt Glenn B. Lindsey (USAF)

The Paveway II is a series of laser-guided bombs based on conventional general-purpose bombs. The guidance kit consists of a laser detector and processor in the front and a set of steering fins in the back. The bomb detects and tracks reflected laser energy off a target. The laser designation can come from the launching aircraft, another aircraft ("buddy lasing"), or from a laser-capable ground unit such as a JTAC.

The Paveway II series was introduced in the early 1970s to replace the first-generation Paveway series of laser-guided bombs. The Paveway II improved sensor reliability and added extendible rear fins to extend glide range. The Paveway II series uses "bang-bang" control (where the fins can only deflect fully in either direction), limiting its maximum range and forcing it to follow a sinusoidal path to the target.

The Paveway II series of weapons can be mounted on any air-to-ground pylon. The GBU-12 can be mounted in pairs using a TER-9A triple ejector rack.

GBU-12. Mk-82 500-pound conventional bomb equipped with a Paveway II laser-guidance kit.

GBU-10. Mk-84 2,000-pound conventional bomb equipped with a Paveway II laser-guidance kit.

Paveway III Laser-Guided Bombs

USAF

The Paveway III is an improved guidance kit over the earlier Paveway II, for 2,000-pound class bombs. The upgrades include new, larger control surfaces that provide greater aerodynamic efficiency, a larger seeker field-of-regard, improved proportional guidance logic for flying shaped trajectories, and terminal impact options for optimizing weapon effects.

The Paveway III enables strike aircraft to perform low-level laser-guided bomb attacks from a wide variety of ranges and altitudes by utilizing the greater flight efficiency and trajectory options provided by the kit.

The Paveway III can be mounted on any air-to-ground pylon.

GBU-24A/B. BLU-109 2,000-pound hardened penetration bomb equipped with a Paveway III laser-guidance kit.

Joint Direct Attack Munition (JDAM)

SMSgt Edward E. Snyder (USAF)

JDAM is an inertial and GPS guidance kit that can be mounted to a general-purpose bomb, enabling it to attack a pinpoint target based on coordinates downloaded from the aircraft. The JDAM's precision is not degraded by weather and the bomb is completely fire-and-forget; however, the JDAM cannot be re-targeted after launch, nor can it engage moving vehicles.

JDAM development began in 1992 from a proposal for an adverse-weather precision-guided munition. The proposal was created in response to degraded laser-guided bomb performance during Operation Desert Storm. The first JDAM kits were delivered to the U.S. military in 1997, and the first employment was from a B-2 during Operation Allied Force in 1999.

The GBU-38 and GBU-31 can be mounted on any air-to-ground pylon. The GBU-38 can be mounted in pairs using a BRU-57 bomb rack.

GBU-38. Mk-82 500-pound conventional bomb equipped with JDAM guidance kit.

GBU-31(V)1/B. Mk-84 2,000-pound conventional bomb equipped with JDAM guidance kit.

GBU-31(V)3/B. BLU-109 2,000-pound hardened penetration bomb equipped with JDAM guidance kit.

AGM-154 Joint Stand-Off Weapon (JSOW)

TSgt Cary Humphries (USAF)

JSOW is an inertially-aided glide bomb with exceptional glide range due to its folding wings. Like JDAM, JSOW can attack pinpoint targets using pre-designated GPS coordinates. The JSOW's precision is not degraded by weather and the bomb is completely fire-and-forget; however, the JSOW cannot be re-targeted after launch, nor can it engage moving vehicles.

Range is dependent on launch parameters, especially the altitude and speed of the aircraft at release.

The AGM-154A can be mounted on any air-to-ground pylon or mounted in pairs using a BRU-57 bomb rack.

AGM-154A. The AGM-154A variant contains 145 BLU-97/B combined effects submunitions, identical to those used in the CBU-87 and CBU-103.

Wind-Corrected Munitions Dispenser (WCMD)

SrA Jonathan E. Ramos (USAF)

WCMD (pronounced "wick-mid") is a precision guidance kit for the CBU-87 and CBU-97 cluster weapons. The tail kit includes an integrated INS which is initialized from the aircraft's onboard GPS position just before release. The guidance system can be programmed with the winds aloft to enhance accuracy, giving it as low as an 85-foot circular error probable (CEP).

The CBU-103 and CBU-105 can be mounted on any air-to-ground pylon or mounted in pairs using a BRU-57 bomb rack.

CBU-103. CBU-87 Combined Effects Munition (CEM) cluster bomb equipped with WCMD guidance kit.

CBU-105. CBU-97 Sensor-Fuzed Weapon (SFW) cluster bomb equipped with WCMD guidance kit.

2.75-inch Unguided Rockets

BrokenSphere (CC-BY-SA)

The Hydra 70 family of 2.75-inch unguided rockets may be equipped with a variety of warhead types and fuzes, which can be loaded onto any air-to-ground pylon using 7-tube LAU-68 or LAU-131 launchers or 19-tube LAU-3 launchers. The following warhead variants are available in DCS: F-16C Viper.

M151 HE. High-explosive warhead with fragmentation effects. Effective against personnel and light vehicles.

M156 WP. White phosphorous warhead that creates a smoke effect on impact. Used for marking ground targets.

Mk5 HEAT. High-explosive anti-tank warhead with both fragmentation and armor piercing effects. Effective against personnel and most vehicles.

Mk61 Practice. Training rocket with an inert warhead.

WTU-1/B Practice. Training rocket with an inert warhead.

External Fuel Tanks

External fuel tanks carry additional fuel to increase the F-16's range and combat radius and can be refueled during air-to-air refueling. Like most munitions, the fuel tanks are capable of being jettisoned if necessary.

370-gallon external wing tank. The 370-gallon wing tank adds approximately 2,500 pounds of fuel. It can be carried on pylons 4 and 6 under each wing.

300-gallon external centerline tank. The 300-gallon centerline tank adds approximately 2,000 pounds of fuel. It can only be carried on pylon 5 under the fuselage.

SMSgt Edward E. Snyder (USAF)

Targeting/Sensor Pods

Externally mounted targeting pods can be equipped to the left and right "chin" hardpoints on either side of the intake. These targeting systems provide additional capabilities for detecting, acquiring, and engaging enemy forces such as ground vehicles and air defenses from outside the visual range of the pilot, and with greater accuracy and fidelity than the air-to-ground modes of the fire control radar.

AN/AAQ-33 Targeting Pod. The AAQ-33 is an electro-optical targeting pod that can be attached to the right chin hardpoint on the F-16C. It includes a television camera with a powerful magnification range for detecting targets at long distances during the day, and a steerable thermal imaging camera for detecting targets during the day as well as night. The AAQ-33 also includes a laser designator/ranger for illuminating targets with laser energy and a laser spot tracker for detecting laser designations from other friendly forces on or over the battlefield.

(See AAQ-33 Advanced Targeting Pod for more information.)

AAQ-33 Advanced Targeting Pod (USAF)

AN/ASQ-213 HARM Targeting System (HTS). The HARM Targeting System is an electronic detection and geolocation sensor that is exclusively designed for the F-16C when performing Suppression of Enemy Air Defense (SEAD) missions. The HTS pod detects and classifies hostile air defense radar emissions and uses signals triangulation to precisely determine the location of threat radar systems on the battlefield. When a threat radar is detected, the HTS pod can then handoff the radar location to the AGM-88 HARM missiles for engagement, even threat radars that are well outside the forward search cone of the HARM missiles themselves.

ASQ-213 HARM Targeting System (USAF)

While the HTS pod is not required to employ the AGM-88 HARM missile, it does enable the targeting of threat radars more efficiently. The HTS pod also dramatically increases the pilot's situational awareness of the threat radar environment in the surrounding airspace and allows the pilot to make critical decisions regarding which threats must be avoided and which threats must be engaged to accomplish their mission.

(See ASQ-213 HARM Targeting System for more information.)

Electronic Countermeasure (ECM) Pods

Electronic Countermeasure pods can be mounted to the centerline station under the fuselage or stations 3 or 7 under the wings. These defensive systems provide an additional layer of protection against radar threats such as surface-to-air missile (SAM) batteries. Depending on the sophistication and range of the radar system that is attempting to acquire and track the aircraft, ECM pods can be used to deny, degrade or delay an attack so that the pilot can escape the engagement envelope of the threat system, evade incoming weapons, or gain additional time to execute their mission before being forced to take evasive maneuvers..

ALQ-131 (Northrop Grumman)

AN/ALQ-131. The ALQ-131 is one of the most proliferated self-protection aircraft-mounted ECM systems to date. The system can employ both barrage ("noise") jamming as well as deception jamming to threat radar systems across multiple frequency bands.

AN/ALQ-184. The ALQ-184 was developed in the 1980's as an upgrade to the 1970's-era ALQ-119. The ALQ-184 uses the same pod as the ALQ-119 but features higher jamming power output, lower response time to threat radar signals, and digital microprocessors to increase its capability against threat radar systems.

AN/ALQ-184 Long. The "Long" version of the ALQ-184 includes additional modules to provide protection against additional radar frequency bands.

(See Electronic Countermeasures for more information.)

AN/ASQ-T50 Tactical Combat Training System (TCTS) Pod

The AN/ASQ-T50 is a Tactical Combat Training System device. It incorporates a sensor platform and datalink transceiver, allowing it to record and transmit real-time aircraft telemetry to monitoring stations. TCTS pods are used during training exercises to monitor and record aircraft positions for many purposes, including debriefing analysis.

The TCTS pod is captive and cannot be released. It can be mounted to either outboard underwing pylon, or either wingtip station.

USAF

MXU-648 Travel Pod

The MXU-648 is a travel pod, used to transport equipment or the pilot's belongings when the aircraft is repositioned. The MXU-648 has a maximum load capacity of 300 pounds, and an internal volume of 4.75 cubic feet.

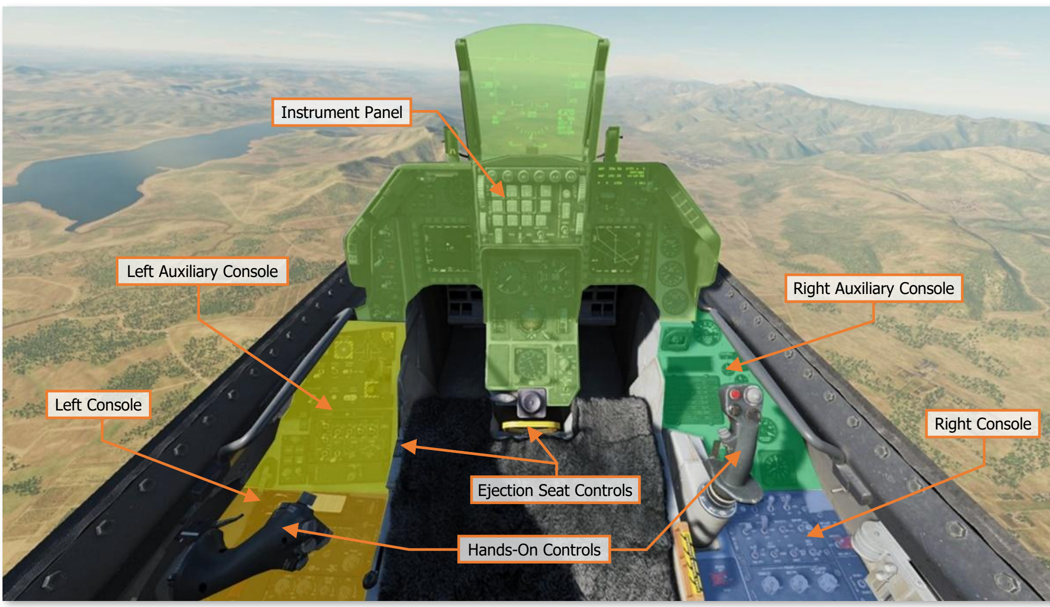
The MXU-648 can be mounted on any air-to-ground pylon.

SrA Theodore J. Koniares (USAF)

COCKPIT OVERVIEW

The F-16's cockpit layout, avionics, and fire control systems are optimized for operation by a single pilot. Critical controls that are needed for aerial combat are located on the Hands-On Controls (Side Stick Controller and Throttle) to provide rapid and seamless control of the radar and weapons during maneuvering flight when moving one's arms and hands under various G forces may be difficult.

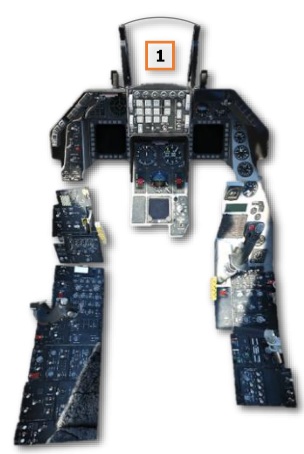
Essential information is displayed on the Head-Up Display (HUD), the two Multi-Function Displays (MFD), and the Data Entry Display (DED). Panels that contain functions that are not typically needed after start-up are concentrated on the right console, with mission-related equipment or functions that may be used throughout the flight are concentrated on the left console for use by the throttle hand.



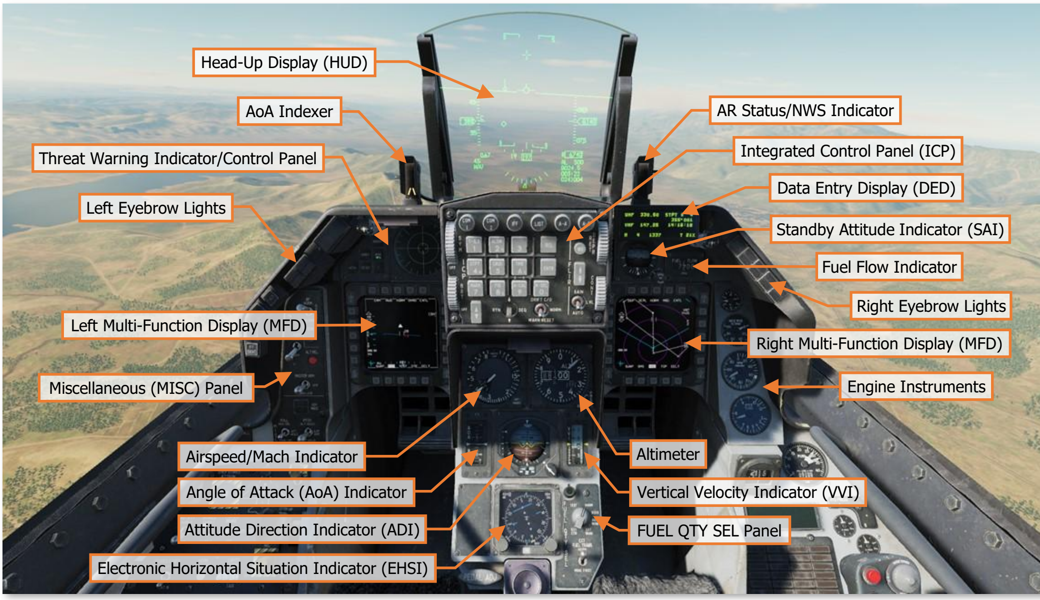
It is important to have a general understanding of where the various controls are located. To help locate items more easily, the cockpit has been delineated into five primary areas: **Left Console**, the **Left Auxiliary Console**, the **Instrument Panel**, the **Right Auxiliary Console,** and the **Right Console**.

Each text box above may be selected to jump to a more detailed description of that instrument panel or console, to include the **Hands-On Controls** and **Ejection Seat Controls**. Selecting the image of the instrument panel or console will return the manual back to this page.

Throughout this manual, a cockpit diagram (as shown at right) may be used to identify specific cockpit components that are used to perform procedures such as start-up, takeoff, navigation, or landing. The component location that is applicable to the step within the procedure will be marked with the corresponding number of the checklist or procedure item to assist the player in rapidly locating it. In the example to the right, the Head-Up Display (HUD) is marked as step 1.



Instrument Panel



Each text box above may be selected to jump to a more detailed description of that individual instrument or panel. Selecting the image of the instrument or panel will return the manual back to this page.

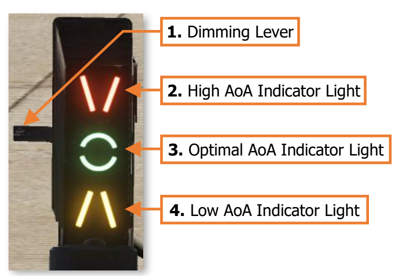
The Head-Up Display (HUD), Integrated Control Panel (ICP), Data Entry Display (DED), and Multi-Function Displays (MFD) are described in dedicated sections following the Hands-On Controls (HOTAS).

The Electronic Horizontal Situation Indicator (EHSI) is described in the Navigation chapter.

The Threat Warning Indicator/Control Panel is described in the Defensive Systems chapter.

AoA Indexer

The Angle-of-Attack Indexer consists of three lights, which are duplicated from the AoA Indicator on the center instrument panel.



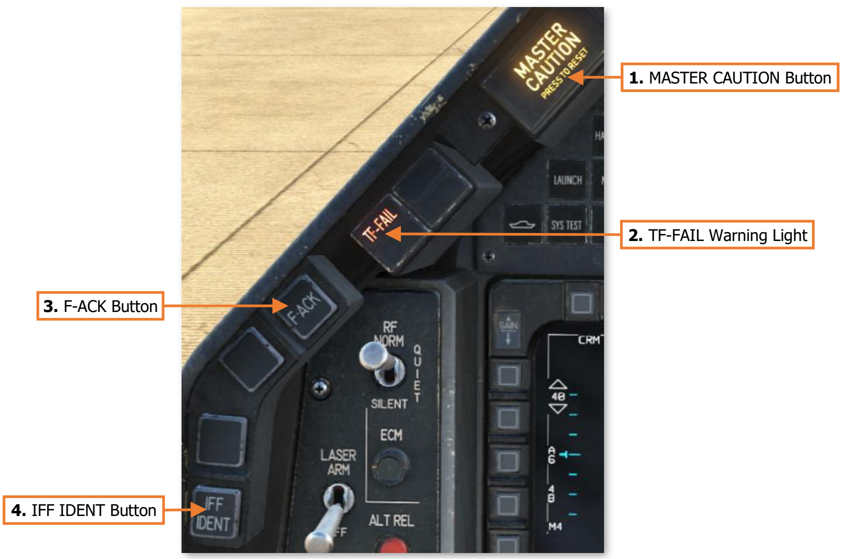
When landing, the pilot should maintain between 11° and 13° of AoA. Note that the AoA Indexer lights are always on, regardless of whether the gear is down or not.

1. **Dimming Lever.** Rotating the lever downward dims the indicator lights.
2. **High AoA Indicator Light.** Aircraft angle-of-attack is greater than 14° or greater. Aircraft is in an energy depleting, greater than optimal, angle-of-attack.
3. **Optimal AoA Indicator Light.** Aircraft angle-of-attack is between 11.1° and 13.9°. Aircraft is on-speed with optimal angle-of-attack.
4. **Low AoA Indicator Light.** Aircraft angle-of-attack is 11° or less. Aircraft is in an energy gaining, less than optimal, angle-of-attack.

AR Status/NWS Indicator

1. **Dimming Lever.** Rotating the lever downward dims the indicator lights.
2. **RDY Indicator Light.** Indicates the aerial refueling door is open and ready.
3. **AR/NWS Indicator Light.** When in the air, indicates that the refueling boom is latched. When on the ground and illuminated, indicates that the nosewheel steering is enabled and controlled using the rudder pedals.
4. **DISC Indicator Light.** Indicates when the refueling boom has disconnected. After a 3-second delay, the system will automatically recycle to ready.

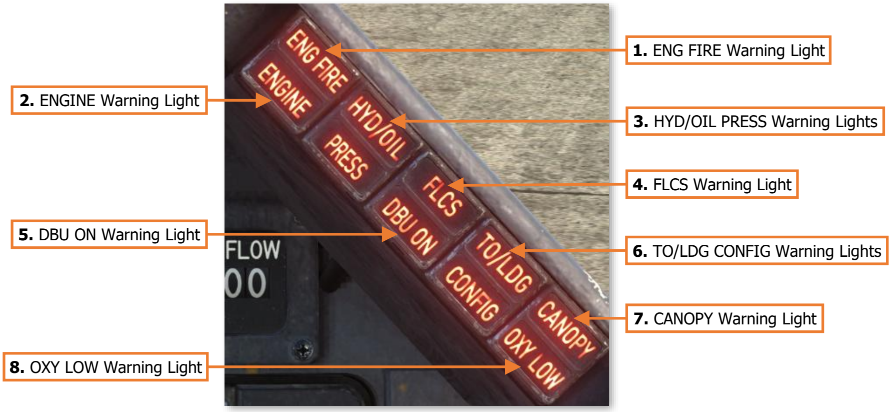
Left Eyebrow Lights



1. **MASTER CAUTION Button.** The MASTER CAUTION pushbutton light will illuminate anytime the Caution Light Panel indicates a malfunction or specific condition has occurred. It can be reset by pressing it.
2. **TF-FAIL Warning Light.** Not functional in the Block 50 F-16.
3. **F-ACK Button.** When a fault appears on the Pilot Fault List Display (PFLD), the Fault Acknowledge (F-ACK) button is pressed to acknowledge the fault message and, depending on the type of fault and severity, clear it from the PFLD.
4. **IFF IDENT Button.** When pressed, the transponder performs an identification-of-position function. This is used to momentarily highlight the ownship position when replying to non-encrypted transponder interrogations (non-Mode 4 interrogations).

Right Eyebrow Lights

Along the right eyebrow are a series of split warning lights that often require immediate action when illuminated.



1. **ENG FIRE Warning Light.** Illuminates if a fire is detected in the engine compartment.
2. **ENGINE Warning Light.** Illuminates when RPM and FTIT indicator signals indicate an over-temperature, flameout, or stagnation has occurred. Extinguishes when the conditions no longer exist.
   - Engine RPM <60%.

     or
   - Engine FTIT >1,100° C for 2 seconds or more.
3. **HYD/OIL PRESS Warning Lights.** Illuminate when low pressures are detected in the engine oil or hydraulics systems.
   - Engine oil pressure <10 PSI for more than 30 seconds. Extinguishes when engine oil PSI >20 PSI.

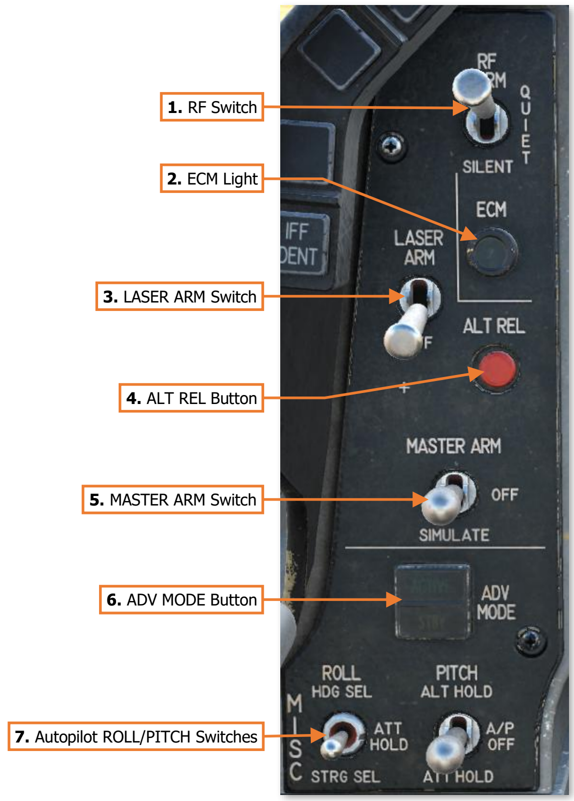
     or
   - Either hydraulic system (A or B) <1,000 PSI. Extinguishes when both hydraulic systems >1,000 PSI.
4. **FLCS Warning Light.** Illuminates when any of the following conditions exist.
   - A malfunction is detected within the FLCS processors, power supplies, input commands or sensors, or angle of attack or air data inputs.
   - FLCS built-in test has failed.
   - Leading-edge flaps are locked.
5. **DBU ON Warning Light.** Illuminates if the FLCS has automatically switched to Digital Backup mode or if manually commanded to DBU mode using the FLT CONTROL Panel.
6. **TO/LDG CONFIG Warning Lights.** Illuminate when each of the following conditions exist. The illumination of these warning lights will be accompanied by the landing gear intermittent horn sound.
   - Altitude <10,000 feet.
   - Airspeed <190 knots.
   - Descent rate >250 feet per minute or weight-on-wheels.
   - The landing gear is not down and locked or trailing edge flaps are not full down.

   NOTE: Applying rapid roll reversal commands may cause the trailing edge flaps to be intermittently detected as not full down, causing intermittent illumination of the TO/LDG CONFIG warning lights.

7. **CANOPY Warning Light.** Illuminates when the canopy is not down and locked.

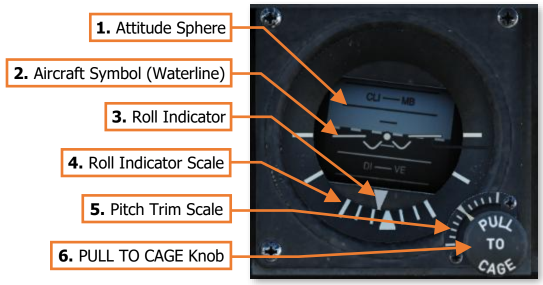
8. **OXY LOW Warning Light.** Illuminates if the Backup Oxygen System (BOS) is depleted and <5 PSI. Illuminates for 10 seconds when an OBOGS BIT has been initiated and will remain illuminated if a fault is detected.

Miscellaneous (MISC) Panel



1. **RF Switch.** The Radio Frequency switch controls emissions from aircraft.
   - **NORM.** FCR emissions are permitted.
   - **QUIET.** FCR emissions are inhibited.
   - **SILENT.** FCR emissions are inhibited.
2. **ECM Enable Light.** Illuminates when the ECM pod is actively emitting jamming signals (if equipped and powered).
3. **LASER ARM Switch.** Arms the targeting pod's laser designator/ranger (if a targeting pod is installed and powered).
   - **LASER ARM.** Laser firing is permitted if targeting pod is not masked.
   - **OFF.** Laser firing is inhibited.
4. **ALT REL Button.** Functions as a backup to the weapons release button on the Side Stick Controller (SSC) in case of its malfunction.
5. **MASTER ARM Switch.** Enables/disables release of aircraft weapons.
   - **MASTER ARM.** FCR and stores management system provide weapons employment cues and symbology. Weapon release and emergency jettison is permitted.
   - **OFF.** Weapons release is inhibited. Emergency jettison is permitted.
   - **SIMULATE.** FCR and stores management system provide weapons employment cues and symbology, however weapon release is inhibited. Emergency jettison is permitted.
6. **ADV MODE Button.** The Advanced Mode button is a terrain following radar function and is not used in the Block 50 F-16.
7. **Autopilot ROLL and PITCH Switches.** Enables/disables the autopilot and selects the autopilot modes of operation. (See Autopilot for more information.)

Standby Attitude Indicator (SAI)



The Standby Attitude Indicator is a self-contained attitude indicator that displays aircraft pitch and roll only. The SAI is electrically powered and is operated by a vertical gyroscope.

The SAI can develop errors during aggressive maneuvers, which may require it to be caged in flight using the PULL TO CAGE knob. The SAI is mounted in the instrument panel at an angle which will cause the instrument to be 4° nose down compared to the ADI when both instruments are set to their respective pitch trim indexes. If the SAI is required to be caged in flight, the aircraft should be flown wings-level with the pitch held at 4° above the horizon.

A red OFF warning flag will appear when the indicator is caged, or electrical power to the SAI has been lost.

1. **Attitude Sphere.** Rotates within the SAI to indicate pitch and roll attitude throughout most orientations of flight, in relation to the Aircraft Symbol. The light blue hemisphere indicates the aircraft nose is pointed above the horizon toward the sky, in a climb. The dark brown hemisphere indicates the aircraft nose is pointed below the horizon toward the ground, in a dive.

2. **Aircraft Symbol (Waterline).** Provides a fixed attitude reference of the aircraft nose around which the Attitude Sphere rotates. The vertical alignment of the symbol can be manually adjusted using the PULL TO CAGE knob.

3. **Bank Angle Indicator.** Indicates bank angle relative to the horizon. When the indicator is aligned with the fixed triangular bank angle index, the aircraft is in a level attitude.

4. **Bank Angle Indicator Scale.** Indicates the bank angle when used in conjunction with the Bank Angle Indicator. A white triangular bank angle index is set at 0° of bank. Major tick marks are placed at 30°, 60° and 90° angles of bank. Minor tick marks are placed at 10° and 20° angles of bank.

5. **Pitch Trim Scale.** Provides a reference scale of aircraft pitch when rotating the PULL TO CAGE knob to adjust the relative pitch of the Aircraft Symbol. Major tick marks are placed at each side of the Pitch Trim Scale at 25° of pitch and minor tick marks are placed at every 5° of pitch.

6. **PULL TO CAGE Knob.** Cages the SAI and used to adjust the relative pitch of the Aircraft Symbol in relation to the Attitude Sphere. If the knob arrow is aligned with the white triangular index on the Pitch Trim Scale, the SAI pitch trim is at zero. When the knob is pulled outward, the Attitude Sphere is caged to a level attitude orientation regardless of the aircraft's actual attitude, causing the OFF warning flag to appear. When pulled outward and rotated counterclockwise, the SAI is locked in the caged position.

Fuel Flow Indicator

The FUEL FLOW Indicator displays the current engine fuel consumption rate in pounds per hour (PPH), in 100-pound increments.

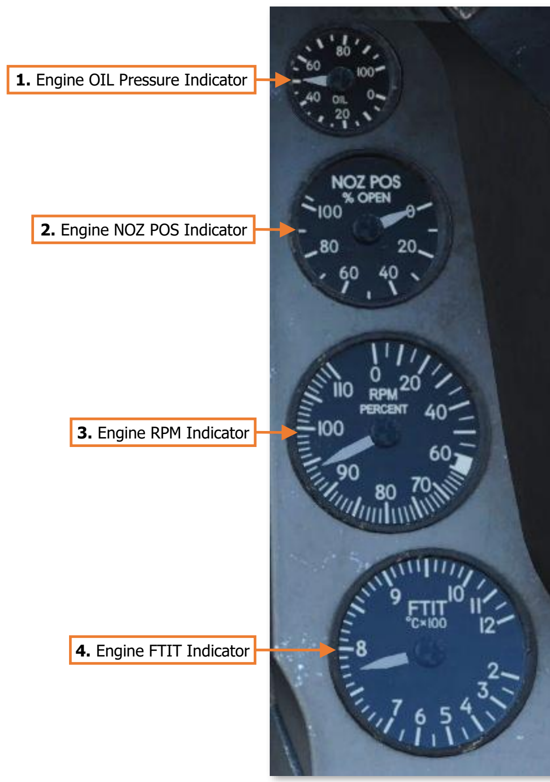
Engine Instruments

1. **Engine OIL Pressure Indicator.** Indicates the current oil pressure within the engine's self-contained oil lubrication system. The indicator range is 0 PSI to 100 PSI, with major tick marks in 10 PSI increments and minor tick marks in 5 PSI increments. Normal indication is 15 PSI when on the ground at idle, and 60 PSI when in the air at military power and above.

2. **Engine NOZ POS Indicator.** Indicates the current engine nozzle position as a percentage, with major tick marks in 20% increments and minor tick marks in 10% increments.

3. **Engine RPM Indicator.** Indicates the current engine RPM as supplied by the engine alternator. The indicator range is 0% to 110%, with major tick marks every 5%, and minor tick marks every 5% from 0%-60% and every 1% above 65%.

4. **Engine FTIT Indicator.** Indicates the current engine Fan Turbine Inlet Temperature (FTIT) in an average temperature in degrees Celsius. The indicator range is 200° C to 1,200° C, with major tick marks every 100° increments from 200°-700° and 1000°-1200°, and every 50° from 700°-1000°. Minor tick marks every 50° increments from 200°-700° and 1000°-1200°, and every 10° from 700°-1000°.



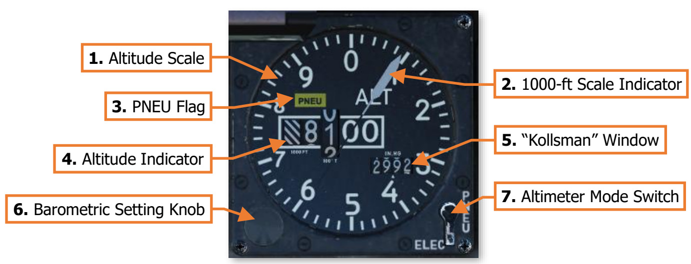
Airspeed and Mach Indicator

The Airspeed and Mach indicator is pneumatically operated by the pitot-static system.

1. **VNE Indicator.** Indicates Velocity Never Exceed. This corresponds with 800 knots at sea level.
2. **Indicated Airspeed Scale.** The outer scale of the instrument, from 80 to 850 knots. Tick marks are set at 10-knot increments between 80 and 400 knots, and 50-knot increments between 400 and 850 knots.
3. **Mach Indicator Window.** Indicates Mach equivalent airspeed from 0.5 to 2.2 Mach.
4. **Airspeed Indicator.** Indicates indicated airspeed along the outer Indicated Airspeed Scale and Mach speed within the Mach Indicator Window.
5. **Airspeed Reference Index.** Pilot-adjustable airspeed reference marker.
6. **SET INDEX Knob.** Adjusts the Airspeed Reference Index position.

Altimeter

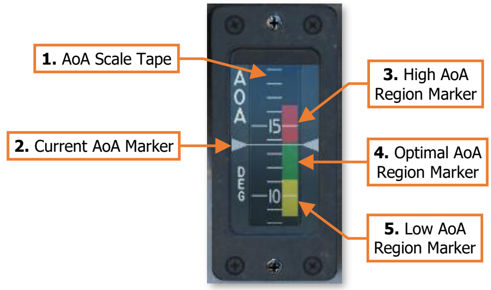
The Altimeter is a dual-mode pressure altimeter that is electrically operated by the CADC when set to the ELEC mode, or by static pressure from the pitot-static system when set to PNEU mode.



1. **1000-foot Altitude Scale.** Each major tick mark corresponds with 100-foot increments, with minor tick marks corresponding to 10-foot increments.
2. **1000-foot Scale Indicator.** Indicates the aircraft altitude on the outer 1000-foot scale.
3. **PNEU Flag.** Indicates the altimeter is operating in PNEU (pneumatic) mode. The altimeter will automatically revert from ELEC to PNEU mode if a malfunction occurs within the CADC or the altimeter electric servo.
4. **Altitude Indicator.** Indicates the current barometric altitude in 100-foot increments from -1,000 feet to 80,000 feet.
5. **"Kollsman" Window.** Indicates current altimeter setting correction in inches of mercury (in/Hg). The altimeter setting on the F-16 is designed to be used in conjunction with QNH barometric altimeter settings to calibrate the altimeter to altitudes above mean sea level (MSL).
6. **Barometric Setting Knob.** Sets altimeter setting correction as displayed in the "Kollsman" Window.
7. **Altimeter Mode Switch.** Selects ELEC (primary) or PNEU (secondary) operating modes of the altimeter by momentarily holding the swtich to either position.

Angle-of-Attack (AoA) Indicator

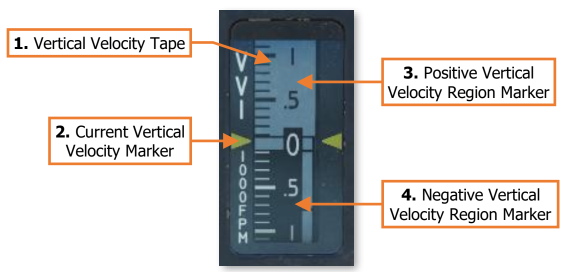
The Angle-of-Attack Indicator displays the same information as the Angle-of-Attack Indexer next to the HUD. The indicator includes colored markers to match the indexer lights next to the HUD.



1. **AoA Scale Tape.** Displays angle-of-attack in a scale from -5° and +32°. Each major tick mark corresponds with 5°-increments, with minor tick marks corresponding to 1°-increments.
2. **Current AoA Marker.** Indicates the aircraft's current angle-of-attack.
3. **High AoA Region Marker.** Indicates an AoA between 14° to 16.5°. Aircraft is in an energy depleting, greater than optimal, angle-of-attack.
4. **Optimal AoA Region Marker.** Indicates an AoA between 11.1° to 13.9°. Aircraft is on-speed with optimal angle-of-attack.
5. **Low AoA Region Marker.** Indicates an AoA between 8.5° to 11°. Aircraft is in an energy gaining, less than optimal, angle-of-attack.

Vertical Velocity Indicator (VVI)

The Vertical Velocity Indicator, or VVI, displays the rate of climb or descent based on information from the CADC.



1. **Vertical Velocity Tape.** Displays vertical velocity in a scale of ±6,000 feet per minute (FPM). Each major tick mark corresponds with 500 FPM increments, with minor tick marks corresponding to 100 FPM increments.
2. **Current Vertical Velocity Marker.** Indicates the current Vertical Velocity.
3. **Positive Vertical Velocity Region Marker.** The light-shaded region indicates a positive vertical velocity or climb.
4. **Negative Vertical Velocity Region Marker.** The dark-shaded region indicates a negative vertical velocity or descent.

Attitude Director Indicator (ADI)

The Attitude Director Indicator, or ADI, displays the aircraft pitch and roll attitude as supplied by the Inertial Navigation System, or INS. When performing an ILS approach, the ADI displays localizer and glideslope indicators.

(See TACAN Navigation or ILS Navigation for more information.)

1. **Attitude Sphere.** Rotates within the ADI to indicate pitch and roll attitude throughout all orientations of flight, in relation to the Aircraft Symbol. The light blue hemisphere indicates the aircraft nose is pointed above the horizon toward the sky, in a climb. The dark brown hemisphere indicates the aircraft nose is pointed below the horizon toward the ground, in a dive.

2. **Upper Bank Angle Indicator.** Indicates bank angle relative to the horizon. When the indicator is aligned with the fixed outside bank angle index, the aircraft is in a level attitude.

3. **Pitch Scale.** Provides an attitude reference scale of aircraft pitch in relation to the Aircraft Symbol. Major tick marks are placed at every 10° of pitch and minor tick marks are placed at every 5° of pitch.

4. **Glideslope Deviation Indicator.** Indicates the relative position of the glideslope along the Glideslope Deviation Scale when performing an ILS approach. If the indicator is aligned with the center tick mark, the aircraft is on glideslope.

5. **Glideslope Deviation Scale.** Provides a vertical reference of relative aircraft position above or below the glideslope when tuned to an ILS approach frequency and roughly aligned with the approach path for the associated landing area. Each white dot corresponds with a 2.5° vertical separation from the glideslope. If the Glideslope Indicator is aligned with the top or bottom white dot of the Glideslope Deviation Scale, the aircraft is 5° above or 5° below the glideslope, respectively. (See ILS Navigation for more information.)

6. **Aircraft Symbol (Waterline).** Provides a fixed attitude reference of the aircraft nose around which the Attitude Sphere rotates. The vertical alignment of the symbol can be manually adjusted using the Pitch Trim knob.

7. **OFF Warning Flag.** Indicates the ADI is not receiving aircraft attitude data from the INS, which may be caused by a failure of the ADI itself, a failure of the INS, or if the INS is powered OFF.

8. **AUX Warning Flag.** Indicates the ADI is receiving degraded attitude data from the INS, which may be caused by a malfunction of the INS or a failure to achieve a coarse alignment.

9. **Lower Bank Angle Scale.** Indicates the bank angle when used in conjunction with the Lower Bank Angle Indicator. A white triangular bank angle index is set at 0° of bank. Major tick marks are placed at 30°, 60° and 90° angles of bank. Minor tick marks are placed at 10° and 20° angles of bank.

10. **Lower Bank Angle Indicator.** Indicates bank angle relative to the horizon. When the indicator is aligned with the fixed outside bank angle index, the aircraft is in a level attitude.

11. **Slip Indicator (Ball).** Indicates whether the aircraft is in coordinated flight. With the ball centered between the two black marks, the aircraft is in coordinated flight, which minimizes drag. When performing a "coordinated turn" with the ball kept in the center of the slip indicator, the centripetal force of the turn is maintained in alignment with the bottom of the aircraft, and no lateral acceleration is experienced by the pilot. If the ball slides to one side in the same direction of a bank, the aircraft is in a non-coordinated "slipping turn". If the ball slides to one side in the opposite direction of a bank, the aircraft is in a non-coordinated "skidding turn".

12. **Rate of Turn Indicator.** Indicates the aircraft rate of turn, with the lower white bar moving left and right to indicate an increased turn rate in that direction. One bar width equates to 1° to 1.2° per second turn rate. If the lower white bar is aligned with the upper white bar in the center, the aircraft is not turning. If the lower white bar is aligned with the upper white bars on the left or right, the aircraft is in a standard rate, 3° per second turn. If the lower white bar is centered between two of the upper white bars, the aircraft is in a half standard rate turn.

13. **Pitch Trim Knob.** Used to adjust the relative pitch of the Attitude Sphere in relation to the Aircraft Symbol. If the knob arrow is aligned with the white dot on the face of the ADI, the ADI pitch trim is at zero. Each click of rotation of the knob will adjust the pitch trim ±0.5°.

FUEL QTY SEL Panel

The Fuel Quantity Select panel allows the pilot to change what fuel tank(s) are used as the indication source(s) for the Fuel Quantity Indicator analog needles; and set fuel transfer priority from external fuel tanks.

1. **FUEL QTY SEL Knob.** Controls the analog fuel pointers on the Fuel Quantity Indicator.

   - **TEST.** Both analog fuel pointers should be set to 2000 pounds. The Fuel Totalizer window should display 6000 pounds. The FWD FUEL LOW and AFT FUEL LOW lights should illuminate on the Caution Light panel.
   - **NORM.** The AL fuel pointer indicates the sum of fuel in the aft reservoir and the A-1 fuselage tank. The FR pointer indicates the sum of fuel in the forward reservoir tank and the F-1 and F-2 fuselage tanks. Enables bingo fuel computation based on total fuselage fuel.
   - **RSVR.** The AL pointer indicates remaining fuel in the aft reservoir tank only. The FR pointer indicates remaining fuel in the forward reservoir tank only.
   - **INT WING.** The AL pointer indicates remaining fuel in the left internal wing tank only. The FR pointer indicates remaining fuel in the right internal wing tank only.
   - **EXT WING.** The AL pointer indicates remaining fuel in the left external wing tank only. The FR pointer indicates remaining fuel in the right external wing tank only.
   - **EXT CTR.** The FR pointer indicates remaining fuel in the external centerline fuel tank. The AL pointer will indicate 0.

2. **EXT FUEL TRANS Switch.** Controls the fuel transfer priority from external fuel tanks.

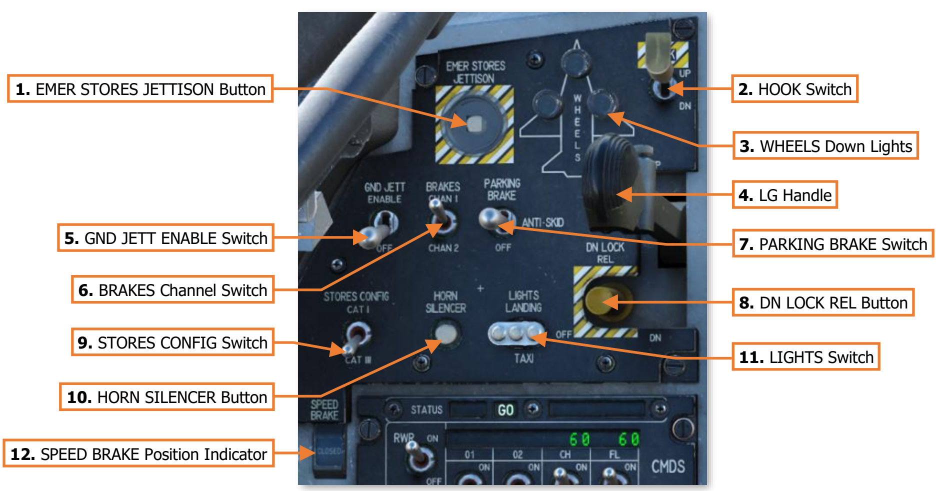
   - **NORM.** Transfers fuel from the external centerline tank, followed by the external wing tanks.
   - **WING FIRST.** Transfers fuel from the external wing tanks, followed by the external centerline tank.

Left Auxiliary Console

Each text box above may be selected to jump to a more detailed description of that panel. Selecting the image of the instrument or panel will return the manual back to this page.

The CMDS Control Panel and THREAT WARNING AUX Control Panel are described in the Defensive Systems chapter.

Landing Gear Panel



1. **EMER STORES JETTISON Button.** When pressed for one full second, this button will apply power to the Stores Management System (SMS) and initiate a jettison sequence of all external fuel tanks, carted suspension racks, and free fall ordnance loaded on stations 3 through 7. Air-to-air missiles will not be jettisoned, nor their missile launchers. There is no requirement for the aircraft to be armed. If the aircraft is on the ground with weight-on-wheels, the GND JETT ENABLE switch is required to initiate the emergency jettison sequence.

2. **HOOK Switch.** This switch extends the hook for emergency arrestment on airfields equipped with an arrestment system. However, once the hook is dropped, it cannot be fully retracted from the cockpit.
   - **UP.** Commands the pneumatic pressure holding the hook extended to release, allowing the hook to be raised over runway arresting wires to taxi clear.
   - **DN.** Commands the hook to be released from its stowed position and held to its full extension using pneumatic pressure.

3. **WHEELS Down Lights.** These show the state of the main landing gear and nosewheel. When green, the respective landing gear is down and locked.

4. **LG Handle.** Movement of the handle operates electrical switches to command landing gear retraction or extension. A warning light in the LG handle illuminates when the gear and doors are in transit or have failed to lock in the commanded position. The LG handle warning light also illuminates when the TO/LDG CONFIG warning light illuminates on the right eyebrow lights panel.

5. **GND JETT ENABLE Switch.** Used by maintenance personnel for checkout and testing of aircraft armament systems.
   - **ENABLE.** All arming and release conditions are permitted, regardless of landing gear or weight-on-wheels conditions.
   - **OFF.** When the landing gear are down and the aircraft has weight-on-wheels emergency jettison, selective jettison, and normal weapons release functions are inhibited. When the landing gear is down, selective jettison and normal weapons release functions are inhibited.

6. **BRAKES Channel Switch.** Selects Channel 1 or Channel 2 through which the toe brakes initiate main landing gear braking action. This switch is normally kept in the CHAN 1 position.

7. **ANTI-SKID Switch.** Controls the anti-skid and parking brake functions of the wheel brakes.
   - **PARKING BRAKE.** Applies full brake pressure to each main landing gear brakes when weight-on-wheels and the throttle is in the OFF or IDLE positions. If the throttle is advanced 1 inch beyond IDLE, the switch will automatically be spring-loaded to the ANTI-SKID position and the parking brake will be disengaged. Can be used as an emergency brake in case of a toe brake failure.
   - **ANTI-SKID.** Available any time the toe brakes are powered. When the toe brakes are applied to less than 85%, the anti-skid system provides deceleration skid control. When the toe brakes are applied at 85% or greater, the anti-skid system provides maximum performance skid control.
   - **OFF.** Anti-skid and parking brake functions are disabled.

8. **DN LOCK REL Button.** Mechanically unlocks the spring-actuated lock that holds the LG handle in place, should the associated electrical solenoid fail or not be powered. It also overrides the weight-on-wheels signal and allows the landing gear to be retracted while on the ground if the LG handle is raised.

9. **STORES CONFIG Switch.** Adjusts FLCS based on stores configuration. When set to CAT III the FLCS limits the angle of attack and onset rates in order to increase departure resistance. This switch has no effect when the FLCS gains are set to takeoff/landing configuration (landing gear deployed or air refueling door open).

    - **CAT I.** Air-to-air loadouts without external wing tanks, or 6-missile air-to-air loadouts with external wing tanks but no centerline tank and no AIM-120s.
    - **CAT III.** Air-to-ground loadouts, any loadout with external wing tanks and a centerline tank, or 6-missile air-to-air loadouts with AIM-120s and external wing tanks.
        - Any air-to-ground munitions are loaded.
        - Two external wing tanks and an external centerline tank are loaded.
        - Two external wing tanks and six air-to-air missiles are loaded, with at least one AIM-120 loaded.
        - Three air-to-air missiles are loaded on only one wing, with at least one AIM-120 loaded.

    If the STORES CONFIG switch is set to the incorrect position given the criteria above, the STORES CONFIG light on the Caution Light Panel will illuminate.

10. **HORN SILENCER Button.** Silences the landing gear warning or low-speed warning audio tones.

11. **LANDING TAXI LIGHTS Switch.** Controls the nose landing gear-mounted light assemblies for takeoff/landing or taxi operations. The lights are automatically disabled when the LG Handle is raised to the UP position.

    - **LANDING.** Enables the Landing light.
    - **OFF.** The Landing and Taxi lights are disabled.
    - **TAXI.** Enables the Taxi light.

12. **SPEED BRAKE Position Indicator.** Indicates whether the speedbrakes are deployed, fully-retracted, or if receiving no power. When the speedbrakes are fully-retracted the indicator displays CLOSED (left image). When the speed brakes are deployed at any angle, the indicator displays a pattern of nine dots (right image). If the speedbrakes have no power, the indicator displays a striped line pattern (not shown).

HMCS Control Panel

Controls the brightness of the HMCS symbology projected onto the helmet visor. Rotating the knob clockwise increases the brightness intensity of the symbology and rotating it to the OFF position removes the HMCS symbology from the visor.

ALT GEAR Handle

The Alternate Gear Handle releases the landing gear in case of a hydraulic failure or inability to lower the main landing gear handle.

Right Auxiliary Console

Each text box above may be selected to jump to a more detailed description of that individual instrument or panel. Selecting the image of the instrument or panel will return the manual back to this page.

Magnetic Compass

The magnetic compass is a self-contained indicator which shows the heading of the aircraft in relation to magnetic north and is for heading reference when there has been a failure of primary power or the navigation system has become unreliable.

Due to magnetic variances and other inaccuracies during normal flight maneuvers, the standby magnetic compass should not be relied upon for precise heading or navigation information. Visual landmarks may be used to maintain awareness of aircraft position and aid in navigation back to maintenance facilities or friendly-controlled areas.

Fuel Quantity Indicator

The FUEL Quantity Indicator displays total remaining fuel in all tanks via the totalizer numerical readout in pounds (lbs) of fuel. Two analog needles indicate fuel in Aft and Left (AL) and Forward and Right (FR) tanks in 100-pound increments.

The FUEL QTY SEL knob can be used to change which internal or external fuel tanks the analog needles are referencing to display calculated fuel quantity.

If the two needles become too divergent, indicating a fuel imbalance, red will be shown at the base of a needle. In such a case, the ENGINE FEED knob on the FUEL Control Panel can be used to correct the imbalance.

Pilot Fault List Display (PFLD)

The Pilot Fault List Display, or PFLD, lists all FLCS detected faults.

Two types of PFLDs are displayed: WARNING level and CAUTION level. Warnings are associated with the FLCS and have a bracket around them. Cautions are associated with other FLCS elements, engine, and avionics systems.

When a PFLD item is displayed, its corresponding caution light indicator will illuminate, and the MASTER CAUTION light will be lit. To clear a PFLD fault, the fault acknowledge (F-ACK) button is pressed.

Caution Light Panel

The Caution Light panel consists of multiple indicator lights associated with possible detected fault conditions.

FLCS FAULT. A dual malfunction has occurred in the Flight Control Computer (FLCC) electronics, the leading-edge flaps (LEF) are locked, or the FLCS BIT has failed.

ENGINE FAULT. An engine-related fault has been detected. Extinguishes when the fault is acknowledged.

AVIONICS FAULT. An avionics-related fault has been detected or the Multiplex Bus (MUX) has lost communication with the engine or the FLCC.

SEAT NOT ARMED. The ejection seat arming lever is in the dis-armed (up) position.

ELEC SYS. An electrical fault has been detected and an associated indicator light is illuminated on the ELEC Control Panel.

SEC. Engine is operating in Secondary control mode.

EQUIP HOT. Cooling air temperature or pressure to the avionics bay is insufficient. Automatically interrupts electrical power to the FCR.

NWS FAIL. A failure in the nose wheel steering system has occurred.

PROBE HEAT. Air flow to the pitot, fuselage air data, or AoA probes has decreased to a level that may indicate an icing condition; or a probe heater or the monitoring system has failed.

FUEL/OIL HOT. Fuel supplied to the engine or the engine oil has become excessively hot.

RADAR ALT. The radar altimeter has malfunctioned.

ANTI SKID. The Anti-Skid switch has been set to the OFF position or a malfunction has been detected in the braking system while ground speed is >5 knots.

CADC. A malfunction in the Central Air Data Computer has been detected.

INLET ICING. Ice accumulation has been detected by the engine inlet ice detector or the inlet ice detector has failed.

IFF. The IFF system has received a Mode 4 interrogation but cannot reply due to Mode 4 replies being inhibited by the RF switch on the Instrument Panel or the MODE 4 REPLY switch on the IFF control panel, or the Mode 4 has been zeroized.

HOOK. The emergency arresting hook is not up and locked in its stowed position.

STORES CONFIG. The STORES CONFIG switch is in the wrong position.

OVERHEAT. An overheat condition has been detected in the engine compartment, main landing gear wheel wells, ECS bay, or EPU bay.

NUCLEAR. Not implemented.

OBOGS. ECS air pressure is <10 PSI.

ATF NOT ENGAGED. No function.

EEC. No function.

CABIN PRESS. Cockpit pressure altitude is >27,000 feet.

FWD FUEL LOW. Forward reservoir fuel quantity is <400 lb.

BUC. No function.

AFT FUEL LOW. Aft reservoir fuel quantity is <250 lb.

Hydraulic Pressure (System A & System B) Indicators

The HYD PRESS A & B gauges indicate the current pressures for hydraulic systems A and B respectively, in 500 PSI increments from 0 to 4000 PSI. Normal operation is between 2,850 and 3,250 PSI.

EPU Fuel Quantity Indicator

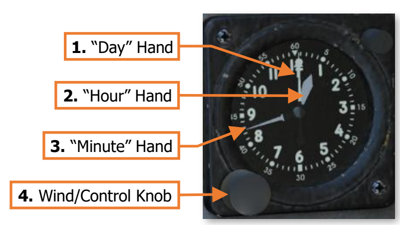
The EPU Fuel Quantity gauge indicates the remaining supply of hydrazine as a percentage in 5% increments. At 100%, the EPU can run for approximately 10-15 minutes.

Cabin Pressure

The Cabin Pressure gauge indicates the current cockpit pressure expressed as an altitude, in 1,000-foot increments from 0 to 50,000 feet.

As an example, an indication of 7 on this gauge indicates the cockpit pressure is equal to a pressure altitude of 7,000 feet.

Mechanical Clock

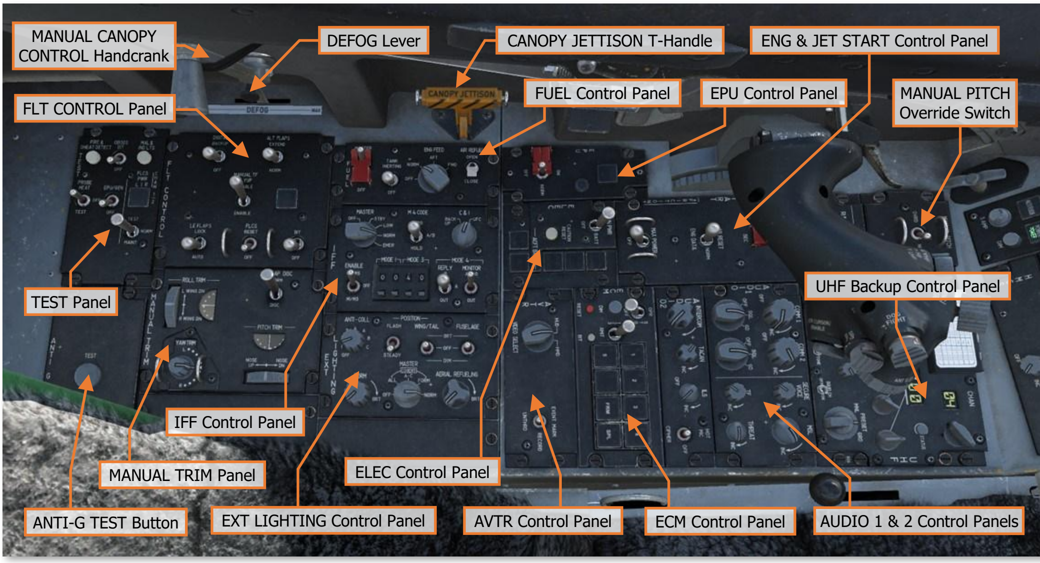


The mechanical clock is an 8-day, manually wound clock. The clock time can be adjusted by pulling the knob and rotating it until the time is set as desired.

1. **"Day" Hand.** One full revolution equals 8 days.
2. **"Hour" Hand.** One full revolution equals 12 hours, indicated by the inner clock ring.
3. **"Minute" Hand.** One full revolution equals 60 minutes, indicated by the outer clock ring.
4. **Wind/Control Knob.** Rotating this knob clockwise winds the clock spring. Rotating this knob in either direction while pulled adjusts the clock to the desired time.

NOTE: The mechanical clock is automatically set to local time at mission start.

Left Console



Each text box above may be selected to jump to a more detailed description of that panel. Selecting the image of the instrument or panel will return the manual back to this page.

The UHF Backup Control Panel is described in the Radio Communications chapter. The ECM Control Panel is described in the Defensive Systems chapter.

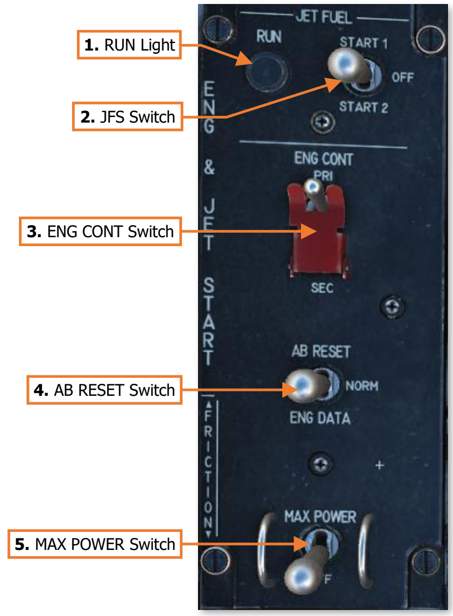
Manual Pitch Override Switch

In case of a deep stall departure, the Manual Pitch Override (MPO) switch allows the pilot to command greater authority from the horizontal stabilators to reinforce pitch oscillations until sufficient pitch rates are present for recovery into controlled flight. The guards on either side of the switch allow the pilot to better grip the switch in case of an inverted departure when hanging upside down from the seat straps.

- **NORM.** Normal operation. The switch is spring-loaded to this position.
- **OVRD.** When held to this position, the horizontal stabilator authority is increased to assist with recovery. Note that pilot roll and yaw commands from the Side Stick Controller (SSC) are inhibited when the switch is held in this position, however the rudder pedals will still retain yaw input authority.

ENG & JET START Control Panel

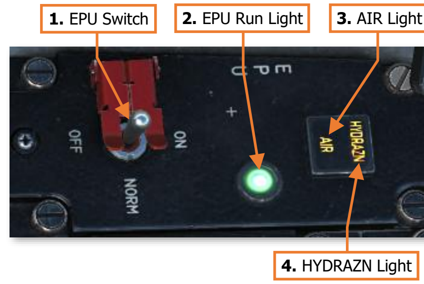
The Engine & Jet Start panel governs the start system for the F110-GE-129 engine and related controls.



1. **JET FUEL – RUN Light.** Illuminates within 30 seconds after JFS initiation to indicate the Jet Fuel Starter (JFS) is operating at its governed speed.
2. **JET FUEL – JFS Switch.** The JET FUEL switch uses one or both brake/JFS accumulators to drive the hydraulic starter motor of the Jet Fuel Starter. The JFS may be started even if the MASTER switch on the FUEL control panel is set to OFF.
   - **START 1.** A single brake/JFS accumulator is used to spool up the JFS into operation.
   - **OFF.** Turns off the Jet Fuel Starter. During ground starts, the JFS will automatically switch OFF when the engine RPM attains 55%. During in-flight restarts the JFS will not automatically shut down and must be manually switched to OFF.
   - **START 2.** Both brake/JFS accumulators are used to spool up the JFS into operation.

     NOTE: START 2 is required when the ambient temperature is above 38°C or below -7°C, or if attempting to restart the engine below 20,000 feet.
3. **ENG CONT Switch.** Manually selects the engine control mode.
   - **PRI.** Sets engine operation to Primary control mode. This position is used for normal operations, which utilizes the Digital Electronic Control (DEC) to manage the functions of the engine and the afterburner. The DEC is an electronic computer that controls fuel flow, fan and core speed limiting, turbine temperature limiting, pressure ratios, nozzle position, and ensures stable operation throughout all altitudes, airspeeds, and maneuvers to prevent compressor stalls or engine damage.
   - **SEC.** Sets engine operation to Secondary control mode and illuminates the SEC caution light on the Caution Light panel. This system uses only the hydromechanical fuel scheduling of the Main Engine Control (MEC) in case of a malfunction or failure in the DEC. This mode may be entered automatically by the DEC or manually selected by the pilot. When operating in Secondary mode the afterburner will be unavailable, the nozzle will be fixed in the closed position, temperature and speed limiting will be disabled, and overall thrust will be reduced but the engine will produce higher thrust at idle power.
4. **AB RESET Switch.** Spring-loaded to the NORM position and used to record engine diagnostic data. (N/I)
   - **AB RESET.** This switch position is not functional in F-16s equipped with the F110-GE-129 engine.
   - **NORM.** Normal position.
   - **ENG DATA.** Momentarily moving switch to this position records 8 seconds of engine data into the Engine Monitoring System Computer (EMSC), starting with 6 seconds prior to the switch being moved to the ENG DATA position to 2 seconds following.
5. **MAX POWER Switch.** This switch is not functional in F-16s equipped with the F110-GE-129 engine.

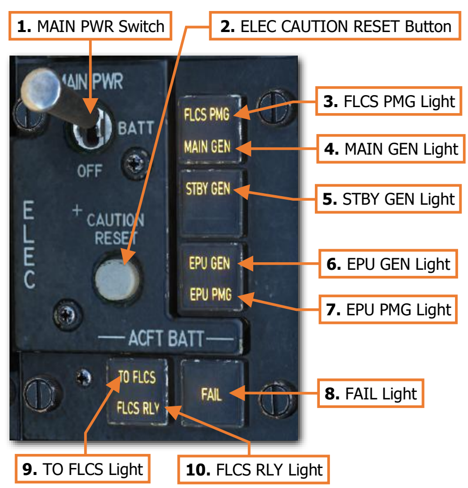
EPU Control Panel



The Emergency Power Unit is a bleed air- and/or hydrazine-powered, self-contained unit that can provide emergency hydraulic and electrical power for approximately 10 to 15 minutes. In the case of an engine failure, the EPU provides power to the Hydraulic system A and electrical systems.

1. **EPU Switch.** Sets the EPU to automatic operation or manually commands the EPU on/off.
    - **OFF.** Manually commands the EPU off during ground operations. Manually commands the EPU off in flight unless both the main and standby generators have failed. EPU operation will be inhibited in flight if the switch has remained in the OFF position since takeoff.
    - **NORM.** Used during normal operations. If set to NORM at any time since takeoff, the EPU will be commanded on automatically if power from the main and standby generators has been lost, or both hydraulic systems have failed. If aircraft is on the ground and the engine is shut down, the EPU will not automatically be commanded to on.
    - **ON.** Manually commands the EPU to on.
2. **EPU Run Light.** Illuminates when the EPU is operating and EPU-driven hydraulic pump discharge pressure is >2,000 PSI.
3. **AIR Light.** Illuminates when the EPU is operating using engine bleed air.
4. **HYDRAZN Light.** Illuminates when the EPU is operating using hydrazine, which is typically required when engine RPM drops below 82%-90%, depending on pressure altitude, or if the engine fails completely.

ELEC Control Panel



The Electrical panel provides controls for the selecting electrical power sources and indications of malfunctions within the electrical system and electrical supply to the FLCS channels.

1. **MAIN PWR Switch.** Selects the electrical power source for the aircraft.
    - **MAIN PWR.** Connects main engine generator or external power to the electrical system. Enables the standby generator. If AC power is not available, battery power is supplied to the battery bus only.
    - **BATT.** Disconnects main generator and external power from the electrical system and resets main generator. Disables the standby generator. Battery power is supplied to the battery bus only.
    - **OFF.** If in flight, disconnects power from main generator and disables the standby generator. If on the ground, disconnects main generator and external power from the electrical system and disables the standby generator.

2. **ELEC CAUTION RESET Button.** Clears MASTER CAUTION and ELEC SYS caution lights and resets the main and standby generators.

3. **FLCS PMG Light.** Illuminates in flight if none of the FLCS branches are receiving power from the FLCS Permanent Magnet Generator. Illuminates on the ground after 60 seconds of weight-on-wheels if one or more of the FLCS branches aren't receiving power from the FLCS PMG.

4. **MAIN GEN Light.** Illuminates when there is no external or main generator power connected to the non-essential AC buses.

5. **STBY GEN Light.** Illuminates when standby generator power is not available.

6. **EPU GEN Light.** The Illuminates when the EPU has been commanded on but is not providing power to both emergency buses. Light is inhibited if EPU switch is set to OFF and aircraft is weight-on-wheels with the engine is running.

7. **EPU PMG Light.** Illuminates when the EPU has been commanded on, but the EPU Permanent Magnet Generator is not providing power to all branches of the FLCS.

8. **ACFT BATT – FAIL Light.** Illuminates in flight to indicate a battery failure (20 volts or less). Illuminates on the ground after 60 seconds of weight-on-wheels to indicate a batter failure or battery charger failure.

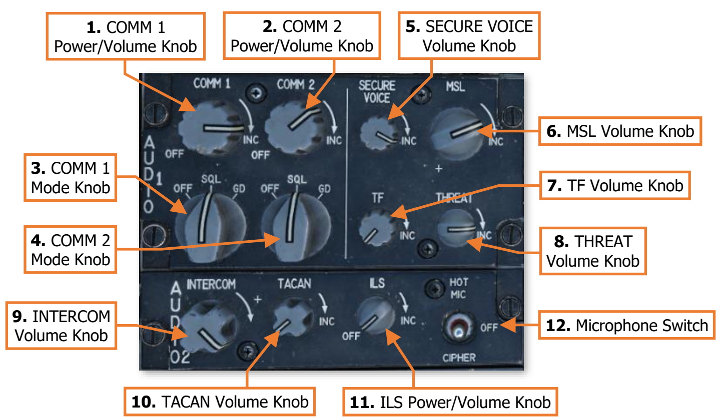
9. **ACFT BATT – TO FLCS Light.** Illuminates in flight if one or more FLCS branches are receiving power from the battery bus of 25 volts or less. Illuminates on the ground if battery power is going to one or more FLCS branches.

10. **ACFT BATT – FLCS RLY Light.** Illuminates if one or more FLCS branches are receiving less than 20 volts from the battery bus or if one or more FLCS branches are not connected to the battery bus. May be reset using the FLCS RESET switch on the FLT CONTROL panel.

AUDIO 1 & AUDIO 2 Control Panels

The AUDIO 1 panel controls the volume of the UHF and VHF radios, missile audio feedback, and RWR threat warning audio. It also includes controls for selecting squelch and GUARD operating modes for the UHF and VHF radios.

The AUDIO 2 panel controls the volume of the intercom, TACAN and ILS, along with the power of the ILS receiver.



1. **COMM 1 Power/Volume Knob.** Rotating this knob clockwise will increase the audio volume from the UHF radio. Rotating this knob fully counterclockwise will disable the UHF radio.

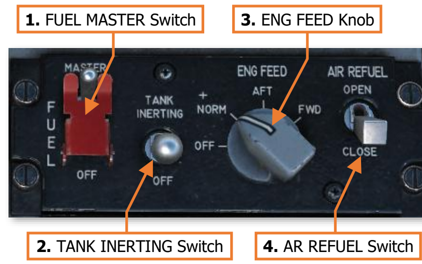
2. **COMM 1 Mode Knob.** Controls the squelch and GUARD functions of the UHF radio.
    - **OFF.** Disables squelch.
    - **SQL.** Enables squelch.
    - **GD.** The UHF radio is tuned to 243.0 MHz and the dedicated GUARD receiver is disabled. This knob position has no effect if C & I knob on IFF control panel is set to BACK UP.

3. **COMM 2 Power/Volume Knob.** Rotating this knob clockwise will increase the audio volume from the VHF radio. Rotating this knob fully counterclockwise will disable the VHF radio.
4. **COMM 2 Mode Knob.** Sets the VHF radio
   - **OFF.** Disables squelch.
   - **SQL.** Enables squelch.
   - **GD.** The VHF radio is tuned to 121.5 MHz.
5. **SECURE VOICE Volume Knob.** No function.
6. **MSL Volume Knob.** Rotating this knob clockwise will increase the audio volume from the currently selected AIM-9 missile.
7. **TF Volume Knob.** No function.
8. **THREAT Volume Knob.** Rotating this knob clockwise will increase the audio volume from the ALR-56M radar warning receiver.
9. **INTERCOM Volume Knob.** Rotating this knob clockwise will increase the audio volume from the intercom system. The intercom system is used to communicate directly to ground crews or the boom operator of an aerial refueling tanker through the refueling boom itself. This knob will also affect the volume of the landing gear and low speed warning tones and avionics voice messages. (N/I)
10. **TACAN Volume Knob.** Rotating this knob clockwise will increase the audio volume from the TACAN receiver. This is used to identify the station the TACAN receiver is tuned to by monitoring the morse code identifier broadcast over the TACAN frequency itself.
11. **ILS Power/Volume Knob.** Rotating this knob clockwise will increase the audio volume from the currently tuned ILS localizer station. This is used to identify the localizer the ILS receiver is tuned to by monitoring the morse code identifier broadcast over the ILS frequency itself. Rotating the knob full counterclockwise to OFF will disable the ILS receiver.
12. **HOT MIC CIPHER Switch.** Controls the operating mode of the intercom and radios. (N/I)
    - **HOT MIC.** Activates direct communication to the ground crew or the boom operator of the aerial refueling aircraft when the boom is seated in the aerial refueling receptacle. Transmitting over the UHF or VHF radios will override this direct communication while transmissions are occurring.
    - **OFF.** Disables HOT MIC and CIPHER functions.
    - **CIPHER.** Placing the switch in this position filters out non-secure radio signals over the UHF and/or VHF radios if secure voice is enabled.

AVTR Control Panel

The Airborne Video Tape Recorder, or AVTR, records the HUD and MFDs or the HMCS and MFDs depending on the setting. (N/I)

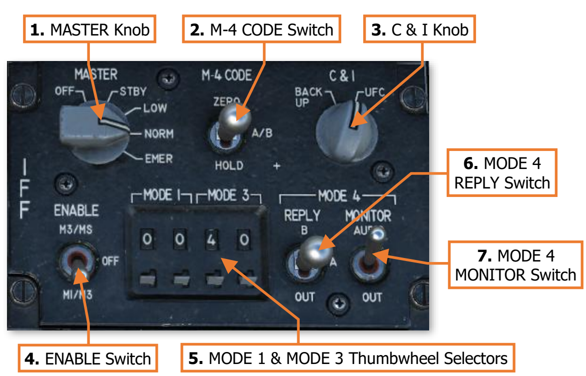
FUEL Control Panel



The Fuel panel includes controls for tank pressurization and fuel system management.

1. **FUEL MASTER Switch.** Opens/closes the main fuel shutoff valve to the engine. This is normally kept in the MASTER position with the guard closed.
2. **TANK INERTING Switch.** When set to the TANK INERTING position, non-volatile halon gas is pumped into the fuel tanks to reduce internal pressure and reduce risk of fire during an emergency (e.g., from battle damage).
3. **ENGINE FEED Knob.** Energizes or de-energizes the fuel pumps and maintains the center-of-gravity with fuel loading. If an imbalance is indicated on the fuel quantity indicator by a divergence between the two fuel needles, the AFT and FWD positions allow selective control for the pumps on the respective fuel tanks to manually shift the center-of-gravity.
   - **OFF.** Disables both fuel pumps. Engine is supplied fuel via the Fuel Flow Proportioner (FFP), which is powered by the Hydraulic system A.
   - **NORM.** Enables both fuel boost pumps. Engine is supplied fuel from the forward and aft fuel tanks. Aircraft center-of-gravity (CG) is maintained automatically through fuel balancing.
   - **AFT.** Enables aft fuel boost pump. Engine is supplied fuel from the aft fuel tank only. Fuel is transferred from the aft tanks to the forward tanks. Aircraft CG is shifted forward.
   - **FWD.** Enables forward fuel boost pump. Engine is supplied fuel from the forward fuel tank only. Fuel is transferred from the forward tanks to the aft tanks. Aircraft CG is shifted rearward.
4. **AIR REFUEL Switch.** Controls the aerial refueling door, associated exterior lighting, and fuel tank pressurization for aerial refueling operations. If the aircraft is less than 400 knots airspeed, when switch is set to OPEN the FLCS gains are set to takeoff/landing configuration.
   - **OPEN.** Opens aerial refueling door, reduces internal tank pressurization and depressurizes external tanks. Activates fuselage- and tail-mounted AR floodlights, which can be adjusted using the AERIAL REFUELING knob on the EXT LIGHTING control panel.
   - **CLOSE.** Closes aerial refueling door, increases internal tank pressurization and repressurizes external tanks. Extinguishes fuselage- and tail-mounted AR floodlights.

IFF Control Panel



The IFF panel provides backup control of essential CNI functions and some primary functions of the APX-113 Advanced IFF transponder/interrogator system.

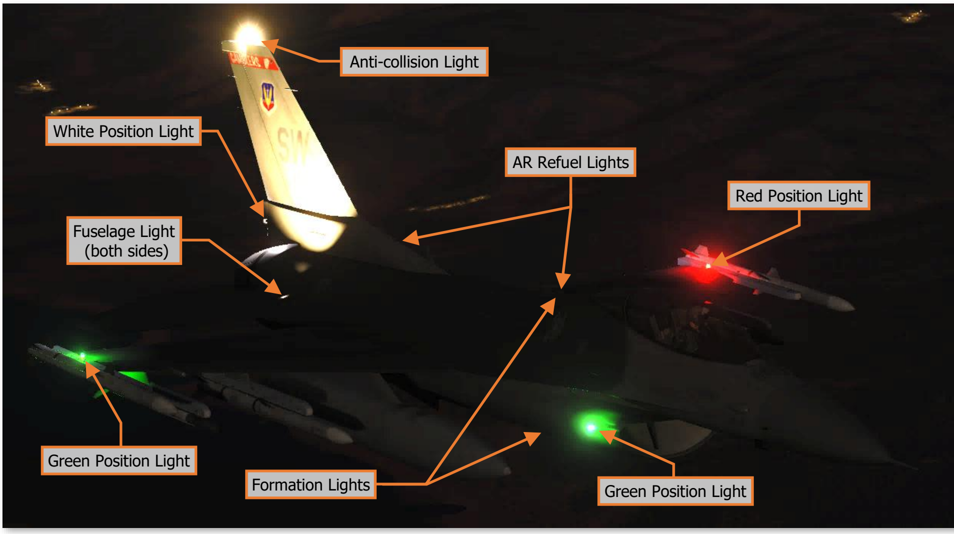
1. **MASTER Knob.** Selects the mode the APX-113 AIFF system operates. This knob functions regardless of the C&I knob position. (N/I)
   - **OFF.** Transponder and IFF interrogation functions are powered off.

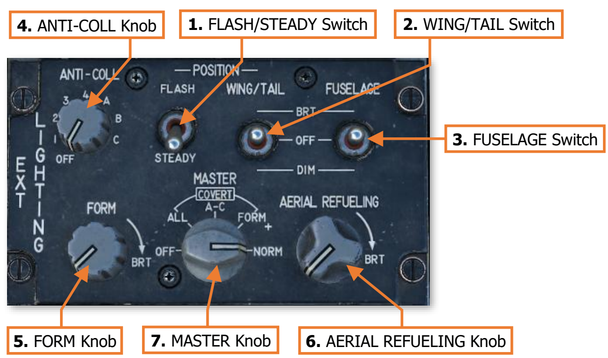
- **STBY.** Transponder functions are inhibited but the IFF interrogator will function normally.
- **LOW/NORM.** Transponder and IFF interrogation functions are operating.
- **EMER.** Transponder will reply with an emergency transponder code when interrogated.

2. **M-4 CODE Switch.** Manages the security of the Mode 4 encrypted codes. (N/I)
   - **A/B.** Enables normal Mode 4 coded replies. Switch is spring-loaded to this position.
   - **ZERO.** Momentarily placing switch in this position will erase encrypted codes from the IFF internal memory.
   - **HOLD.** Momentarily placing switch in this position prior to placing the MASTER knob to OFF will retain the Mode 4 encrypted codes in the IFF internal memory. Otherwise, the encrypted codes will be erased after the IFF is powered off or the aircraft is shut down.
3. **C & I Knob.** Controls how the pilot interacts with the IFF system and UHF radio.
   - **UFC.** Pilot controls primary IFF functions and UHF radio using the Upfront Controls (ICP and DED).
   - **BACK UP.** Pilot controls all IFF functions using the IFF control panel itself. The UHF Backup control panel is used to control the UHF radio.
4. **Enable Switch.** Selects between using Mode 3 and Mode S codes or Mode 1 and Mode 3 codes when the C&I knob is set to the BACK UP position. (N/I)
   - **M3/MS.** Mode 3/A and Mode S are enabled.
   - **OFF.** Mode 1, Mode 3/A, Mode 4 and Mode S are disabled.
   - **M1/M3.** Mode 1 and Mode 3/A are enabled.
5. **MODE 1 & MODE 3 Thumbwheel Selectors.** Allows the pilot to input Mode 1 and Mode 3 codes when the C&I knob is set to the BACK UP position. Note that only the first two digits of Mode 3 can be entered in this manner. The third and fourth digits are internally set to zero, permitting only Mode 3 codes ending in "00" to be used. (N/I)
6. **MODE 4 REPLY Switch.** Allows the pilot to select how the IFF system should reply to Mode 4 interrogations when the C&I knob is set to the BACK UP position. (N/I)
   - **A.** The first IFF encrypted code is used to reply to Mode 4 interrogations.
   - **B.** The second IFF encrypted code is used to reply to Mode 4 interrogations.
   - **OUT.** Replies to Mode 4 interrogations are inhibited.
7. **MODE 4 MONITOR Switch.** Allows the pilot to control the audio tone notification for Mode 4 replies. (N/I)
   - **AUDIO.** An audio tone will sound whenever the IFF transponder system sends an encrypted reply to a Mode 4 interrogation.
   - **OUT.** Mode 4 audio tone is disabled.

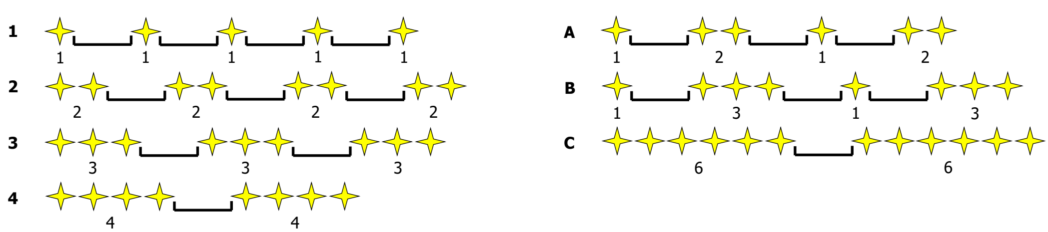
EXT LIGHTING Control Panel

The Exterior Lighting panel controls all externally mounted lights on the aircraft.





1. **POSITION – FLASH/STEADY Switch.** Toggles the WING/TAIL position lights between flashing and steady modes.
2. **POSITION – WING/TAIL Switch.** This switch sets the wingtip and intake red/green and the tail mounted white position lights to fixed brightness levels of bright or dim. If the switch is set to OFF, the wingtip mounted red/green position lights revert to the brightness level set by the FORM knob.
3. **FUSELAGE Switch.** This switch controls the fuselage mounted lights that illuminate the vertical tail.
4. **ANTI-COLL Knob.** This knob can be set to OFF or one of 7 options that vary the flash pattern of the anti-collision light.



ANTI-COLL Knob - Flash Patterns

5. **FORM Knob.** Controls the brightness of the red and green formation lights on each wingtip and the white formation lights on the top and bottom of the center fuselage. The FORM knob functionality is only active for the wingtip lights when the POSITION – WING/TAIL switch is set to OFF.

All lights on and set to bright

All lights off except FORM knob; FORM knob set to minimum

6. **AERIAL REFUELING Knob.** Sets the brightness of the lights that illuminate the dorsal refueling receptacle to assist the air refueling boom operator during night refueling operations. The AERIAL REFUELING knob functionality is only active when the AR REFUEL switch on the FUEL control panel is set to OPEN.

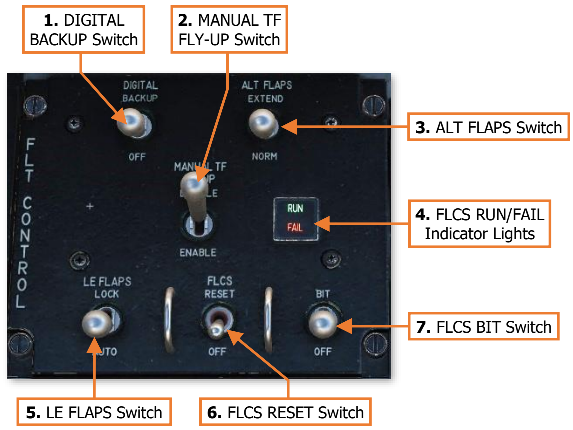
7. **MASTER Knob.** Sets the exterior lighting master mode. The table below details how each position of the MASTER knob enables or overrides the respective lighting system's switch or knob.

	OFF	**COVERT ALL**	**COVERT A-C**	**COVERT FORM**	**ALL**
ANTI-COLL	Off	Off	Off	Switch	Switch
WING/TAIL	Off	Off	Switch	Off	Switch
FUSELAGE	Off	Off	Switch	Off	Switch
FORM	Off	Off	Knob [1]	Off	Knob [1]
AERIAL REFUELING	Off	Knob [2]	Knob [2]	Knob [2]	Knob [2]

1. Requires the WING/TAIL switch to be set to OFF to control the brightness of each wingtip light
2. Requires the AR REFUEL switch on the FUEL Control Panel to be set to OPEN

FLT CONTROL Panel

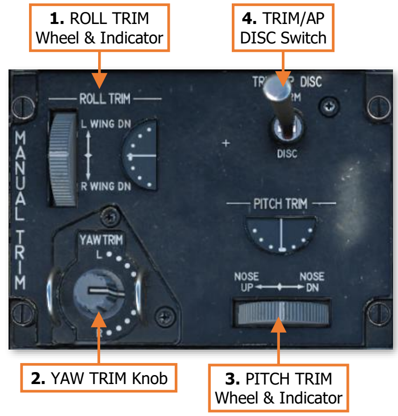
The Flight Control panel controls manual settings of the flight control systems. This panel is normally not used due to the automated nature of the F-16C's flight control systems.



1. **DIGITAL BACKUP Switch.** Selects the FLCC backup software. When enabled, the DBU ON warning light on the right eyebrow panel will illuminate and the HUD will display a flashing WARN message.
2. **MANUAL TF FLY-UP Switch.** This is a terrain-following radar function and is not used in the Block 50 F-16.
3. **ALT FLAPS Switch.** Controls manual deployment of the trailing edge flaps.
   - **EXTEND.** Manually deploys the trailing-edge flaps (TEF) at low speeds prior to landing if the trailing edge flaps have failed to deploy with the landing gear.
   - **NORM.** Enables automatic scheduling of trailing-edge flaps based on FLCS commands
4. **FLCS RUN/FAIL Indicator Lights.** When a FLCS BIT is initiated, the green RUN light illuminates and will extinguish when the test is complete. If a problem is encountered during the BIT, the red FAIL light illuminates, and the failure will be displayed on the Pilot Fault List Display (PFLD).
5. **LE FLAPS Switch.** Controls manual deployment of the leading-edge flaps. (N/I)
   - **LOCK.** Manually locks the leading-edge flaps in position and illuminates the FLCS warning light. This might be used in the case of a leading-edge flap failure with asymmetric flap settings.
   - **AUTO.** Enables automatic scheduling of leading-edge flaps based on FLCS commands.
6. **FLCS RESET Switch.** Resets the FLCS warning lights and servo/electrical failures within the FLCS system. Resets FLCS warning light, MASTER CAUTION light, CADC caution light, FLCS caution light, and clears PFLD if the associated faults are actually cleared.
7. **FLCS BIT Switch.** Commands a BIT test of the FLCS if there is weight-on-wheels and ground speed is <28 knots. Setting the switch to the BIT position will initiate the flight control surface test sequence and is performed during start-up. The test will run for approximately 45 seconds, during which time the switch is magnetically held in the BIT position. When the test is complete the switch is released and will return to the OFF position.

MANUAL TRIM Panel

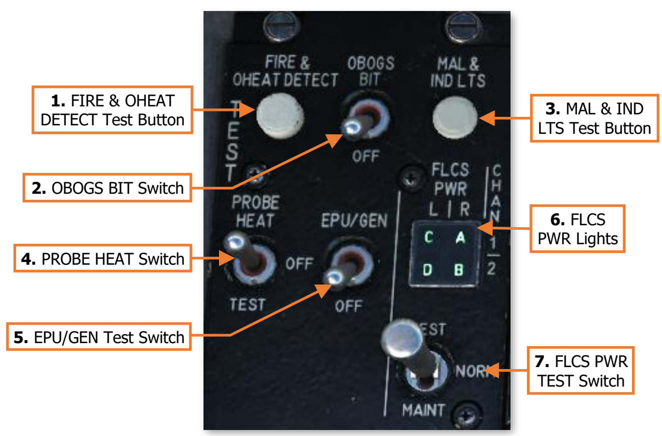
The Manual Trim panel controls manual trim values in pitch, roll and yaw. This might be used in the case of a malfunction with Trim Switch on the Side Stick Controller (SSC). This panel is normally not used since the F-16C's flight control systems provide automatic trim in pitch, and the pilot can trim in pitch and roll using the 4-way trim switch on the SSC.



1. **ROLL TRIM Wheel & Indicator.** Trims aircraft in the roll axis and indicates the degree of manual trim applied.
2. **YAW TRIM Knob.** Trims aircraft in the yaw axis. The degree of manual yaw trim applied is indicated by the outside dot pattern.
3. **PITCH TRIM Wheel & Indicator.** Trims aircraft in the pitch axis and indicates the degree of manual trim applied.
4. **TRIM/AP DISC Switch.** Controls source of trim inputs and autopilot engagement.
    - **NORM.** Pitch/Roll trim is controlled using either the 4-way Trim Switch on the SSC or this panel. Autopilot engagement is permitted.
    - **DISC.** Pitch/Roll trim is exclusively controlled using this panel. Trim Switch on the SSC is disabled. Autopilot engagement is inhibited.

TEST Panel

The Test panel includes several controls for performing built-in tests (BIT) of several F-16C systems and test all cockpit indicator lights.

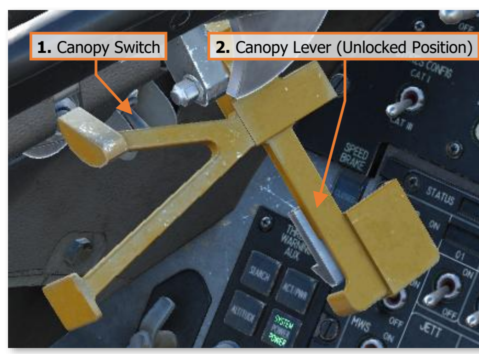


1. **FIRE & OHEAT DETECT Test Button.** Tests the circuit continuity of the fire and overheat detection systems. This will cause the ENG FIRE warning light and the OVERHEAT caution lights to illuminate. This will in turn trigger the MASTER CAUTION light.
2. **OBOGS BIT Switch.** Tests the On-Board Oxygen Generation System (OBOGS). Moving this switch momentarily to the OBOGS BIT position will cause the OXY LOW eyebrow warning light to illuminate for 10 seconds. If no faults are detected within the OBOGS monitoring system, the light will extinguish. If the OXY LOW warning light remains illuminated, a fault has been detected.
3. **MAL & IND LTS Test Button.** Illuminates all warning, caution, and indication lights to verify their function, as well as audio voice messages.

4. **PROBE HEAT Switch.** Controls the external air data probes and probe heat monitoring system when on the ground. When in flight, the pitot, fuselage air data, AoA, and total temperature probes and the probe heat monitoring system are always active.
    - **HEAT.** Enables heating of the pitot, fuselage air data, AoA, and total temperature probes when on the ground. Also enables the probe heat monitoring system.
    - **OFF.** Disables heating of the data probes when on the ground.
    - **TEST.** Performs a test of the probe heat monitoring system. The PROBE HEAT caution light will flash on the Caution Light Panel following a successful test. If it does not illuminate or does not flash, the probe heat monitoring system is inoperative.
5. **EPU/GEN Switch.** Momentarily pressing this switch to the TEST position tests the EPU generator and EPU PMG (Permanent Magnet Generator) output to the FLCS channels without using hydrazine while on the ground.
6. **FLCS PWR Lights.** Illuminates to indicate power output to each of the four redundant flight control channels (A, B, C and D) when the FLCS PWR switch is set to TEST.
7. **FLCS PWR TEST Switch.** Tests power output to the FLCS (pronounced "flick-iss") when MAIN PWR switch is set to BATT or MAIN PWR positions.
    - **TEST.** Tests power output to the FLCS channels.
    - **NORM.** Tests EPU PMG availability when EPU/GEN switch is set to TEST and MAIN PWR switch is set to MAIN PWR.
    - **MAINT.** Used for maintenance tests by ground personnel.

Canopy Switch & Canopy Handle

The Canopy Switch controls the actuator to raise and lower the canopy. The Canopy Handle locks/unlocks the canopy and inflates/deflates the canopy pressure seal.



1. **Canopy Switch.** Controls the canopy actuator.
    - **Up.** When the Canopy Lever is in the unlocked position, this position raises the canopy actuator to full extension. The switch will automatically snap back to the center position when the canopy actuator reaches full extension.
    - **Center.** The canopy actuator stops canopy motion.
    - **Down.** This position lowers the canopy actuator to full retraction. The switch is spring-loaded to center from this position and must be held to lower and close the canopy.
2. **Canopy Lever.** Prevents the canopy from un-latching and controls the canopy pressure seal.
    - **Unlocked (open, pulled outward).** The canopy pressure seal is deflated, and the CANOPY eyebrow warning light illuminates. The Canopy Lever should be placed in this position prior to lowering the canopy. The Canopy Lever also physically limits the full travel of the throttle lever.
    - **Locked (closed, up against cockpit wall).** The canopy is locked and the pressure seal is inflated.

Canopy Jettison T-Handle

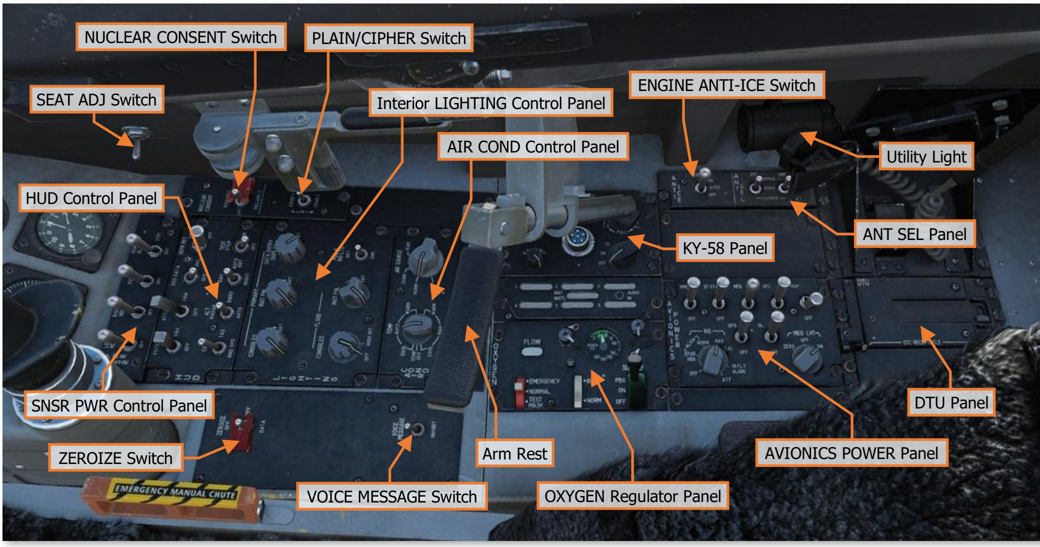
In case of an emergency, the CANOPY JETTISON T-handle provides an alternate means to separate the canopy from the aircraft. This can be used if the primary ejection handle is pulled but the canopy fails to separate, preventing ejection.

DEFOG Lever

The DEFOG lever can be moved forward and back to provide de-fogging to the canopy.

- **MIN.** Most of the airflow is diverted to the vents behind the seat.
- **MAX.** Most of the airflow is diverted to the forward canopy area and the air vent at the bottom of the center instrument panel.
  - When set to the full MAX position with the TEMP knob set to AUTO, the air flow will be set to full warm for 3 minutes. Retarding the lever and returning it to MAX will restart this 3-minute period of full warm.

Right Console

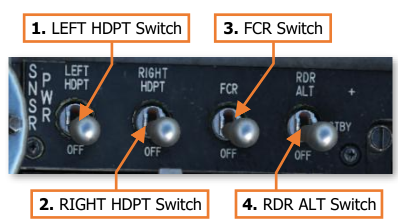


Each text box above may be selected to jump to a more detailed description of that panel. Selecting the image of the instrument or panel will return the manual back to this page.

The HUD Control Panel is described in a dedicated section following the Hands-On Controls (HOTAS).

SNSR PWR Control Panel

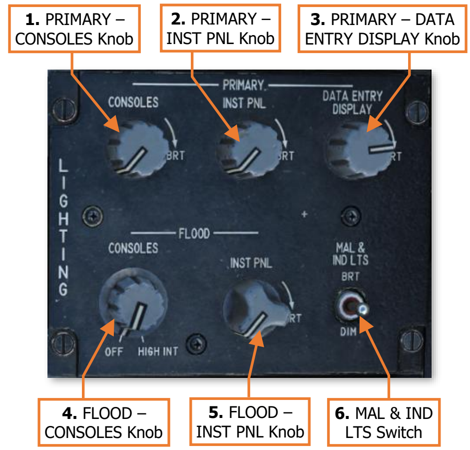
The Sensor Power panel consists of four switches that enable power to the primary sensors.



1. **LEFT HDPT Switch.** Powers the sensor mounted to the left "chin" hardpoint. This will normally be the AN/ASQ-213 HARM Targeting System pod.
2. **RIGHT HDPT Switch.** Powers the sensor mounted to the right "chin" hardpoint. This will normally be the AN/AAQ-33 advanced targeting pod.
3. **FCR Switch.** Powers the AN/APG-68 fire control radar.
4. **RDR ALT Switch.** Powers the radar altimeter.
    - **RDR ALT.** The radar altimeter is set to transmit.
    - **STBY.** The radar altimeter is powered on but will not transmit.
    - **OFF.** The radar altimeter is powered off.

Interior LIGHTING Control Panel

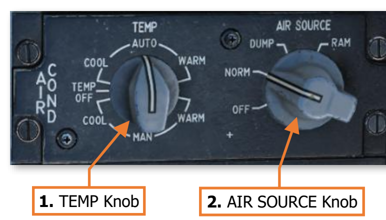
The Interior Lighting panel consists of five knobs that control the brightness of the cockpit instruments, switch panel backlighting, and flood lights. Most of the lighting is green to support night vision systems.



1. **PRIMARY – CONSOLES Knob.** Controls the brightness of the panel backlighting on the left auxiliary console, left console and right console.
2. **PRIMARY – INST PNL Knob.** Controls the brightness of the panel backlighting on the instrument panel and right auxiliary console.
3. **PRIMARY – DATA ENTRY DISPLAY Knob.** Controls the brightness of the DED and PFLD displays.
4. **FLOOD – CONSOLES Knob.** Controls the flood light intensity on the left auxiliary console, left console and right console.
5. **FLOOD – INST PNL Knob.** Controls the flood light intensity on the instrument panel and right auxiliary console.
6. **MAL & IND LTS Switch.** Sets the malfunction and indicator lights and the CMDS expendable inventory counters to either BRT (Bright) or DIM. BRT is automatically selected if the FLOOD – CONSOLES knob is moved past the HIGH INT detent, if the PRIMARY – INST PNL knob is rotated fully counterclockwise, or if emergency DC power is lost.

AIR COND Control Panel

The Air Conditioning panel controls the environmental control systems.



1. **TEMP Knob.** Controls cockpit temperature. (N/I)
2. **AIR SOURCE Knob.** Selects the air source for ventilation of the cockpit and avionics. Note that placing the knob in OFF or RAM will prevent fuel from being transferred from external fuel tanks.
   - **OFF.** Closes all engine bleed air valves. All air conditioning and cooling functions cease. Pressurization functions are disabled, including G-suit and pressure breathing, OBOGS, canopy seal, and fuel tank pressurization.
   - **NORM.** Sets environmental control and pressurization systems to automatic operation.
   - **DUMP.** Dumps cockpit pressure and uses conditioned bleed air to ventilate the cockpit and avionics.
   - **RAM.** Dumps cockpit pressure and closes engine bleed air valves. All air conditioning and cooling functions cease. Pressurization functions are disabled, including G-suit and pressure breathing, OBOGS, canopy seal, and fuel tank pressurization. Uses external ram air to ventilate cockpit and avionics.

KY-58 Secure Voice Panel

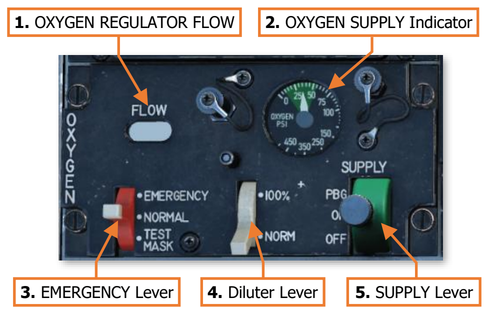
The KY-58 secure voice system is used to provide encryption of voice communications. (N/I)

PLAIN/CIPHER Switch

The Plain/Cipher switch toggles between using unencrypted or encrypted communications over either the UHF or VHF radio. (N/I)

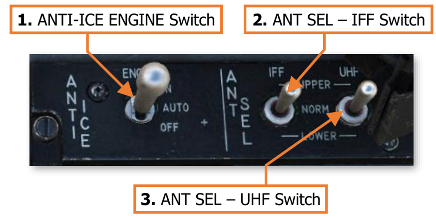
OXYGEN Regulator Panel

The Oxygen Regulator panel controls the flow of O_2 to the pilot's facemask and the oxygen system's mode of operation.



1. **OXYGEN REGULATOR FLOW Indicator.** Alternates between white and black indications. White indicates oxygen flow; black indicates no oxygen flow.
2. **OXYGEN SUPPLY Indicator.** Indicates oxygen pressure, with normal operation between 10 and 55 PSI.
3. **EMERGENCY Lever.** Controls positive pressure mode of oxygen supply system. (N/I)
   - **EMERGENCY.** Provides maximum amount of oxygen under positive pressure. Used by the pilot to test for leaks.
   - **NORMAL.** Positive pressure is provided if cockpit pressure altitude exceeds 28,000 feet.
   - **TEST MASK.** Provides maximum amount of oxygen under positive pressure. Used by life support personnel to test for leaks.
4. **Diluter Lever.** Controls the mixture of cockpit air and pure oxygen. (N/I)
   - **100%.** Maximum amount of oxygen is provided to the pilot.
   - **NORM.** Regulated mix of cockpit air and oxygen is provided to the pilot based on cockpit pressure altitude.
5. **SUPPLY Lever.** Controls mode of operation for the oxygen supply system. When set to PBG (Pressure Breathing for G), the oxygen regulator provides pressure breathing above 4 G's to enhance G tolerance and reduce pilot fatigue.
   - **PBG.** Oxygen is supplied to pilot's facemask. Pressure breathing based on G-force is available.
   - **ON.** Oxygen is supplied to pilot's facemask. Pressure breathing is not available.
   - **OFF.** Turns off the oxygen supply to pilot's facemask.

ANTI ICE & ANT SEL Switches



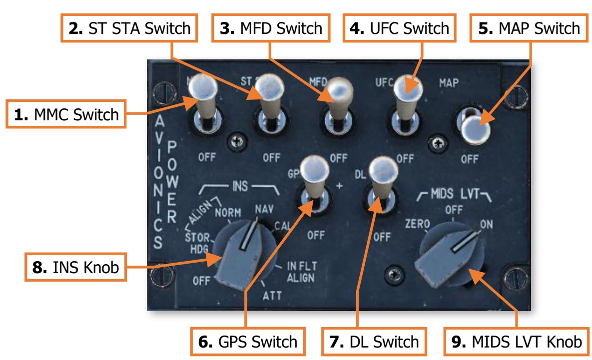
The engine Anti-Ice system prevents ice buildup within the engine intake and includes an inlet ice detector.

1. **ANTI-ICE ENGINE Switch.** Controls automatic or manual activation of the inlet anti-ice heating elements, and enables/disables the inlet ice detector.
   - **ON.** Manually activates the engine anti-ice system and inlet strut heater. The inlet ice detector will still illuminate the INLET ICING caution light on the Caution Light panel if ice accumulation is detected.
   - **AUTO.** If ice accumulation is detected by the inlet ice detector, the engine anti-ice system and inlet strut heater will automatically activate and the INLET ICING caution light will illuminate on the Caution Light panel.
   - **OFF.** The inlet ice detector, engine anti-ice system, and inlet strut heater are disabled.

The Antenna Select panel is used to select the upper, lower, or both antennas for transmissions from the UHF radio and IFF system.

2. **ANT SEL – IFF Switch.** Selects automatic or manual antenna selection for IFF interrogation replies.
   - **UPPER.** Upper IFF antenna is used to receive and reply to IFF interrogation signals.
   - **NORM.** The IFF antenna automatically selects which antenna is used to reply to IFF interrogation signals based on which antenna is receiving the strongest signal.
   - **LOWER.** Lower IFF antenna is used to receive and reply to IFF interrogation signals.
3. **ANT SEL – UHF Switch.** Selects single or both UHF antennas for radio transmission.
   - **UPPER.** Upper UHF antenna is used to transmit and receive UHF radio signals.
   - **NORM.** Both antennas are used to transmit in a cyclic pattern to provide omnidirectional radio transmissions.
   - **LOWER.** Lower UHF antenna is used to transmit and receive UHF radio signals.

AVIONICS POWER Control Panel



The Avionics Power panel enables/disables power to the various avionics systems and controls the alignment functions of the Inertial Navigation System (INS).

1. **MMC Switch.** Powers the Modular Mission Computer.
2. **ST STA Switch.** Powers the underwing and fuselage centerline stores stations.
3. **MFD Switch**. Powers the two cockpit Multi-Function Displays (MFD).
4. **UFC Switch**. Powers the Upfront Controls (ICP and DED).
5. **MAP Switch**. Not functional in the Block 50 F-16.

6. **GPS Switch.** Powers the GPS receiver. The GPS receiver must have an unobstructed line-of-sight to the sky to obtain data from multiple GPS satellites. If the aircraft is parked inside a hanger or hardened aircraft shelter, GPS timing signals and position data may not be obtained until after taxiing clear of the structure.

   NOTE: GPS will only be available if the DCS mission date is 28 March 1994 or later. In addition, GPS precision will be degraded unless USA is one of the countries assigned to the player's coalition within the DCS mission. However, these limitations may be overridden if *both* of the following conditions are true:

   - **Unrestricted SATNAV** is enabled in the player's GAMEPLAY options or is enforced as enabled in the Mission Options for the mission being played.
   - **Unrestricted SATNAV** is not enforced as disabled in the Mission Options for the mission being played.

7. **DL Switch.** Powers the Secure Modem Datalink (SMDL). (N/I)

8. **INS Knob.** Sets the operating mode of the Inertial Navigation System (INS) and determines the method of alignment when necessary. While the INS is performing an alignment on the ground, it is imperative that the aircraft is not moved or repositioned in any way, to include reconfiguring externally mounted equipment or arming/re-arming weapons stations. (See INS Alignment for more information.)

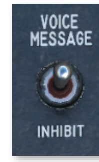
   - **OFF.** Removes power from the INS. The INS knob should remain in this position on aircraft power for a minimum of 10 seconds before moving the INS knob from off or shutting down the aircraft.
   - **ALIGN – STOR HDG.** Initiates a Stored Heading Alignment of the INS using previous alignment data stored within the MMC. This allows the alignment process to be completed more rapidly than a Normal Gyrocompass Alignment but requires that the aircraft not be moved after the INS is powered off (assuming the INS had a good alignment prior to the power being removed).
   - **ALIGN – NORM.** Initiates a Normal Gyrocompass Alignment of the INS from manually entered position data. This alignment mode requires more time to complete but allows the aircraft to regain position confidence if the aircraft has been repositioned by ground crews since the last time the INS was powered and properly aligned.
   - **NAV.** Sets the INS to normal navigation functionality after an alignment has been performed successfully.
   - **CAL.** No function.
   - **IN FLT ALIGN.** Initiates an In-Flight Alignment of the INS but requires the pilot to maintain a stable attitude on a constant heading while the alignment proceeds. When the INS knob is initially moved to IN FLT ALIGN, the INS will automatically enter Attitude mode until a coarse alignment can be completed.
   - **ATT.** Attitude mode provides pitch, roll, and heading information only and is used as a degraded mode of operation when the situation dictates. No navigational information will be available except TACAN.

9. **MIDS LVT Knob.** The Multifunctional Information Distribution System (MIDS) knob enables/disables or zeroizes the MIDS radio terminal. (See Tactical Net Datalink for more information.)

   - **ZERO.** Zeroizes sensitive data within MIDS LVT internal memory.
   - **OFF.** Disables power to the MIDS LVT.
   - **ON.** Enables power to the MIDS LVT.

VOICE MESSAGE Switch

The Voice Message switch is used to silence all aircraft voice messages when set to INHIBIT. This is normally only performed when a voice message is repeating in an erroneous manner.



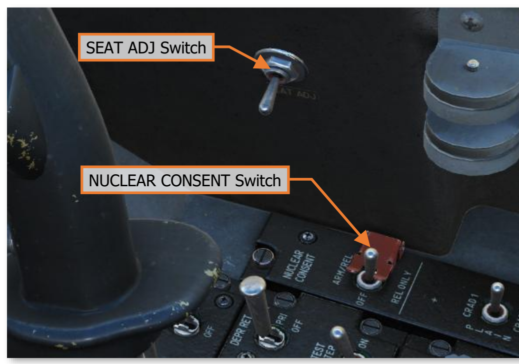
ZEROIZE Switch

In an emergency, the ZEROIZE switch can erase all sensitive data from the systems such as secure voice encryption, GPS keys, and others.

SEAT ADJ Switch

The Seat Adjustment switch controls an electric motor that raises or lowers the pilot seat. This function allows the pilot to ensure their sitting height corresponds with a comfortable view of the instrument panel and alignment of their viewpoint through the HUD. The seat can also be raised during landing for increased visibility over the nose, if desired.

The switch is spring-loaded to the center "off" position, and must be held up or down to adjust the seat height.



NUCLEAR CONSENT Switch

This switch is not implemented.

Ejection Seat Controls

Ejection Handle

The Ejection Handle is pulled to initiate the ejection sequence in an emergency where continued flight or a safe landing is no longer possible or is in doubt. Pulling the handle jettisons the canopy, followed by igniting a rocket motor mounted to the seat, expelling the seat itself along with the pilot to descend to the surface under a parachute.

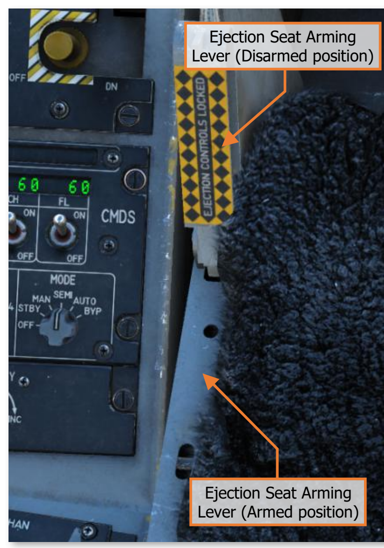
The ejection handle itself is not implemented in DCS: F-16C Viper. The ejection sequence can be initiated by pressing **[LCtrl]+[E]**.

Ejection Seat Arming Lever

The Ejection Seat Arming lever arms the Ejection Handle and associated mechanisms for performing an ejection from the cockpit in an emergency.

When the handle is placed in the upright position, the ejection seat is disarmed, and the SEAT NOT ARMED caution light illuminates on the Caution Light Panel.

When the handle is rotated aft and down so that it is flush with the ejection seat surface, the ejection seat is armed and the SEAT NOT ARMED caution light extinguishes.



Emergency Manual Chute Lever

The Emergency Manual Chute lever allows the pilot to manually initiate seat separation and deployment of his/her parachute following an ejection sequence. (N/I)

This may be necessary if the separation and deployment sequence does not initiate automatically or malfunctions.

HANDS-ON CONTROLS (HOTAS)

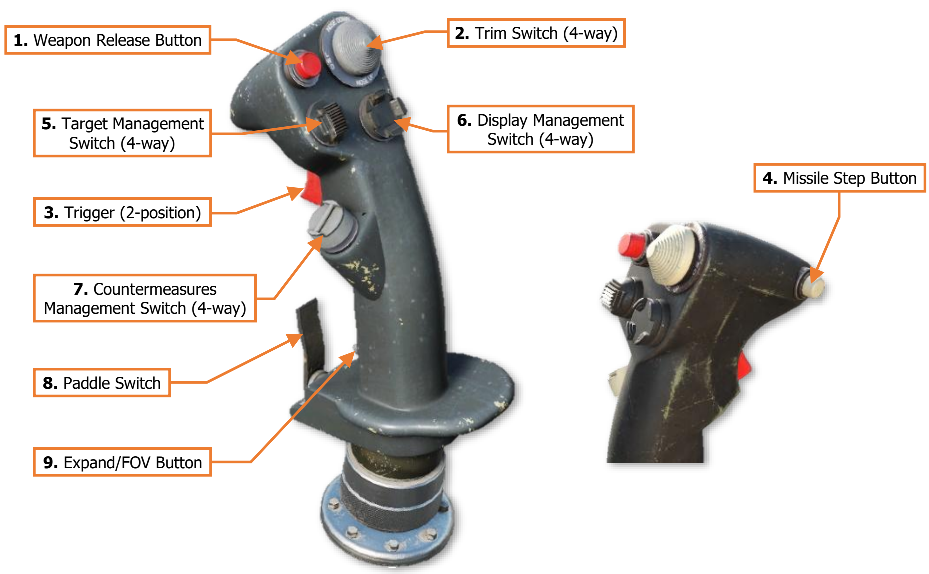
The Hands-On Controls, sometimes referred to as Hands on Throttle and Stick (HOTAS), allows the pilot to interact with the fire control system and various weapons delivery functions without taking his or her hands off the flight controls. Some of these switches are multipurpose and their function at any given time depends upon the aircraft master mode, weapons delivery mode, and/or the selected Sensor-Of-Interest (SOI).

NOTE: The descriptions of Hands-On Control functions below and the visual diagrams in Appendix D do not include all possible functions. Reference the applicable sensor and weapon chapters for remaining functions.

Side Stick Controller (SSC)

The primary function of the Side Stick Controller is to provide pitch and roll commands to maneuver the aircraft. Pushing/pulling on the SSC affects aircraft pitch (moves the horizontal tails) and moving the SSC left/right affects roll (moves the wing trailing edge flaperons and horizontal tails; and to a lesser extent, the vertical rudder).

The SSC has several buttons and multi-position switches that permit manipulation of the key systems.



1. **Weapon Release Button.** Press and hold to fire air-to-air missiles or release any air-to-ground munition.

2. **Trim Switch.** Positioning the button forward and aft trims the aircraft nose up (Trim switch aft) and nose down (Trim switch forward). Positioning the button left and right trims the aircraft left wing down and right wing down respectively.

3. **Trigger.** Squeezing and holding the trigger to the first detent fires the laser designator/ranger for accurate ranging if a targeting pod is equipped and powered. Squeezing the trigger to the second detent fires the gun if selected and armed, or fires the laser designator/ranger for 30 seconds in CCIP or STRF sub-modes.

4. **Missile Step Button.** This button has different functions depending on the state of the aircraft.

   - **Nose-wheel Steering.** On the ground, momentarily pressing the button activates nosewheel steering via the rudder pedals. Pressing the button a second time disables nosewheel steering.

- **AR Disconnect.** When in flight and the AIR REFUEL switch is in the OPEN position, pressing the button manually disconnects the refueling boom from the aircraft's dorsal refueling receptacle.
- **Missile Step.** When in flight and in Air-to-Air, Missile Override or Dogfight modes, a short press (<0.5 sec) will select the next missile station of that type, and a long press (>0.5 sec) will cycle the missile type. When in flight and in Air-to-Ground (A-G) mode, a short press cycles between CCIP, DTOS and CCRP modes; or selects the next missile station if AGM-65 or AGM-88 is selected on the SMS format.

ACTION		NAV MODE	A-A MODE	MSL ORIDE MODE	DGFT MODE	A-G MODE	A-G MODE (AGM-65)	A-G MODE (AGM-88)
MSL STEP	Air Short	(No Action)	Missile Step			CCIP→DTOS →CCRP	Missile Step	
	Air Long	(No Action)	Cycle Missile Type			(No Action)		
	Air Refuel	Manually Disconnect Aerial Refueling Boom						
	Ground	Engage/Disengage Nosewheel Steering (NWS)						

5. **Target Management Switch (TMS).** The TMS controls target designation and management of the selected Sensor-Of-Interest (SOI). Short press duration is <0.5 second; long press duration is >0.5 second. Exceptions to the long press duration are bolded in the table below, which require a full 1 second press.

ACTION		HUD SOI	HMCS SOI	FCR SOI	HSD SOI	HAD SOI	TGP SOI	WPN SOI
FWD	Short	DTOS/VIS Designate	Designate	Designate / ACM BORE	Designate / Display Ring	Designate	Point Track (upon release)	Track / Force Correlate
	Long	SOI to HMCS	(No Action)	Spotlight Scan (while held)	(No Action)	Cycle HARM POS (**1 sec**)	Area Track (while held)	(No Action)
LEFT	Short	(No Action)		Scan Interrogate	(No Action)	DED to SEAD	TV/FLIR/ FLIR Polarity	HARM Table / MAV Polarity
	Long	(No Action)		NCTR/LOS Interrogate	(No Action)	Initiate TDOA	(No Action)	
RIGHT	Short	*Sighting Point Rotary	(No Action)	Target Step / ACM 30×20 / *	(No Action)	Target Step	Area Track / IR Pointer (2x)	HARM Target Step
	Long	(No Action)		TWS Toggle (**1 sec**)	(No Action)		Inertial Track	(No Action)
AFT	Short	Target Reject	Target Reject / SOI to HUD	Target Reject / ACM 10×60	Drop PDLT / Hide Ring	Target Reject / DED to CNI	Slave Mode / Cursor Zero	Target Reject / MAV Slave
	Long	(No Action)				Terminate TDOA	Declutter (while held)	(No Action)

* When sighting point options are available in Air-to-Ground (A-G) master mode, pressing TMS Right while the HUD or FCR is set as SOI will cycle through the available sighting points.

6. **Display Management Switch (DMS).** The DMS is used to control Sensor-Of-Interest (SOI) selection. Short press duration is <0.5 second; long press duration is >0.5 second.

ACTION		HUD SOI	HMCS SOI	FCR SOI	HSD SOI	HAD SOI	TGP SOI	WPN SOI
FWD	Short	(No Action)		SOI to HUD				
	Long	(No Action)						
LEFT	Short	Cycle Left MFD Format						
	Long	(No Action)						
RIGHT	Short	Cycle Right MFD Format						
	Long	(No Action)						
AFT	Short	SOI to MFD		Swap SOI between MFDs				
	Long	Helmet Display Unit On/Off						

7. **Countermeasures Management Switch (CMS).** The CMS controls deployment of countermeasures and operation of the ECM pod, if installed. (See Defensive Systems for more information.)

ACTION		COUNTERMEASURE FUNCTION
FWD	**ALL**	Dispense 1x Manual Program 1-4 (as selected by CMDS PRGM knob)
LEFT	**ALL**	Dispense 1x Manual Program 6
RIGHT	**MAN**	Deactivate ECM Emissions
	SEMI	Disable ECM Emissions
	AUTO	Disable Dispensing of Auto Program / Interrupt Dispensing of current Program
AFT	**MAN**	Activate ECM Emissions if set to Mode 3
	SEMI	Dispense 1x Auto Program / Enables ECM Emissions if set to Mode 1 or 2
	AUTO	Enable Continuous Dispensing of Auto Program

8. **Paddle Switch.** Momentarily disengages the autopilot for the duration that the switch is pressed and held, allowing the pilot to manually maneuver the aircraft as necessary. When released, the autopilot will attempt to capture new reference values of pitch, roll, and/or altitude, depending on the autopilot modes that have been selected using the PITCH and ROLL switches on the MISC panel. (See Autopilot for more information.)

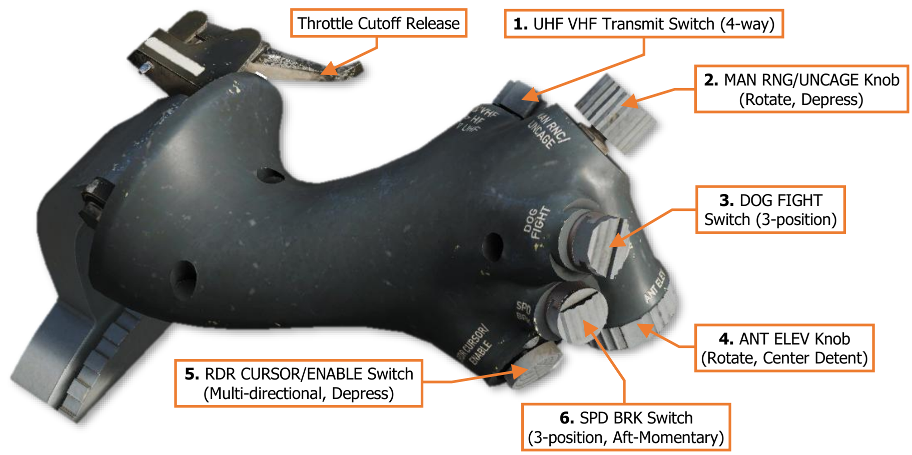
9. **Expand/FOV Button.** Pressing this button cycles through the available fields-of-view for the sensor or system that is currently selected as SOI. If AGM-65 is selected on the SMS MFD format, pressing this button toggles the seeker field-of-view on the selected AGM-65 missile. If AGM-88 is selected on the SMS format, pressing this button will either cycle the seeker field-of-view between WIDE, CTR, LT, and RT on the selected AGM-88 missile when in HAS sub-mode; or will cycle the POS sub-mode between EOM, RUK, and PB.

ACTION		HUD SOI	HMCS SOI	FCR SOI	HSD SOI	HAD SOI	TGP SOI	WPN SOI
EXP/ FOV DEPR	**Short**	(No Action)		Cycle FCR EXP Modes	Cycle HSD EXP Modes	Cycle HAD EXP Modes	Cycle FOV / XR Zoom (2x)	Cycle Missile FOV/POS
	Long	HSD ZOOM Mode (while held)						

Throttle

The engine is controlled by a throttle mounted above the left console with detents at OFF, IDLE, MIL, and MAX AB. The OFF position terminates engine ignition and fuel flow. The IDLE position commands minimum thrust and is used for all ground starts and air starts. From IDLE to MIL, the throttle controls the output of the engine. Forward of the MIL position, the throttle controls the operation of the afterburner.

The throttle has several multi-position switches and knobs that permit manipulation of the key systems. As with the Side Stick Controller, the Hands-On Controls functions on the throttle vary in functionality depending on the state and operational modes of the aircraft.



1. **UHF VHF Transmit Switch.** The switch initiates UHF (aft) and VHF (forward) radio transmissions. Pressing IFF IN (right/inboard) or IFF OUT (left/outboard) using short presses (<0.5 sec) controls datalink filters on the FCR. Pressing inboard with long presses (>0.5 sec) controls transmissions to Flight/Team members over the selected datalink. Short press duration is <0.5 second; long press duration is >0.5 second

ACTION		DATALINK FUNCTION
LEFT (IFF OUT)	Short	Toggle Datalink Information on FCR
	Long	(No Action)
RIGHT (IFF IN)	Short	Cycle Datalink Filters on FCR
	Long	Transmit selected Steerpoint, SPI, or SEAD Target over Datalink

2. **MAN RNG/UNCAGE Control.** The Manual Range/Uncage knob has different functions depending on the master mode and selected system. Rotating the knob controls manual zoom level for targeting pod video. A short depress (<0.5 sec) commands the AIM-9 seeker to uncage, the TGP to enter/exit LST mode, or declutters the HUD when landing. When the aircraft is airborne with the landing gear down, depressing UNCAGE will remove the Roll Indicator and ILS Bars from the HUD and re-position the Heading Scale to the top portion of the HUD. A long depress (>1.0 sec) enters/exists Gun Strafe mode.

ACTION		NAV MODE (LG DOWN)	A-A / MSL / DGFT MODE	A-G MODE
DEPRESS	Short	Declutter ILS Deviation Bars and Roll Indicator from HUD	Uncage AIM-9 Seeker (SMS AIM-9)	Toggle Laser Spot Track (TGP SOI)
	Long	(No Action)		Toggle Gun STRF Mode

3. **DOG FIGHT Switch.** The Dogfight/Missile Override switch is a three-position switch that overrides any mode except emergency jettison. Returning the switch to the center returns to the last selected Master Mode.

   - **Dogfight (outboard).** This position will automatically select ACM radar mode, but the radar will go to standby until commanded to transmit. The HUD will display symbology for 20mm gun engagement along with the targeting reticles for AIM-9 or AIM-120, depending on which missile is selected. "DGFT" is displayed in the HUD Master Mode Status.
   - **Missile Override (inboard).** This position will automatically select RWS radar mode and display HUD symbology for A-A missile delivery. Gun will be unavailable for selection. "MRM", "SRM" or "HOB" will be displayed in the HUD Master Mode Status, depending on which missile type is selected. If no air-to-air missiles have been loaded, "MSL" is displayed in the HUD Master Mode Status.

4. **ANT ELEV Knob.** The Antenna Elevation knob is used to manually set the radar antenna elevation angle.

5. **RDR CURSOR/ENABLE Control.** Used for slewing the cursor on the FCR, HSD, and HAD pages; the cursor on the WPN page when AGM-88 is selected in HAS mode; slewing the TGP sensor; or slewing the AGM-65 seeker. When in A-A master mode, pressing and holding this control swaps the BORE/SLAVE option for the AIM-9 missiles while the control is depressed. When in A-G master mode with AGM-65 missiles selected, pressing this control will step through PRE/VIS/BORE mode options.

ACTION	HUD / HMCS SOI	FCR / HSD / HAD SOI	TGP SOI	WPN SOI (AGM-65)	WPN SOI (AGM-88)
SLEW	Slew TD Box / Mark Cue	Slew MFD Cursor	Slew TGP Sensor	Slew MAV Seeker	Slew HAS Cursor

ACTION	A-A MODE	MSL ORIDE MODE	DGFT MODE	A-G MODE (AGM-65)	A-G MODE (AGM-88)
DEPRESS	Swap AIM-9 BORE/SLAVE (for duration of press)			PRE→VIS →BORE	HAS↔POS

6. **SPD BRK Switch.** The aft position extends the speedbrakes and the forward position retracts the speedbrakes, with the switch spring-loaded out of the aft position back to center. Extension and retraction movement occurs for as long as the SPD BRK switch is held in either position, allowing the speedbrakes to be stopped at any intermediate position as desired.

   The speedbrakes may be fully extended to 60° when the right main landing gear is not down and locked. When the right main landing gear is down and locked, the speedbrakes are limited to 43° to prevent the lower speedbrake surfaces from striking the ground upon landing. This limitation may be temporarily overridden by holding the SPD BRK switch to the aft position. When the nose landing gear compresses after landing, the speedbrakes may once again be fully opened without needing to hold the SPD BRK switch aft.

Side Stick Controller (SSC) Hands-On Control Functions

ACTION		NAV MODE	A-A MODE	MSL ORIDE MODE	DGFT MODE	A-G MODE	A-G MODE (AGM-65)	A-G MODE (AGM-88)
MSL STEP	Air Short	(No Action)	Missile Step			CCIP→DTOS →CCRP	Missile Step	
	Air Long	(No Action)	Cycle A-A Missile Type			(No Action)		
	Air Refuel	Manually Disconnect Aerial Refueling Boom						
	Ground	Engage/Disengage Nosewheel Steering (NWS)						

ACTION		HUD SOI	HMCS SOI	FCR SOI	HSD SOI	HAD SOI	TGP SOI	WPN SOI
DMS FWD	Short	(No Action)		SOI to HUD				
	Long	(No Action)						
DMS LEFT	Short	Next Left MFD Format						
	Long	(No Action)						
DMS RIGHT	Short	Next Right MFD Format						
	Long	(No Action)						
DMS AFT	Short	SOI to MFD		Swap SOI between MFDs				
	Long	Helmet Display Unit On/Off						
TMS FWD	Short	DTOS/VIS Designate	Designate	Designate / ACM BORE	Designate / Show Ring	Designate	Point Track (upon release)	Track / Force Correlate
	Long	SOI to HMCS	(No Action)	Spotlight Scan (while held)	(No Action)	Cycle HARM POS (**1 sec**)	Area Track (while held)	(No Action)
TMS LEFT	Short	(No Action)		Scan Interrogate	(No Action)	DED to SEAD	TV/FLIR/ FLIR Polarity	HARM Table / MAV Polarity
	Long	(No Action)		NCTR / LOS Interrogate	(No Action)	Initiate TDOA	(No Action)	
TMS RIGHT	Short	*Sighting Point Rotary	(No Action)	Target Step / ACM 30×20 / *	(No Action)	Target Step	Area Track / IR Pointer (2x)	HARM Target Step
	Long	(No Action)		TWS Swap (**1 sec**)	(No Action)		Inertial Track	(No Action)
TMS AFT	Short	Target Reject	Target Reject / SOI to HUD	Target Reject / ACM 10×60	Drop PDLT / Hide Ring	Target Reject / DED to CNI	Slave Mode / Cursor Zero	Target Reject / MAV Slave
	Long	(No Action)				Terminate TDOA	Declutter (while held)	(No Action)
CMS FWD	ALL	Dispense 1x Manual Program 1-4 (as selected by CMDS PRGM knob)						
CMS LEFT	ALL	Dispense 1x Manual Program 6						
CMS RIGHT	MAN	Deactivate ECM Emissions						
	SEMI	Disable ECM Emissions						
	AUTO	Disable Dispensing of Auto Program / Interrupt Dispensing of current Program						
CMS AFT	MAN	Activate ECM Emissions if set to Mode 3						
	SEMI	Dispense 1x Auto Program / Enables ECM Emissions if set to Mode 1 or 2						
	AUTO	Enable Continuous Dispensing of Auto Program						
EXP/ FOV	Short	(No Action)		Cycle FCR EXP Modes	Cycle HSD EXP Modes	Cycle HAD EXP Modes	Cycle FOV / Zoom XR (2x)	Toggle Missile FOV/POS
	Long	HSD ZOOM Mode (while held)						
PADDLE SWITCH		Interrupts Autopilot authority to the flight controls / Sets new Autopilot reference values upon release						

Throttle Grip Hands-On Control Functions

ACTION	HUD / HMCS SOI	FCR / HSD / HAD SOI	TGP SOI	WPN SOI (AGM-65)	WPN SOI (AGM-88)
RDR CURSOR SLEW	Slew TD Box / Mark Cue	Slew MFD Cursor / ACM SLEW	Slew TGP Sensor	Slew MAV Seeker	Slew HAS Cursor

ACTION	A-A MODE	MSL ORIDE MODE	DGFT MODE	A-G MODE (AGM-65)	A-G MODE (AGM-88)
ENABLE DEPRESS	Swap AIM-9 BORE/SLAVE (for duration of press)			PRE$\rightarrow$VIS $\rightarrow$BORE	HAS$\leftrightarrow$POS

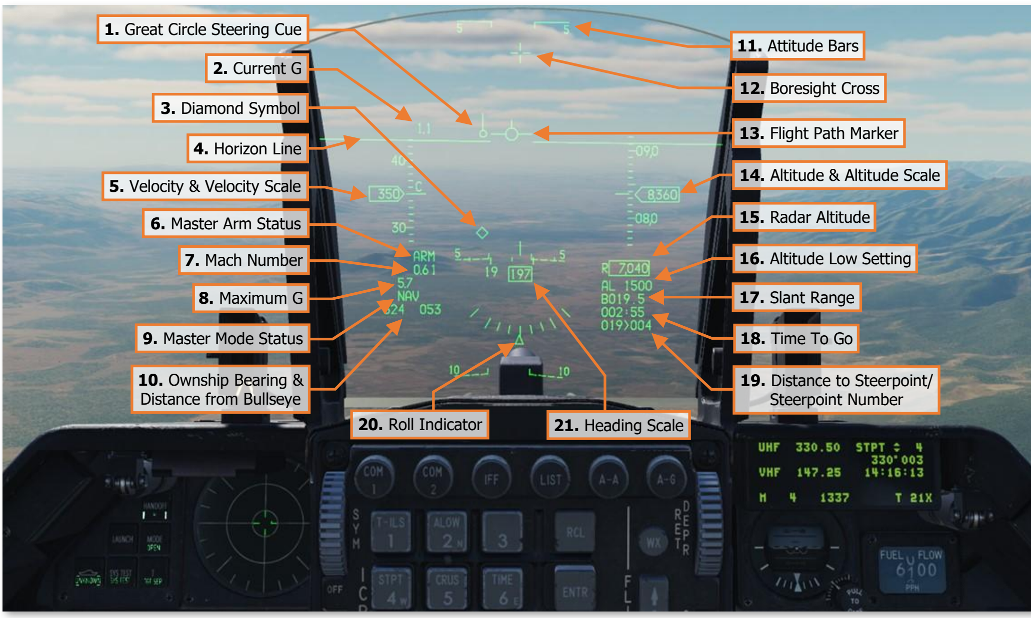
ACTION		COMMAND
UHF VHF FWD		Transmit over ARC-222 VHF-AM/FM Radio
UHF VHF AFT		Transmit over ARC-164 UHF-AM Radio
UHF VHF LEFT	Short	Toggle Datalink Information on FCR
	Long	(No Action)
UHF VHF RIGHT	Short	Cycle Datalink Filters on FCR
	Long	Transmit selected Steerpoint, SPI, or SEAD Target over Datalink
SPD BRK FWD		Retract Speed Brakes
SPD BRK CTR		Hold Speed Brakes in current position
SPD BRK AFT		Extend Speed Brakes
DOG FIGHT UP (OUT)		Enter DOGFIGHT Master Mode, set FCR Mode to ACM, set FCR to Standby
DOG FIGHT CTR		Revert Master Mode to previous Master Mode/Sub-mode prior to entering DOGFIGHT/MISSILE OVERRIDE
DOG FIGHT DOWN (IN)		Enter MISSILE OVERRIDE Mode, set FCR Mode to CRM, set FCR Sub-mode to RWS
ANT ELEV ROTATE		Increase/Decrease FCR Antenna Elevation
MAN RNG ROTATE		Increase/Decrease TGP Manual Zoom Level

ACTION		NAV MODE (LG DOWN)	A-A / MSL / DGFT MODE	A-G MODE
UN-CAGE	Short	Declutter ILS Deviation Bars and Roll Indicator from HUD	Uncage AIM-9 Seeker (SMS AIM-9)	Toggle Laser Spot Track (TGP SOI)
	Long	(No Action)		Toggle Gun STRF Mode

Visual diagrams of the Hands-On Control functions based on Master Mode/SOI may be viewed in Appendix D.

HEAD-UP DISPLAY (HUD)

The Head-Up Display, or HUD, is one of the most important instruments and provides valuable information regarding aircraft flight performance, navigation, targeting, and visual cues for weapons employment. All information is displayed on a combining glass mounted in the forward field-of-view at eye level. The display surface field of view is 25° in diameter and extends down to a line 10.5° below the field-of-view center, with the symbology focused at infinity and superimposed upon the outside world along the flightpath of the aircraft.



Some elements of the HUD symbology are always present, others will be displayed or removed based on the selected master mode, available sensor(s), or weapon profile; and some elements can be optionally displayed or removed based on pilot preference. (See HUD Control Panel for more information.)

HUD Symbology Elements

1. **Great Circle Steering Cue.** Provides a lateral steering indication to the selected steerpoint. The steering cue functions using the great circle method, in that the most direct route across a 3-dimensional sphere is used to determine the course to the destination instead of a fixed heading across a 2-dimensional surface.

   The line extending from the cue indicates the relative bearing of the selected steerpoint from the nose. If the line is pointed to the 12 o'clock, the steerpoint is directly ahead. If the line is pointed to the 3 or 9 o'clock, the steerpoint is 90 to the right or left respectively. If the line is pointed to the 6 o'clock, the steerpoint is behind the aircraft. (See Navigation by Steerpoints for more information.)

2. **Current G.** Displays the current aircraft G-load value. The G value is displayed to the nearest tenth of a G, and ranges from +9.9 to -9.9 G's.

3. **Diamond Symbol.** Displays the 3-dimensional position of the selected steerpoint, in both position and altitude. When the Diamond Symbol is out of the HUD field-of-view an X is superimposed across the symbol. (See Navigation by Steerpoints for more information.)

4. **Horizon Line.** The Horizon Line is an element of the Attitude Bars that indicates 0° pitch, relative to the Boresight Cross.

5. **Velocity & Velocity Scale.** Velocity is displayed in knots, between 60 to 900 knots CAS. When below 60 knots CAS, the HUD will display 0 knots. Each major tick mark on the Velocity Scale represents 50 knots and is accompanied by a 2-digit label, and each minor tick mark represents 10 knots.

   The Velocity may be set to calibrated airspeed (CAS), true airspeed (TAS), or ground speed (GND SPD) using the Velocity Switch on the HUD Control Panel. A "C" is displayed to the right of the Velocity Scale when set to calibrated airspeed, a "T" is displayed when set to true airspeed, and a "G" is displayed when set to ground speed. The Velocity Scale will automatically revert to calibrated airspeed if in Dogfight mode or if the landing gear is deployed.

6. **Master Arm Status.** Displays the position of the MASTER ARM Switch on the MISC panel.
   - **ARM.** The MASTER ARM Switch is in the MASTER ARM position.
   - **(Blank).** No text is displayed if the MASTER ARM Switch is in the OFF position.
   - **SIM.** The MASTER ARM Switch is in the SIMULATE position.

7. **Mach Number.** Displays the current Mach number to the hundredths value.

8. **Maximum G.** Displays the maximum G-loading measured during the flight. This value may be reset to 1.0 by momentarily placing the Drift Cut-Out/Warning Reset switch on the ICP to the WARN RESET position.

9. **Master Mode Status.** Displays the current master mode or sub-mode.
   - **NAV.** Navigation master mode.
   - **AAM.** Air-to-Air Missile sub-mode with no missile type selected.
   - **MSL.** Missile Override mode with no missile type selected.
   - **DGFT.** Dogfight master mode.
   - **MRM.** Medium Range Missile type selected (AIM-120B/C) while in A-A or MSL master modes.
   - **SRM.** Short Range Missile type selected (AIM-9L/M/P/P3/P5) while in A-A or MSL master modes.
   - **HOB.** High-Angle Off-Boresight missile type selected (AIM-9X) while in A-A or MSL master modes.
   - **EEGS.** Enhanced Envelope Gun Sight for employing the M61 cannon while in A-A master mode and GUN sub-mode.
   - **JETT.** Selective Jettison or Emergency Jettison master modes.
   - **HARM.** HARM Missile designation sub-mode while in A-G master mode.
   - **HTS.** HARM Targeting System designation sub-mode while in A-G master mode.
   - **CCIP.** Continuously Computed Impact Point weapon delivery sub-mode while in A-G master mode.
   - **CCRP.** Continuously Computed Release Point weapon delivery sub-mode while in A-G master mode.
   - **DTOS.** Dive/Toss weapon delivery sub-mode while in A-G master mode.
   - **LADD.** Low Altitude Drogue Delivery weapon delivery sub-mode while in A-G master mode.
   - **MAN.** Manual weapon delivery sub-mode for manual bomb delivery while in A-G master mode.
   - **VIS.** Visual weapon delivery sub-mode for employing AGM-65 (EO-VIS) or JDAM (VIS) while in A-G master mode; or when the HUD Mark Cue is active.
   - **PRE.** Pre-planned weapon delivery sub-mode for employing AGM-65 (EO-PRE) or JDAM (PRE) while in A-G master mode.
   - **BORE.** Boresight weapon delivery sub-mode for employing AGM-65 while in A-G master mode.
   - **STRF.** Strafe weapon delivery sub-mode for employing the 20mm M61 rotary cannon while in A-G master mode.

10. **Ownship Bearing & Distance from Bullseye.** Displays the azimuth and distance as measured from the Bullseye location to the aircraft.

    The Ownship Bearing & Distance from Bullseye can be toggles using the BULL DED page.

11. **Attitude Bars.** A series of horizontal bars (including the Horizon Line) spaced at 5° intervals to indicate aircraft pitch attitude, relative to the Boresight Cross. At pitch angles greater than 60, the attitude bar intervals are spaced at 10 intervals. Positive pitch angles are indicated by a solid attitude bar, and negative pitch angles are indicated by a dashed bar. Each bar includes a small line along the outside pointing toward the Horizon Line.

    The Attitude Bars are caged to the Flight Path Marker in azimuth, which may occur in high crosswinds or lateral drift. The Drift Cut-Out/Warning Reset switch on the Integrated Control Panel (ICP) can be used to cage the Attitude Bars and FPM to the center of the HUD when set to the DRIFT C/O position.

12. **Boresight Cross.** The Boresight Cross is displayed in all master modes and represents the fuselage reference line.

13. **Flight Path Marker.** The Flight Path Marker (FPM) consists of a circle with three lines extending outward from the circumference at the 12, 3, and 9 o'clock positions. The FPM indicates the aircraft inertial velocity vector.

    When the FPM is out of the HUD field-of-view, which may occur in high crosswinds, lateral drift or high angles-of-attack, an X is superimposed across the symbol. The Drift Cut-Out/Warning Reset switch on the ICP can be used to cage the Attitude Bars and FPM to the center of the HUD when set to the DRIFT C/O position.

    When in Air-to-Ground master mode, the FPM will flash when a weapon is released.

14. **Altitude & Altitude Scale.** The Altitude & Altitude Scale is in feet, to the nearest 10 feet. Each major tick mark on the Altitude Scale represents 500 feet and is accompanied by a 2-digit label, and each minor tick mark represents 100 feet.

15. **Radar Altitude.** The Radar Altitude is displayed within a box marked by an "R", to the nearest 10 feet. If the radar altimeter is set to standby or is otherwise not transmitting, the display will be blank.

16. **Altitude Low Setting.** Displays the current CARA ALOW setting in feet. When the radar altimeter indicates an altitude less than this setting, this data field will flash and will be accompanied by an "Altitude…altitude" voice message alert.

17. **Slant Range.** The Slant Range is the direct, straight-line distance from the aircraft to the current target or SPI location. For range values greater than 1.0 NM, the range is displayed as a four-digit value to the nearest tenth of a nautical mile (e.g., 15.2 NM is displayed as "015.2"). For range values less than 1.0 NM, the range value is displayed as a three-digit value to the nearest hundred feet (e.g., 5500 feet is displayed as "055"). The letter on the left of the display indicates the method the range is determined.

    - **B.** The slant range is determined based on the barometric altitude and steerpoint elevation.
    - **R.** The slant range is determined based on the radar altimeter.
    - **F.** The slant range is determined based on ranging data from the FCR.
    - **L.** The slant range is determined based on ranging data from the TGP laser.
    - **M.** A Manual range is being used in an air-to-air mode or in air-to-ground CCIP mode.

18. **Time to Go.** Displays the time that is estimated to elapse before arriving at the selected steerpoint, based on the current ground speed. (See Navigation by Steerpoints for more information.)

19. Distance to Steerpoint/Steerpoint Number. The distance to the selected steerpoint is displayed to the left of the chevron in 1 nautical mile increments. The selected steerpoint number is displayed to the right of the chevron. (See Navigation by Steerpoints for more information.)

20. Roll Indicator. The Roll Indicator consists of increment marks at 0°, 10°, 20°, 30° and 45° bank angles. As the aircraft rolls in either direction, the caret symbol will rotate along the indicator arc to indicate the current bank angle.

21. Heading Scale. The Heading Scale indicates the magnetic heading of the aircraft. A fixed lubber line along the top of the scale and a digital readout below the scale displays the magnetic heading. Each major tick mark on the tape represents 10° of magnetic heading and is accompanied by a 2-digit label, and each minor tick mark represents 5° of magnetic heading.

When the Velocity Scale is set to ground speed, a triangle symbol is presented along the Heading Scale indicating the aircraft's course track across the ground.

22. Bank Angle Indicator. The Bank Angle Indicator consists of increment marks at 15°, 30°, 45°, and 60° bank angles. The increment marks are caged to the Flight Path Marker and the FPM wings are used as indicators of the bank angle.

The Bank Angle Indicator is displayed in place of the Roll Indicator and is only displayed in NAV master mode and when the Scales Switch is in the VV/VAH position on the HUD Control Panel.

23. Vertical Velocity Scale. The Vertical Velocity Scale is displayed to the left of the Altitude Scale when in NAV master mode. Each major tick mark on the Vertical Velocity Scale represents 1000 feet per minute, and each minor tick mark represents 500 feet per minute.

The Vertical Velocity Scale is only displayed in NAV master mode and when the Scales Switch is in the VV/VAH position on the HUD Control Panel.

24. Manual Bombing Reticle. The Manual Bombing Reticle is displayed using the Primary or Secondary reticle patterns. Using the RET DEPR knob on the ICP, the reticle can be positioned vertically from 0 to -260 mils with respect to the Boresight Cross, and it is fixed horizontally on the HUD center line and not wind-corrected.

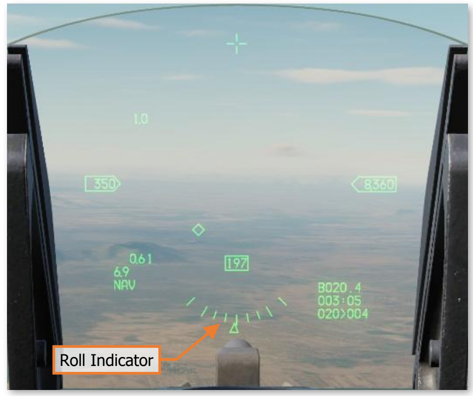
- **Primary Reticle.** The primary reticle consists of a 2-milliradian dot surrounded by a dashed 50-milliradian inner circle and a solid 100-milliradian dotted outer circle.
- **Secondary Reticle.** The secondary reticle consists of a 2-milliradian dot surrounded by dotted 50-milliradian inner circle and a dotted 100-milliradian outer circle. Four 6-milliradian tick marks are positioned along the outer circle marking the 12, 3, 6, and 9 o'clock locations.
- **Manual Reticle Depression Setting.** Indicates the current reticle depression setting of the Manual Bombing Reticle, as set by the RET DEPR knob on the ICP.

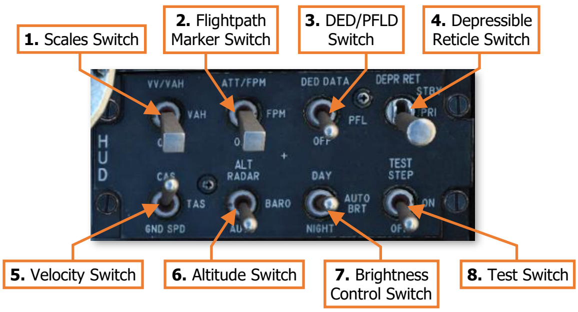
Additional HUD symbology elements associated with the various sensors and weapons are described in the applicable chapters of this manual.

HUD Control Panel

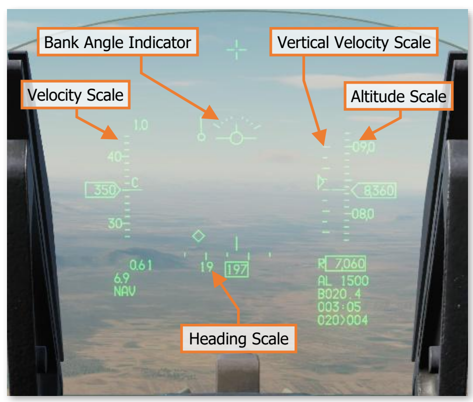
The HUD Control Panel provides the pilot with the ability to tailor which HUD symbology elements are displayed at any given time to suit the current mission, situation, or personal preference.

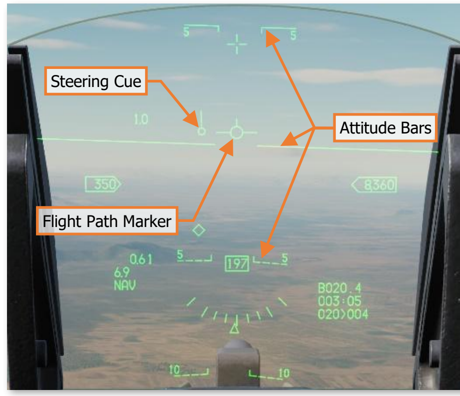
In Navigation master mode, with no targets being tracked by the FCR, the HUD can be de-cluttered as shown in the image to the right.





1. **Scales Switch.** Enables/disables the display of analog scales for primary flight data.
   - **VV/VAH.** Vertical Velocity, Velocity, Altitude, and Heading scales are displayed. If the Flight Path Marker (FPM) is displayed, the Roll Indicator is removed and the Bank Angle Indicator is placed around the FPM.
   - **VAH.** Velocity, Altitude and Heading scales are displayed. The Vertical Velocity scale is removed.
   - **OFF.** Removes all scales, leaving only the digital readouts for velocity, altitude, and heading.





2. Flightpath Marker Switch. Enables/disables the display of attitude and flight path information.

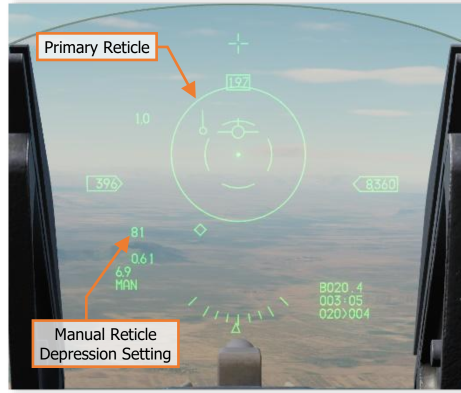
- **ATT/FPM.** Displays the Attitude Bars (horizon line and pitch ladder), the Flight Path Marker (FPM), and the Steering Cue
- **FPM.** Displays the Flight Path Marker and Steering Cue. The Attitude Bars are removed.
- **OFF.** The Attitude Bars, Flight Path Marker, and Steering Cue are removed.

3. DED/PFLD Switch. Enables/disables the display of PFLD or DED information in the lower portion of the HUD.

- **DED DATA.** Removes the Roll Indicator and displays a data repeater of the DED.
- **PFL.** Removes the Roll Indicator and displays a data repeater of the Pilot Fault List Display (PFLD).
- **OFF.** Displays the Roll Indicator.

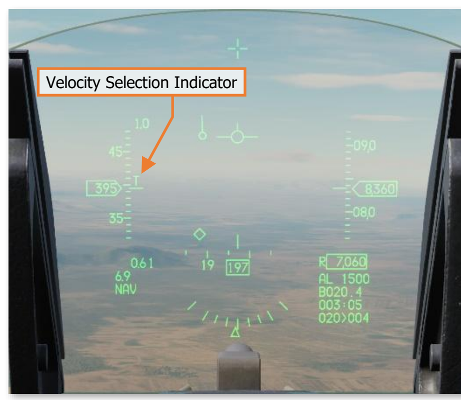
4. **Depressible Reticle Switch.** Controls the display of the Manual Bombing Reticles and Manual Reticle Depression Setting.

- **STBY.** Displays the Standby Reticle and Manual Reticle Depression Setting. Removes all other HUD elements.
- **PRI.** Displays the Primary Reticle and Manual Reticle Depression Setting. All HUD symbology elements are retained.
- **OFF.** Removes the Primary/Standby Reticle and the Manual Reticle Depression Setting.



5. **Velocity Switch.** Controls the velocity scale displayed in the HUD. The velocity selection indicator is only displayed when the Scales switch is in the VV/VAH or VAH positions.

- **CAS.** Displays calibrated airspeed, indicated by a "C" next to the Velocity Scale. The HUD will automatically revert to CAS if in Dogfight mode or if the landing gear are down.
- **TAS.** Displays true airspeed, indicated by a "T" next to the Velocity Scale.
- **GS.** Displays ground speed, indicated by a "G" next to the Velocity Scale. The Heading Scale, if shown, will display the current ground track of the aircraft, indicated by an inverted triangle symbol along the top of the Heading Scale.



6. **Altitude Switch.** (N/I)
7. **Brightness Control Switch.** Controls HUD brightness intensity automatically or manually.
    - **DAY.** HUD brightness is manually selected to day intensity level.
    - **AUTO BRT.** HUD brightness is automatically adjusted based on ambient light levels. (N/I)
    - **NIGHT.** HUD brightness is manually selected to night intensity level.
8. **Test Switch.** (N/I)

UPFRONT CONTROLS (UFC)

The Upfront Controls (UFC) include the Integrated Control Panel (ICP) and the Data Entry Display (DED). These components provide a method of quick access for navigation control, communications, fire control system modes, and data entry throughout the mission. The most commonly used functions are available on the ICP itself; but less frequently used functions, such as power and audio volume, are located on console panels.

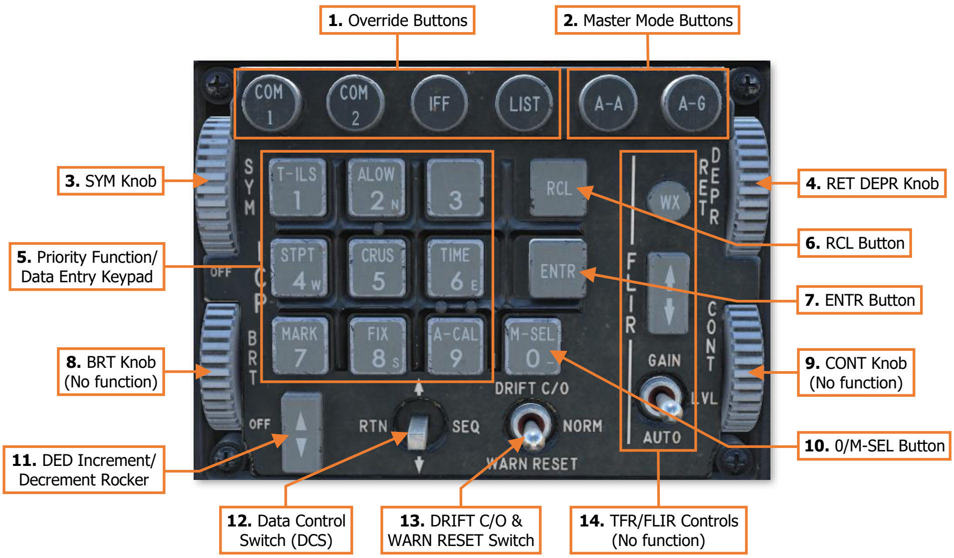
Data accessed through the ICP is displayed on the DED.

The Upfront Controls are available when the C & I knob is set to the UFC position on the [IFF control panel.](#) During normal operations, the Upfront Controls are used for various data entry and system management functions of communications, navigation, and IFF. In the event there is a failure with the Upfront Controls, the C & I knob can be set to the BACK UP position, which allows control of the UHF radio and IFF through the use of the UHF Backup panel and the IFF control panel.

Note that even when the C & I knob is set to the UFC position, the MASTER knob on the IFF control panel is still used to enable/disable operation of the APX-113 Advanced IFF transponder/interrogator system.

Integrated Control Panel (ICP)

The Integrated Control Panel fills the top center portion of the instrument panel and is one of the core components for interfacing with the communications, navigation, and IFF systems (also called CNI) of the F-16C. In addition to the CNI-related functions, the ICP provides master mode selection, controls for manipulating and entering data into the DED, and HUD symbology brightness control.



1. **Override Buttons.** Provides quick selection and access of priority DED pages. These buttons override the current DED page to show the page that corresponds with the override button. When pressed a second time, the DED will return to the previous page.
   - **COM 1.** Selects the UHF DED page.
   - **COM 2.** Selects the VHF DED page.
   - **IFF.** Selects the IFF DED page.
   - **LIST.** Selects the List DED page. The List page displays less frequently used DED pages.
2. **Master Mode Buttons.** Selects Air-to-Air (A-A) or Air-to-Ground (A-G) master modes, respectively. Pressing the same button of the current master mode returns to Navigation (NAV) master mode.
3. **SYM Knob.** Rotating this knob up/down will increase/decrease the HUD symbology brightness.
4. **Reticle Depression (RET DEPR) Control.** This knob raises and lowers the depressible reticle when it is displayed on the HUD during MAN bombing mode. Values from 0 to 260 milliradians can be set.
5. **Priority Function/Data Entry Keypad.** When the CNI DED page is displayed, pressing any of these buttons accesses frequently used DED pages. The keypad is also used to input or modify data on the currently displayed DED page, as necessary.
6. **Recall (RCL) Button.** The first press of this button erases the previous digit of new data that was input, similar to a Backspace key on a computer keyboard. The second press of this button rejects any newly input data entirely and restore the original data.
7. **Enter (ENTR) Button.** This button accepts and enters new data into the highlighted data field.

8. **BRT Knob.** The HUD raster intensity knob is not used in the Block 50 F-16.
9. **CONT Knob.** The HUD raster contrast knob is not used in the Block 50 F-16.
10. **Mode Select (M-SEL) Button.** Cycles through available modes or settings on various DED pages. The button is also used to input a zero or a negative value on the currently displayed DED page, as necessary. It's specific functionality for each DED page is described in the respective DED page sections.
11. **DED Increment/Decrement Rocker.** This switch increases or decreases values for the field selected on the current DED page. Values that can be increased or decreased are identified by an up and down arrow next to them on the DED page. The DCS is used to cycle between available fields.
12. **Data Control Switch (DCS).** Also known as the "Dobber" switch; moves the asterisks or the increment/decrement symbol on the DED, sequences through different data fields, and returns the DED to the CNI page. It's specific functionality for each DED page is described in the respective DED page sections.
13. **DRIFT C/O & WARN RESET Switch.** Cages/releases HUD symbology to indicate the aircraft's true flight path and removes messages from the center of the HUD.
    - **DRIFT C/O.** Setting the switch to this position will horizontally cage the Flight Path Marker to the center of the HUD and the Attitude Bars to the Boresight Cross. This may be used if the FPM and Attitude Bars drift out of view from crosswinds or sideslip, or if a failure or degradation has occurred in the INS and it is operating in Attitude mode.
    - **NORM.** Spring-loaded to this position from WARN RESET. Allows the FPM and Attitude Bars to drift left or right with the aircraft's true flight path.
    - **WARN RESET.** Resets warnings presented on the HUD and their associated voice messages. Resets the HUD Maximum G indicator to 1.0.
14. **TFR/FLIR Controls.** The TFR WX button, FLIR Increment/Decrement rocker, and FLIR GAIN/LVL/AUTO switch are not used in the Block 50 F-16.

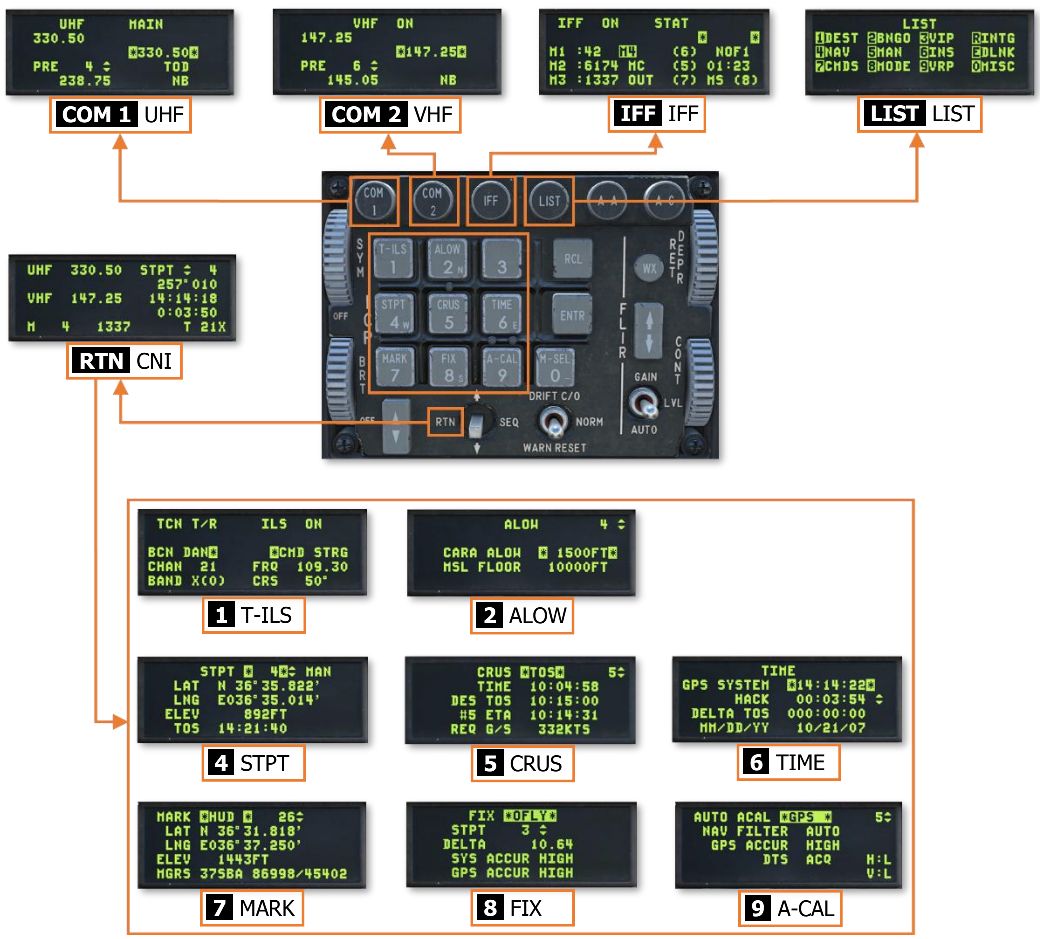
Data Entry Display (DED)

The Data Entry Display is an LED-display that allows the pilot to access a variety of mission and system settings and, if necessary, edit or modify mission data or system settings directly from the cockpit.

The CNI DED page may be considered the "home" page, in that the CNI page is commonly displayed during a mission when the DED is not in active use. In addition, the ICP Priority Function buttons can only be accessed when the CNI is displayed on the DED. Any time the Data Control Switch (DCS), also called the "Dobber" switch, is moved to the RTN position, the DED will return to the CNI page. When returning to the CNI page, any data that was entered but not accepted on the previous DED page will be erased.

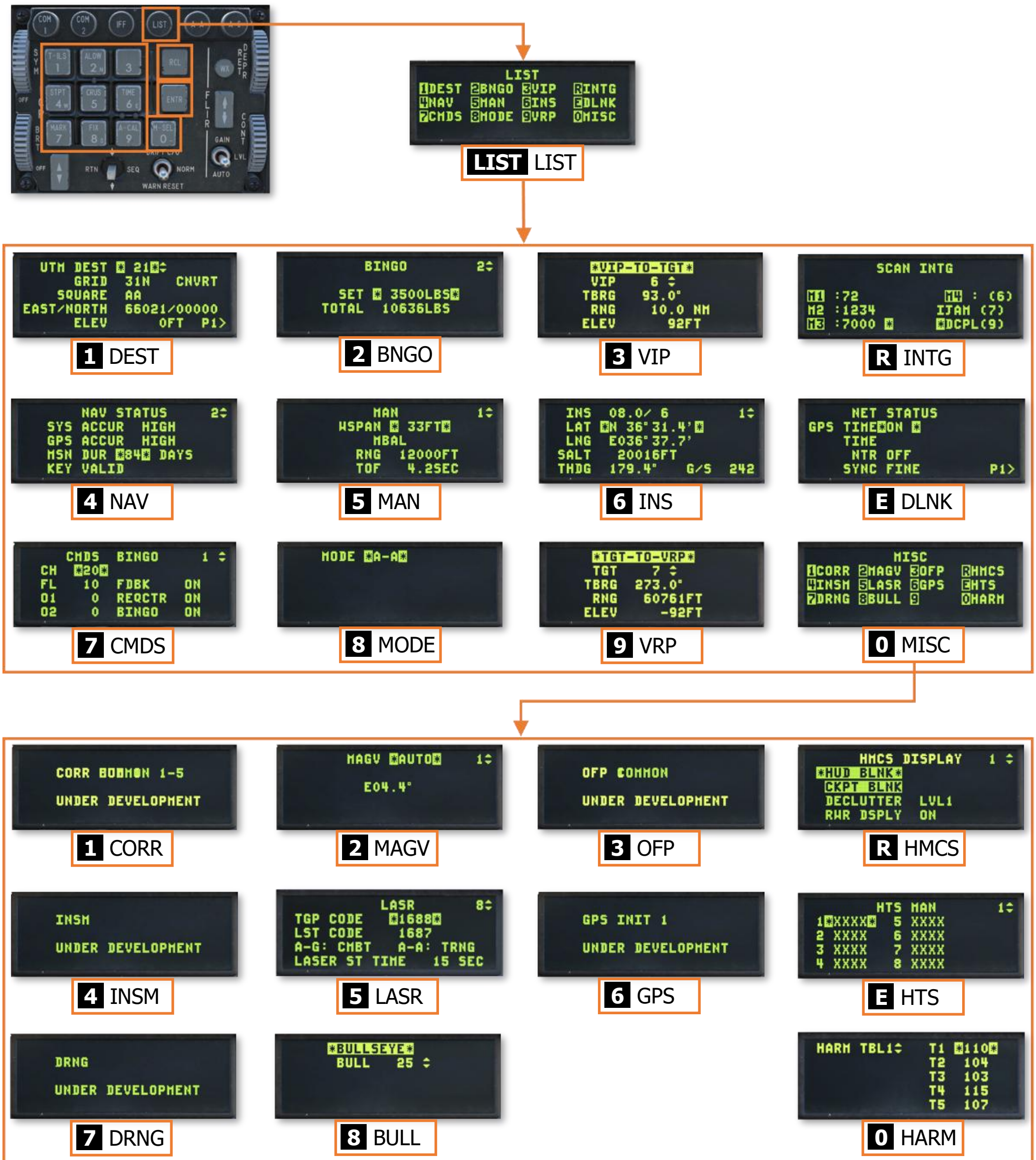
Any time the UHF, VHF, IFF or LIST pages are called up using their respective Override buttons along the top of the ICP, pressing the button a second time will return the DED to the previous state.

Each of the DED page labels in the figure below and on the following page may be left-clicked to immediately move to the corresponding manual section describing the function of that page.



Data Entry Display – Priority Functions

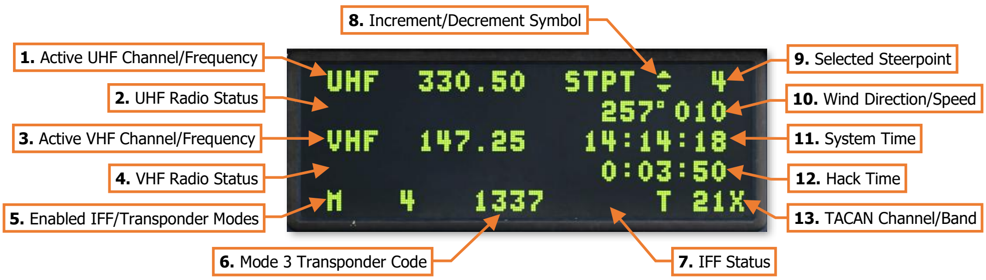
Less frequently used DED pages can be accessed by pressing the LIST Override button, and then use the ICP keypad to select the corresponding page displayed on the DED page. An additional list of miscellaneous DED pages can be accessed through the LIST page by pressing the **0/M-SEL** button on the ICP keypad.

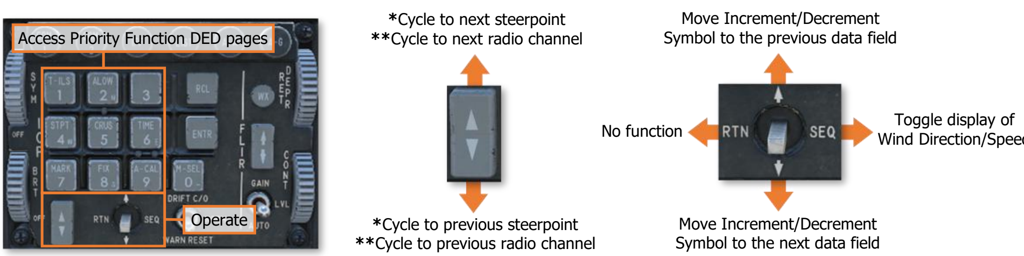


Data Entry Display – Secondary and Miscellaneous Functions

CNI DED Page

The Communications/Navigation/IFF DED page displays the currently tuned radio frequencies/channels for the UHF and VHF radios, the steerpoint selected for navigation, TACAN data, wind data, system time, and IFF status. The CNI page is the default DED page displayed at power-up and can be accessed at any time by momentarily moving the Data Control Switch (DCS), also called the "Dobber" switch, to the RTN (Return) position.





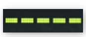
* Cycles to the next/previous steerpoint when the Increment/Decrement Symbol is adjacant to the Selected Steerpoint data field.

** Cycles to next/previous UHF or VHF preset channel when the Increment/Decrement Symbol is adjacent to the UHF or VHF data field respectively, and the corresponding radio is already tuned to a preset channel.

1. **Active UHF Channel/Frequency.** Displays the preset radio channel or the manual radio frequency to which the ARC-164 UHF radio is currently tuned.
2. **UHF Radio Status.** Displays the operating mode of the ARC-164 UHF radio.
   - **(Nothing Displayed).** Radio is powered on and controlled via the Upfront Controls (UFC).
   - **GRD.** Radio is powered on and tuned to the UHF GUARD frequency 243.0.
   - **BUP.** Radio is powered on and controlled via the UHF Backup control panel.
   - **OFF.** Radio is powered off.
3. **Active VHF Channel/Frequency.** Displays the preset radio channel or the manual radio frequency to which the ARC-222 VHF radio is currently tuned.
4. **VHF Radio Status.** Displays the operating mode of the ARC-222 VHF radio.
   - **(Nothing Displayed).** Radio is powered on and controlled via the Upfront Controls (UFC).
   - **GRD.** Radio is powered on and tuned to the VHF GUARD frequency 121.5.
   - **BUP.** Radio is powered on but cannot be controlled in BACK UP mode.
   - **OFF.** Radio is powered off.

5. **Enabled IFF/Transponder Modes.** (N/I)
6. **Mode 3 Transponder Code.** (N/I)
7. **IFF Status.** Displays the operating mode of the APX-113 Advanced IFF system.
   - **(Nothing Displayed).** IFF is controlled via the Upfront Controls (UFC) via the IFF DED page.
   - **BUP.** IFF is controlled via the IFF control panel.
8. **Increment/Decrement Symbol.** Indicates which data field the Increment/Decrement rocker will modify.
9. **Selected Steerpoint.** Displays the currently selected navigational steerpoint.
10. **Wind Direction/Speed.** Displays the current magnetic wind direction and speed as calculated by the CADC. When the winds cannot be determined by the CADC, DFLT will be displayed to the left of the wind direction, indicating default values are currently displayed in the data field.
11. **System Time.** Displays the internal system time in a 24-hour time format based on Zulu time (UTC). System time is automatically entered into the avionics system based on GPS data. No manual entering of time is required.
12. **Hack Time.** Displays the current Hack time as set on the TIME DED page. If the Hack time is zeroized, Hack time is removed from the CNI page.
13. **TACAN Channel/Band.** Displays information regarding the TACAN receiver.
   - 

     TACAN is powered and set to REC or T/R mode. Tuned channel and band (X/Y) are displayed.
   - 

     TACAN is powered and set to A/A T/R mode. Distance measurement to the paired TACAN station is displayed between 00.1 and 99.9 NM.
   - 

     TACAN is powered and set to A/A T/R mode. No distance measurement available.

   (See Tactical Air Navigation for more information.)

UHF & VHF DED Pages

The UHF and VHF DED pages are accessed by pressing the COM 1 or COM 2 override buttons (respectively) on the ICP, regardless of the currently displayed DED page. Pressing the same button a second time will return the DED to the previous page. (See Radio Communications for more information.)

IFF DED Page

The Identification-Friend-or-Foe DED page is accessed by pressing the IFF override button on the ICP, regardless of the currently displayed DED page. Pressing the IFF button a second time will return the DED to the previous page.

This page is not implemented.

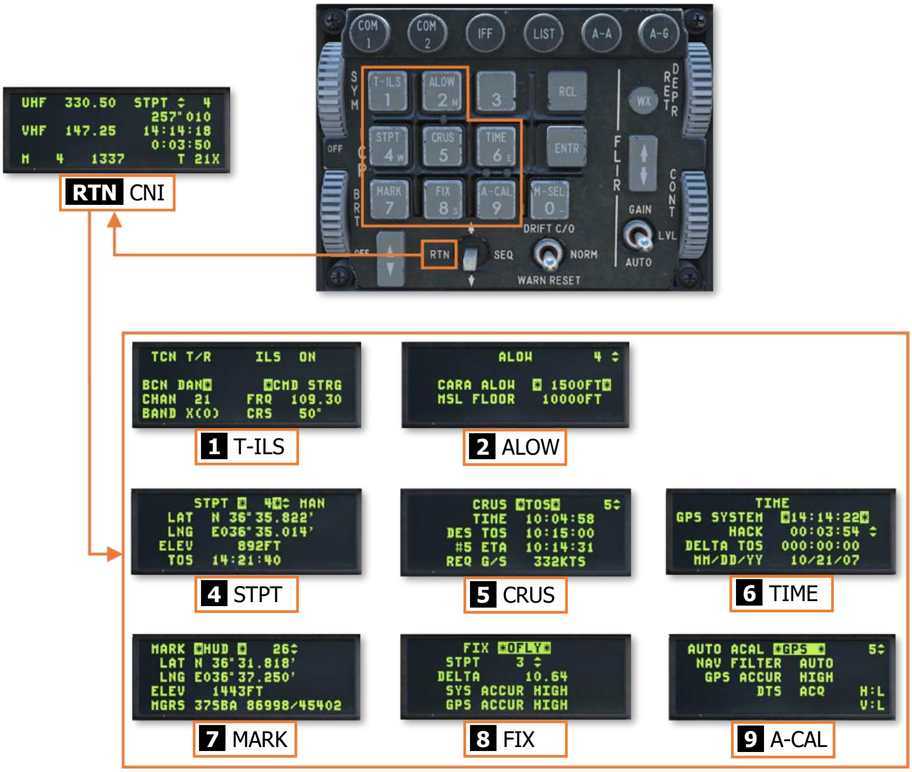
LIST DED Page

The List DED page is accessed by pressing the LIST override button on the ICP, regardless of the currently displayed DED page. Pressing the LIST button a second time will return the DED to the previous page. The LIST page displays a list of secondary DED pages that may be accessed. The ICP keypad is used to select a page from the list.

An additional list of miscellaneous DED pages may be accessed by pressing the 0/M-SEL button on the ICP keypad while the LIST page is displayed.

Priority Function DED Pages

When the CNI DED page is displayed, the buttons on the ICP keypad access eight frequently used DED pages. Each button is labeled with the corresponding DED page that will be accessed when the button is pressed.



Data Entry Display – Priority Functions

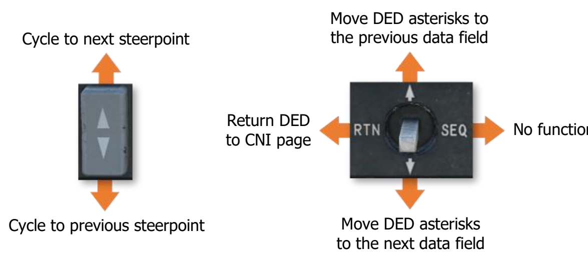
The following Priority Function DED pages are described in the applicable sections.

- **T-ILS –** Tactical Air Navigation (TACAN) & Instrument Landing System (ILS)
- **FIX –** Navigation Updates
- **A-CAL –** Navigation Updates

The remaining Priority Function DED pages are described on the pages that follow.

ALOW DED Page

The Altitude Low DED page is accessed by pressing the **2/ALOW** button on the ICP keypad when the CNI DED page is displayed. Two low altitude warnings may be set; one that is triggered by the Combined Altitude Radar Altimeter (CARA) and the other that is triggered by the barometric altimeter.



1. **CARA ALOW.** Displays the altitude above ground level (AGL) at which the Combined Altitude Radar Altimeter will trigger a low altitude warning. May be modified by placing the DED asterisks over the data field, entering an altitude (in feet) using the ICP keypad, and pressing ENTR.

   When the radar altimeter indicates the aircraft is below this altitude, the Altitude Low Setting will flash in the HUD and an accompanying "Altitude…altitude" voice message will be heard.

   Note that this setting is based on the altitude above ground level (AGL) and requires the radar altimeter to be powered on and transmitting for this warning to function. If the landing gear is down, the voice message is inhibited.

2. **MSL FLOOR.** Displays the altitude above mean sea level (MSL) at which the altimeter will trigger a low altitude warning. May be modified by placing the DED asterisks over the data field, entering an altitude (in feet) using the ICP keypad, and pressing ENTR.

   When the barometric altimeter indicates the aircraft is below this altitude, an "Altitude…altitude" voice message will be heard.

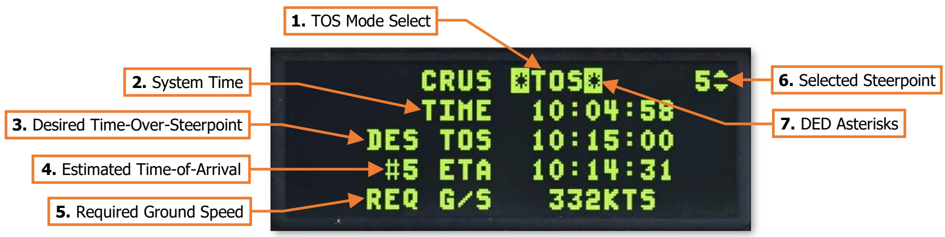
3. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

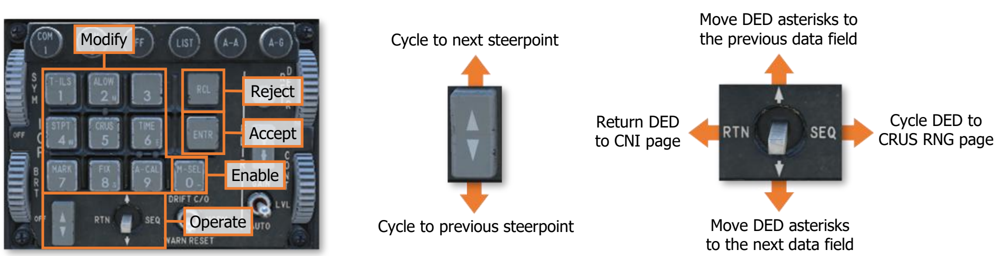
4. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

CRUS TOS DED Page

The Cruise Time-Over-Steerpoint DED page is accessed by pressing the **5/CRUS** button on the ICP keypad when the CNI DED page is displayed, followed by momentarily pressing the DCS switch to the SEQ position as necessary. This page displays the desired Time-Over-Steerpoint (TOS) of the selected steerpoint, the estimated time of arrival (ETA) over the next steerpoint in the route with a valid TOS, and the required ground speed.

If any CRUS mode (TOS, RNG, HOME, or EDR) is enabled when the **5/CRUS** button is pressed to access the CRUS DED pages, the DED will default to the corresponding DED page of the enabled CRUS mode.





1. **TOS Mode Select.** Enables/disables CRUS TOS mode by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when CRUS TOS mode is enabled. See the example on the following page for more information.

   Only one CRUS mode may be enabled at any given time. Enabling CRUS TOS mode will disable any other CRUS mode that is already enabled.

2. **System Time.** Displays the aircraft system time in a 24-hour time format.

3. **Desired Time-Over-Steerpoint.** Displays the desired TOS for the selected steerpoint, in a 24-hour time format, if the TOS is valid (positive value). If the TOS for the selected steerpoint is invalid (negative value), this data field will be blank.

4. **Estimated Time-of-Arrival.** Displays the number of the next steerpoint within the route with a valid TOS and the estimated time that the aircraft will arrive over that steerpoint, if flown directly toward the selected steerpoint and each sequential steerpoint in the route, at the current ground speed.

5. **Required Ground Speed.** Displays the ground speed that is required in order to arrive over the next steerpoint within the route with a valid TOS. If no steerpoints with a valid TOS remain within the route sequence, this data field will be blank.

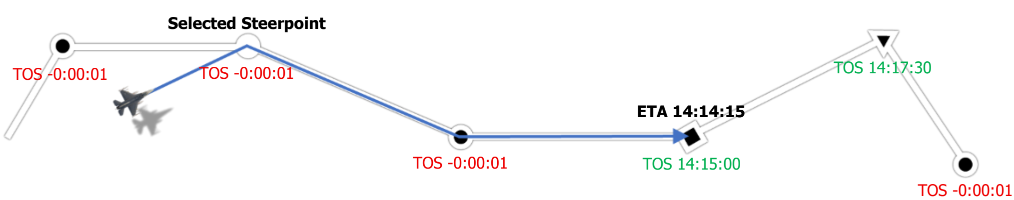
6. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

7. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

When CRUS TOS mode is enabled, a speed caret will be displayed along the HUD Velocity Scale (if shown) that corresponds with the speed required to arrive at the next steerpoint in the route with a valid TOS, if flown directly toward the selected steerpoint and each sequential steerpoint in the route. The HUD Time To Go data field will be replaced with the Estimated Time-of-Arrival (ETA) to that steerpoint at the current ground speed.

If the landing gear is down, the caret is removed from the HUD.

In the example above, the Desired Time-Over-Steerpoint (DES TOS) for steerpoint 5 is 10:15:00, but the Estimated Time of Arrival (ETA) at the current ground speed is 10:14:15, which is 45 seconds early. The speed caret indicates that the pilot should reduce the ground speed so that the ETA is delayed to match the DES TOS.



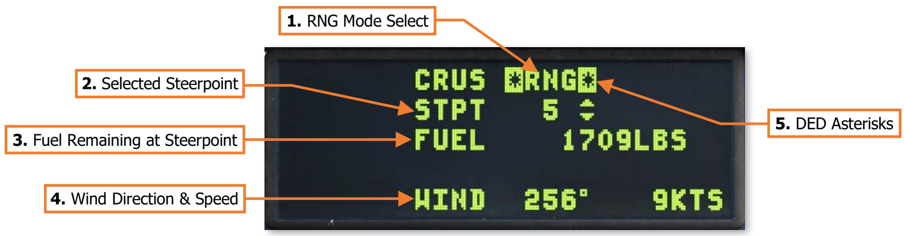
Time-Over-Steerpoint Calculations

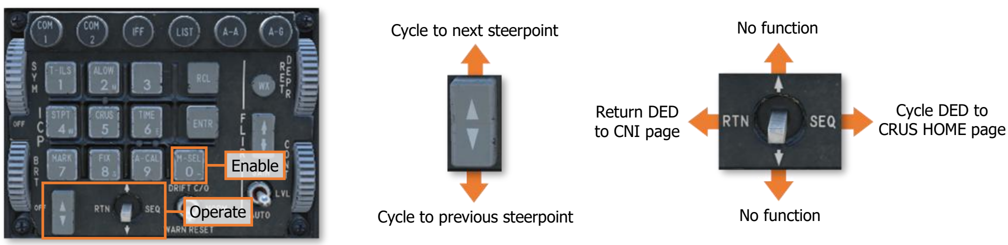
The CRUS TOS functionality may be used to synchronize tactical actions with other forces within the battlespace, such as ensuring that munitions are delivered to a target while other friendly aircraft are suppressing enemy air defenses or providing cover against enemy fighters that may be defending the target area.

CRUS RNG DED Page

The Cruise Range DED page is accessed by pressing the **5/CRUS** button on the ICP keypad when the CNI DED page is displayed, followed by momentarily pressing the DCS switch to the SEQ position as necessary. This page displays an estimate of the remaining fuel onboard when the aircraft arrives at the selected steerpoint.

If any CRUS mode (TOS, RNG, HOME, or EDR) is enabled when the **5/CRUS** button is pressed to access the CRUS DED pages, the DED will default to the corresponding DED page of the enabled CRUS mode.





1. **RNG Mode Select.** Enables/disables CRUS RNG mode by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when CRUS RNG mode is enabled. See the example on the following page for more information.

   Only one CRUS mode may be enabled at any given time. Enabling CRUS RNG mode will disable any other CRUS mode that is already enabled.

2. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

3. **Fuel at Steerpoint.** Displays an estimate of the remaining fuel onboard when the aircraft arrives at the selected steerpoint based on the current ground speed, range to the selected steerpoint, current fuel consumption, and wind data. If the landing gear is down, this data field will remain at the last calculated value.

4. **Wind Direction/Speed.** Displays the current wind direction (in degrees magnetic) and wind speed as calculated by the CADC. If the landing gear is down, this data field will remain at the last calculated value.

5. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

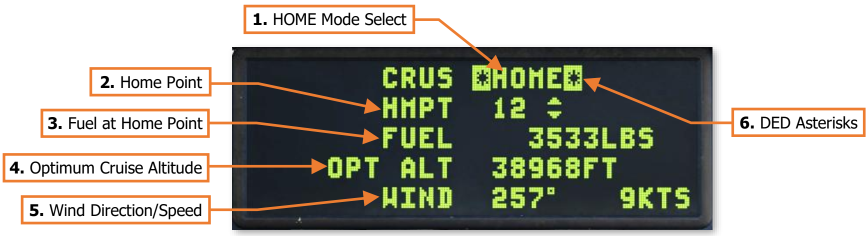
When CRUS RNG mode is enabled, a speed caret is displayed along the HUD Velocity Scale (if shown) that corresponds with the speed that will result in the maximum flight range based on the current altitude and wind data.

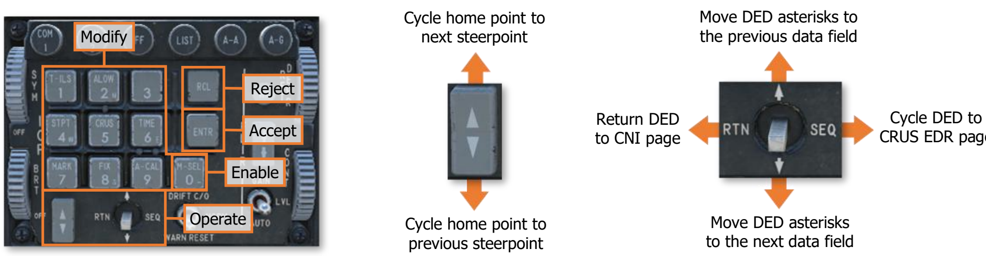
If the landing gear is down, the caret is removed from the HUD.

CRUS HOME DED Page

The Cruise Home DED page is accessed by pressing the **5/CRUS** button on the ICP keypad when the CNI DED page is displayed, followed by momentarily pressing the DCS switch to the SEQ position as necessary. This page displays the estimated remaining fuel onboard when the aircraft arrives at the home steerpoint and the optimum cruising altitude.

If any CRUS mode (TOS, RNG, HOME, or EDR) is enabled when the **5/CRUS** button is pressed to access the CRUS DED pages, the DED will default to the corresponding DED page of the enabled CRUS mode.





1. **HOME Mode Select.** Enables/disables CRUS HOME mode by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when CRUS HOME mode is enabled. See the example on the following page for more information.

   Only one CRUS mode may be enabled at any given time. Enabling CRUS HOME mode will disable any other CRUS mode that is already enabled.

2. **Home Point.** Displays the steerpoint to which flight profile calculations are being performed. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.

3. **Fuel at Home point.** Displays an estimate of the remaining fuel onboard when the aircraft arrives at the steerpoint that is set as the Home point, if flown directly toward the steerpoint at optimum speed and altitude. This value is also displayed on the HUD below the Master Mode, in hundreds of pounds. If the landing gear is down, this data field will remain at the last calculated value.

4. **Optimum Cruise Altitude.** Displays the altitude that will result in the most fuel efficient flight profile based on the current gross weight and corresponding angle-of-attack required to maintain level flight. As fuel is burned and weight decreases, this altitude will also increase due to the increased fuel efficiency for lower angles-of-attack. If the landing gear is down, this data field will remain at the last calculated value.

5. **Wind Direction/Speed.** Displays the current wind direction (in degrees magnetic) and wind speed as calculated by the CADC. If the landing gear is down, this data field will remain at the last calculated value.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

When CRUS HOME mode is enabled, the steerpoint set as the Home point becomes the selected steerpoint, and speed and altitude carets are displayed along the HUD Velocity Scale and Altitude Scales (if shown) that correspond with the speed and altitude profile that will return to the Home steerpoint using the minimum amount of fuel. The profile includes a minimum fuel climb at military power or a descent at idle power to the optimum altitude, a gradual cruise climb in which the altitude increases as fuel is burned, and a final descent at idle power to a point 5,000 feet over the Home steerpoint.

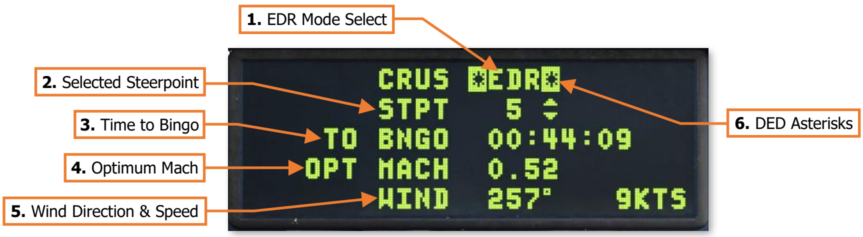
If the landing gear is down, the carets are removed from the HUD.

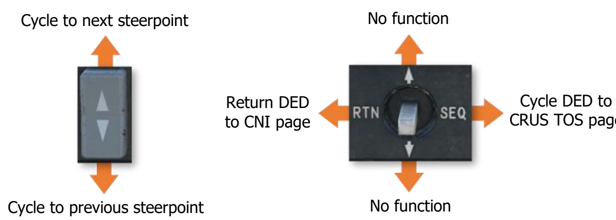
In the example above, the estimated remaining fuel onboard when the aircraft arrives over the Home point, steerpoint 11, is 6124 lbs. (pounds), based on the assumption the pilot adheres to the speed/altitude profile that is displayed in the HUD along the Velocity Scale and Altitude Scale. The fuel displayed in the lower left corner of the HUD is rounded to the nearest hundred pounds of fuel, indicating 06100 lbs.

CRUS EDR DED Page

The Cruise Endurance DED page is accessed by pressing the **5/CRUS** button on the ICP keypad when the CNI DED page is displayed, followed by momentarily pressing the DCS switch to the SEQ position as necessary. This page displays the estimated time until the onboard fuel reaches the Bingo value set on the BNGO DED page and the optimum Mach number to maximize flight endurance.

If any CRUS mode (TOS, RNG, HOME, or EDR) is enabled when the **5/CRUS** button is pressed to access the CRUS DED pages, the DED will default to the corresponding DED page of the enabled CRUS mode.





1. **EDR Mode.** Enables/disables CRUS EDR mode by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when CRUS EDR mode is enabled. See the example on the following page for more information.

   Only one CRUS mode may be enabled at any given time. Enabling CRUS EDR mode will disable any other CRUS mode that is already enabled.

2. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

3. **Time to Bingo.** Displays the estimated time remaining until the onboard fuel reaches the Bingo fuel entered on the BNGO DED page, based on the current rate of fuel consumption. If the landing gear is down, this data field will remain at the last calculated value.

4. **Optimum Mach.** Displays the Mach number that will result in the maximum endurance based on the current altitude. If the landing gear is down, this data field will remain at the last calculated value.

5. **Wind Direction/Speed.** Displays the current magnetic wind direction and speed as calculated by the CADC. If the landing gear is down, this data field will remain at the last calculated value.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

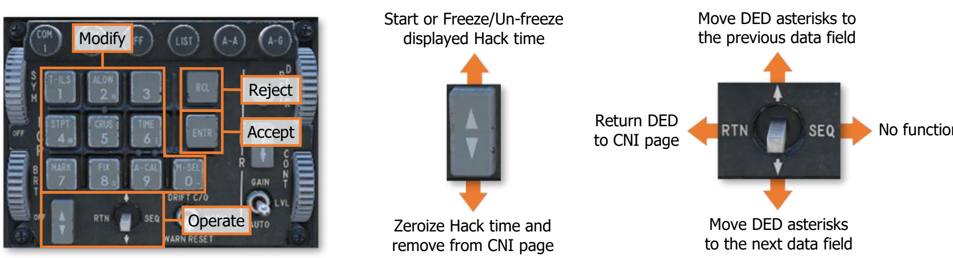
When CRUS EDR mode is enabled, a speed caret is displayed along the HUD Velocity Scale (if shown) that corresponds with the Mach number that will result in the maximum endurance, or flight duration, based on the current altitude.

If the landing gear is down, the caret is removed from the HUD.

In the example above, the onboard fuel quantity will be depleted to the Bingo value in approximately 58 minutes, based on the current rate of fuel consumption. The speed caret indicates that the pilot should reduce the Mach number to 0.57 to minimize the rate of fuel consumption, based on the current altitude, to maximize the remaining flight endurance.

TIME DED Page

The Time DED page is accessed by pressing the **6/TIME** button on the ICP keypad when the CNI page is displayed on the DED. This page displays the aircraft system time and date; and allows the pilot to set an additional time reference and adjust the Time-Over-Steerpoint (TOS) for all steerpoints simultaneously.



1. **System Time.** Displays the internal system time in a 24-hour time format based on Zulu time (UTC). May be modified by placing the DED asterisks over the data field, inputting a time in HHMMSS format using the ICP keypad, and pressing ENTR.

   When GPS data is available, time is automatically entered and "GPS SYSTEM" will be displayed. Time may be entered if necessary and "SYSTEM" will be displayed; but is not required unless GPS data is not available.

2. **Hack Time.** Displays an additional time reference independent of System Time or employed as a stopwatch for low-level navigation or vulnerability periods. May be modified by placing the DED asterisks over the data field, inputting a time in HHMMSS format using the ICP keypad, and pressing ENTR. The ICP Increment/Decrement rocker may be pressed to the INC position to start time progression from zero or freeze/un-freeze the hack time display while the time continues to progress in the background. The ICP Increment/Decrement rocker may be pressed to the DEC position to zeroize the hack time to zero.

3. **Delta Time-Over-Steerpoint.** Updates the Time-Over-Steerpoint (TOS) values across all steerpoints using a single delta value. This may be used if coordinated strikes or tactical actions must be dynamically adjusted in which the entire mission timeline may be moved later or earlier as needed. Applying a positive or negative Delta TOS will automatically increase or decrease, respectively, all valid TOS entries for each steerpoint. Valid Delta TOS entries range from -23:59:59 to 23:59:59 in HHMMSS format. A negative delta, to adjust all TOS entries to an earlier time, is entered by pressing 0/M-SEL to enter a negative symbol, followed by the delta itself (e.g., "-00:05:00" will adjust all TOS entries 5 minutes earlier).

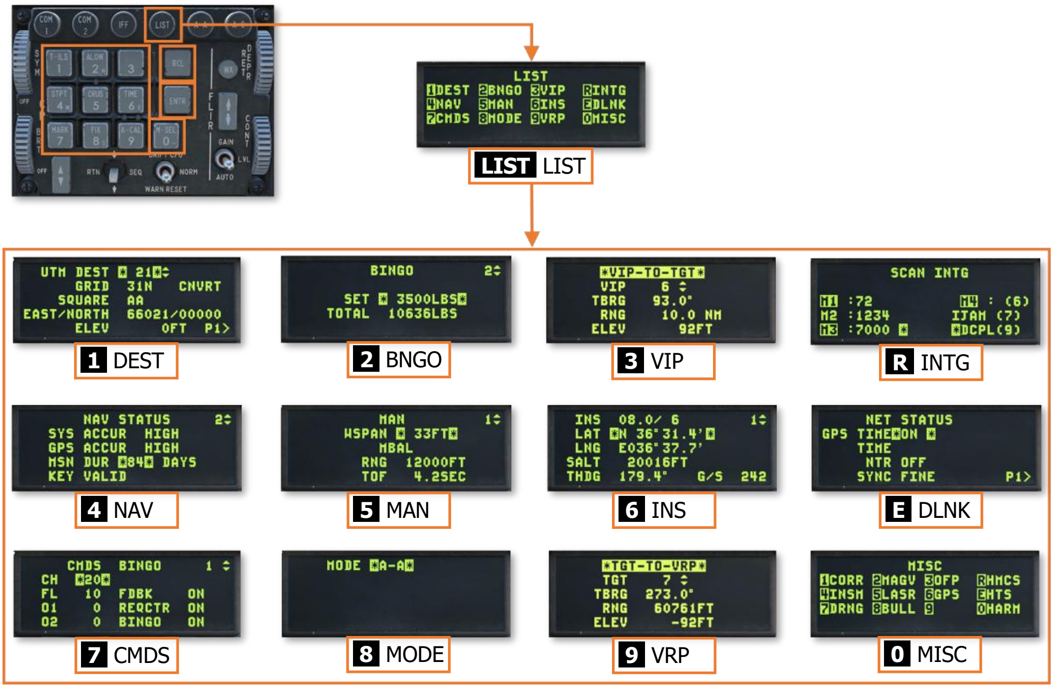
   NOTE: Delta TOS adjustments are cumulative while the TIME DED page is displayed. However, if the DED is set to a different page, the DELTA TOS data field itself will be zeroed even though the TOS adjustments to all steerpoints will remain applied.

4. **System Date.** Displays the internal system date. System date is automatically entered into the avionics system based on GPS data. No manual entering of the date is required.

5. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

LIST DED Pages

The LIST page displays a list of secondary DED pages that may be accessed by pressing the corresponding buttons on the ICP keypad. An additional list of miscellaneous DED pages may be accessed by pressing the 0/M-SEL button on the ICP keypad while the LIST page is displayed.



Data Entry Display – Secondary Functions

The following LIST DED pages are described in the applicable sections.

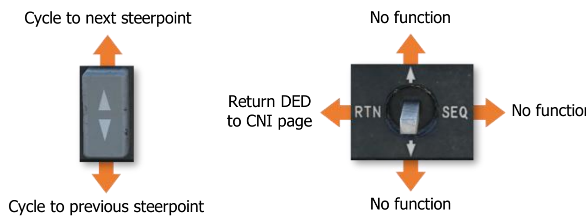
- **DEST** – Editing a Steerpoint
- **VIP –** Visual Reference Point & Visual Initial Point
- **NAV –** Navigation Solutions
- **INS –** INS Alignment
- **DLNK –** TNDL Datalink
- **CMDS –** Defensive Systems
- **VRP –** Visual Reference Point & Visual Initial Point

The following LIST DED pages are not implemented: **INTG**

The remaining LIST DED pages are described on the pages that follow.

BNGO DED Page

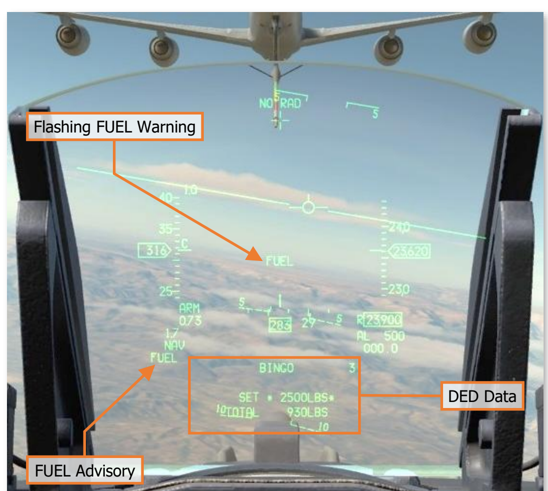
The Bingo DED page is accessed by pressing **2/ALOW** on the ICP keypad when the LIST DED page is displayed. The value set on this page will notify the pilot when the onboard fuel level reaches the corresponding quantity.



1. **Bingo Setting.** Displays the Bingo fuel setting, in pounds. May be modified using the ICP keypad by inputting a fuel value and pressing ENTR.
2. **Total Fuel.** Displays the total onboard fuel, to include external fuel tanks, in pounds.
3. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
4. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

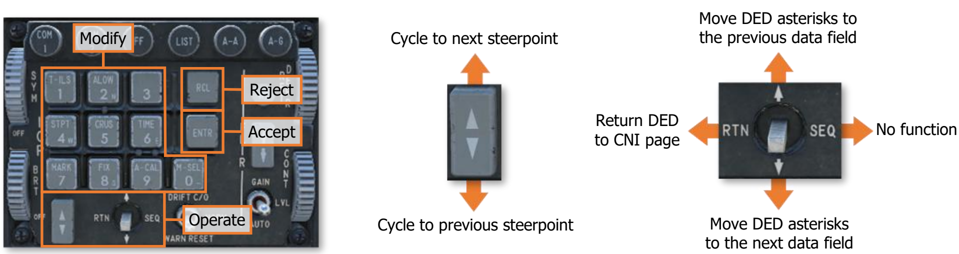
When the onboard fuel quantity decreases below the Bingo setting, a FUEL advisory will be displayed in the lower left corner of the HUD, accompanied by a "Bingo…bingo" voice message. A FUEL warning message will also flash in the center of the HUD, which may be acknowledged by momentarily setting the Drift Cut-Out/Warning Reset switch on the ICP to the WARN RESET position.

NOTE: The FUEL warning and associated voice message are triggered any time the combined fuselage fuel tanks or total fuel quantities fall below the Bingo setting. If the Bingo quantity is set to any amount over ~6070 pounds when the Fuel Quantity Select knob on the FUEL QTY SEL panel is in the NORM position, or if the Bingo quantity is set to any amount over 6667 pounds when the Fuel Quantity Select Knob is in any position other than NORM, the Bingo fuel warning and voice message will be triggered.



MAN DED Page

The Manual DED page is accessed by pressing **5/CRUS** on the ICP keypad when the LIST DED page is displayed. This page is used to adjust the wingspan settings of the EEGS gun solution or ballistics data for air-to-ground weapons that lack an integrated SMS profile within the F-16C avionics.



1. **Wingspan.** Displays the manual target wingspan in use by the EEGS sub-mode. This value adjusts the width of the EEGS Funnel to account for aircraft of different wingspans. When the target wings are perfectly bracketed within the EEGS Funnel, an optimal air-to-air gun solution has been obtained. May be modified using the ICP keypad by placing the DED asterisks over the data field, inputting a wingspan value (in feet), and pressing ENTR.

   This is particularly important when engaging a hostile aircraft when using the Enhanced Envelope Gun Sight (EEGS) in Level II, in which case a passive ranging solution is necessary due to lack of an FCR-derived weapon solution. (See Air-to-Air Gunnery for more information.)

2. **Range.** Displays the horizontal distance a free-fall weapon is expected to travel under specific conditions. (N/I)

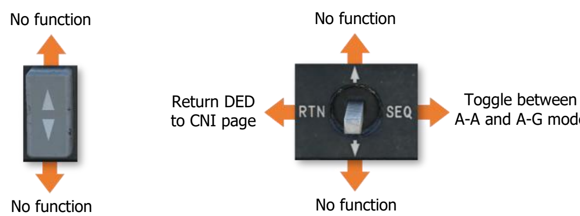
3. **Time-Of-Fall.** Displays the time that is expect to elapse between the time of weapon release and the surface impact under specific conditons. (N/I)

4. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

5. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

MODE DED Page

The Mode DED page is accessed by pressing **8/FIX** on the ICP keypad when the LIST DED page is displayed. This page is used as a backup method to change the master mode between NAV, A-A, or A-G, in case there is a failure of the physical Master Mode buttons on the ICP itself.



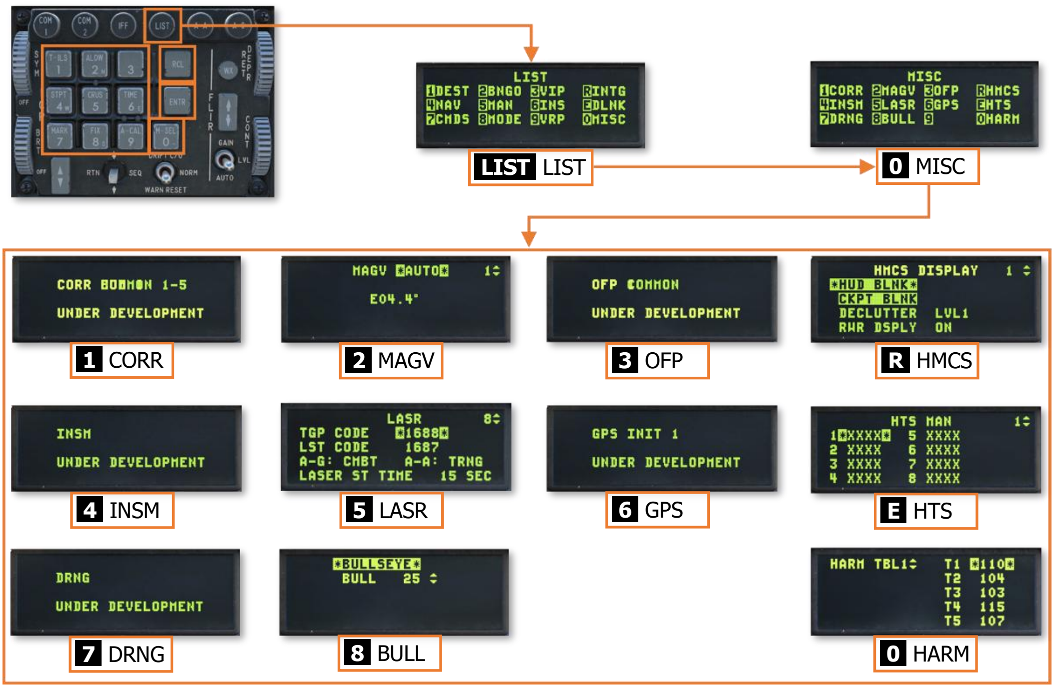
1. **Mode Select.** Displays the master mode ("A-A" or "A-G") that will be entered if the 0/M-SEL button is pressed. Momentarily setting the DCS ("Dobber switch") to the SEQ position or pressing any button on the ICP keypad will toggle the DED page between A-A and A-G modes. If the current master mode matches the mode displayed on the DED Mode page, the text between the DED Asterisks will be highlighted. Pressing the 0/M-SEL button when the DED Mode Select data field is highlighted will set the master mode to NAV.

   NOTE: This page is not functional if the Dogfight switch on the throttle is set to the outboard (Dogfight) or inboard (Missile Override) positions.

2. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

MISC DED Pages

The Miscellaneous DED page extends the LIST page by displaying additional DED pages that may be accessed by pressing the corresponding buttons on the ICP keypad.



Data Entry Display – Miscellaneous Functions

The following MISC DED pages are described in the applicable sections.

- **MAGV –** INS Alignment
- **HMCS –** Joint Helmet-Mounted Cueing System
- **LASR –** AAQ-33 Advanced Targeting Pod
- **HTS –** ASQ-213 HARM Targeting System
- **BULL –** "Bullseye" Reference Point
- **HARM –** AGM-88 HARM

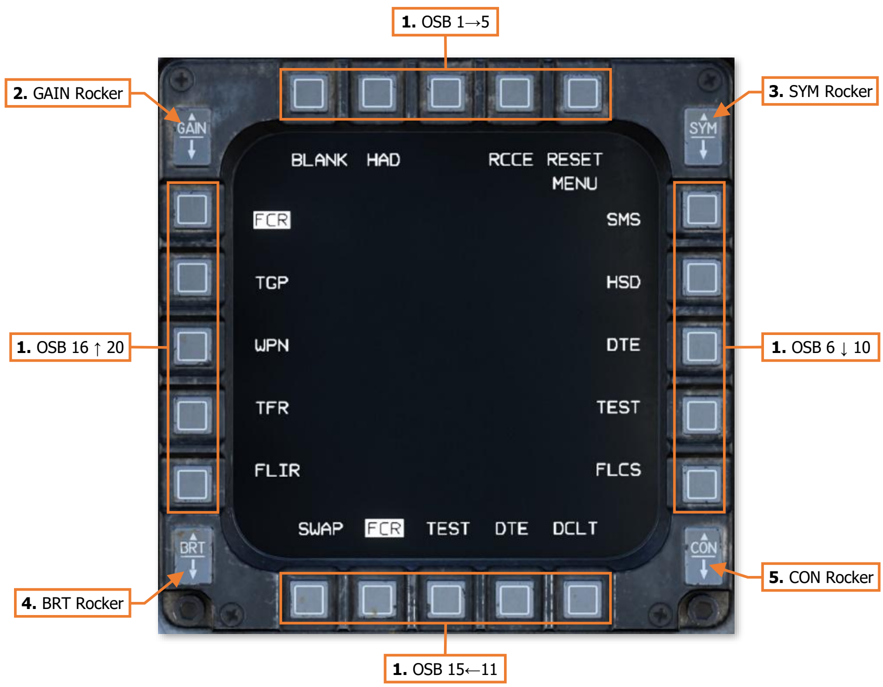
The following MISC DED pages are not implemented: **CORR**, **OFP**, **INSM**, **GPS**, **DRNG**.

MULTI-FUNCTION DISPLAYS (MFD)

Two 4 × 4 inch color liquid crystal Multi-Function Displays (MFD) provide video and text presentations to the pilot for the aircraft's various sensors. The MFDs also serve as the primary interface to the aircraft's external stores, data transfer and loading equipment, and diagnostics for the aircraft systems and flight controls.

Each sensor or aircraft system can be accessed via their respective MFD "format". Some MFD formats will include multiple "pages" that can be selected to access additional options or settings. The options and settings associated with the systems of each format or page are controlled through Option Select Buttons (OSBs) around the display bezel of each MFD. Each OSB interacts with the text displayed next to it to toggle through functions or select a different page. If the OSB text is highlighted, the option is enabled or the associated command is in progress.

Additionally, four rocker buttons are present on each MFD that allows the pilot to adjust the appearance of the video and text on the MFD screen itself.



1. **Option Select Button (OSB).** Selects the option corresponding with the displayed text adjacent to the MFD button itself.
    - **OSB 1-5.** The top row of Option Select Buttons are numbered from 1 starting on the far left to 5 on the far right.
    - **OSB 6-10.** The right column of Option Select Buttons are numbered from 6 starting at the top to 10 at the bottom.
    - **OSB 11-15.** The bottom row of Option Select Buttons are numbered from 11 starting on the far right to 15 on the far left.
    - **OSB 16-20.** The left column of Option Select Buttons are numbered from 16 starting at the bottom to 20 at the top.

2. **GAIN Rocker.** Adjusts the intensity of the MFD sensor video. The video is adjusted independently of the symbology intensity or overall brightness/contrast settings of the MFD itself. If held continuously to either position, the video will continuously increment to the minimum or maximum allowable brightness settings.

   - If the FCR MFD format is displayed and the FCR is set to Ground Map (GM) or Sea (SEA) mode, the GAIN rocker adjusts the intensity of the radar map underlay independently of the MFD symbology.
   - If the FCR MFD format is displayed and the FCR is set to Ground Moving Target (GMT) mode, the GAIN rocker adjusts the gain of the Moving Target Indicators independently of the radar map underlay or the remaining MFD symbology
   - If the TGP MFD format is displayed and the FLIR Gain Control Mode on the TGP Control page is set to Manual Gain Control (MGC) at OSB 18, the GAIN rocker adjusts the thermal gain setting of the targeting pod's FLIR camera.

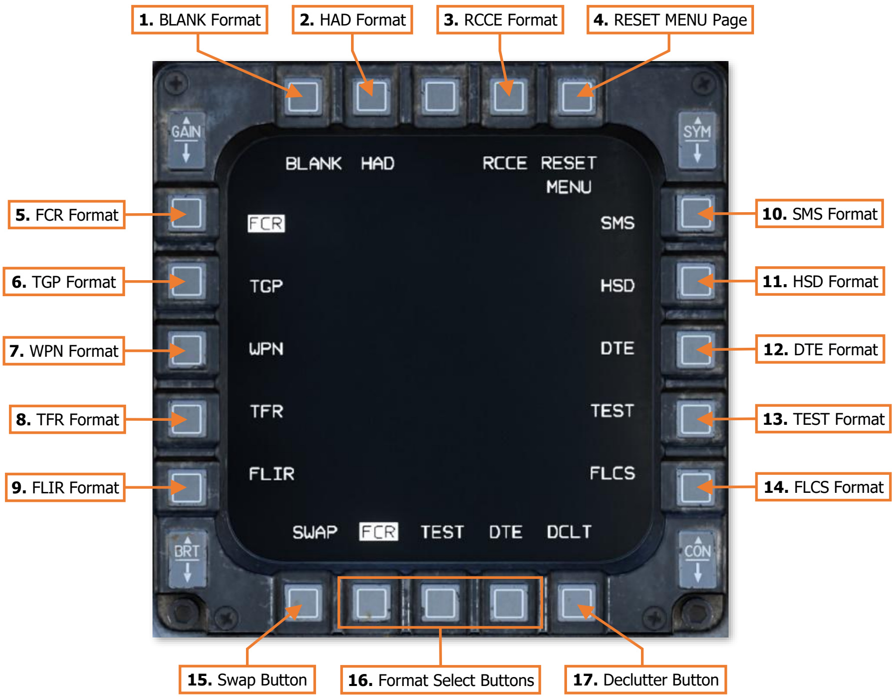
3. **SYM Rocker.** Adjusts the intensity of the MFD symbology independently of the MFD sensor video or overall brightness/contrast settings of the MFD itself. If held continuously to either position, the symbology intensity will continuously increment to the minimum or maximum allowable settings.

4. **BRT Rocker.** Adjusts the overall brightness setting of the MFD display. If held continuously to either position, the brightness setting will continuously increment to the minimum or maximum allowable settings.

5. **CON Rocker.** Adjusts the overall contrast setting of the MFD display. If held continuously to either position, the contrast setting will continuously increment to the minimum or maximum allowable settings.

Format Selection Master Menu Page

The Format Selection Master Menu page is used to assign a specific MFD format to the Format Select buttons (OSB 13, OSB 14, and OSB 15). Additionally, the RESET MENU page is accessed from Master Menu page, which can be used to reset the MFD symbology, brightness and contrast settings to their default values.



1. **BLANK Format.** Assigns the BLANK MFD format to the highlighted Format Select button. When a Format Select button is assigned to the BLANK format, no text will be displayed above the OSB. The format selection corresponding with that OSB will be removed from the MFD format selection cycle when the DMS Left and DMS Right commands are used on the Side Stick Controller (SSC).

2. **HARM Attack Display (HAD) Format.** Assigns the HAD MFD format to the highlighted Format Select button. The HAD format is used to operate the externally-mounted HARM Targeting System pod. The HTS pod is used for detection and geo-location of air defense radar systems. The HTS pod is most commonly used during the Suppression of Enemy Air Defenses (SEAD) mission and can hand-off specific threat radar emitters to AGM-88 HARM anti-radar missiles for engagement or generate target locations for other onboard sensors or weapons. (See ASQ-213 HARM Targeting System for more information.)

3. **RCCE Format.** The Reconnaissance MFD format is not functional in the F-16C variant that is simulated by DCS: F-16C Viper.

4. **RESET MENU Format.** Displays the Reset Menu page. This page includes options to reset the MFD to the default or pre-programmed values for symbology intensity, brightness and contrast. (N/I)

5. **Fire Control Radar (FCR) Format.** Assigns the FCR MFD format to the highlighted Format Select button. The FCR format is used to operate the APG-68 radar system. The APG-68 is used in air-to-air mode for detection, tracking and engagement of hostile aircraft; and in air-to-ground mode for ground mapping, ranging, and detection and targeting of ground vehicles or maritime vessels. (See APG-68 Fire Control Radar for more information.)

6. **Targeting Pod (TGP) Format.** Assigns the TGP MFD format to the highlighted Format Select button. The TGP format is used to operate externally mounted electro-optical sensor pods such as the AAQ-33. Targeting pods are used for medium to high altitude reconnaissance; optical detection and tracking of ground targets; or for designation of ground targets for engagement by precision guided munitions (PGM). (See AAQ-33 Advanced Target Pod for more information.)

7. **Weapon (WPN) Format.** Assigns the WPN MFD format to the highlighted Format Select button. The WPN format is used to relay sensor video and targeting data from munitions such as the AGM-65 TV/IR guided missiles or the AGM-88 HARM anti-radar missile so the pilot can directly control the respective missile's targeting systems prior to weapons release. (See AGM-65 Maverick and AGM-88 HARM for more information.)

8. **TFR Format.** The Terrain Following Radar MFD format is not functional in the F-16C variant that is simulated by DCS: F-16C Viper.

9. **FLIR Format.** The Forward Looking Infrared MFD format is not functional in the F-16C variant that is simulated by DCS: F-16C Viper.

10. **Stores Management System (SMS) Format.** Assigns the SMS MFD format to the highlighted Format Select button. The SMS format is used to select different munitions for employment, select and modify weapon release profiles, set warhead fuzing, and adjust terminal attack parameters. (See the Tactical Employment chapter for more information.)

11. **Horizontal Situation Display (HSD) Format.** Assigns the HSD MFD format to the highlighted Format Select button. The HSD format provides the pilot with a top-down view of the battlespace around the aircraft to include navigational data, airspace and tactical boundaries, air defense threats, and fuses onboard radar data with tactical information derived from allied aircraft (such as other flight members and AWACS). (See the Tactical Employment chapter for more information.)

12. **Data Transfer Equipment (DTE) Format.** Assigns the DTE MFD format to the highlighted Format Select button. The DTE format is used to upload pre-planned mission data and aircraft configuration settings from the cockpit Data Transfer Unit (DTU) into the MMC memory.

13. **Test (TEST) Format.** Assigns the TEST MFD format to the highlighted Format Select button. The TEST format is used to display the Maintenance Fault List (MFL) and perform Built-In Tests (BIT) during system diagnostics and maintenance procedures. (N/I)

14. **Flight Control System (FLCS) Format.** Assigns the FLCS MFD format to the highlighted Format Select button. The FLCS format is used to display data from of Flight Control Computer (FLCC). (N/I)

15. **Swap Button.** Pressing this button will swap the currently displayed MFD formats between the left and right MFDs. In addition, the MFD formats assigned to each Format Select Button will be swapped as well.

16. **Format Select Buttons.** Selects the corresponding MFD format for display on the MFD. When the Format Selection Master Menu page is displayed, selecting the OSB will highlight the text above it and enable a new format to be assigned to that button. If the text displayed above the OSB is already highlighted, pressing the same OSB will leave the Format Selection Master Menu page and display the MFD format that is assigned to that button.

17. **Declutter Button.** Removes the text symbology adjacent to each corresponding OSB on the MFD. However, the associated commands for each OSB will still remain. (N/I)

Re-assigning MFD Formats

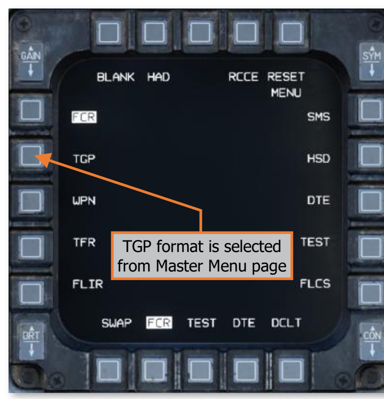
Each of the seven avionics master modes (Navigation, Air-to-Air, Air-to-Ground, Missile Override, Dogfight, Selective Jettison, and Emergency Jettison) are initialized with pre-configured MFD formats assigned to each Format Select button of each MFD. These MFD format assignments can be re-configured by the pilot at any time via the Format Selection Master Menu page.

To assign a different format to a Format Select button (OSB 12, OSB 13 or OSB 14) on either MFD, set the avionics to the master mode that is meant to be edited, and perform the following:

1. If the MFD text above the Format Select OSB that is intended to be re-assigned to a different MFD format is already highlighted, press that same OSB to open the Format Selection Master Menu page.

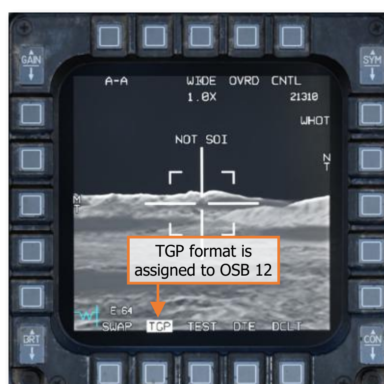
If the MFD text above the Format Select OSB that is intended to be re-assigned to a different MFD format is not highlighted, press that same OSB to highlight the corresponding text above it, and then press that same OSB a second time to open the Format Selection Master Menu page.

If the Format Select OSB that is intended to be re-assigned to a different MFD format is assigned the BLANK format with no corresponding text above it, press that same OSB to highlight the empty field above it, and then press that same OSB a second time to open the Format Selection Master Menu page.



2. Press the OSB next to the corresponding MFD format in the menu to assign that format to the currently selected Format Select OSB. The MFD will exit the Master Menu page and display the assigned format for that Format Select button.

The MFD format that is already assigned to the currently selected Format Select OSB will be highlighted among the available formats displayed on the Master Menu page. If the pilot does not wish to change the MFD format of the currently selected Format Select OSB, selecting the format that is already assigned to that Format Select button or selecting any of the Format Select buttons themselves along the bottom of the MFD will exit the Master Menu page without applying any change.



NOTE: In any given master mode, an MFD format can only be assigned to one Format Select button on either MFD at a time. The exception to this limitation is the BLANK format, which can be assigned to multiple Format Select buttons. It is possible that all six Format select buttons on the MFDs could be assigned to the BLANK format for a given master mode, despite the impracticality of it.

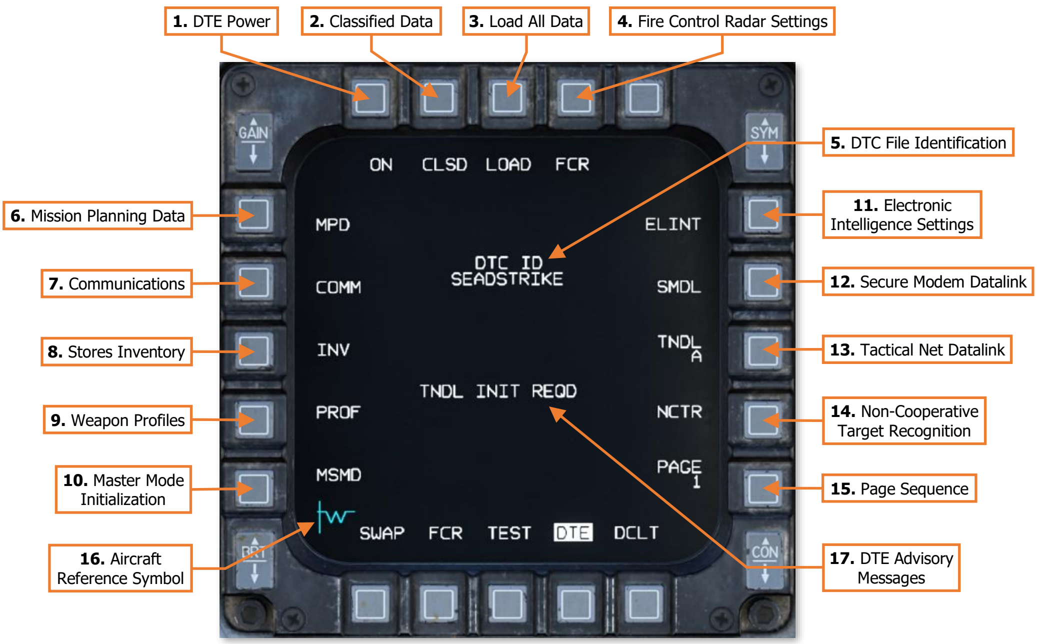
If an MFD format is assigned from the Master Menu page that is already assigned to another Format Select button on either MFD, that format will be removed from the other Format Select button and assigned to the currently highlighted OSB, and the BLANK format will be assigned to the former.

DATA TRANSFER EQUIPMENT (DTE)

The avionics of the F-16C features numerous options that may be customized for a given mission and a large volume of data can be stored within the Modular Mission Computer (MMC) such as routes, targets, locations of enemy air defenses, weapon settings, and chaff/flare programs. Although many of avionics settings and mission data can be manually configured or input within the cockpit itself, a Data Transfer Unit (DTU) is mounted in the right console to facilitate a rapid upload of data into the MMC from a removeable Data Transfer Cartridge (DTC).

Data Transfer Equipment (DTE) MFD Format

The DTE MFD format provides the pilot with an interface to DTU, allowing individual file partitions or the entire DTC data file to be uploaded into the MMC.



1. **DTE Power Status.** Displays the powered state of the DTE.
2. **Classified Data (CLSD).** Not implemented.
3. **Load All Data (LOAD).** Sequentially uploads all partitions of the data file loaded in the DTC.
4. **Fire Control Radar Settings (FCR).** Uploads the default FCR configuration and FCR CNTL page settings.
5. **DTC File Identification.** Displays the name of the data file loaded on the DTC currently inserted into the cockpit DTU receptacle.
6. **Mission Planning Data (MPD).** Uploads steerpoint data, navigation route data, VIP/VRP settings, ATDT ROE settings, CMDS programs, and other miscellaneous settings such as TACAN, ILS, BINGO, etc.

   NOTE: The CMDS MODE knob must be set to the STBY position on the CMDS control panel prior to uploading the MPD file partition to prevent erroneous data entry into the CMDS settings.

7. **Communications (COMM).** Uploads the preset frequencies for the ARC-164 UHF AM radio and the ARC-222 VHF AM/FM radio.

8. **Stores Inventory (INV).** Uploads the external stores configuration into the Stores Management System (SMS).

9. **Weapon Profiles (PROF).** Uploads the default weapon delivery settings into the SMS.

10. **Master Mode Initialization (MSMD).** Uploads the default MFD formats, FCR modes, TGP modes, HSD CNTL page, and HAD CNTL page settings for each MMC master mode.

11. **Electronic Intelligence Settings (ELINT).** Uploads ALR-56 RWR threat tables, AGM-88 HARM threat tables, ASQ-213 HARM Targeting System threat classes.

12. **Secure Modem Datalink (SMDL).** Not implemented.

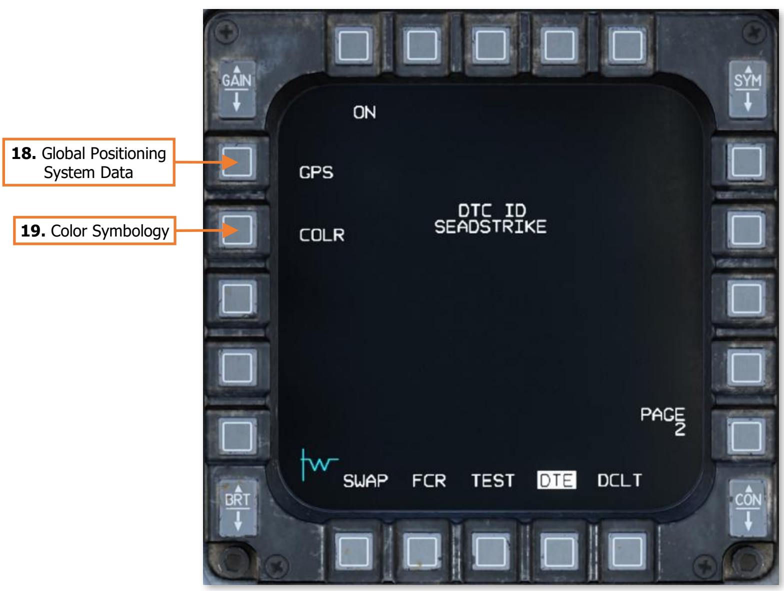
13. **Tactical Net Datalink (TNDL).** Uploads the TNDL network configuration, ownship settings, and Flight/Team member and Donor STN data.

14. **Non-Cooperative Target Recognition (NCTR).** Not implemented.

15. **Page Sequence.** Cycles the MFD between Page 1 and Page 2 of the DTE MFD format.

16. **Aircraft Reference Symbol.** Displays the relative alignment of the aircraft heading with the selected steerpoint, System Point-of-Interest (SPI), or weapon release solution. If the line is to the left or right of the watermark, the pilot must turn left or right respectively toward the vertical line to align the aircraft on course toward the selected steerpoint, SPI, or weapon release solution.

17. **DTE Status Messages.** Displays advisories regarding the DTE components or data upload errors.



18. **Global Position System Data (GPS).** Uploads GPS receiver data.

19. **Color Symbology (COLR).** Uploads color settings for MFD symbology, text, and OSB labels.

AUTOPILOT

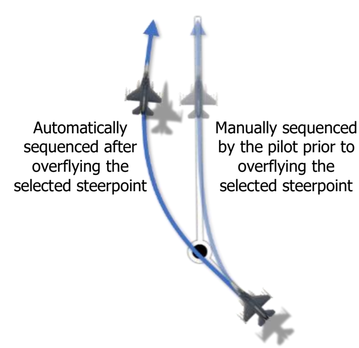
The F-16's autopilot provides a "hands-off" flight control capability for reduced pilot workload. When the autopilot is engaged, the Flight Control Computer (FLCC) electronically commands movement to the flight control servo-actuators in accordance with the enabled autopilot modes based on data received from the Inertial Navigation System (INS) and the Central Air Data Computer (CADC).

Depending on the configuration of the autopilot controls (described on the following pages), the autopilot may be configured to perform the following tasks.

- Maintain a heading, as set by the pilot.
- Maintain a direct course to the selected steerpoint, as set by the pilot or the navigation route.
- Maintain the current aircraft altitude.
- Maintain the current aircraft attitude.

It is important to note that the autopilot is only intended to reduce pilot workload, allowing the pilot to focus on other cockpit tasks such as reviewing kneeboard information, tuning radios, or interacting with aircraft sensors. The autopilot is not capable of navigating a flight plan, which includes speed and altitude changes, nor is it capable of precisely flying along a navigation route. The pilot must continue to monitor and adjust the autopilot settings as necessary.

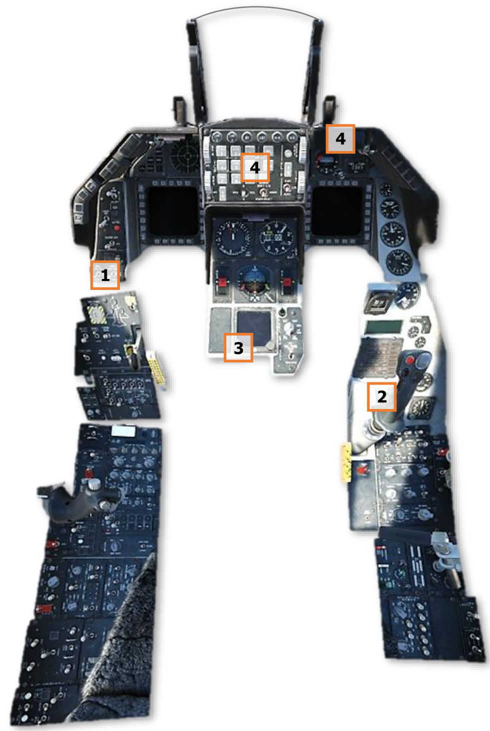
As an example, if steerpoint sequencing has been set to AUTO on the STPT DED page, the next steerpoint in the route is selected when the aircraft is within 2 nautical miles of the selected steerpoint and the range to the selected steerpoint is increasing. If the autopilot is configured to maintain a direct course to the selected steerpoint, the autopilot will turn toward the next steerpoint after the selected steerpoint has been overflown. Alternatively, the pilot may manually sequence to the next steerpoint to initiate the turn in advance of the selected steerpoint so that the aircraft rolls out of the turn along the navigation route itself.



Autopilot steering with AUTO steerpoint sequencing

Autopilot Controls

The autopilot is enabled and configured by the autopilot switches, along with additional controls within the cockpit, depending on the selected modes of operation.



1. **Autopilot Switches.** The PITCH and ROLL switches located along the bottom of the MISC panel engage the autopilot and allow the pilot to select the desired autopilot modes.

   (See Autopilot Settings for more information.)

2. **Paddle Switch.** The Paddle switch on the base of the Side Stick Controller (SSC) is used to momentarily disengage the autopilot for the duration that the switch is depressed and held. When released, the autopilot will attempt to capture new reference values of pitch, roll, and/or altitude, depending on the autopilot modes that have been selected using the PITCH and ROLL switches on the MISC panel.

   (See Hands-On Controls for more information.)

3. **EHSI Heading Set Knob.** When the autopilot is engaged and the ROLL switch is set to the HDG SEL position, the Heading Set knob on the EHSI is used to select the heading reference to which the autopilot will turn toward and maintain.

   (See Electronic Horizontal Situation Indicator for more information.)

4. **Steerpoint Navigation.** When the autopilot is engaged and the ROLL switch is set to the STRG SEL position, the Upfront Controls may be used to select the steerpoint used for navigation.

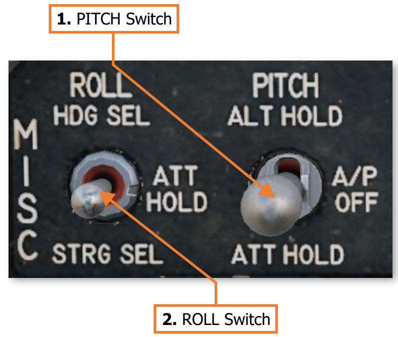
   (See Selecting a Steerpoint for more information.)

The autopilot modes selected by the corresponding PITCH and ROLL switch positions are described below.

		PITCH		
		ALT HOLD	**A/P OFF**	**ATT HOLD**
ROLL	**HDG SEL**	**Autopilot enabled** • Maintains level altitude • Maintains heading set by Heading Set knob on EHSI	**Autopilot disabled**	**Autopilot enabled** • Maintains pitch attitude • Maintains heading set by Heading Set knob on EHSI
	ATT HOLD	**Autopilot enabled** • Maintains level altitude • Maintains roll attitude	**Autopilot disabled**	**Autopilot enabled** • Maintains pitch attitude • Maintains roll attitude
	STRG SEL	**Autopilot enabled** • Maintains level altitude • Maintains course to the selected steerpoint	**Autopilot disabled**	**Autopilot enabled** • Maintains pitch attitude • Maintains course to the selected steerpoint

Autopilot Settings

The PITCH and ROLL switches located along the bottom of the MISC panel engage the autopilot and allow the pilot to select the desired autopilot modes.



1. **PITCH Switch.** Enables/disables the autopilot and selects the autopilot mode of operation in the pitch axis.
    - **ALT HOLD.** Enables the autopilot and selects Altitude Hold mode. The autopilot will hold the current barometric altitude.
    - **A/P OFF.** Disables the autopilot.
    - **ATT HOLD.** Enables the autopilot and selects Attitude Hold mode. The autopilot will hold the current pitch attitude.
2. **ROLL Switch.** Selects the autopilot's mode of operation within the roll axis.
    - **HDG SEL.** If the PITCH switch is set to the ALT HOLD or ATT HOLD positions, the autopilot will turn toward and maintain the heading reference selected by the Heading Set knob on the Electronic Horizontal Situation Indicator (EHSI).
    - **ATT HOLD.** If the PITCH switch is set to the ALT HOLD or ATT HOLD positions, the autopilot will hold the current roll attitude.
    - **STRG SEL.** If the PITCH switch is set to the ALT HOLD or ATT HOLD positions, the autopilot will turn toward and maintain a direct course to the selected steerpoint.

Autopilot Engagement

If the autopilot is enabled by setting the PITCH switch to the ALT HOLD or ATT HOLD positions, and the Paddle switch on the SSC is not depressed, the autopilot will engage the modes of operation as selected by the PITCH and ROLL switches. When engaged, the autopilot will be limited to pitch command rates of +3.0 to -1.0 G, roll rates of 20° per second, and bank angles of ±30°.

When set to the ALT HOLD or ATT HOLD positions, the PITCH switch is held in place by an electrical solenoid. If any criteria is met that results in an automatic disengagement of the autopilot, the solenoid holding the PITCH switch in place will release and the switch will spring back to the A/P OFF position.

PITCH switch set to ALT HOLD or ATT HOLD

Paddle switch not pressed

Pitch rate +3.0 to -1.0 G

Roll rate ≤ 20° per second

Bank angle ±30°

Autopilot Command Authority

Depressing the Paddle switch on the SSC will only momentarily disengage the autopilot for the duration that the switch is depressed and held; the PITCH switch will remain in ALT HOLD or ATT HOLD. This allows the pilot to assign new reference values of pitch, roll, and/or altitude when the Paddle switch is released.

Autopilot Disengagement

If any of the following criteria is met, the autopilot will automatically disengage, the solenoid holding the PITCH switch in place will release, and the switch will spring back to the A/P OFF position.

- Angle-of-Attack exceeds 15°.
- Bank angle exceeds 60°.
- Low speed audio warning is triggered.
- Landing gear is extended and locked.
- The autopilot has failed or malfunctioned.
- The FLCS is operating on Digital Backup software.
- ALT FLAPS switch is set to EXTEND position below 400 knots.
- TRIM/AP DISC switch is set to DISC position.
- AIR REFUEL switch is set to OPEN position.
- MANUAL PITCH switch is set to OVRD position.

Autopilot Disengagement Conditions

PROCEDURES

USAF Photo
by SrA Julianne Showalter

AIRCRAFT START

The F-16 is designed to be started without ground support equipment and can be airborne within minutes. Although it can be operated off external power sources during extended ground operations or maintenance procedures, it is not necessary.

After performing a walkaround, the pilot climbs into the cockpit, secures seat restraints, oxygen supply hoses, and communications leads. Initial electrical system checks are conducted and the pilot initiates a start of the Jet Fuel Starter (JFS). The JFS is a small gas turbine engine that is used to spool the main engine to sufficient speed prior to introducing fuel into the main engine combustion section. Once the engine RPM has accelerated to 20% and the SEC light on the Caution Light panel extinguishes, the pilot advances the throttle from OFF to IDLE to introduce fuel.

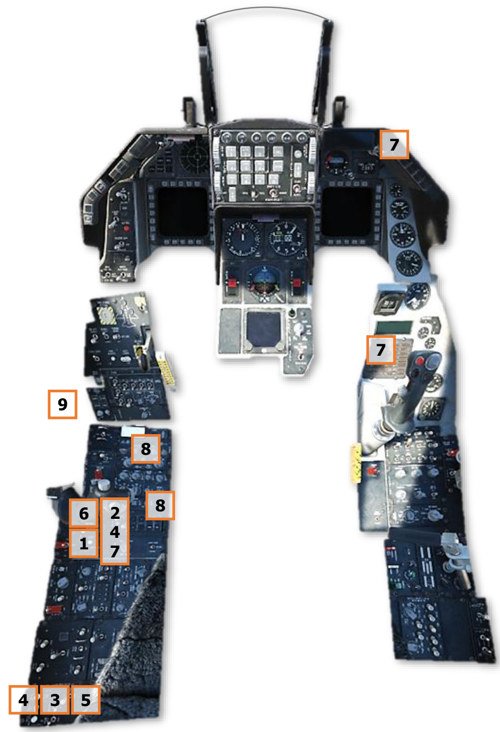
Once the engine stabilizes at idle speed and is providing primary electrical power via the main generator, the pilot initializes the aircraft systems, performs an alignment of the inertial navigation system, and performs remaining pre-flight checks.

If desired, the DCS: F-16C Viper may be started using an auto-start sequence by pressing **[LWin]+[Home]**. To cease the auto-start sequence, press **[LWin]+[End]**.

NOTE: When the auto-start sequence is complete, the following systems will be configured as shown.

- INS Knob – ALIGN NORM
  - Must be set to NAV prior to initiating taxi.
- IFF MASTER Knob – STBY.
- ALR-56M Radar Warning Receiver (RWR) – Powered Off.
- CMDS MODE Knob – OFF.
- ECM PWR Switch – OFF.
  - Requires a 3-minute warm-up prior to operation.

Before Engine Start



1. MAIN PWR switch – BATT.

NOTE: The amount of power available from the battery is limited so do not leave the MAIN PWR switch in BATT or MAIN PWR for more than 5 minutes without starting the engine or applying external power if more time is needed.

2. Verify light on ELEC Control Panel:

- ACFT BATT **FLCS RLY** – On.

3. FLCS PWR TEST switch – TEST and hold.

4. Verify lights on ELEC Control Panel:

- **FLCS PMG** – On.
- ACFT BATT **TO FLCS** – On.
- ACFT BATT FLCS RLY – Off.

Verify lights on TEST Panel:

- FLCS PWR **A**, **B**, **C**, and **D** – On.

5. FLCS PWR TEST switch – Release.

6. MAIN PWR switch – MAIN PWR.

7. Verify warning lights on Right Eyebrow:

- **ENGINE** – On.
- **HYD/OIL PRESS** – On.

Verify lights on Caution Light Panel:

- **ELEC SYS** – On.
- SEC – On.

Verify lights on ELEC Control Panel:

- ACFT BATT **FLCS RLY** – On.
- EPU GEN and EPU PMG – Off.

NOTE: Illumination of either light indicates criteria for EPU activation is met. The EPU will activate and create a hazardous condition if the EPU safety pin is removed by the ground crew. If either of these lights are illuminated, turn MAIN PWR switch to OFF and abort the aircraft (re-start the mission).

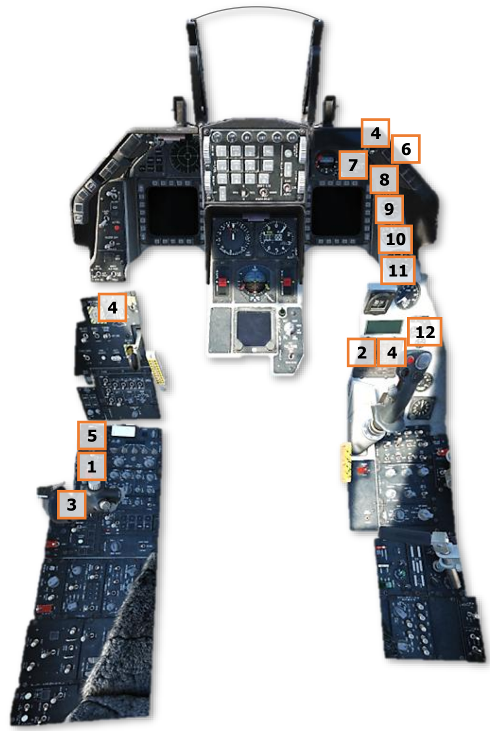
8. Communications – Established with ground crew and Air Traffic Control (ATC) as required for engine start.

9. Canopy – As desired.

10. Chocks – In place.

11. Ground crew – Clear of intake and other danger areas.

Engine Start



1. JFS switch – START 2. The JET FUEL – RUN light illuminates within 30 seconds indicating the Jet Fuel Starter is operational. Engine RPM should start to increase.

   Power is applied to the Flight Control System relays when the JFS switch is set to either the START 1 or START 2 position. The ACFT BATT FLCS RLY light should extinguish and the ACFT BATT **TO FLCS** light should illuminate.

2. SEC caution light – Off.

3. Throttle – Advance to IDLE at 20% RPM minimum. Engine combustion should occur within a few seconds and engine RPM and FTIT should increase.

   NOTE: When starting on battery power only (no external power applied), only the RPM and FTIT engine instruments will function until the standby generator is online.

4. ENGINE warning light – Off (approximately 60% RPM, when the standby generator becomes operational).

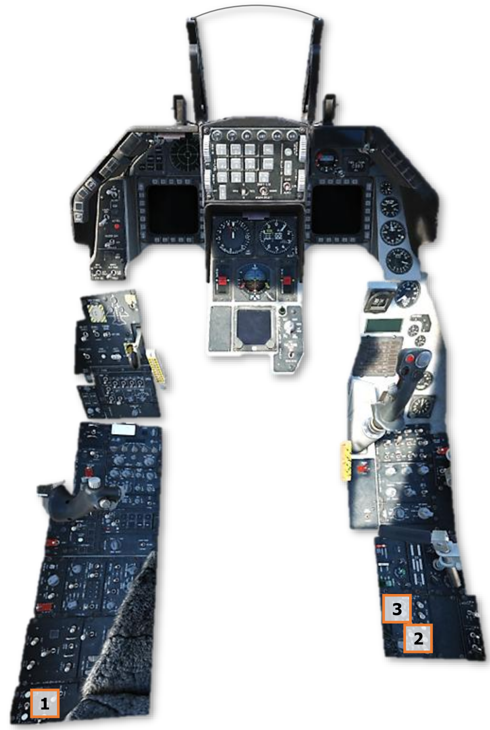
5. Verify the following to confirm the emergency busses are being powered by the standby generator.
   - **SEAT NOT ARMED** caution light – On.
   - Three green WHEELS down lights – On.

   Within 5-10 seconds, the main generator will come online, and the standby generator will go offline.

Once engine RPM is at idle speed, perform the following checks.

6. JFS switch – Confirm OFF; manually set to OFF if necessary.
7. HYD/OIL PRESS warning light – Off.
8. FUEL FLOW – 700-1700 PPH.
9. Engine OIL pressure – 15 PSI or greater.
10. Engine NOZ POS – above 94%.
11. Engine RPM – 62%-80%.
12. Engine FTIT – 650° C or less.
13. HYD PRESS A & B – 2850-3250 PSI.

After Engine Start



1. TEST switch panel – Check:

- PROBE HEAT switch – PROBE HEAT. Ensure PROBE HEAT caution light is extinguished.

  If the light is illuminated, one or more probe heaters are inoperative or a failure of the monitoring system has occurred.

- PROBE HEAT switch – TEST. **PROBE HEAT** caution light should flash 3-5 times per second.

  If this does not occur, the probe heat monitoring system is inoperative

- PROBE HEAT switch – OFF.

- FIRE & OHEAT DETECT button – Press. Ensure **ENGINE FIRE** warning light illuminates when the button is pressed.

  This checks for continuity of the fire and overheat detection loops.

- MAL & IND LTS button – Press. Ensure all cockpit warning, caution and indicator lights illuminate when the button is pressed.

  A brief LG warning horn should be heard followed by Voice Message System (VMS) audio alerts, played in priority sequence ("Pull up", "Altitude", "Warning", etc.).

2. AVIONICS POWER panel – Set:

- MMC switch – MMC.
- ST STA switch – ST STA.
- MFD switch – MFD.
- UFC switch – UFC.
- GPS switch – GPS.
  - The GPS receiver must have an unobstructed line-of-sight to the sky to obtain data from multiple GPS satellites. If the aircraft is parked inside a hanger or hardened aircraft shelter, GPS timing signals and position data may not be obtained until after taxiing clear of the structure.

3. INS – Align. (See INS Alignment for more information.)

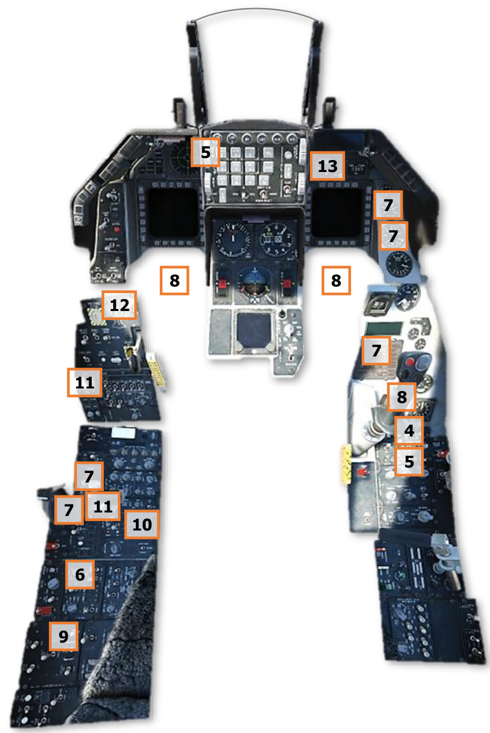
- DL switch – DL. (N/I)
- MIDS LVT knob – ON
  - The MIDS LVT knob should only be set to ON after the GPS receiver has been powered and the GPS timing signal has been received, indicated by "GPS SYSTEM" being displayed on the TIME DED page.

4. SNSR PWR panel:

- LEFT HDPT switch – As required. (If an HTS pod is installed, enable power to the hardpoint).
- RIGHT HDPT switch – As required. (If a targeting pod is installed, enable power to the hardpoint)
- FCR switch – FCR.
- RDR ALT switch – RDR ALT.

5. HUD – As desired. Ensure the SYM knob on the ICP is rotated up to increase HUD brightness as necessary.

(See HUD Control Panel for more information.)



6. C & I knob – UFC.

7. Secondary (SEC) engine control mode – Check. (May be performed during Before Takeoff check.)

- ENG CONT switch – SEC.
  - SEC caution light – On.
  - Engine RPM – Stabilized. RPM may drop up to 10% from PRI value before stabilizing. Stabilized SEC idle RPM may be up to 5% lower than that in PRI.
  - Throttle – Snap to MIL, and then snap to IDLE when RPM reaches 85%. Check for normal indications and smooth operation.
  - NOZ POS – 10% or less within 30 seconds after selecting SEC.
- ENG CONT switch – PRI.
  - SEC caution light – Off.
  - NOZ POS – Greater than 94%.

8. Flight controls – Cycle to ensure maximum deflection of flight control surfaces prior to the FLCS BIT.

9. FLCS BIT – Initiate and monitor.

- BIT switch – BIT. FLCS RUN light will illuminate for approximately 45 seconds until FLCS BIT completes.
- BIT switch will automatically return to OFF when FLCS BIT completes. Ensure FLCS FAIL light is not illuminated when complete.

10. ECM panel – As required. (If an ECM pod is installed, set ECM power switch to STBY)

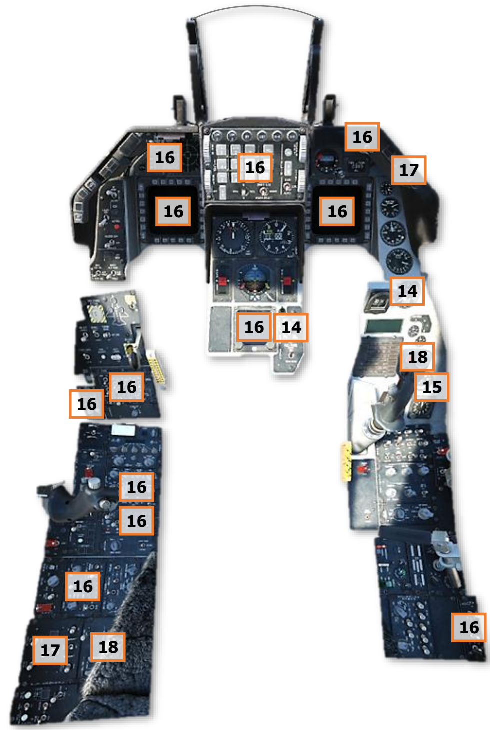
11. SPD BRK switch – Cycle to extended position and then retract.

12. WHEELS down lights – Three green.

13. Standby Attitude Indicator – Uncage and set.

14. FUEL QTY SEL knob – Check.

- TEST – FR and AL pointers should indicate 2,000 (±100) pounds and the totalizer should indicate 6,000 (±100) pounds. Verify the **FWD FUEL LOW** and **AFT FUEL LOW** caution lights illuminate on the Caution Light Panel.
- NORM – AL pointer should indicate approximately 2,810 pounds and FR pointer should indicate approximately 3,250 pounds (if fully-fueled with JP-8).
- RSVR – Each reservoir should indicate approximately 480 pounds.
- INT WING – Each wing should indicate approximately 550 pounds.
- EXT WING – Each external wing tank should indicate approximately 2,420 pounds, if full.
- EXT CTR – FR pointer should indicate approximately 1,890 pounds, if full. AL pointer should indicate 0.
- FUEL QTY SEL knob – As desired.



15. EPU FUEL quantity – 95-102%.

16. Avionics, MFD's, and radios – Configure as required via DTE MFD format or manually.

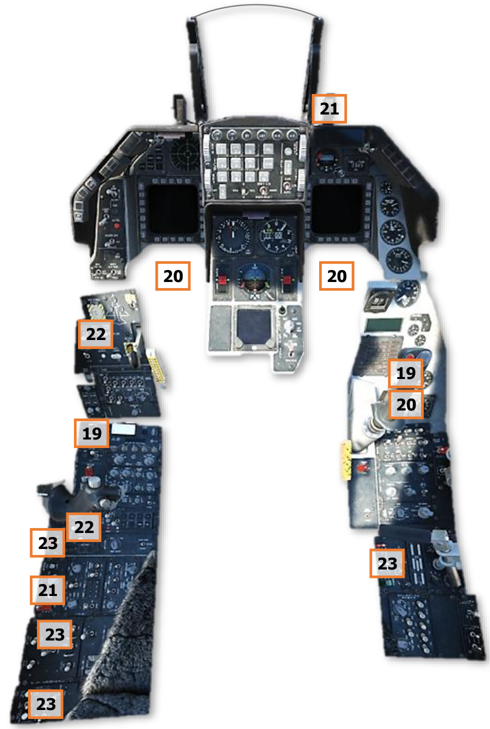
After the FLCS BIT is complete:

17. DBU – Check.

- DIGITAL BACKUP switch – BACKUP. Verify **DBU ON** warning light illuminates
- Operate flight controls – Ensure all flight control surfaces respond normally.
- DIGITAL BACKUP switch – OFF. Verify DBU ON warning light extinguishes.

18. TRIM – Check.

- TRIM/AP DISC switch - DISC.
- Side Stick Controller TRIM switch - Activate in roll and pitch. Verify no movement of flight control surfaces and no TRIM wheel/indication motion on the FLT CONTROL Panel.
- TRIM/AP DISC switch - NORM.
- Side Stick Controller TRIM switch - Check and center. Verify movement of flight control surfaces and TRIM wheel/indication motion on the FLT CONTROL Panel.
- Rudder trim check - YAW TRIM knob check and center.



19. MPO – Check.

- Side Stick Controller – Full forward and hold; note horizontal tail deflection.
- MPO switch – OVRD and hold. Confirm that horizontal tail trailing edges deflect further downward.
- Stick and MPO switch – Release. Confirm that the horizontal tail returns to its original position.

20. Operate controls – Verify all surfaces respond normally and no FLCS lights illuminate.

21. Air refueling system (if required) – Check.

- AIR REFUEL switch – OPEN. Verify **RDY** light illuminates and the DISC light remains off.
- AIR REFUEL switch – CLOSE. Verify RDY light extinguishes.

22. EPU GEN and EPU PMG lights – Confirm off. If either light is illuminated, cycle the EPU switch to OFF, then back to NORM. If either of these lights remain illuminated, abort the aircraft (re-start the mission).

23. EPU – Check. This check verifies EPU electrical power is available in case of an emergency. (May be performed during Before Takeoff check.)

- OXYGEN Diluter Lever – 100%.
- Throttle – Increase engine RPM 10% above normal idle.
- EPU/GEN TEST switch – EPU/GEN and hold.
- Verify lights on EPU Control Panel:
  - **AIR** – On.
  - EPU Run light – On, for a minimum of 5 seconds.
- Verify lights on ELEC Control Panel:
  - EPU GEN – Off; but may come on momentarily at start of test.
  - EPU PMG – Off; but may come on momentarily at start of test.
- Verify lights on TEST Panel:
  - FLCS PWR **A**, **B**, **C**, and **D** – On.
- EPU/GEN TEST switch – OFF.
- Throttle – IDLE.
- OXYGEN Diluter Lever – NORMAL.

TAXI

Once the engine is operating and the INS has been aligned, the aircraft may be taxied to the runway. Although it is typical to initialize the remaining avionics systems and perform other pre-flight checks prior to taxi, it may not be possible in a scenario in which the aircraft must be scrambled into the air without delay.

However, even if an immediate takeoff is required, some systems may be initialized or some checks may be performed during the taxi itself, depending on the distance between the aircraft's parking location and the active runway. In such an instance, the priority should be given to those systems that ensure the aircraft is ready to fight as soon as it is airborne.

When ready to taxi, ensure nosewheel steering is engaged by pressing the Missile Step button on the Side Stick Controller (SSC), which may be confirmed by the illumination of the "AR NWS" AR Status light on top of the Instrument Panel to the right of the HUD.

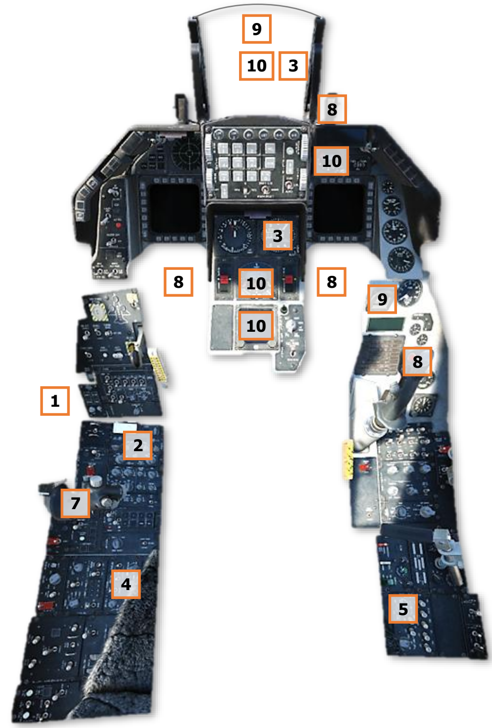
Nosewheel steering gain is proportional to ground speed. As speeds increases, the nosewheel steering will become less sensitive for a given pedal input. However, due to the F-16's narrow landing gear "footprint", care should be taken when turning on the ground to prevent a roll-over and impacting either wingtip (or underwing stores), damaging the aircraft. If high-speed taxi is necessary, the aircraft should be gently braked to a lower speed before turning.

Only small throttle inputs are necessary to begin a taxi roll, and even at IDLE the aircraft may start to roll forward when operating at low gross weights. Once the desired taxi speed has been reached, retard the throttle back to IDLE to prevent gradual and excessive acceleration.

NOTE: When starting a mission from parking with the aircraft engine running and systems initialized, the following systems will be configured as shown.

- Nosewheel Steering (NWS) – Disengaged.
- ALR-56M Radar Warning Receiver (RWR) – Powered Off.
- CMDS MODE Knob – STBY.
- HMCS Symbology Knob – OFF.

Before Taxi



1. Canopy – Close and lock.

2. Backup UHF radio – Set and check as required.

3. Altimeter and altitude indications – Set and check. Verify altitude displayed on the HUD matches the altitude on the altimeter.

- Check that the altimeter readings in ELEC and PNEU are ±75 feet of a known elevation and are ±75 feet of one another.

4. Exterior lights – As required.

5. INS knob – NAV. If a complete alignment is desired prior to taxi, verify "RDY" is visible and flashing on the INS DED page and/or "ALIGN" is visible and flashing in the lower left corner of the HUD.

(See INS Alignment section for information.)

6. Chocks – Remove.

Taxi

7. Throttle – Advance. A throttle setting just beyond idle will be required to begin rolling. Return throttle to idle after desired speed is reached.

8. Brakes and NWS – Check.

Press the Missile Step button on the SSC to engage nosewheel steering (NWS). The **AR/NWS** AR status light to the right of the HUD should illuminate.

Gently test the brakes and nosewheel steering immediately after the aircraft begins to move forward. Heat may build up quickly if brakes are used for an extended period so do not ride the brakes to control taxi speed. Use one firm application of the toe brakes to slow the aircraft.

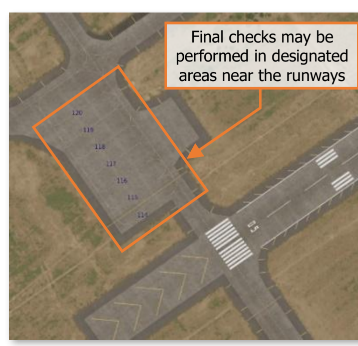
9. Heading – Check.

10. Flight instruments – Check for proper operation. Verify aircraft heading updates as the aircraft turns and that all instruments behave as expected.

TAKEOFF

The F-16C's powerful F110-GE-129 engine affords the aircraft impressive acceleration at takeoff for its size. Even when heavily loaded, the F-16C can accelerate quite rapidly when the afterburner is fully engaged. As a result, it is critical that the pilot ensures the landing gear is fully retracted and the landing gear doors are closed prior to exceeding 300 knots. This prevents wiring or other landing gear components from becoming detached or causing damage to the landing gear doors.

A series of final checks are made just prior to entering the runway, to ensure the aircraft is properly configured for flight, the ejection seat is armed, and to perform one final check for malfunctions within the flight controls.



Some airfields have arm/de-arm areas near the runway (often called "EOR" or "End of Runway" areas) that may be used to keep the taxiway clear for other traffic. These checks may also be performed while on the taxiway, in queue for takeoff.

Once aligned on the active runway, the brakes are applied and the throttle is advanced no further than 90% RPM. This allows the pilot to perform a final scan of the engine instruments to verify the engine is operating as expected; a critical check for a single-engine fighter prior to takeoff. Once this brief check is complete, the brakes are released and the throttle advanced to either MIL or AB.

When departing as a flight, each aircraft takes off one at a time, in short intervals, and then rejoins once airborne.

NOTE: When starting a mission on the runway for takeoff, the following systems will be configured as shown.

- Nosewheel Steering (NWS) – Disengaged.
- ALR-56M Radar Warning Receiver (RWR) – Powered Off.
- CMDS MODE Knob – STBY.
- HMCS Symbology Knob – OFF.

Before Takeoff

Prior to entering the runway for takeoff, perform the following.

1. ALT FLAPS switch – Verify NORM.

2. Trim – Check.

- Pitch and yaw trim – Centered.
- Roll trim - As required.

This is a final verification the trim settings are correct for takeoff and have not been changed.

3. ENG CONT switch – Verify PRI (guard down).

4. Speedbrakes – Verify closed.

5. Canopy – Verify closed and locked.

- Verify CANOPY UNLOCKED caution light is not illuminated.

6. IFF – Set and check. (N/I)

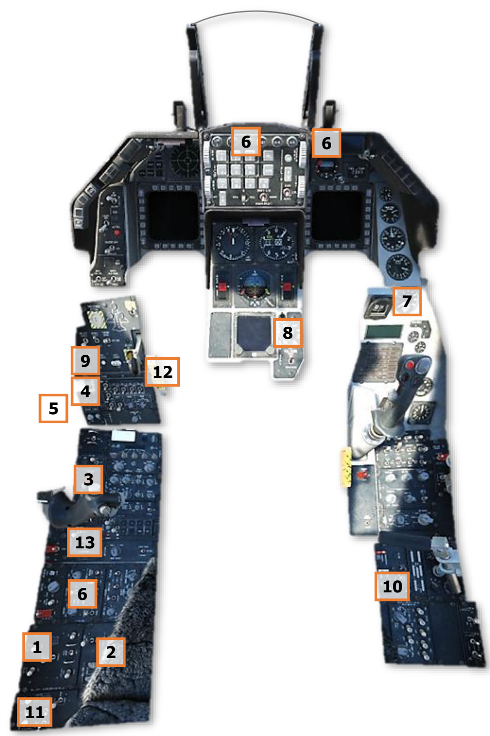
7. External fuel tanks – Verify feeding.

Wing external fuel tanks should feed first and have a lower quantity than at engine start. The internal wing tanks should be full.

If three external tanks are installed, verify that the centerline tank is feeding.

8. FUEL QTY SEL knob – NORM.

The FUEL QTY SEL knob must be set to the NORM position to enable proper function of the automatic forward fuel transfer system and trapped fuel warning, and for the BINGO fuel warning computation to be based on fuselage fuel.



9. STORES CONFIG switch – As required. (See Landing Gear Panel for more information.)

- CAT I: Air-to-air loadouts without external wing tanks, or 6-missile air-to-air loadouts with external wing tanks but no centerline tank and no AIM-120s.
- CAT III: Air-to-ground loadouts, any loadout with external wing tanks and a centerline tank, or 6-missile air-to-air loadouts with AIM-120s and external wing tanks.

10. OXYGEN SUPPLY lever – PBG (if high-G maneuvers are expected immediately following takeoff).

11. PROBE HEAT switch – PROBE HEAT.

This should be done at least two minutes prior to takeoff if icing conditions exist. Manual activation of probe heat on the ground when icing is not expected may cause overheat and damage to probe components.

Probe heat is automatically active once airborne.

12. Ejection safety lever – Down (Armed).

This arms the ejection seat and allows ejection when the ejection handle is pulled. This is delayed for as long as possible to prevent inadvertent ejection on the ground. Egress through other means is usually preferable.

13. Flight controls – Cycle. This is to verify freedom of movement and ensure controls are not obstructed.

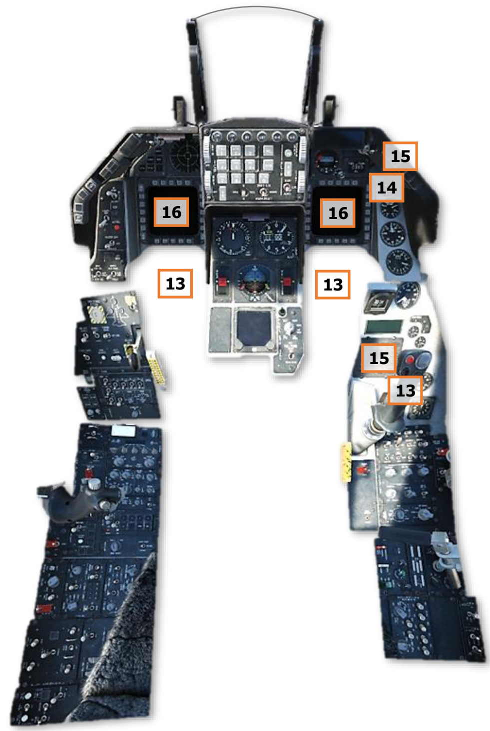
14. Engine OIL pressure – 15-65 PSI.

15. Warning and caution lights – Verify no unexpected conditions.

16. Targeting pod – STBY mode (if installed).

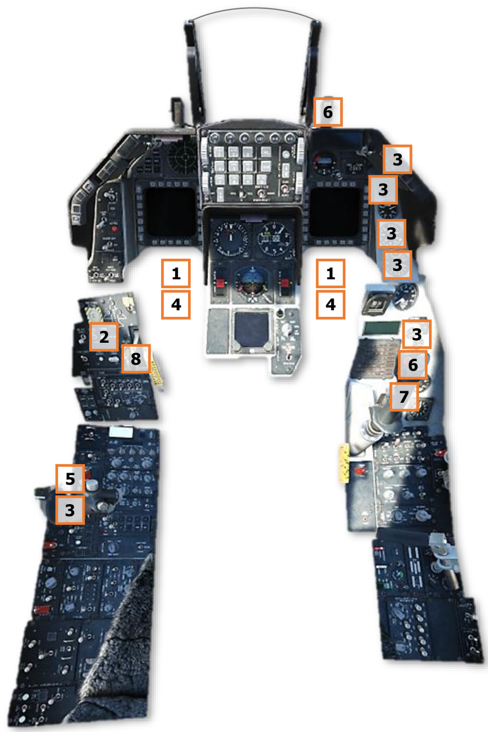
The targeting pod's sensor turret is placed in the stowed position by selecting STBY mode from the TGP Mode Menu page.

This is done prior to takeoff and before landing to prevent foreign object damage to components.



Takeoff

Once lined up for takeoff on the directed runway, perform a final run-up check and initiate the takeoff roll:



1. Brakes – Hold.
2. Parking Brake – Verify disengaged.
3. Throttle – 90% RPM. Check for normal engine indications:
    - HYD/OIL PRESS warning light – Off
    - OIL pressure – 25-65 PSI
    - FTIT – 935° C or less
    - HYD PRESS A & B – 2850-3250 PSI
4. Brakes – Release.
5. Throttle – Advance to desired thrust.
6. NWS – Disengage at 70 knots (or as necessary to maintain controllability) to prevent oversteering.
7. Pull back on the stick 10 knots below takeoff speed for MIL power or 15 knots below takeoff speed for AB and establish takeoff attitude (8–12°). (See chart below for takeoff speed)

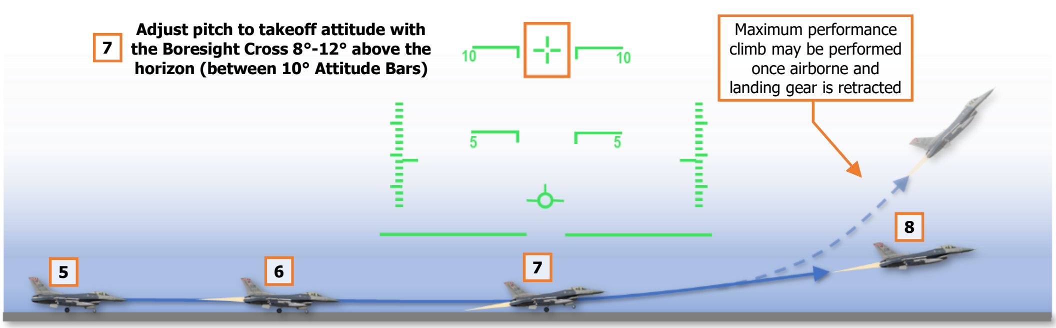
    NOTE: Pulling back on the stick too soon may lead to over-rotation, skipping, or wallowing and will increase the distance needed to take off.

8. LG Handle – UP; after a positive rate of climb is established. The trailing edge flaps retract with the the landing gear and may cause the aircraft to settle and scrape the runway when lift is lost.

NOTE: Ensure landing gear is fully retracted with the gear doors closed before exceeding 300 KCAS.

TAKEOFF SPEED BASED ON AIRCRAFT GROSS WEIGHT

GROSS WEIGHT (GWT)	20,000 lbs.	24,000 lbs.	28,000 lbs.	32,000 lbs.	36,000 lbs.	40,000 lbs.	44,000 lbs.
TAKEOFF SPEED (KCAS)	128 kts	142 kts	156 kts	168 kts	178 kts	188 kts	198 kts



Takeoff

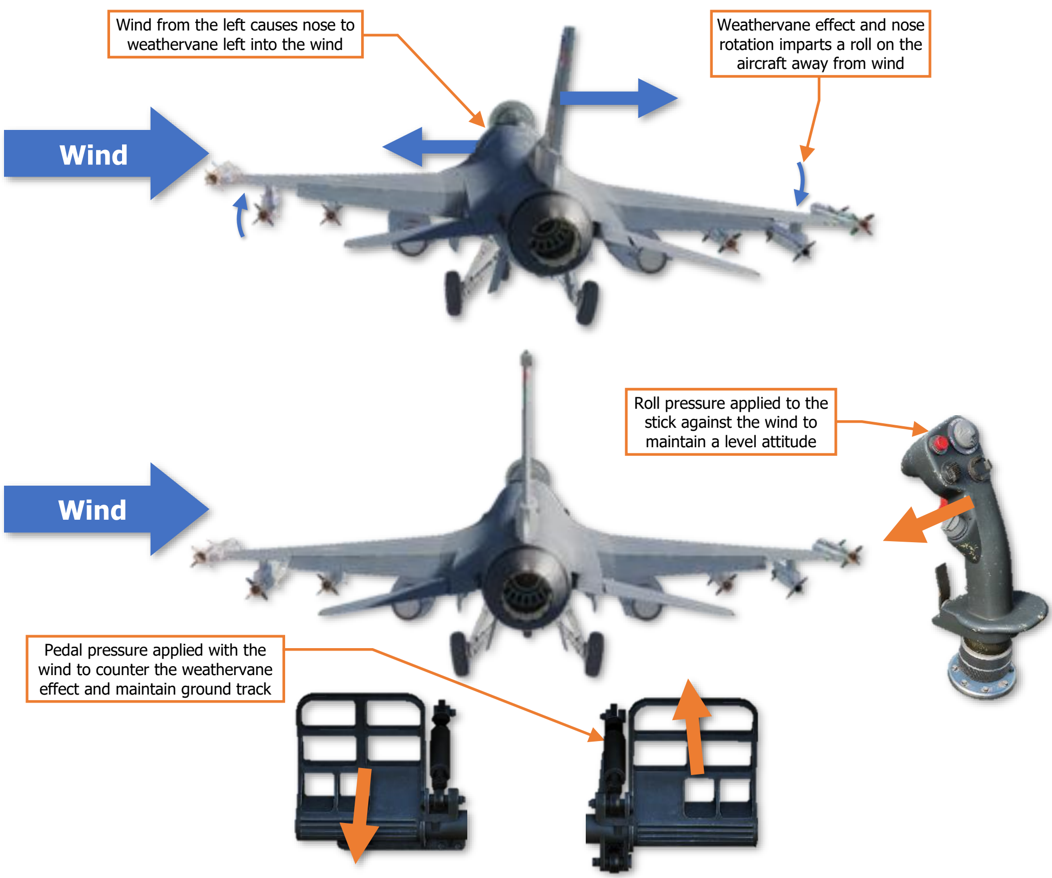
Crosswind Takeoff

When taking off in a crosswind, the wind acting upon the vertical tail will create a "weathervane" effect, causing the nose to turn into the wind. This will in turn raise the upwind wing, causing the aircraft to roll away from the wind direction.

To counter the effects of the crosswind during the takeoff roll:

1. Apply a slight amount of left/right stick pressure against the wind direction to keep the wings level.
2. Apply slight rudder input with the wind, or as necessary, to keep the aircraft centered on the runway throughout the takeoff roll.

During the rotation to takeoff attitude, smoothly remove the countering rudder input as necessary to allow the nose to weathervane back into the wind and establish a proper crab angle into the wind. With a proper crab angle, the Flight Path Marker (FPM) should be aligned down the runway when becoming airborne.



Control inputs to counter crosswinds during takeoff

LANDING

Compared to other fighter aircraft, the F-16 can be somewhat difficult to land. Due to its aerodynamics and narrow "footprint" of its landing gear, maintaining control throughout the final approach, touchdown and deceleration can be a challenge for inexperienced pilots.

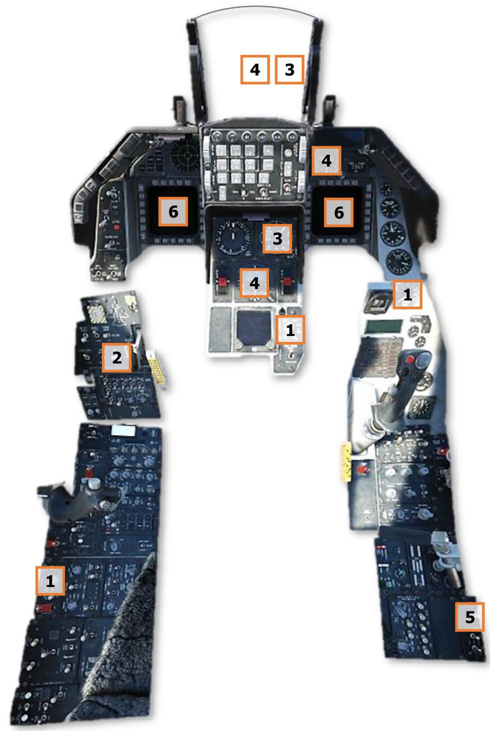
Depending on the type of approach to be flown, weather conditions, and the nature of the airfield and its operations, a straight-in approach or an overhead break may be flown.

The F-16C relies on the combined effects of aerodynamic drag and main landing gear wheel brakes to decelerate the aircraft after touchdown. Just prior to contact with the runway, the pilot raises the nose in a "flare" maneuver to reduce the descent rate as much as possible. This flare maneuver is especially critical when landing with high gross weights to prevent over-stressing the main landing gear, but it also allows the pilot to maintain a nose-high attitude after touchdown for aerodynamic braking; instead of slamming the nose gear down onto the runway following a touchdown with a high descent rate.

This type of landing, in which only the main landing gear is used during the initial touchdown and roll-out, is called a "two-point" landing. The pilot uses forward/aft stick inputs to maintain the nose-high attitude, which generates aerodynamic drag across the underside of the wings and fuselage to decelerate the aircraft. The nose is typically lowered around 100 knots to allow the nose landing gear to contact the ground, after which the wheel brakes on the main landing gear are used to bring the aircraft to a stop.

Descent/Before Landing

Prior to committing to the approach, configure the aircraft for landing:



1. Fuel – Check quantity/transfer/balance.
2. Landing Light – On.
3. Altimeter – Set and check.

   Verify altitude displayed on the HUD matches the altitude on the altimeter.

   Check that the altimeter readings in ELECT and PNEU are ±75 feet of a known elevation and are ±75 feet of one another.
4. Attitude References – Check.

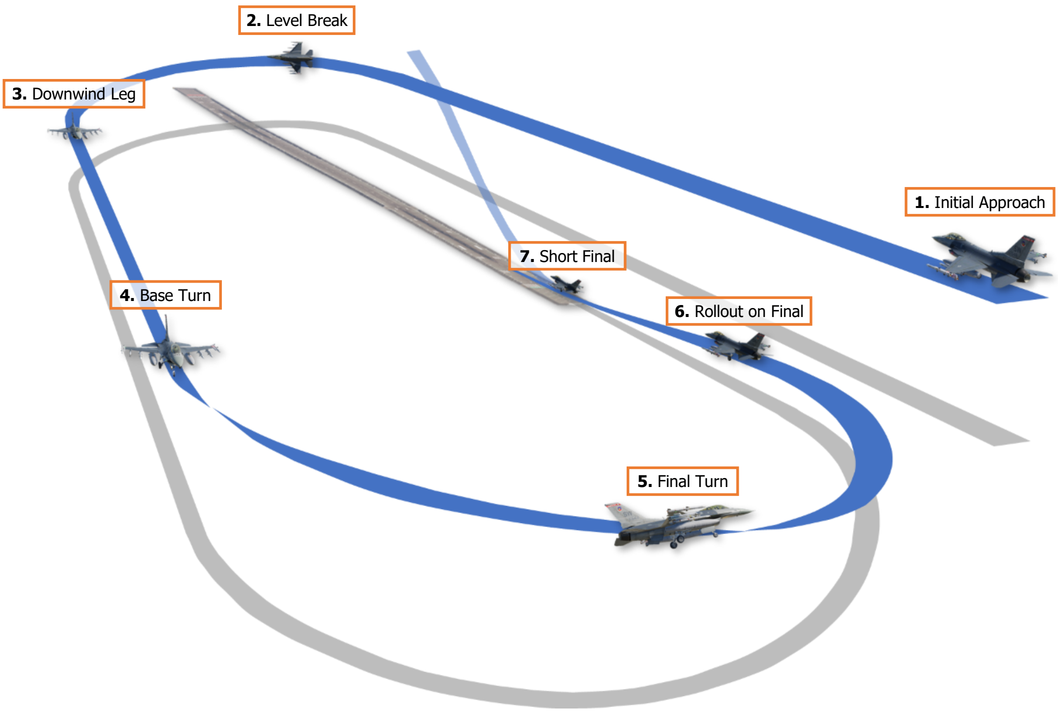
   Attitude indications for ADI, HUD and SAI should agree.
5. ANTI ICE switch – As required.
6. Targeting pod – STBY mode (if installed).

   The targeting pod's sensor turret is placed in the stowed position by selecting STBY mode from the TGP Mode Menu page.

   This is done prior to takeoff and before landing to prevent foreign object damage to components.

Overhead Break

The overhead break is a type of visual approach pattern used by military pilots to expedite landing procedures in an efficient manner. These landings expedite the approach into an airfield by using a 180° turn at a low throttle setting to rapidly deplete airspeed and can also be used to rapidly generate precise timing intervals between wingmen when a formation of aircraft is coming in for landing.

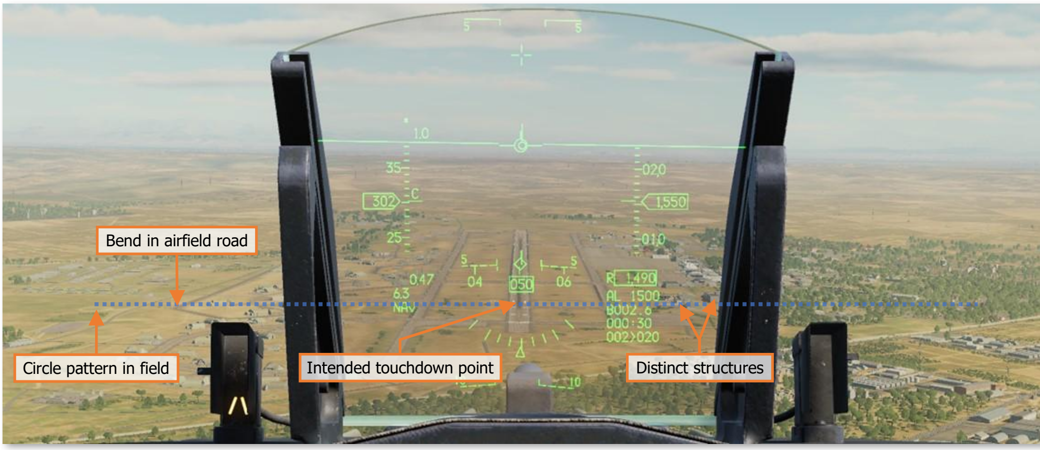


Overhead Break Pattern

1. **Initial Approach.** Upon initial approach to the airfield, align the aircraft with the landing runway at 1,500 feet above ground level (AGL) and 300 knots calibrated airspeed (KCAS). When aligned with the runway, note the current aircraft heading on the HUD and calculate the reciprocal heading; this will be the heading for the downwind leg following the turn into the level break.

   As the intended landing area comes into view, it is recommended to visually identify one or multiple distinct reference points in the airfield environment that are adjacent to the intended touchdown point. The turn into the level break is normally initiated when directly over the intended touchdown point, but as this location will be directly below the aircraft and cannot be seen from within the cockpit, visual reference points directly abeam the touchdown location will allow the pilot to determine when the aircraft is indeed over the touchdown point. (see figure on the following page)

   Alternatively, if no visual reference points are available, the level break could be initiated once overhead the center of the airfield, or simply executed based on the pilot's judgement of when it is appropriate to do so.

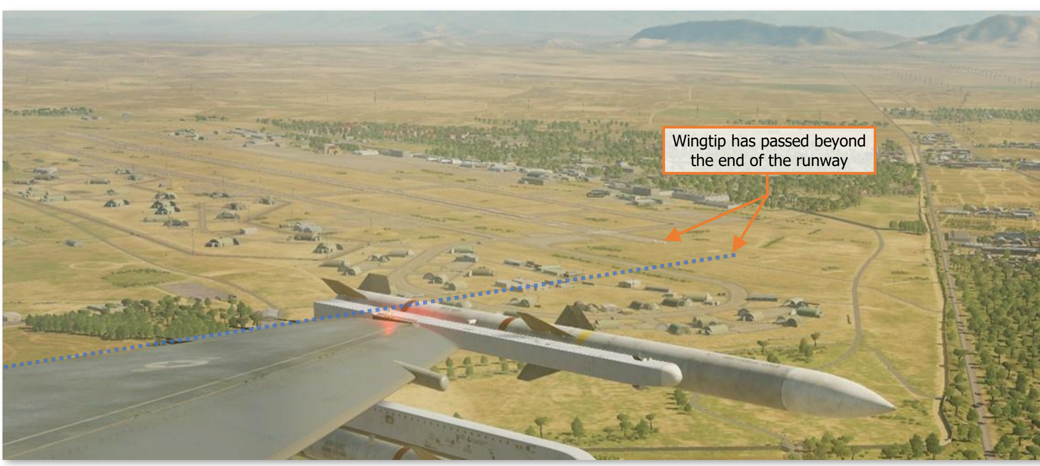


Visual reference points during initial approach

2. **Level Break.** When the aircraft is overhead the touchdown point, roll the aircraft to approximately 70° of bank into the intended break direction, set throttle to about 80% RPM, and open the speedbrakes. Pull into the break at approximately 3 G. Adjust the attitude as necessary to keep the Flight Path Marker (FPM) on the HUD aligned with the Horizon Line to maintain a level altitude throughout the turn.

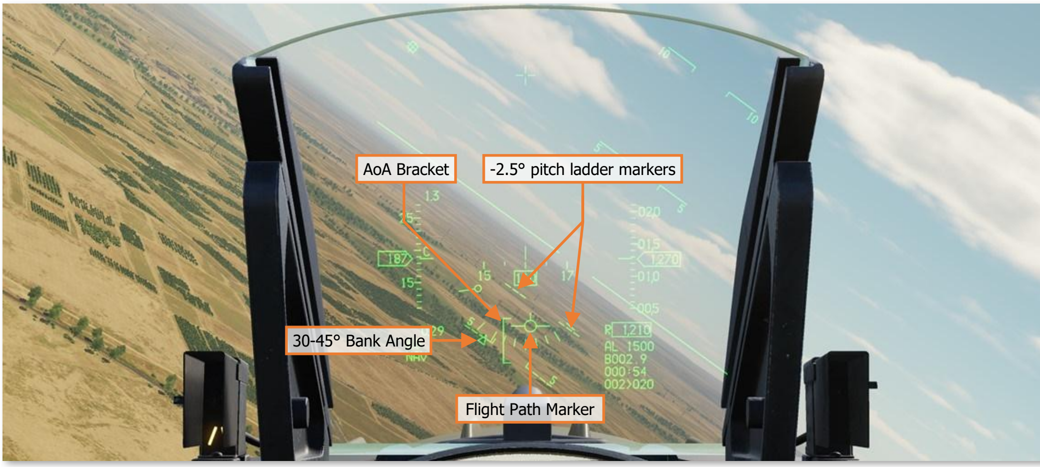
3. **Downwind Leg.** Roll out on the downwind leg opposite the landing heading between 200-220 KCAS and 1,500 feet AGL. Extend the landing gear and confirm three green WHEELS down lights are illuminated. Reduce speed as required to prevent excessive airspeed buildup in the base turn and trim to an Angle-of-Attack (AoA) of 11°.

4. **Base Turn.** Initiate the base turn when abeam the intended point to rollout on final. This may be estimated by viewing the wingtip from the cockpit. Once the wingtip is at the end of the runway, lower the nose slightly so the FPM is between the -2.5° and -5° pitch ladder markers, enter a 30-45° bank angle and fly the turn at approximately 11° AoA, which will correspond with the top of the AoA Bracket symbol.



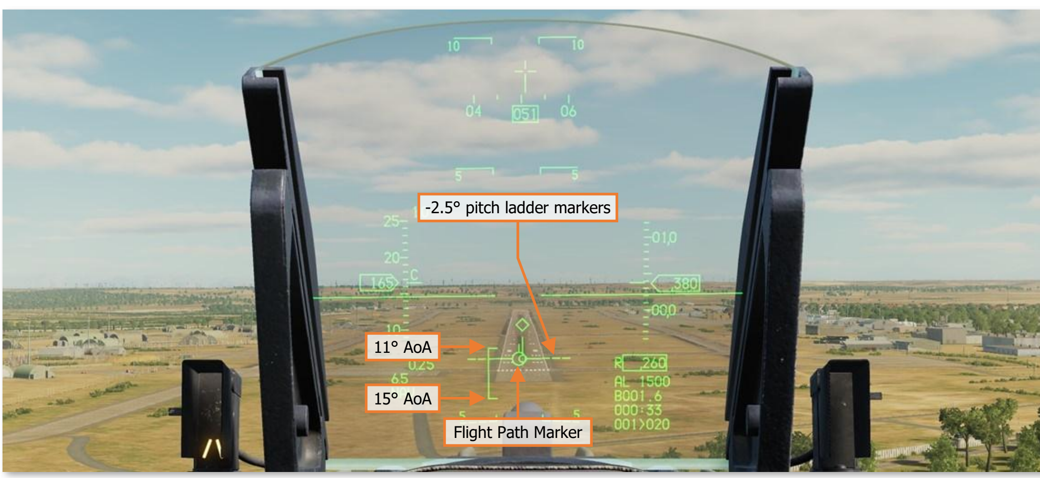
Wingtip reference for initiating base turn

5. **Final Turn.** Use the throttle to control airspeed while using the Side Stick Controller to maintain the AoA at approximately 11-13° through the turn from base to final. Maintain a bank angle between 30-45°, or as necessary to ensure the aircraft is aligned with the runway upon roll-out.



AoA and glide path references in base turn to final

6. **Rollout on Final.** Roll out on final and adjust the controls to achieve the desired glide path and maintain the appropriate AoA. The intent is to roll out of the turn aligned with the runway, approximately one nautical mile from the touchdown point and 300 feet AGL. Align the HUD Flight Path Marker (FPM) and 2.5° pitch ladder with the runway threshold to ensure proper glide path while maintaining 11-13° AoA.



AoA and glide path references on final

If desired, the MAN RNG/UNCAGE knob may be depressed to the Un-cage position to declutter the lower portion of the HUD. When this occurs, the Heading Tape will be repositioned to the top portion of the HUD and the Roll Indicator will be removed (as will the ILS indicators if in use).

7. **Short Final.** See Landing procedure on the following page.

Landing

1. **Rollout on Final.** Align the HUD Flight Path Marker (FPM) and 2.5° pitch ladder markers with the runway threshold to ensure proper glide path while maintaining 11-13° AoA.

   NOTE: If necessary to perform a go-around for another approach and landing attempt, initiate the go-around prior to performing the flare over the runway.

   Go-around. Increase throttle, arrest the descent rate, and begin a climb. When a positive rate of climb is established, retract the landing gear. Ensure landing gear is fully retracted with the gear doors closed before exceeding 300 KCAS. Turn onto crosswind to re-enter the pattern when at the appropriate altitude to do so.

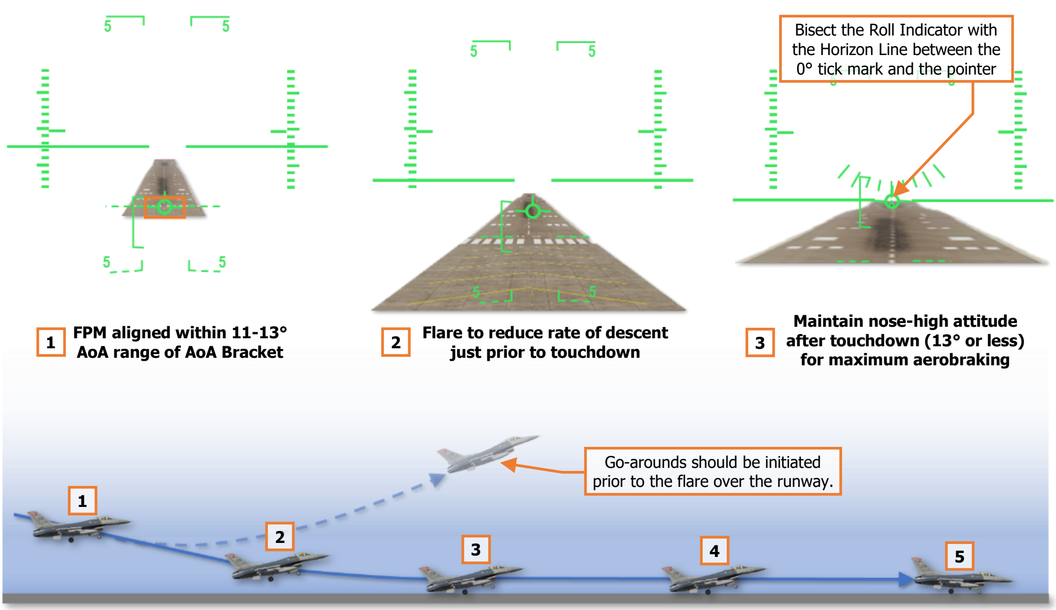
2. **Short Final.** When crossing the runway overrun (the portion of the runway before the primary surface starts), apply aft pressure on the stick to shift the FPM forward to a point 300-500 feet further down the runway. Gently pull back on the stick to flare and reduce the descent rate but do not level off.

3. **Two-Point Touchdown.** Retard the throttle to idle and touchdown with a maximum AoA of 13°. An AoA greater than 15° during the touchdown or aerodynamic braking may cause the speedbrakes, ventral fins, or engine nozzle to contact the runway. Use small inputs to the stick to avoid overcontrolling the aircraft.

4. **Two-Point Aerobraking.** Maintain a nose-up attitude (13° maximum) for two-point aerodynamic braking until the airspeed has been reduced to approximately 100 knots.

   NOTE: A good reference to use for maximum aerobraking is the Roll Indicator. Adjust the back pressure on the stick so that the Horizon Line bisects the lower curve of the Roll Indicator, between the 0° tick mark and the pointer.

5. **Three-Point Roll-Out.** At approximately 100 knots, reduce back pressure on the stick and lower the nosewheel to the runway. Apply moderate to heavy braking to slow the aircraft. After the nosewheel has compressed, the speedbrakes may be fully opened and full aft pressure on the stick may be applied for maximum braking effectiveness (for short-field landings). Engage nosewheel steering when below 30 knots unless it is required earlier to maintain ground track and/or prevent departure from the runway.



Short Final and Landing Roll-out

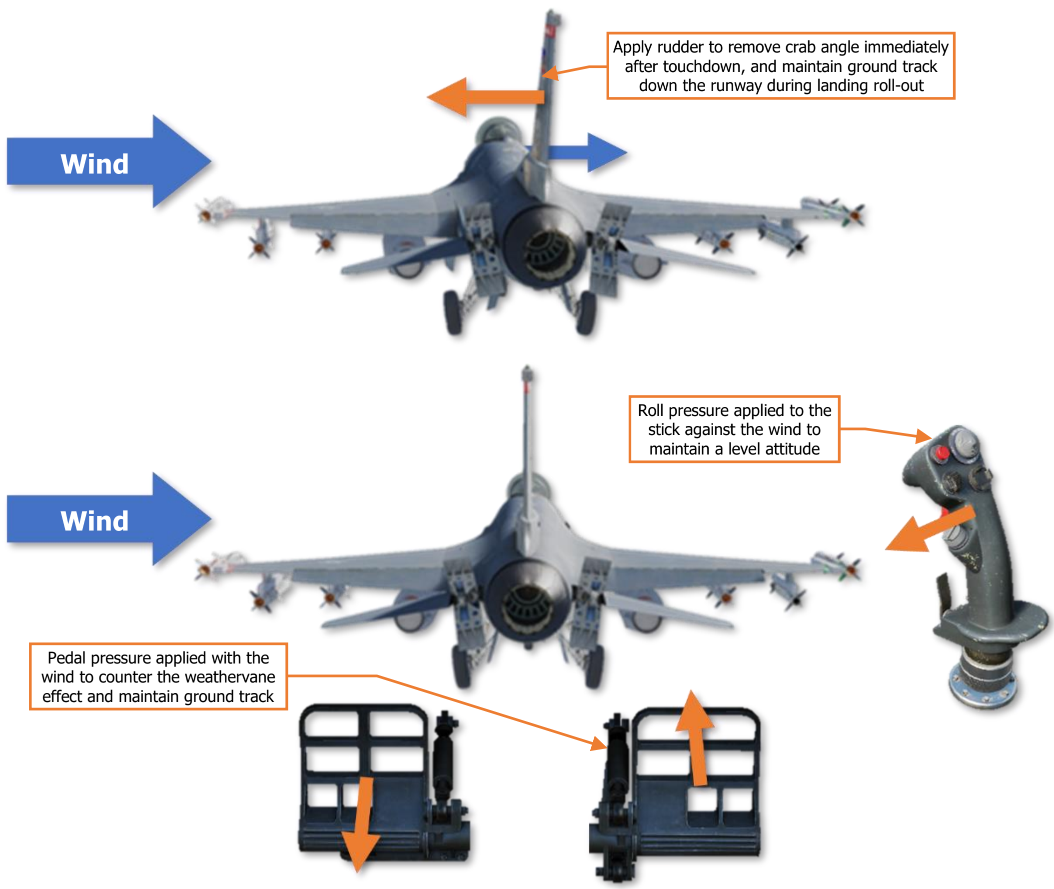
Crosswind Landing

When landing in a crosswind, the wind acting upon the vertical tail will create a "weathervane" effect, causing the nose to turn into the wind. During the approach, maintain wings-level and allow the aircraft to crab with the nose into the wind until touchdown.

At touchdown of the main landing gear, counter the effects of the crosswind during the landing roll-out:

1. Immediately apply rudder input to remove the crab angle and maintain alignment down the runway, or use differential wheel braking as necessary, to keep the aircraft centered on the runway throughout the roll-out.
2. Apply a slight amount of left/right stick pressure against the wind direction to keep the wings level.
3. Perform the remainder of the landing roll-out with normal two-point aerobraking until below 100 knots or until aircraft control becomes difficult and nosewheel steering is necessary to maintain ground track down the runway.

Use caution when engaging nosewheel steering as a strong pedal input may cause an abrupt yaw when nosewheel steering is engaged. If possible, center the rudder before engaging the nosewheel steering and then gently re-apply rudder input as necessary to maintain ground track down the runway.



Control inputs to counter crosswinds during landing

AIRCRAFT SHUTDOWN

Once the aircraft is safely back on the ground and the flight is to be terminated, an After Landing check is performed after departing the runway. This configures the aircraft for ground operations and makes the aircraft safe to approach by ground personnel.

These checks may be configured while taxiing to the parking area or may be performed in designated arm/de-arm areas immediately after departing the runway (often called "EOR" or "End of Runway" areas).

After arriving at the intended parking location, ground crews place wheel chocks to prevent any un-intended aircraft movement and the pilot powers down the various avionics and aircraft systems.

Due to its small, lightweight airframe, the F-16 is not equipped with an integrated boarding ladder and relies on the ground crew to place such equipment next to the cockpit for egress. The pilot secures his or her gear, climbs out of the cockpit, discusses with the ground crew about any maintenance-related issues encountered during the flight, and then departs for debriefing while the ground personnel regenerate the aircraft for future sorties.

After Landing

When clear of the runway, perform the following.

1. PROBE HEAT switch – Verify OFF.

Manual activation of probe heat on the ground when icing is not expected may cause overheat and damage to probe components.

2. ECM Power switch – OFF.

3. Speedbrakes – Close.

4. Ejection Safety Lever – Safe (Up).

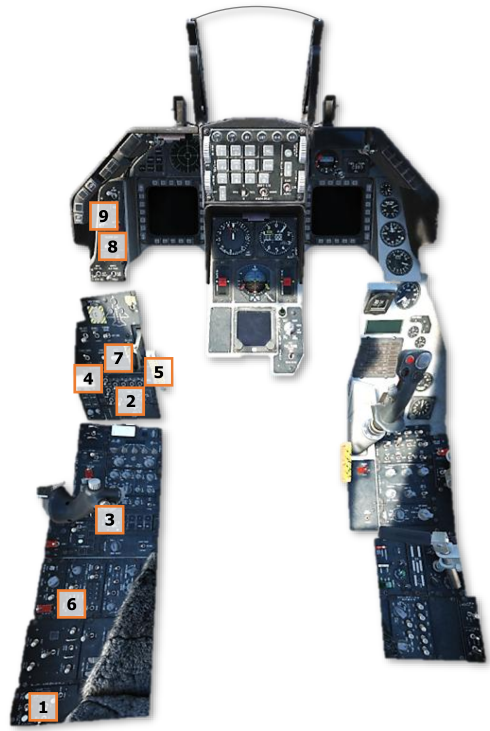
The ejection seat is safed after landing to prevent inadvertent ejection. A ground egress is usually preferable to ejection in case of an emergency while on the ground.

5. IFF MASTER knob – STBY.

6. LANDING/TAXI Light switch – As required.

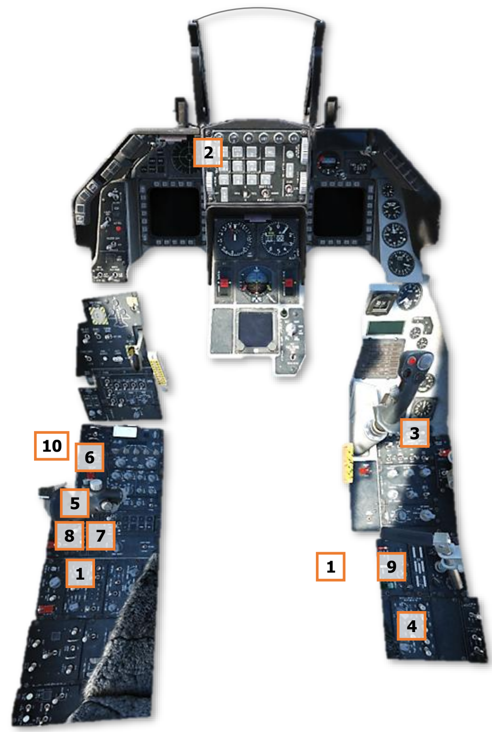
7. MASTER ARM and LASER ARM switches – OFF.

This should be accomplished before ground personnel approach the aircraft.



Engine Shutdown

After reaching the designated parking location, perform the following.



1. C & I knob – BACKUP.
2. HUD SYM knob – Minimize.
3. SNSR PWR panel – Set:
    - LEFT HDPT – OFF.
    - RIGHT HDPT – OFF.
    - FCR – OFF.
    - RDR ALT – OFF.
4. AVIONICS POWER panel – Set:
    - INS knob – OFF.
    - MIDS LVT knob – OFF.
    - DL switch – OFF. (N/I)
    - GPS switch – OFF.
    - UFC switch – OFF.
    - MFD switch – OFF.
    - ST STA switch – OFF.
    - MMC switch – OFF.
5. Throttle – OFF.

    NOTE: Wait at least 10 seconds after INS knob has been moved to OFF before shutting down the engine. This allows the INU to complete its shutdown sequence before the engine spools down and the generator drops offline.
6. JFS RUN light – Confirm off.
7. EPU GEN and EPU PMG – Confirm off.

    Check after main generator power drops offline. Lights on may indicate impending activation of the EPU and a hazardous condition.
8. MAIN PWR switch – OFF.

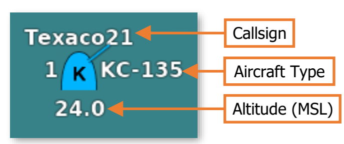
    Delay placing MAIN PWR switch to OFF until after engine rpm decreases through 20 percent. This delay should allow the exhaust nozzle to remain open and makes it easier for the crew chief to accomplish the post flight inspection.
9. OXYGEN SUPPLY lever – OFF.
10. OXYGEN Diluter lever – 100%.
11. Canopy – Open.

AERIAL REFUELING

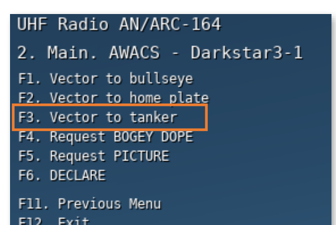
Aerial refueling enables the F-16 and other aircraft to extend their range beyond what may be achieved with internal fuel or external fuel tanks without landing at an airfield to refuel. Aerial refueling is often critical when performing trans-oceanic flights, conducting long-range sorties beyond the reach of airbases in friendly or allied territory, or extending the duration of combat air patrols.

Even if additional fuel is not required to fly to the objective, execute the mission, and return to base, it may be prudent to perform aerial refueling prior to committing to the objective area. This allows the pilot additional loiter time over the objective, the option to conduct low-level ingress or egress at higher speeds, more liberal use of the afterburner in combat, or provide additional options for any contingencies encountered during the mission.

Air-to-Air Refueling (AAR) tracks are areas within which aerial refueling tanker aircraft, such as the KC-135, will orbit during a mission. These AAR track locations are normally included within the mission briefing; however, the F10 map may also be referenced during the mission itself to aid in locating these aircraft (assuming the mission options allow such information to be displayed on the F10 map). Aerial refueling tankers will be designated by friendly aircraft icons marked with a "K".

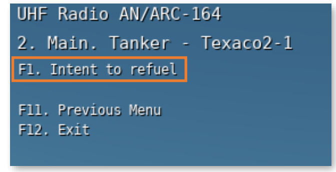


Alternatively, if an AWACS is on-station, a vector to the nearest tanker may be requested over the AWACS radio frequency to aid in navigation to an AAR track.

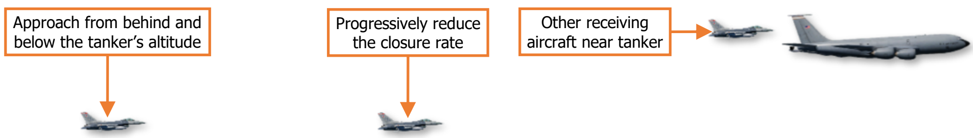


Approach and Rendezvous

When approaching the AAR track, prior to performing the rendezvous with the tanker, a radio call should be made to the tanker crew to announce an intent to refuel. The tanker crew will respond with their current altitude and airspeed, and whether the receiving aircraft is cleared to the Pre-Contact position. The receiving aircraft should ensure altitude separation is established prior to entering the AAR track and visual or radar contact has been made with the tanker aircraft prior to initiating the rendezvous.



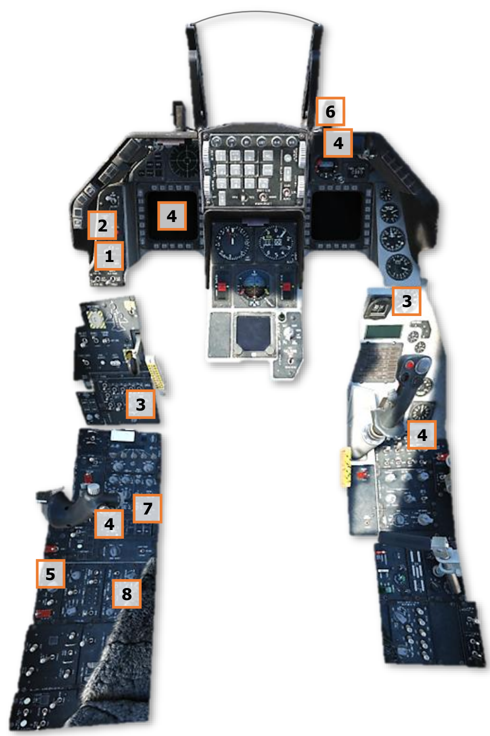
When performing the rendezvous with the tanker, the closure speed and relative altitude should be closely monitored. The approach should be made from behind and below. There may be other aircraft performing refueling operations in the vicinity of the tanker, so caution should be exercised to avoid a mid-air collision.



Approach and rendezvous with refueling tanker

Pre-refueling Checklist

Prior to completing the rendezvous with the tanker, perform the following steps.



1. MASTER ARM switch – OFF.

2. LASER ARM switch – OFF.

3. CMDS MODE knob – STBY.

4. Emitters – Off or Standby:

- FCR – Set to STBY Mode.
- ECM Power switch – STBY.
- TACAN – Set to REC mode.
- RDR ALT switch – STBY.

NOTE: Emitters should be disabled prior to reaching the Pre-contact position.

5. AIR REFUEL switch – OPEN.

This should be done 3-5 minutes prior to refueling if equipped with external fuel tanks to depressurize the tanks and allow them to be filled.

NOTE: FLCS gains are set to takeoff/landing configuration when set to OPEN.

6. AR Status Light – Verify **RDY**.

7. HOT MIC/CIPHER switch – HOT MIC.

8. Exterior Lights – As required. At night, exterior lights should be set to DIM and STEADY settings and the Anti-Collision light should be set to OFF.

Pre-contact Position

When cleared to Pre-contact position, the receiving aircraft lines up directly behind the tanker and matches its speed. The Pre-contact position allows the boom operator to ensure they have positioned the boom for contact, the refueling system is set to the appropriate transfer rate for the type of aircraft being refueled, and the boom operator establishes their required visual reference points on the receiving aircraft below them.

As a technique, the BNGO page may be displayed on the DED (and the HUD if desired), which will display the total fuel in a cockpit location that is more conducive to maintaining a focus on the tanker. This precludes the pilot from needing to look down at the fuel quantity indicator in the cockpit.

(See BNGO DED Page for more information.)

To display the DED page directly on the HUD, set the DED/PFLD switch to the DED DATA position on the HUD Control Panel.

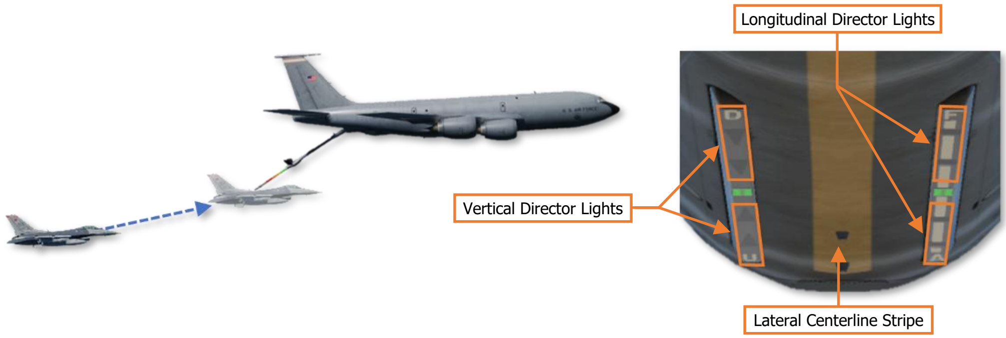
Once stable and ready to move in for refueling, the pilot in the receiving aircraft radios to the boom operator that he/she is established in the Pre-contact position and is ready to move into the contact position.

Pre-contact Position

Contact Position

Once cleared to the Contact position by the boom operator, use small but smooth control inputs, with very slight changes to the throttle. After a throttle adjustment, it is prudent to wait several moments to see the effects of the change before making another.

Allow the boom to pass just left or right of the canopy, about 2 or 3 feet overhead. Continue to move forward slowly, maintaining lateral alignment with the yellow stripe painted along the underside of the KC-135.

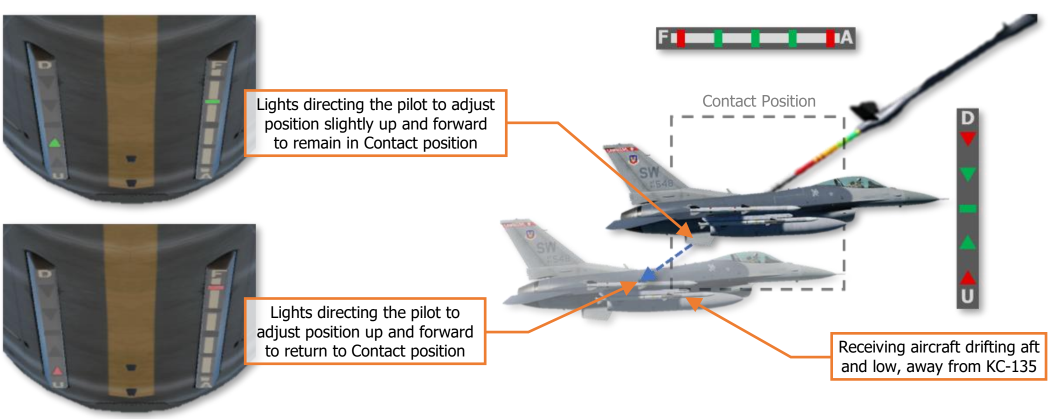


Contact Position

Use the director lights along the underside of the tanker's forward fuselage to establish and maintain the Contact position. The boom operator will "fly" the refueling boom using the boom-mounted control surfaces to align and insert the boom into the F-16's dorsal refueling receptacle.

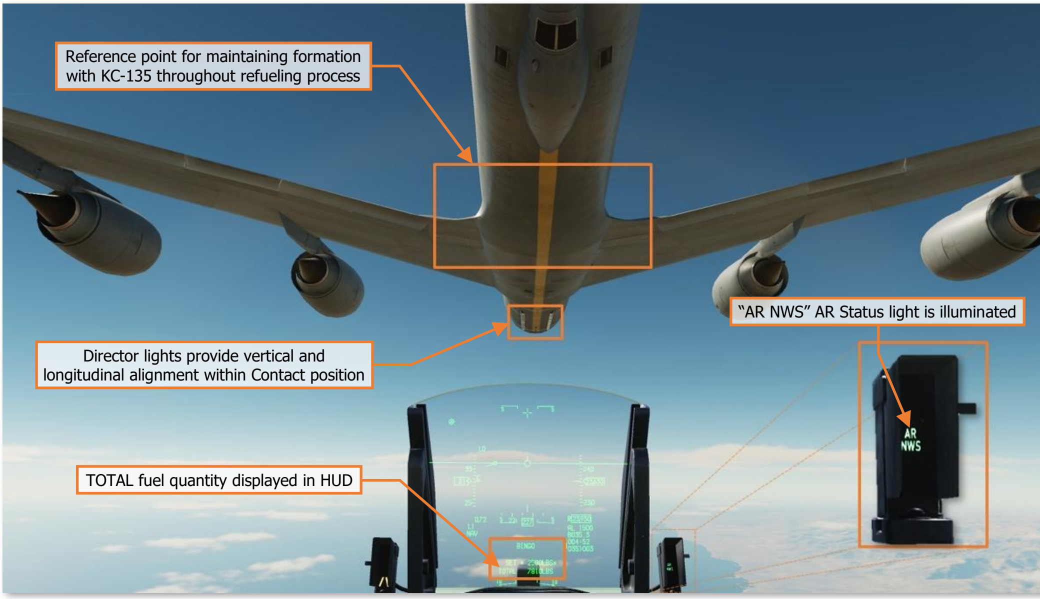
The lights under the forward fuselage of the KC-135 are directive in nature, meaning they indicate to the pilot the required corrections that must be made to remain within the ideal Contact position. The left row of lights indicates vertical alignment, and the right row of lights indicates longitudinal alignment. Green lights indicate a slight correction and red lights indicate the aircraft is at the limits of the boom's travel within the Contact position.

- Arrows that are biased toward the "D" or the "U" indicate a required correction "Down" or "Up", respectively, and are corrected by slight forward/aft pressures on the stick.
- Dashes that are biased toward the "F" or the "A" indicate a required correction "Forward" or "Aft", respectively, and are corrected by small adjustments of the throttle.



KC-135 Director Light Corrections

When the boom has been seated within the receiving aircraft's receptacle, the boom operator will announce "Contact" and confirm positive fuel flow. When this occurs, the "AR NWS" AR Status light illuminates.



Once refueling has begun, the receiving aircraft simply needs to maintain the Contact position relative to the KC-135 and monitor the total fuel quantity. It is not wise to focus on the boom, nor should the pilot's focus be solely on the director lights or the cockpit indications for more than a brief moment. A good reference point for maintaining formation with the KC-135 is the center fuselage along the trailing edge of the main wing roots. This location is close enough to detect small deviations from the intended position before they become apparent on the director lights, and the wing roots serve as an immediate attitude indicator of the KC-135 (which is especially important as the tanker enters or rolls out from a turn within the AAR track). Occasional cross-checks of the director lights, HUD flight information, total fuel quantity, and the **AR NWS** light should be conducted throughout the refueling, but the primary focus should remain on the KC-135 itself.

Note that the flying characteristics of the aircraft will subtlety and continuously change as the aircraft takes on fuel and the gross weight increases. This will cause the aircraft to drop away from the KC-135, requiring a slight adjustment to the pitch attitude to maintain altitude. This will in turn increase the AoA of the aircraft, which will require a slight adjustment of the throttle to counter the increase in drag and maintain airspeed.

It is possible to unintentionally disconnect at some point during the refueling process. If this occurs, the **DISC** AR Status light will illuminate. The pilot may adjust the flight controls to re-enter the correct alignment within the Contact position, at which the boom operator will repeat "Contact" and confirm resumption of fuel flow, or the pilot may back away to the Pre-contact position prior to approaching the Contact position again.

If it is necessary to disconnect from the tanker prior to receiving a full offload, the Missile Step button may be pressed on the Side Stick Controller, which will disconnect the boom from the refueling receptacle and illuminate the **DISC** AR Status light.

Once clear of the boom, the aircraft should be slowly backed away to the Pre-contact position while maintaining alignment directly behind the tanker. Prior to leaving the Pre-contact position, ensure to visually scan the immediate areas to the left and right of the tanker for other aircraft waiting to refuel, or wingmen waiting for you to finish before departing from the tanker's wing.

Breakaway Procedure

At any point during the refueling, if the distance and/or closure rate is such that a potential mid-air collision with the tanker or the refueling boom is likely, the boom operator will call for an emergency breakaway maneuver by stating "Breakaway, breakaway." When an emergency breakaway is commanded, immediately apply forward pressure on the stick to initiate a descent away from the tanker and retard the throttle to reduce airspeed and gain separation. The maneuver should be deliberate and expeditious in nature, but not necessarily aggressive.

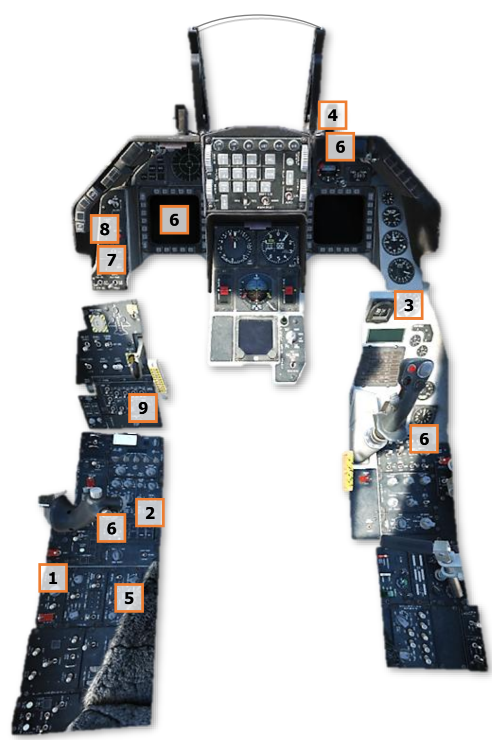
Breakaway Maneuver

After completing a breakaway, the boom operator will clear the receiving aircraft back to the Pre-contact position prior to resuming the refueling process, if necessary.

Post-refueling Checklist

After completing refueling and gaining a safe distance from the tanker, perform the following.

1. AIR REFUEL switch – CLOSE.
2. HOT MIC/CIPHER switch – OFF.
3. Fuel quantity – Check. Verify proper transfer and balance.
4. AR Status Lights – All off.
5. Exterior Lights – As required.
6. Emitters – As required:
   - FCR – As required.
   - ECM Power switch – As required.
   - TACAN – As required.
   - RDR ALT switch – RDR ALT.
7. MASTER ARM – As required.
8. LASER ARM – As required.
9. CMDS MODE knob – As required.

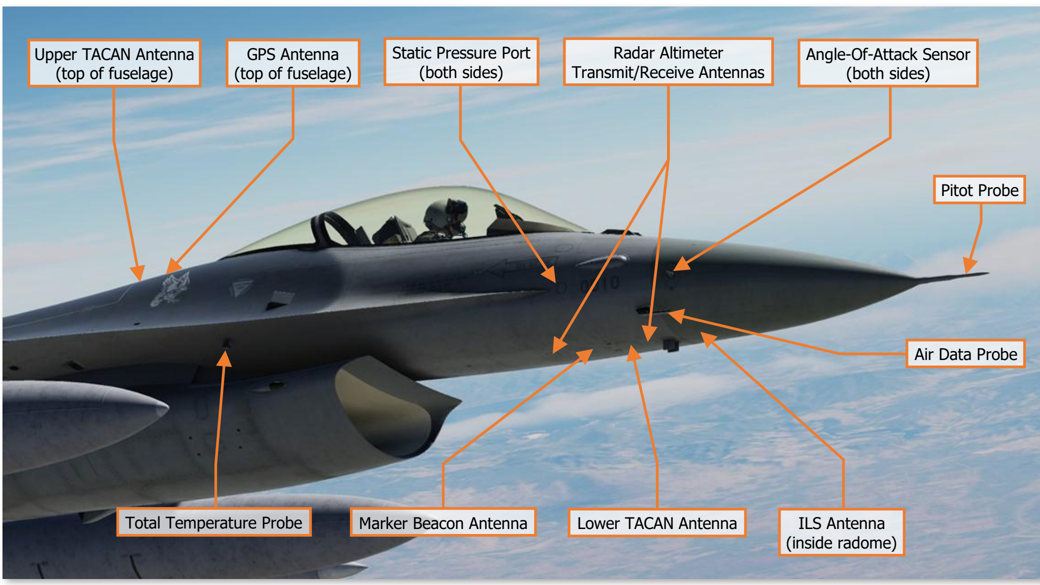



NAVIGATION
USAF Photo
by MSgt Burt Traynor

NAVIGATION

The F-16C primarily navigates by an Inertial Navigation System (INS), which is aided by a Global Positioning System (GPS) receiver, a Central Air Data Computer (CADC), and a navigation database of steerpoints within the Modular Mission Computer (MMC). After power is applied to the aircraft, whether it be from the engine-driven generator or an external power supply, the pilot must initiate an alignment of the INS. Once aligned, the INS will continuously calculate the aircraft heading, attitude, altitude, and velocity within a 3-dimensional "system navigation solution", which produces a horizontal navigation position as well as a vertical altitude position.

While in flight, the F-16C receives continuous position updates from GPS satellites for increased reliability and precision of the INS system navigation solution. In the event GPS signals are unreliable or unavailable, the INS system navigation solution may gradually accumulate small errors over time. In these instances, the INS may be updated in flight by performing a Position Fix or an Altitude Calibration.



Navigational Sensors

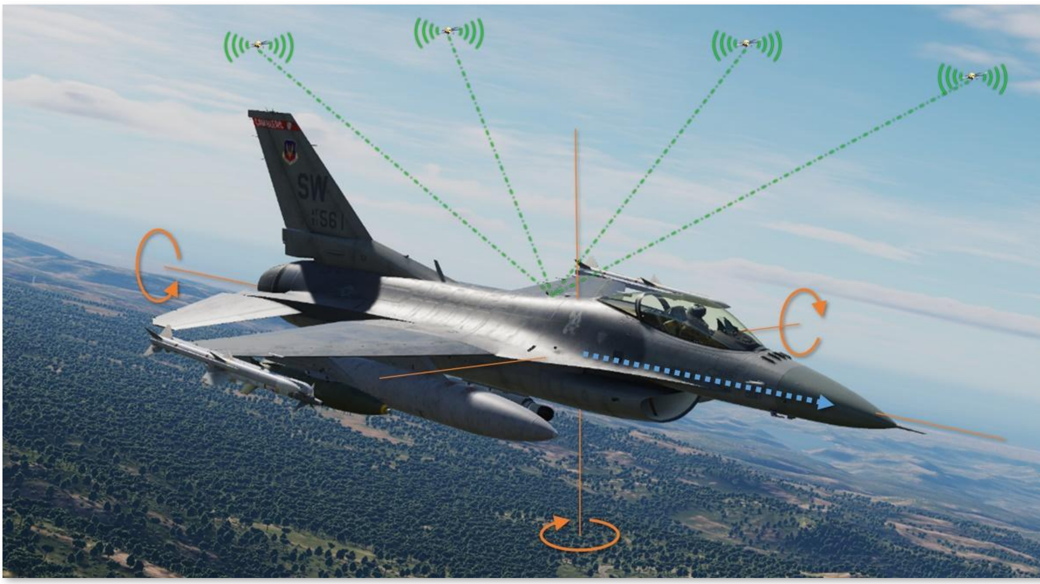
The F-16C also utilizes several external sensors to supply data to the Flight Control Computer (FLCC) and the Central Air Data Computer (CADC).

- A nose-mounted pitot probe provides static and total air pressure data to the CADC and FLCC, and drives the analog Altimeter and Airspeed/Mach Indicator on the Instrument Panel.
- A side-mounted air data probe also provides static and total air pressure data to the CADC and FLCC, along with angle-of-attack (AOA) and sideslip data.
- A pair of AOA transmitters on either side of the nose provide proportional AOA data to the FLCC.
- A pair of static pressure ports on either side of the nose provide differential sideslip data to the FLCC.
- A total temperature probe along the underside of the right leading-edge extension provides analog temperature data to the CADC for computing true airspeed and air density.

During operations in low-visibility conditions, the F-16C is equipped with Tactical Air Navigation (TACAN) capability through its MIDS LVT terminal, Instrument Landing System (ILS) and Marker Beacon radio receivers, and a Combined Altitude Radar Altimeter (CARA) for precisely measuring the aircraft altitude above ground level (AGL).

INERTIAL NAVIGATION SYSTEM (INS)

The Inertial Navigation System is the primary navigation system of the F-16C. Once aligned, the INS utilizes internal accelerometers and gyroscopic sensors to track the aircraft orientation and position in three dimensions, which provides aircraft heading, attitude, altitude, velocity, and horizontal and vertical steering for navigation. The INS also receives data from Global Positioning System (GPS) satellites for increased reliability and precision.



The combined values of aircraft orientation, position, and velocity are output from the INS as the "system navigation solution" and are utilized by various onboard systems. In addition to navigation steering, the system navigation solution also determines the orientation and position accuracy of aircraft sensors, information transmitted across the datalink, calculating weapon ballistics, or targeting data transferred to precision munitions.

Three navigation solutions are separately maintained within the onboard Modular Mission Computer (MMC):

- INS-only solution, which utilizes inertial data from the gyros and accelerometers within the INS itself.
- GPS-only solution, which utilizes position and timing signals received from GPS satellites.
- Blended solution, which utilizes a Kalman filter within the MMC to combine the data from the INS and GPS.

Prior to any flight, an INS "alignment" must be performed to ensure the accelerometers and gyros within the INS itself are properly calibrated to the aircraft's true position, orientation, and velocity. As inertial-based navigation systems are prone to errors that gradually accumulate over time, a lower quality alignment produces less accurate calculations of the aircraft's navigation solution. As a result, a lower quality alignment will accumulate greater errors within a shorter amount of time compared to a higher quality alignment.

If necessary, the pilot may correct errors that have accumulated within the INS by performing a Position Fix to correct horizontal errors within the INS-only solution or an Altitude Calibration to correct vertical errors within the INS-only altitude. However, in the event that the pilot must perform a correction to the navigation steering to ensure weapon delivery calculations and symbology are properly aligned with the intended target, but there are no locations suitable to perform a fix or there is insufficient time to do so, a temporary "cursor slew" may be performed in lieu of performing an actual update to the navigation system.

(See Navigation Solutions and Navigation Updates for more information)

INS Alignment

Three types of INS alignments may be performed, which may be selected on the AVIONICS POWER control panel. If performing a Normal Gyrocompass Alignment or a Stored Heading Alignment, it is imperative that the aircraft is not moved or repositioned in any way, to include reconfiguring externally mounted equipment or arming/re-arming any weapons stations.

Normal Gyrocompass Alignment. Aligns the INS within ~8 minutes to full position confidence.

Stored Heading Alignment. Rapidly aligns the INS within ~90 seconds, but requires the aircraft not be moved if the INS is powered off following a Normal Gyrocompass Alignment.

In-Flight Alignment. Permits an INS alignment while in flight but requires a level flight attitude at a constant speed and heading while the alignment proceeds. GPS data is required to achieve a reliable alignment quality.

NOTE: When a DCS mission begins in which the player must start the F-16 themselves, the aircraft will always have been pre-aligned by the ground crew, allowing the player to perform a Stored Heading Alignment if desired.

Prior to initiating an alignment, the following criteria must be met.

- The AC bus is powered by the engine-driven main or standby generators or by external power supply.
- The Modular Mission Computer is enabled via the MMC switch on the AVIONICS POWER control panel. The EHSI will be powered but will display the INU flag, indicating the INS is not providing data.
- The Upfront Controls (ICP and DED) are enabled via the UFC switch on the AVIONICS POWER control panel. The DED will initialize to the CNI page.
- If performing a Normal Gyrocompass Alignment, the Altimeter on the Instrument Panel is set to the primary operating mode by momentarily holding the mode switch to the ELEC position until the PNEU flag is removed, and the Altimeter itself is calibrated to the airfield elevation by adjusting the barometric setting knob. This step is not required if performing a Stored Heading Alignment.

INS Initialization

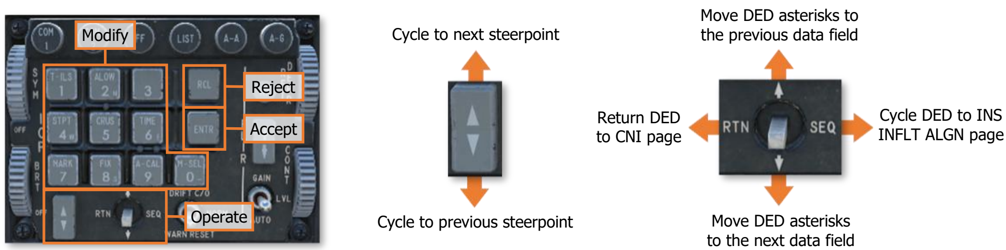
The INS knob sets the operating mode of the Inertial Navigation System and initializes an alignment.

- **OFF.** Removes power from the INS. The INS knob should remain in this position on aircraft power for a minimum of 10 seconds before moving the INS knob from OFF or shutting down the aircraft.
- **ALIGN – STOR HDG.** Initiates an alignment using previous alignment data stored within the MMC.
- **ALIGN – NORM.** Initiates an alignment from manually input position data.
- **NAV.** Sets the INS to normal navigation functionality after an alignment has been performed.
- **IN FLT ALIGN.** Initiates an alignment using GPS data or a manual position fix to attain position data.
- **ATT.** Provides backup pitch, roll, and heading information only and is used if the INS alignment is no longer usable for navigation but the attitude data is still valid. Navigation data will be unavailable except TACAN.

When performing an alignment of the INS, the INS DED page allows the pilot to monitor the status of the alignment and, when used in conjunction with the ICP, allows the pilot to input position, altitude, and heading data if required for the type of alignment that is being performed.

INS DED Page

The Inertial Navigation System DED page is accessed by pressing the **6/TIME** button on the ICP keypad when the LIST DED page is displayed. The DED will automatically display this page any time a Normal Gyrocompass Alignment or a Stored Heading Alignment is initiated by setting the INS knob to the respective positions on the AVIONICS POWER control panel. This page displays the position, altitude, true heading, and ground speed within the INS-only solution.



1. **Time Into Alignment/Alignment Status.** The value to the left of the slash indicates the elapsed time in minutes that the alignment has been underway (e.g., a displayed value of "1.6" indicates approximately 1 minute and 36 seconds).

   The value to the right of the slash provides an indication as to the state of alignment that has been achieved. As the alignment proceeds, this value will decrement downward, indicating the following states.

   - **99.** An alignment of the INS has not been performed.
   - **98-91.** The INS inertial platform is being leveled and the aircraft true heading is being attained.
   - **90.** The INS has attained accurate attitude data and coarse alignment begins. This status is typically achieved within 30 seconds after an alignment has been initialized.
   - **79-63.** The INS is performing a coarse alignment.
   - **62.** The INS has attained a coarse alignment state that is usable for navigation, albeit with much greater inaccuracy compared to a fully aligned state.
   - **60-11.** The INS is performing a fine alignment, indicated by a Circular Error Probability (CEP) multiplier. A CEP multiplier of 10 corresponds with the precision of a fully aligned state of 1.0, and a CEP multiplier of 60 corresponds with a precision error 6.0 times that of a fully aligned state. As the alignment status decrements, the CEP is reduced to indicate an increase in INS alignment accuracy.
   - **10.** The INS has attained a fine alignment state with a fully aligned CEP factor of 1.0.

2. **RDY Status Message.** If a Normal Gyrocompass Alignment or a Stored Heading Alignment is being performed, "RDY" will be displayed to the right of the alignment status to indicate that the INS has attained the minimum alignment state that is required for navigation.

3. **Latitude (LAT).** Displays the latitude of the aircraft as output by the INS, in DD°MM.M' format. When performing a Normal Gyrocompass Alignment, may be modified by placing the DED asterisks over the data field, inputting a value in DDMMMMM format using the ICP keypad, and pressing ENTR.

4. **Longitude (LNG).** Displays the longitude of the aircraft as output by the INS, in DDD°MM.M' format. When performing a Normal Gyrocompass Alignment, may be modified by placing the DED asterisks over the data field, inputting a value in DDDMMMMM format using the ICP keypad, and pressing ENTR.

5. **System Altitude (SALT).** Displays the system altitude of the aircraft, in feet above mean sea level (MSL). The system altitude may be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

   NOTE: If performing a Normal Gyrocompass Alignment, the INS-only altitude is initialized based on the CADC altitude. Therefore, prior to initiating the INS alignment, it is important that the pilot ensures the Altimeter on the Instrument Panel is set to ELEC operating mode and calibrated to the airfield elevation by adjusting the barometric setting knob. This ensures the INS-only altitude is accurately initialized to the aircraft altitude above mean sea level (MSL). (See System Altitude for more information.)

6. **True Heading (THDG).** Displays the true heading of the aircraft as output by the INS. The aircraft magnetic heading is then subsequently derived based on the magnetic variation setting on the MAGV DED page.

7. **Ground Speed (G/S).** Displays the ground speed of the aircraft as output by the INS, in nautical miles per hour (knots).

8. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

9. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

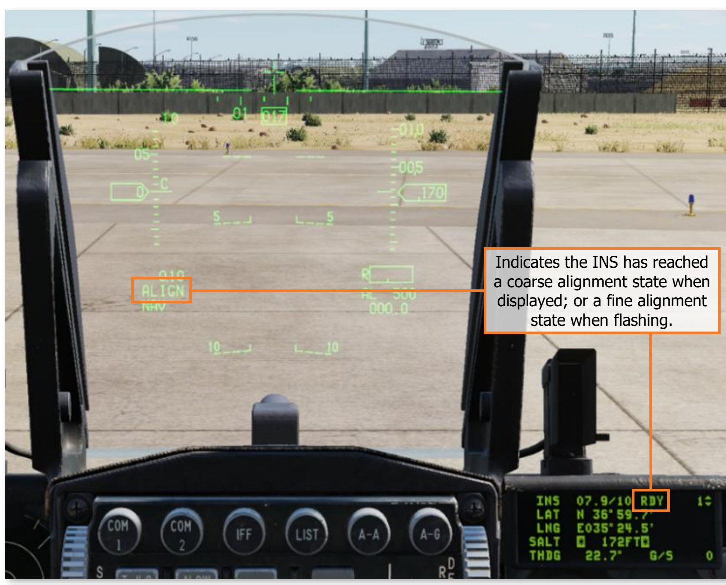
Indications of a Coarse/Fine Alignment

When performing a Normal Gyrocompass Alignment or a Stored Heading Alignment, and a coarse, but usable, alignment state has been attained by the INS, the INS DED page will display "RDY" to the right of the alignment state and the HUD will display "ALIGN" in place of the Maximum G value. These indicate to the pilot that the INS has reached a minimum alignment quality with which navigation may possible.

When performing a Normal Gyrocompass Alignment or a Stored Heading Alignment, and the INS has reached a fully aligned state, "RDY" and "ALIGN" will flash to indicate the alignment is complete.

When performing an In-Flight Alignment, the HUD will display "ALIGN" in place of the Maximum G value when true heading data of the aircraft has been attained by the INS.

If the INS automatically enters AUTO-NAV mode, the INS knob is manually set to the NAV position, or an In-Flight Alignment has reached a fully aligned state, "RDY" and "ALIGN" will be removed from the INS DED page and the HUD, respectively.

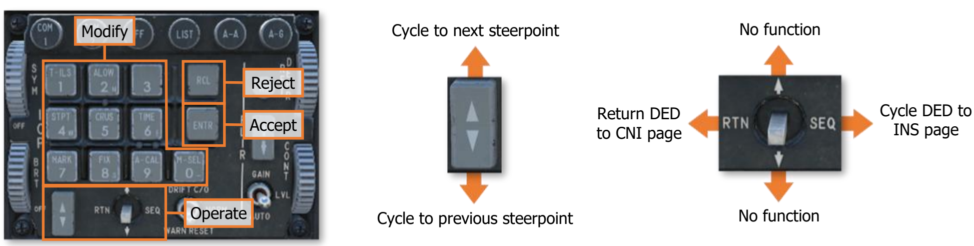


Indications of a Coarse/Fine Alignment

INS INFLT ALGN DED Page

The INS In-Flight Alignment DED page is accessed by pressing the **6/TIME** button on the ICP keypad when the LIST DED page is displayed, and then momentarily setting the ICP DCS switch to the SEQ position. The DED will automatically display this page any time an In-Flight Alignment is initiated by setting the INS knob to the IN FLT ALIGN position on the AVIONICS POWER control panel. This page allows the pilot to manually input the magnetic heading of the aircraft if performing an In-Flight Alignment without GPS-aiding.

During an In-Flight Alignment with GPS-aiding, the aircraft position and altitude data is derived solely from the GPS data. The GPS receiver must be powered and have an unobstructed line-of-sight to the sky to obtain data from multiple GPS satellites (i.e., the aircraft cannot be inside a hanger or hardened aircraft shelter). If GPS data is not available, the FIX NECESSARY message will be displayed to indicate that a Position Fix must be performed to complete the alignment. (See In-Flight Alignment for more information.)



1. **Compass Heading.** Displays the magnetic heading of the aircraft, which may be converted to true heading based on the magnetic variation displayed on the MAGV DED page, to achieve initial heading data for an inflight alignment. May be modified by placing the DED asterisks over the data field, inputting a compass heading without any leading zeros (in degrees magnetic) using the ICP keypad, and pressing ENTR.

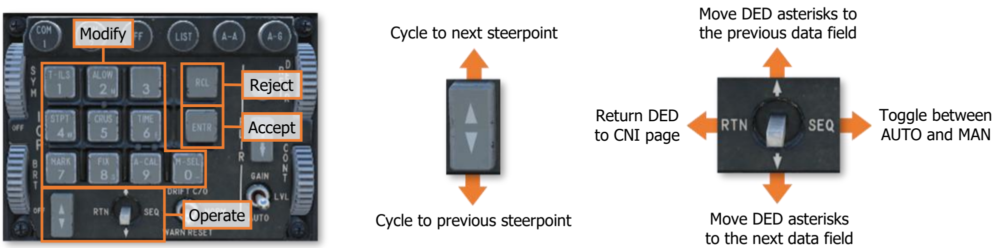
   NOTE: The Magnetic Compass on the Right Auxiliary Console may be used as a magnetic heading reference.

2. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

3. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

MAGV DED Page

The Magnetic Variation DED page is accessed by pressing the **2/ALOW** button on the ICP keypad when the MISC DED page is displayed on the DED. This page displays the magnetic difference between true heading and magnetic heading, which varies globally based on location. The magnetic variation setting may be automatically determined based on a data table stored within the aircraft, or manually input using the ICP.



1. **Magnetic Variation Mode.** Displays the source of magnetic variation data used to convert true heading data from the INS to magnetic heading. May be toggled between AUTO and MAN by momentarily pressing the ICP DCS switch to the SEQ position.
   - **AUTO.** Conversions are performed based on data tables stored within the aircraft memory. The magnetic variation cannot be edited by the pilot but is automatically updated as necessary based on the geographical position of the aircraft.
   - **MAN.** Conversions are performed based on the Magnetic Variation value manually input on this page. The magnetic variation may be edited by the pilot but will not be automatically updated based on the aircraft geographical position.
2. **Magnetic Variation.** Displays the magnetic variation value that is used to convert true heading to magnetic heading. If the Magnetic Variation Mode is set to MAN, may be modified by placing the DED asterisks over the data field, inputting a magnetic variation using the ICP keypad, and pressing ENTR.

   The format for entry includes keypad buttons 4 for West or 6 for East, followed by the variation value itself to the tenth of a degree, with a leading zero if necessary, in one continuous string without the decimal. As an example, a magnetic variation of "E05.5" would be input as "6055", followed by ENTR.
3. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
4. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Normal Gyrocompass Alignment (NORM)

When performing a Normal Gyrocompass Alignment, the current latitude, longitude, and altitude of the aircraft must be input within two minutes after the alignment has been initiated. The true heading is determined automatically.

If any of these data values are accurate in that they already reflect the current latitude, longitude, and/or altitude of the aircraft, they must still be confirmed by setting the DED asterisks around the data field and pressing ENTR on the ICP. If the latitude, longitude, and altitude are not input (or confirmed) within two minutes after the alignment has been initiated, the alignment will fail and will automatically restart.

To complete a Normal Gyrocompass Alignment of the INS, perform the following:

1. INS Knob – **ALIGN NORM**. The DED will automatically display the INS page.

2. ICP Keypad – Input **2** for N (North) or **8** for S (South).

3. ICP **Keypad** – Input Latitude in DD°MM.M' format, which is input as DDMMM in a continuous string of five numbers.

4. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.

5. ICP DCS Switch – **Down** to move DED asterisks around LNG data field.

6. ICP Keypad – Input **6** for E (East) or **4** for W (West).

7. ICP **Keypad** – Input Longitude in DDD°MM.M' format, which is input as DDDMMM in a continuous string of six numbers, to include a leading zero if necessary.

8. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.

9. ICP DCS Switch – **Down** to move DED asterisks around SALT data field.

10. ICP **Keypad** – Input Altitude in feet.

11. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.

The alignment will continue regardless of whether the INS page is displayed on the DED. When the INS alignment status decrements to 62 (typically within 2 minutes or less), "RDY" will be displayed on the INS DED page and "ALIGN" will be displayed in the bottom left corner of the HUD in place of the Maximum G value.

Steps 2 and 3

Steps 6 and 7

Step 10

AUTO-NAV Mode

If a degraded alignment has been attained, and the INS detects any movement of the aircraft, whether it be from taxiing the aircraft or if external stores are being reconfigured by the ground crew, the INS will automatically enter NAV mode internally even if the INS knob is still in the NORM position.

When AUTO-NAV is entered, the following will occur:

- "RDY" is removed from the INS DED page.
- "ALIGN" is removed from the HUD and replaced by the Maximum G value.
- The Time Into Alignment will stop incrementing.
- The Alignment Status will stop decrementing.

NOTE: Even if the INS enters AUTO-NAV, the INS knob must be manually set to the NAV position prior to takeoff.

NARF Mode

If the INS knob is still set to the NORM position after the INS has entered AUTO-NAV mode and the INS no longer detects aircraft motion, the INS will automatically initialize a pseudo-alignment mode called Nav Auto Realign Feature (NARF). When NARF is active, the INU will continue to refine the alignment quality as long as the aircraft is stationary.

When NARF is activated, the following will occur:

- The Time Into Alignment will resume incrementing.
- The Alignment Status will resume decrementing.

Manually Resuming Normal Gyrocompass Alignment

If a degraded alignment has been attained (indicated by "RDY" on the INS DED page and "ALIGN" in the HUD), the alignment may be manually interrupted by rotating the INS knob to the NAV position. This will allow the aircraft to be taxied and/or allow the ground crew to reconfigure the external stores.

When the aircraft is once again truly stationary and/or the ground crew has finished reconfiguring the external stores, rotate the INS knob back to the NORM position to resume the Normal Gyrocompass Alignment.

If the INS entered AUTO-NAV mode and then subsequently entered NARF mode, rotating the INS knob momentarily to the NAV position and then back to NORM will disable NARF and resume the Normal Gyrocompass Alignment.

Accepting the Alignment

When the INS alignment status reaches a state of 10 (typically within 8 minutes), "RDY" will begin to flash on the INS DED page and "ALIGN" will begin to flash in the HUD. This indicates that the alignment is complete.

12. INS Knob – NAV.

Stored Heading Alignment (STOR HDG)

When performing a Stored Heading Alignment, the INS will utilize the previous alignment data stored within the MMC to perform a rapid alignment. This may be useful in the event the aircraft must depart in a hasty manner, but requires a Normal Gyrocompass Alignment to have been completed prior to the aircraft being shut down in its current position.

NOTE: Unlike a Normal Gyrocompass Alignment, the aircraft position *is not* input nor confirmed when the alignment is initiated. However, any movement of the aircraft, to include reconfiguring the external stores, will still incur a degraded or failed alignment.

To complete a Stored Heading Alignment of the INS, perform the following:

1. INS Knob – **ALIGN STOR HDG**. The DED will automatically display the INS page.

The alignment will continue regardless of whether the INS page is displayed on the DED. When the alignment status decrements to 62 (typically within 2 minutes or less), "RDY" will be displayed on the INS DED page and "ALIGN" will be displayed in the bottom left corner of the HUD in place of the Maximum G value.

AUTO-NAV Mode

If a degraded alignment has been attained and the INS detects any movement of the aircraft, whether it be from taxiing the aircraft or if external stores are being reconfigured by the ground crew, the INS will automatically enter NAV mode internally even if the INS knob is still in the STOR HDG position.

When AUTO-NAV is entered, the following will occur:

- "RDY" is removed from the INS DED page.
- "ALIGN" is removed from the HUD and replaced by the Maximum G value.
- The Time Into Alignment will stop incrementing.
- The Alignment Status will stop decrementing.

NOTE: Even if the INS enters AUTO-NAV, the INS knob must be manually set to the NAV position prior to takeoff.

Interrupting Stored Heading Alignment

If a Stored Heading Alignment is interrupted, even after a degraded alignment has been attained, the alignment cannot be resumed, nor can the INU enter Nav Auto Realign Feature (NARF). The aircraft must remain stationary throughout the entire alignment process, otherwise the alignment must be restarted. Alternatively, if GPS signals are available, the degraded alignment may be accepted if an in-flight alignment can be performed after takeoff.

Accepting the Alignment

When the INS alignment status reaches a state of 10 (typically within 90 seconds), "RDY" will begin to flash on the INS DED page and "ALIGN" will begin to flash in the HUD. This indicates that the alignment is complete.

2. INS Knob – NAV.

In-Flight Alignment (IN FLT ALIGN) with GPS-aiding

When performing an In-Flight Alignment with the aid of GPS data, whether in-flight or stationary on the ground, the GPS receiver must be powered and have an unobstructed line-of-sight to the sky to obtain data from multiple GPS satellites (i.e., the aircraft cannot be inside a hanger or hardened aircraft shelter).

(See In-Flight Alignment without GPS-aiding if GPS data is not available.)

NOTE: During the initial stage of an In-Flight Alignment in which the INS inertial platform is being leveled and true heading is being attained, the aircraft must be maintained in a level, unaccelerated flight state, or remain stationary on the ground, to minimize INS degradation.

To complete an In-flight Alignment with the aid of GPS, perform the following:

1. Establish level flight at a constant heading, altitude, and airspeed using backup instruments; or remain stationary on the ground.

2. INS Knob – **IN FLT ALIGN**. The DED will automatically display the INS INFLT ALGN page and "STBY" will be displayed in lower left corner of the HUD in place of the Maximum G value.

When true heading is attained by the INS (typically within 20 seconds), "STBY" will be replaced by "ALIGN" in the lower left corner of the HUD.

3. **(Optional)** ICP DCS Switch – **SEQ** to display the INS page and monitor the alignment status.

The alignment will continue regardless of whether the INS page is displayed on the DED.

Accepting the Alignment

When the INS alignment status reaches a state of 10, "ALIGN" will be replaced by "NAV" in the lower left corner of the HUD. This indicates that the alignment is complete.

4. INS Knob – NAV.

In-Flight Alignment (IN FLT ALIGN) without GPS-aiding

An In-Flight Alignment may be performed without the aid of GPS data. However, the quality of the alignment will be severely degraded. In addition, a recognizable landmark must be near the aircraft's flight path, and saved as a steerpoint within the navigation database, to which a Position Fix may be performed.

(See In-Flight Alignment with GPS-aiding if GPS data is available.)

NOTE: During the initial stage of an In-Flight Alignment in which the INS inertial platform is being leveled and true heading is being attained, the aircraft must be maintained in a level, unaccelerated flight state, or remain stationary on the ground, to minimize INS degradation.

To complete an In-flight Alignment without the aid of GPS, perform the following:

1. Establish level flight at a constant heading, altitude, and airspeed using backup instruments; or remain stationary on the ground.

2. INS Knob – **IN FLT ALIGN**. The DED will automatically display the INS INFLT ALGN page and "STBY" will be displayed in lower left corner of the HUD in place of the Maximum G value.

3. ICP **Keypad** – Input the magnetic heading of the aircraft, without leading zeros (e.g., 045° would be input as "45").

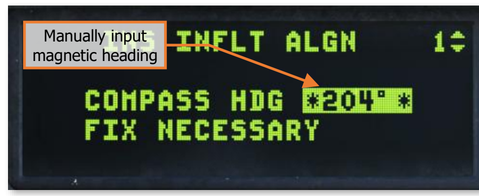
4. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.

When true heading is attained by the INS (typically within 20 seconds), "STBY" will be replaced by "MAN" in the lower left corner of the HUD.

5. ICP DCS Switch – **SEQ** to display the INS page and monitor the alignment status.

6. ICP DCS Switch – **RTN** when the alignment state reaches 75.

7. ICP Keypad – Press **8/FIX**. Perform a position fix using the FCR or TGP to attain position and velocity data. (See Performing a Position Fix for more information.)



Step 3

The alignment will continue regardless of whether the INS page is displayed on the DED.

Accepting the Alignment

When the INS alignment status reaches a state of 10, "MAN" will be replaced by "NAV" in the lower left corner of the HUD. This indicates that the alignment is complete.

8. INS Knob – NAV.

Attitude Mode (ATT)

When operating in Attitude mode, the INS will only provide pitch, roll, and heading information and will not provide navigation data, requiring the pilot to solely rely on TACAN for navigation or even dead reckoning using time/distance/heading calculations. This mode may be used if an immediate takeoff is required that does not permit the INS to attain a coarse alignment, or if the INS position and/or velocity accuracy has degraded to the extent that it is no longer useable for navigation but the attitude and heading data remain valid.

The INS may be set to Attitude mode by setting the INS knob to the ATT position on the AVIONICS POWER control panel. However, the INS will automatically enter ATT mode internally, regardless of the INS knob position, under any of the following conditions.

- A Normal Gyrocompass Alignment or a Stored Heading Alignment is being performed and aircraft motion is detected before a coarse alignment can be attained.
- A Normal Gyrocompass Alignment or a Stored Heading Alignment is being performed and the INS knob is set to the NAV position before a coarse alignment can be attained.
- An In-Flight Alignment is being performed.

When the INS is set to Attitude mode, the EHSI will display a yellow ATT flag but will continue to provide magnetic heading indication. However, the EHSI will only display navigation data provided by TACAN or ILS radio signals; the EHSI will not provide bearing, range, or course deviation information to any steerpoints.

If the EHSI Magnetic Heading Compass is suspected to be misaligned or inaccurate, the compass may be manually adjusted by depressing the HDG knob, and then rotating the knob as required to correct any misalignment.

Attitude-only Alignment Quality

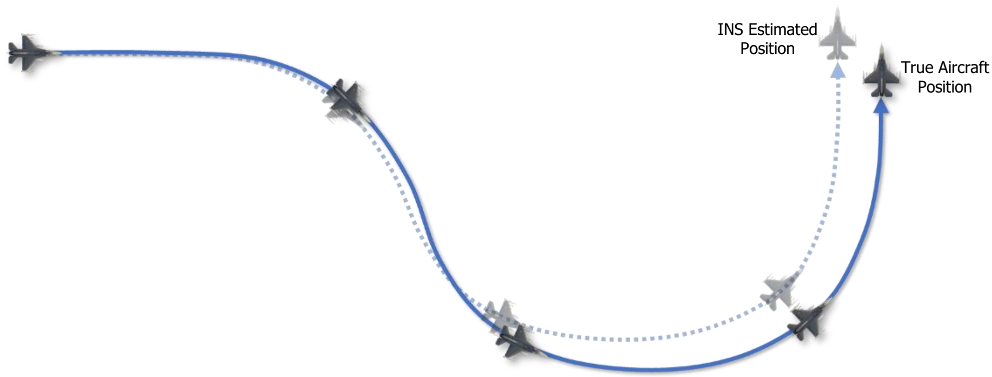
Although Attitude mode does not require the INS attain a coarse alignment, it does require that the INS attain valid heading and attitude data. When performing a ground alignment, this is normally attained within 30 seconds after the alignment has been initialized, when the Alignment State on the INS DED page indicates a value of 90.

If an immediate takeoff is necessary before a coarse alignment can be attained, the INS may be set to Attitude (ATT) Mode after valid heading and attitude data is attained and the alignment status decrements to 90, but the HUD Flight Path Marker (FPM) will not be functional and will remain frozen at the Boresight Cross. In addition, the Pitch Ladder will not provide an indication of sideslip or wind drift, regardless of whether Drift Cut-Out (DRIFT C/O) has been enabled on the Integrated Control Panel (ICP).

The Scales switch on the HUD Control Panel may be set to the VV/VAH position to display the Vertical Velocity scale in the HUD, which provides an indication of a climb or descent in lieu of the FPM.

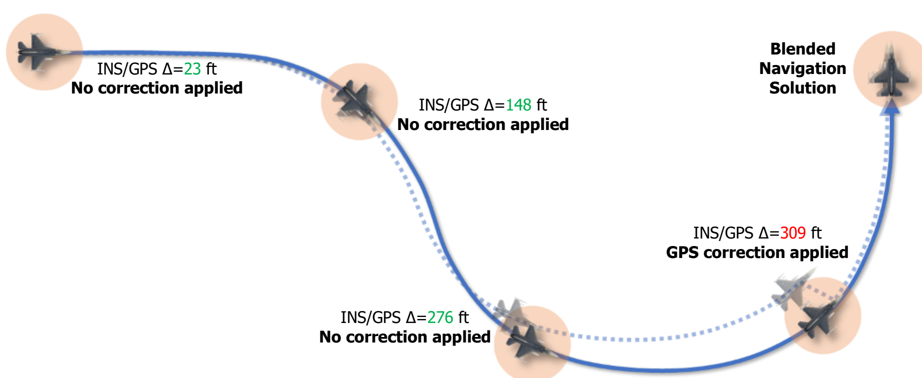
Navigation Solutions

Prior to the introduction of satellite-based navigation such as GPS, military aircraft were reliant on inertial navigation systems (INS) to track and maintain their estimated position anywhere in the world. Based on inertial measurements of attitude, velocity, and acceleration, the position of the aircraft would be continuously and automatically updated without relying on radio-based navigational aids such as TACAN. However, even with the most sophisticated and reliable INS, errors will gradually accumulate from electronic noise within the accelerometers and imperfections in the alignment, leading to "drift" in the estimated position of the aircraft compared to its true physical location. As a mission progresses, this drift may cause significant errors in navigation and targeting as the aircraft's estimated position (referred to as the navigation solution) continues to diverge further from where the aircraft is truly located at any given time.



INS Accumulation of Errors

Using position signals received from Global Positioning System (GPS) satellites in orbit around the Earth, navigation accuracy can be maintained throughout the mission by applying corrections derived from the GPS constellation. The F-16C's Modular Mission Computer (MMC) utilizes the Kalman filter algorithm to mathematically incorporate both the INS and GPS data into a "blended" navigation solution to achieve the stability and autonomy of INS and the precision of GPS. However, such corrections are only applied if the difference, or "delta", between the INS-only and GPS-only solutions exceeds 300 feet (91 meters). If the delta is less than 300 feet, the MMC will not apply any correction and the system navigation solution will remain solely based on the INS-only solution.

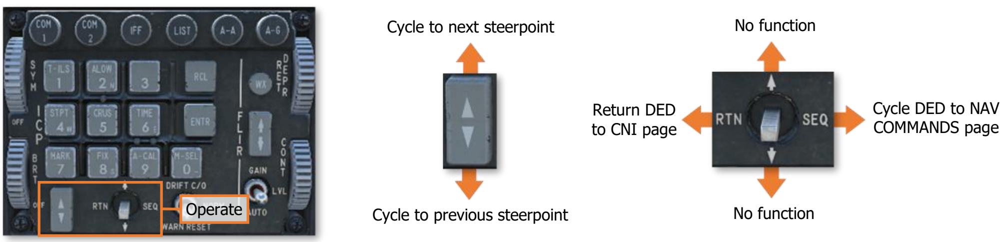


INS/GPS Blended Solution

The estimated accuracy of the navigation system may be viewed on the NAV STATUS DED page, and the MMC Kalman filter may be disabled altogether to utilize an INS-only solution on the NAV COMMANDS DED page.

NAV STATUS DED Page

The Navigation Status DED page is accessed by pressing the **4/STPT** button on the ICP keypad when the LIST DED page is displayed. This page displays the overall accuracy of the navigation system.

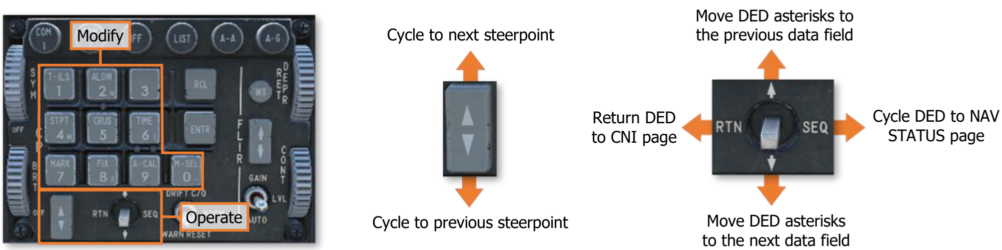


1. **System Accuracy.** Displays the accuracy of the system navigation solution as estimated by the MMC Kalman filter, even if the filter mode is set to INS ONLY on the NAV COMMANDS DED page. Accuracy will not be displayed if a blended navigation solution is unavailable or the GPS receiver is powered off.
   - **HIGH.** The system navigation accuracy is estimated to be <300 feet. A blended solution using GPS-aiding is required to achieve this level of accuracy.
   - **MED.** The system navigation accuracy is estimated to be >300 feet but <6000 feet.
   - **LOW.** The system navigation accuracy is estimated to be >6000 feet.
2. **GPS Accuracy.** Displays an estimate of the GPS-solution accuracy. The status will not be displayed if the GPS receiver is not fully initialized or is powered off.
   - **HIGH.** The onboard GPS receiver is tracking 4 GPS satellites. The estimated horizontal position error of the GPS-solution is <300 feet.
   - **LOW.** The onboard GPS receiver is tracking less than 4 GPS satellites or the estimated horizontal position error of the GPS-solution is >300 feet.
   - **NO TRK.** The onboard GPS receiver is not tracking any GPS satellites.

   NOTE: GPS will only be available if the DCS mission date is 28 March 1994 or later. In addition, GPS precision will be degraded unless USA is one of the countries assigned to the player's coalition within the DCS mission. However, these limitations may be overridden if *both* of the following conditions are true:
   - **Unrestricted SATNAV** is enabled in the player's GAMEPLAY options or is enforced as enabled in the Mission Options for the mission being played.
   - **Unrestricted SATNAV** is not enforced as disabled in the Mission Options for the mission being played.
3. **Mission Duration.** Displays the number of consecutive days that valid GPS keys are required. (N/I)
4. **GPS Key Status.** Displays the validity status of the cryptographic keys loaded within the GPS receiver.
5. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

NAV COMMANDS DED Page

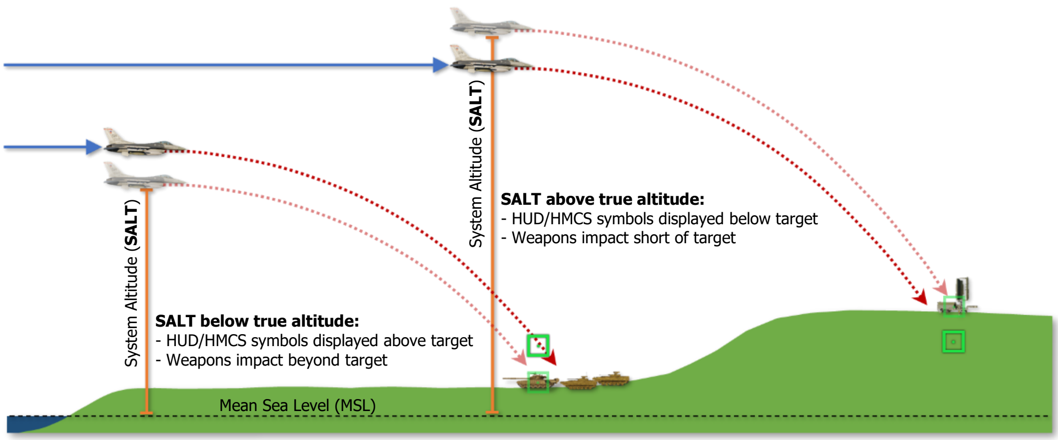
The Navigation Commands DED page is accessed by pressing the **4/STPT** button on the ICP keypad when the LIST DED page is displayed, which displays the NAV STATUS DED page, followed by momentarily pressing the DCS switch to the SEQ position. This page allows the pilot to inhibit GPS data from being used within the system navigation solution or reset the GPS position data altogether, if necessary.



1. **Filter Mode.** Displays the filter mode for deriving the system navigation solution. May be toggled between AUTO and INS ONLY by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field.
    - **AUTO.** When GPS data is available, the MMC will utilize the Kalman filter to combine GPS and INS data to generate a blended navigation solution. The GPS receiver must be powered and have an unobstructed line-of-sight to the sky to obtain data from multiple GPS satellites (i.e., the aircraft cannot be inside a hanger or hardened aircraft shelter).
    - **INS ONLY.** The system navigation solution will only utilize INS data, even if GPS data is available.
2. **Reset GPS.** Resets the GPS receiver, which will restart the satellite acquisition and tracking process. May be commanded by placing the DED asterisks around the data field and pressing the 0/M-SEL button, which will highlight the text within the data field to confirm execution of the command.
3. **Zeroize GPS.** Erases the enhanced precision cryptographic keys loaded into the GPS receiver. GPS-aiding will still be available, but the accuracy of the GPS data will be reduced. May be commanded by placing the DED asterisks around the data field and pressing the 0/M-SEL button, which will highlight the text within the data field to confirm execution of the command.
4. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
5. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

System Altitude (SALT)

As a multirole fighter capable of performing strikes against ground targets, a key aspect of the F-16's Modular Mission Computer (MMC) is accurately determining the aircraft altitude above mean sea level (MSL) when performing weapon delivery calculations. Using the combined values of external air pressure, temperature, and inertial acceleration, and aided by GPS signals and digital terrain data, the MMC generates a "system altitude solution" to accurately display symbology within the HUD and HMCS, provide more precise indications of altitude and vertical velocity, and determine appropriate elevation of sensors and aiming cursors.



System Altitude (SALT)

The MMC system altitude is derived from one of three sources, in ascending order of priority:

- CADC altitude, which utilizes raw pressure data from external air sensors.
- INS-only altitude, which utilizes inertial data from accelerometers within the INS itself combined with CADC-derived altitude data.
- Blended altitude, which utilizes the INS-only altitude combined with vertical position data received from either GPS satellites or from the Digital Terrain System (DTS).

If a blended altitude is not valid or enabled, the MMC will utilize the INS-only altitude as the system altitude. If neither the blended altitude nor the INS-only altitude is valid or enabled, the MMC will utilize the CADC altitude as the system altitude.

The Central Air Data Computer (CADC) provides atmospheric pressure and temperature data for computing true airspeed and air density, which is then combined with vertical acceleration data derived from the Inertial Navigation System (INS). Incorporating inertial acceleration generates a system altitude that is more responsive to changes in vertical velocity and aircraft movement, overcoming the delays that are typically present in an analog system relying solely on detecting changes in the external static air pressure around the aircraft.

If performing a Normal Gyrocompass Alignment of the INS, the INS-only altitude is initialized based on the CADC altitude. Therefore, prior to initiating the INS alignment, it is important that the pilot ensures the Altimeter on the Instrument Panel is set to ELEC operating mode by holding the mode switch to the ELEC position until the PNEU flag is removed, and the Altimeter is calibrated to the airfield elevation by adjusting the barometric setting knob. This ensures the INS-only altitude is accurately initialized to the aircraft altitude above mean sea level (MSL).

However, just as the INS-only navigation solution may accumulate errors over time, the INS-only altitude may "drift", leading to errors in the estimated altitude of the aircraft compared to its true altitude. The accuracy of the system altitude may be automatically updated using data from GPS satellites or the onboard Digital Terrain System (DTS); or, if necessary, the pilot may manually correct errors that have accumulated within the INS-only altitude by performing an Altitude Calibration.

Automatic altitude calibration is enabled by setting the ACAL DED page to the AUTO sub-mode. When ACAL is set to AUTO, the MMC will generate a "blended" system altitude using either GPS or DTS data to overcome variations in atmospheric air pressure during the mission and accumulated errors within the INS-only altitude.

Unlike the blended navigation solution, which is generated by the MMC by applying GPS-derived corrections through the Kalman filter when the delta between the INS-only and GPS-only solutions exceeds 300 feet, the MMC generates the blended system altitude solution by applying GPS- or DTS-derived corrections continuously without the Kalman filter. However, corrections are only applied when the vertical position accuracy of the GPS and/or DTS are within the specified thresholds for the selected master mode, as specified below.

The AUTO ACAL DED page allows the pilot to select which source of data (GPS, DTS, or both) is used by the MMC to generate the blended system altitude, provided the following criteria are met.

- **AUTO ACAL – GPS.** The vertical position accuracy of the onboard GPS receiver must be within the thresholds for the corresponding master modes:
  - A-G master mode: <50 feet.
  - All other master modes: <100 feet.
- **AUTO ACAL – BOTH.** The vertical position accuracy of the onboard GPS receiver and the DTS Terrain Referenced Navigation must be within the thresholds for the corresponding master modes:
  - A-G master mode: <50 feet (GPS); <20 feet (DTS).
  - All other master modes: <100 feet (GPS); <100 feet (DTS).
- **AUTO ACAL – DTS.** The vertical position accuracy of the DTS Terrain Referenced Navigation must be within the thresholds for the corresponding master modes:
  - A-G master mode: <20 feet.
  - All other master modes: <100 feet.

When AUTO ACAL is set to BOTH, only one source of data may be used to generate the blended system altitude. The MMC will automatically select the sensor that is providing the most accurate data, provided the vertical position accuracy for the corresponding sensor(s) are within the appropriate thresholds.

If the blended system altitude cannot be generated, whether it be due to the GPS and/or DTS data exceeding the corresponding thresholds or they have become invalid or unavailable, the system altitude will revert to the INS-only altitude until valid GPS and/or DTS data is restored. If the INS-only altitude becomes invalid or unavailable, whether that be due to the INS being powered off, not aligned, or the INS has malfunctioned or failed in some manner, the system altitude will revert to CADC altitude.

Automatic altitude calibration may be disabled by setting the ACAL DED page to the MAN sub-mode. When ACAL is set to MAN, the blended system altitude solution is disabled and the MMC system altitude will revert to the INS-only altitude.

(See Navigation Update via Altitude Calibration for more information regarding manual altitude calibration.)

Digital Terrain System (DTS)

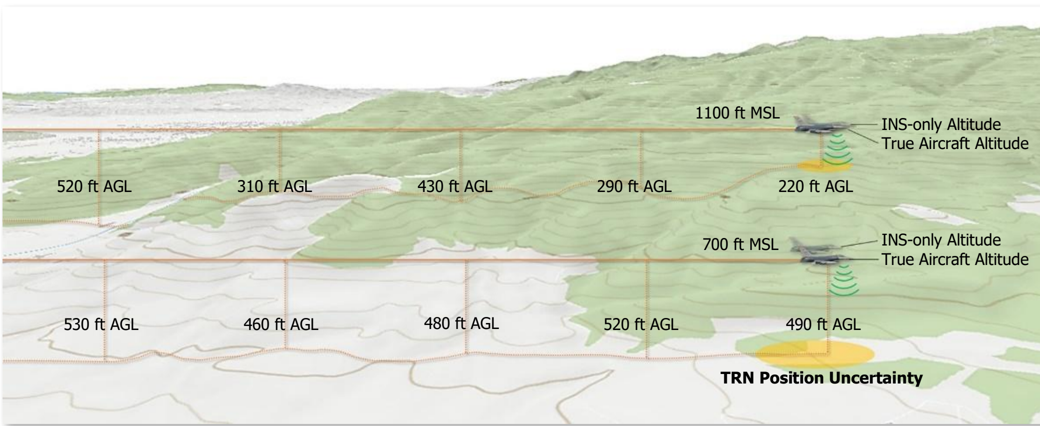
The Digital Terrain System is a software component of the F-16C's onboard avionics that uses Digital Terrain Elevation Data (DTED) stored within the aircraft memory to provide accurate navigation and altitude solutions independently of other aircraft sensors such as the FCR or GPS. When DTED data is loaded into the onboard memory through the Data Transfer Cartridge (DTC), DTS creates a Digital Flight Map (DFM) of the mission area, representing a 3-dimensional terrain model that can be utilized for navigation and weapon delivery functions.

With regards to navigation, the DTS can utilize the radar altimeter to "track" the aircraft position over the DFM using a function known as Terrain Referenced Navigation (TRN). By measuring the changes in terrain elevation below the aircraft during flight, the TRN process generates a profile of the terrain below the aircraft and then correlates that terrain profile with the 3-dimensional terrain model of the DFM. The TRN-estimated position and altitude of the aircraft is then compared to the INS to determine if there are any errors. The TRN process is fully automatic and does not require pilot input; however, the DTS requires an INS alignment for TRN to function.

In addition to valid INS data, TRN requires ground speeds between approximately 150 and 640 knots to reliably function. If the INS is powered off, is not aligned, or has malfunctioned or failed in some manner, or if the ground speed is outside usable thresholds, TRN will be disabled. The status and accuracy of TRN is continuously assessed by the DTS software, which provides separate indications of the estimated horizontal and vertical accuracy of TRN on the AUTO ACAL DED page. The accuracy of TRN is dependent on the factors specified below.

- The accuracy and resolution of the DFM, which is dependent on accurate DTED data stored on the DTC.
- The accuracy of the Combined Altitude Radar Altimeter (CARA), which is limited to 50,000 feet above the surface and pitch/roll attitudes of ±60° below 3000 feet. Above 3000 feet, the attitude limits may be less.
- The characteristics of the terrain over which the aircraft is flying.

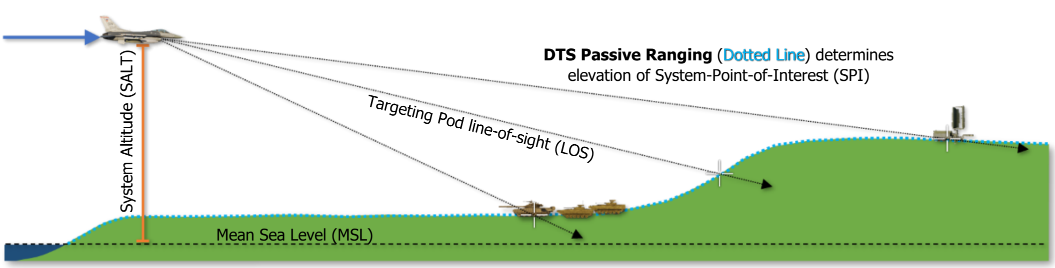
If the aircraft is flying over mountains or rolling hills with sufficient variations in elevation, TRN will generate a terrain profile that can be accurately correlated to a unique location on the DFM, reducing the position uncertainty of TRN (Shaded Area) and increasing the accuracy of any DTS-derived corrections to the blended system altitude.



DTS Terrain Referenced Navigation

If the aircraft is flying over relatively flat terrain with minimal variations in elevation, such as open plains, non-mountainous deserts, large plateaus, basins, or bodies of water, TRN will be unable to generate a terrain profile that can be correlated to a unique location on the DFM. Alternatively, if flying over extremely rugged terrain that generates *too much* variation in the measurements supplied by the radar altimeter, TRN may be unable to accurately correlate the terrain profile to any location on the DFM.

With regards to targeting and weapons delivery, if TRN is tracking the aircraft position on the DFM, DTS can be used as a passive ranging sensor to determine the elevation of the System-Point-of-Interest (SPI) independently of other aircraft sensors such as FCR Air-to-Ground Ranging (AGR) or the TGP laser rangefinder/designator.



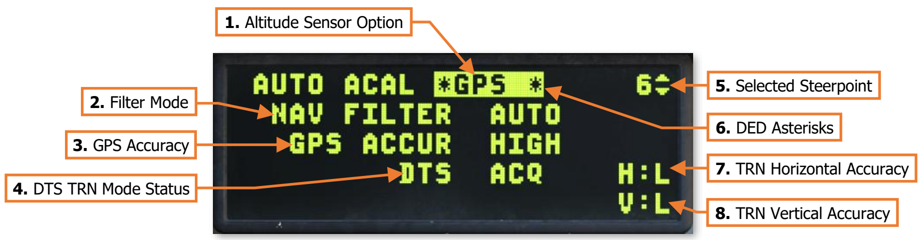
DTS Passive Ranging (PR)

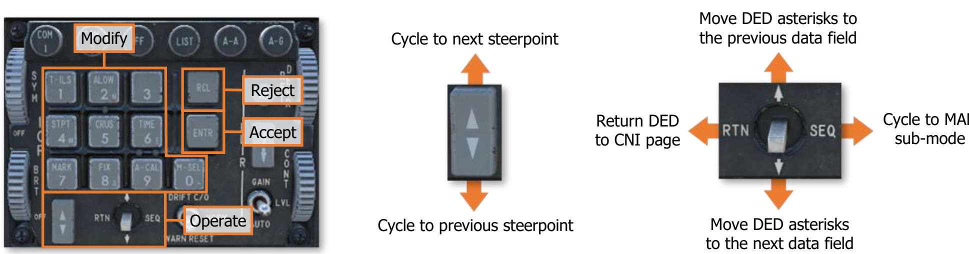
AUTO ACAL DED Page

The Altitude Calibration DED page is accessed by pressing the **9/A-CAL** button on the ICP keypad when the CNI DED page is displayed. The AUTO ACAL DED page allows the pilot to select the sensor(s) that are used to automatically correct vertical errors within the INS-only altitude and displays the status and overall accuracy of the Digital Terrain System (DTS). When the AUTO ACAL sub-mode is selected, the MMC will utilize the Kalman filter to combine GPS or DTS data with the INS-only altitude to generate a blended system altitude (SALT).

NOTE: The AUTO ACAL page is the default ACAL sub-mode. However, MAN ACAL sub-mode may be selected, if necessary. If the MAN ACAL sub-mode is displayed, AUTO ACAL sub-mode may be selected by placing the DED asterisks over the MAN data field and pressing any ICP keypad button 1-9.

(See MAN ACAL DED page for more information.)





1. **Altitude Sensor Option.** Displays the sensor that is being used to generate the blended system altitude. May be cycled between GPS, BOTH, and DTS by pressing any ICP keypad button 1-9. If the data field is not highlighted, the currently selected sensor is not available to generate the blended system altitude (e.g., if the GPS receiver is not powered or is not tracking any satellites, "GPS" won't be highlighted)
    - **GPS.** When GPS data is available, the MMC will combine GPS data with the INS-only altitude to generate a blended system altitude.
    - **BOTH.** The MMC will combine GPS or DTS data with the INS-only altitude to generate a blended system altitude. The MMC will automatically select GPS or DTS data, based on the sensor that is providing the most accurate data.
    - **DTS.** When DTS data is available and DTS TRN is in Track mode, the MMC will combine DTS data with the INS-only altitude to generate a blended system altitude.
2. **Filter Mode.** Displays the filter mode for deriving the system navigation solution. May be toggled between AUTO and INS ONLY on the NAV COMMANDS DED page.
    - **AUTO.** When GPS data is available, the MMC will utilize the Kalman filter to combine GPS and INS data to generate a blended navigation solution.
    - **INS ONLY.** The system navigation solution will only utilize INS data, even if GPS data is available.

3. **GPS Accuracy.** Displays an overall estimate of the GPS-solution accuracy. The status will not be displayed if the GPS is not fully initialized or is powered off.

   - **HIGH.** The onboard GPS receiver is tracking 4 GPS satellites. The estimated horizontal position error of the GPS-solution is <300 feet.
   - **LOW.** The onboard GPS receiver is tracking less than 4 GPS satellites or the estimated horizontal position error of the GPS-solution is >300 feet.
   - **NO TRK.** The onboard GPS receiver is not tracking any GPS satellites.

   NOTE: GPS will only be available if the DCS mission date is 28 March 1994 or later. In addition, GPS precision will be degraded unless USA is one of the countries assigned to the player's coalition within the DCS mission. However, these limitations may be overridden if *both* of the following conditions are true:

   - **Unrestricted SATNAV** is enabled in the player's GAMEPLAY options or is enforced as enabled in the Mission Options for the mission being played.
   - **Unrestricted SATNAV** is not enforced as disabled in the Mission Options for the mission being played.

4. **DTS TRN Mode Status.** Displays the operating mode of the Terrain Referenced Navigation (TRN) function of the Digital Terrain System (DTS).

   - **ACQ.** DTS TRN is in Acquisition mode. The DTS uses the INS navigation solution and the radar altimeter (CARA) to create a profile of the terrain below the aircraft. The terrain profile is compared to Digital Flight Map (DFM) stored within the onboard memory in an attempt to locate the aircraft's position.
   - **TRK.** DTS TRN is in Track mode. The DTS has successfully located the aircraft's position over the Digital Flight Map (DFM) stored within the onboard memory.

5. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

7. **TRN Horizontal Accuracy.** Displays an estimate of the horizontal position accuracy of the Terrain Referenced Navigation (TRN) function of the Digital Terrain System (DTS).

   - **High (H).** The estimated horizontal position error of DTS is <395 feet.
   - **Medium (M).** The estimated horizontal position error of DTS is 395-655 feet.
   - **Low (L).** The estimated horizontal position error of DTS is >655 feet.

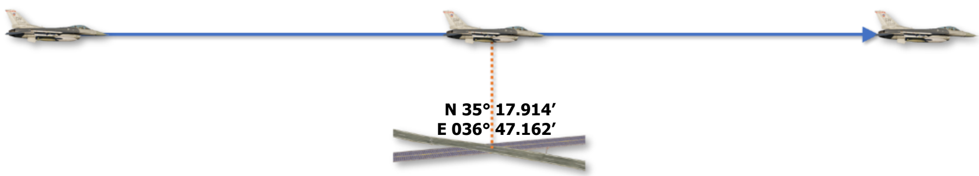
8. **TRN Vertical Accuracy.** Displays an estimate of the vertical position accuracy of the Terrain Referenced Navigation (TRN) function of the Digital Terrain System (DTS).

   - **High (H).** The estimated vertical position error of DTS is <21 feet.
   - **Medium (M).** The estimated vertical position error of DTS is 21-40 feet.
   - **Low (L).** The estimated vertical position error of DTS is >40 feet.

Navigation Updates

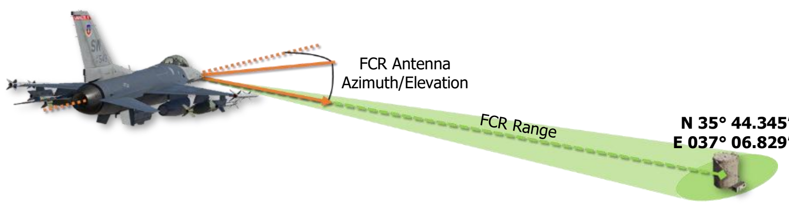
Although the onboard INS utilizes GPS-aiding to maintain navigation accuracy throughout the mission, the F-16C retains the ability to accept manual updates to the INS-only solution in the event the blended solution becomes invalid, or GPS signals are unavailable or unreliable. Under these circumstances, the F-16C will be solely reliant on the INS and may need to periodically obtain a position "fix" to correct horizontal errors within the INS-only solution or perform an altitude calibration to correct vertical errors within the INS-only solution.

Several methods may be used while in flight to update an aircraft's position to mitigate accumulated errors within the INS which is especially crucial for long-distance or long-duration flights. These methods may include simply overflying a recognizable landmark (such as rail line crossing a paved road along the planned flight route), of which the precise coordinates are known, and timing the position update as the aircraft passes over the location.



Navigation update by direct overflight

Other methods may utilize the onboard sensors such as the fire control radar (FCR) to locate and range known landmarks to obtain the aircraft's relative position from the landmark in lieu of performing a direct overflight.



Navigation update by sensor track

However, if it is not feasible to perform a navigation update, which may be the case just prior to arriving over the intended target or if performing low-level flight in an area devoid of any useable landmarks, or if a small aiming correction is required to ensure weapon release calculations are accurate, a temporary correction may be applied by "slewing" the Navigation cursor. In this case, the INS-only solution is not updated, but navigation steering and weapon release calculations are adjusted to account for small inaccuracies in the system navigation solution. The difference between performing a cursor slew correction compared to performing an actual update to the navigation system by fix-taking is described on the following pages.

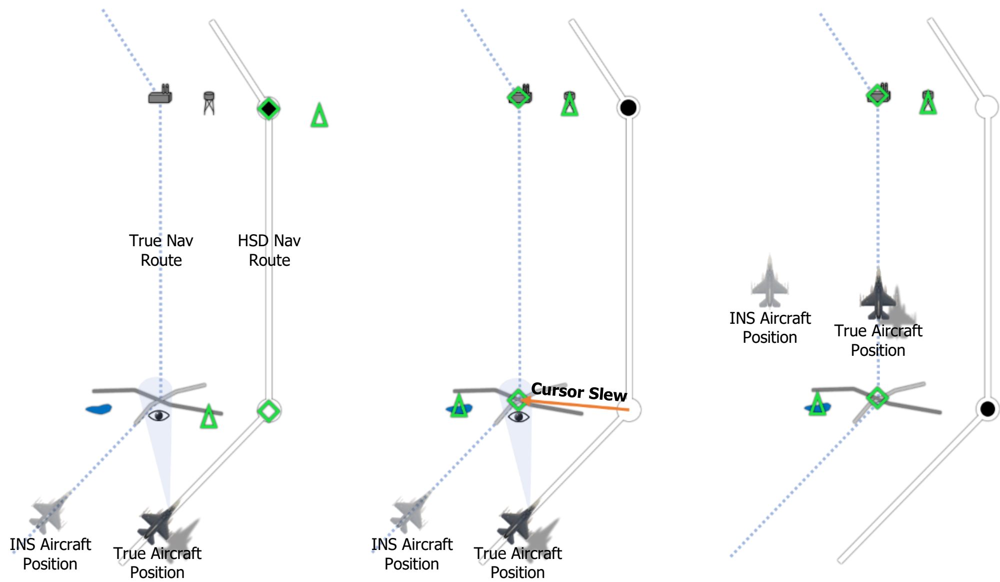
If the SYS ACCUR data field is displayed as HIGH on the NAV STATUS DED page, position fix-taking and altitude calibrations are not necessary since the accuracy of the system navigation solution already exceeds the precision that can normally be obtained from a manual update to the INS. When utilizing the Kalman filter to generate a blended navigation solution, the MMC will continuously apply corrections derived from GPS data to improve system navigation accuracy if the delta between the INS-only solution and the GPS-only solution exceeds 300 feet (91 meters). If the INS-only solution is updated by performing a position fix or altitude calibration in a manner that incurs a delta of 300 feet or more from the GPS-only solution, the MMC Kalman filter algorithm will gradually remove the update over a period of time until the SYS ACCUR status is returned to HIGH.

GPS-aiding will typically ensure a system navigation solution with less than 300 feet of error; however, slight misalignments in the HUD/HMCS symbology or sensor aiming precision may be noticeable. Although errors up to 300 feet may still occur, these are typically rare and intermittent as the MMC Kalman filter continuously refines and updates the blended navigation solution during the mission.

Navigation Correction via Cursor Slew

In the figure below on the left, the aircraft is proceeding along the planned navigation route and appears to be on course. However, while approaching the next steerpoint, the pilot visually observes the Diamond symbol that marks the steerpoint location is offset from the physical landmark that corresponds with the true steerpoint location, in this case a rail line crossing a paved road. The INS solution estimates that the aircraft is located along the intended navigation route, but sufficient errors have accumulated within the INS to the extent the aircraft has drifted noticeably off course.

In the figure below in the center, the pilot sets the FCR to Ground Map (GM) mode, assigns the FCR MFD format as the Sensor-Of-Interest (SOI), and uses the RDR CURSOR/ENABLE switch on the throttle grip to slew the Navigation cursor until the Diamond symbol is aligned with the railroad crossing. To verify the railroad crossing is the correct landmark, which should be near a small lake that has been planned as an offset aimpoint, the pilot cycles the sighting point to OA1, and an Offset Aimpoint triangle symbol appears aligned over the small lake nearby, thus confirming the Diamond symbol is aligned to the correct location.



Navigation Cursor Corrections

In the figure above on the right, the pilot proceeds on course to the next steerpoint without performing an update to the navigation solution. Since the navigation solution was not updated, the INS estimates that the aircraft is now off course, which will appear as a deviation from the navigation route on the HSD MFD format. However, despite the indicated course deviation, the manual correction that has been applied to the symbology by slewing the Navigation cursor accounts for the drift of the INS navigation solution, thus ensuring the Diamond symbol is aligned with the true location of the next steerpoint, which corresponds with a factory building.

Applying a cursor correction also affects the calculated trajectory and weapon release points for the selected munition if a "pre-planned" weapon delivery sub-mode is being employed. If the factory was the intended target, the manual correction applied by the cursor slew would provide accurate steering symbology and weapon release cues to the true location of the target. As before, if an offset aimpoint has been planned for the selected steerpoint, the pilot may cycle the sighting point to OA1 or OA2 as necessary to confirm the Offset Aimpoint symbol is properly aligned with the corresponding physical landmark that is visually identified through the HUD or HMCS. (See Sighting Points and Cursor Slews in the Tactical Employment chapter for more information.)

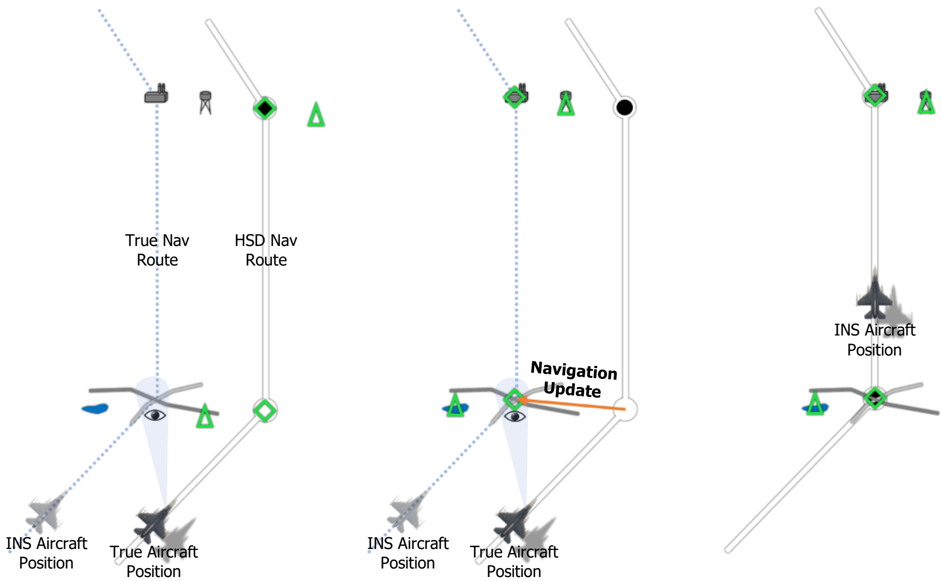
However, the pilot may remove the accumulated cursor slews that have been applied to the Navigation cursor using the Cursor Zero (CZ) function, restoring the symbology to the current INS navigation solution, if necessary.

Navigation Update via Position Fix

In the figure below on the left, the aircraft is proceeding along the planned navigation route and appears to be on course. However, while approaching the next steerpoint, the pilot visually observes the Diamond symbol that marks the steerpoint location is offset from the physical landmark that corresponds with the true steerpoint location, in this case a rail line crossing a paved road. The INS solution estimates that the aircraft is located along the intended navigation route, but sufficient errors have accumulated within the INS to the extent the aircraft has drifted noticeably off course.

In the figure below in the center, the pilot presses the **8/FIX** button on the ICP keypad when the CNI page is displayed on the DED in preparation for performing a position fix and sets the sensor option on the FIX DED page to "HUD". The pilot uses the RDR CURSOR/ENABLE switch on the throttle grip to slew the Navigation cursor until the Diamond symbol within the HUD is aligned with the railroad crossing.

NOTE: Offset aimpoints cannot be selected when performing a position fix or altitude calibration, but are shown in the figure below to illustrate how their alignment would be affected by a navigation solution update.



Navigation Solution Update

In the figure above on the right, the pilot accepts the position fix by pressing the **ENTR** button on the ICP keypad, which applies the cursor delta to the INS navigation solution, and then proceeds on course to the next steerpoint. Since the navigation solution is now updated to correct the position error that had accumulated within the INS, the INS solution now accurately reflects the true position of the aircraft. The INS will now indicate the aircraft is on course toward the selected steerpoint with no deviation from the navigation route on the HSD MFD format, and the Diamond symbol is aligned with the true location of the next steerpoint, which corresponds with a factory building.

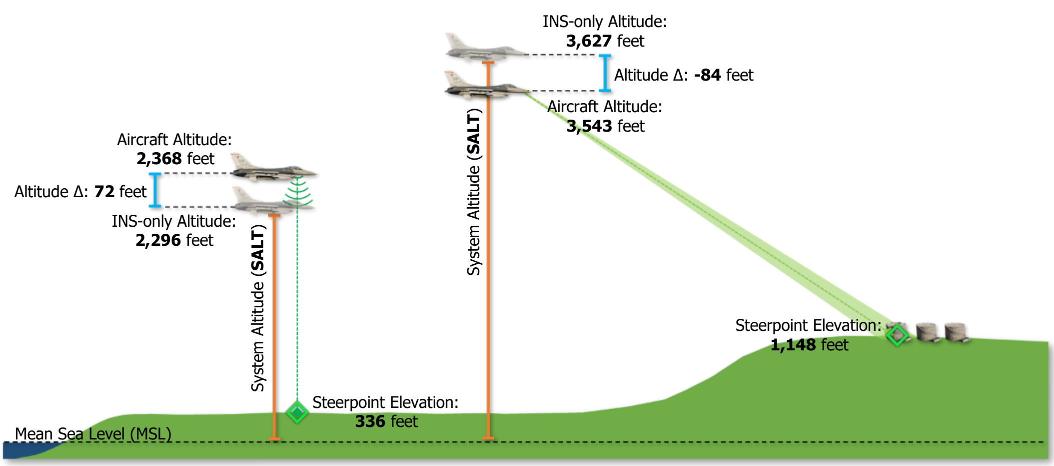
Alternatively, the pilot may elect to use the "OFLY" option to update the navigation solution by directly overflying the rail line crossing. When given adequate line-of-sight and a radar-reflective object to identify on the fire control radar (FCR) in Ground Map (GM) mode, the pilot may elect to use the FCR to update the navigation solution; or the targeting pod may be used to identify a landmark from high altitude when updating the navigation solution.

Navigation Update via Altitude Calibration

If a blended system altitude cannot be generated from GPS or DTS data, or if the ACAL DED page is set to MAN sub-mode, the MMC system altitude will revert to the INS-only altitude. Under these circumstances, it may be necessary to update the system altitude during the mission by performing an altitude calibration to manually correct errors that have accumulated within the INS-only altitude. Several methods may be used while in flight to update the INS-only altitude, which include simply overflying a steerpoint, of which the precise elevation is known, and using the radar altimeter to perform an altitude calibration as the aircraft passes overhead. Other methods may utilize onboard sensors such as the fire control radar (FCR) or targeting pod (TGP) to locate and range known landmarks to obtain the aircraft's altitude relative to the landmark's elevation in lieu of performing a direct overflight.

In the figure below on the left, the pilot presses the **9/A-CAL** button on the ICP keypad when the CNI page is displayed on the DED in preparation for performing a manual altitude calibration and sets the sensor option on the MAN ACAL DED page to "RALT". The pilot maneuvers the aircraft to directly overfly the steerpoint, and presses TMS Forward when the aircraft is directly overhead the steerpoint location to freeze the altitude delta as measured by the radar altimeter.

When directly overhead the steerpoint, the INS-only altitude was 2,296 feet above mean sea level (MSL), which would equate to 1,960 feet above ground level (AGL), assuming the steerpoint elevation was accurate. However, the radar altimeter measurement of the aircraft altitude was 2,032 feet AGL, which produced a delta of 72 feet. When the pilot presses the **ENTR** button on the ICP keypad, the delta of 72 feet is used to update the INS-only altitude to 2,368 feet MSL, reflecting the true aircraft altitude above mean sea level.



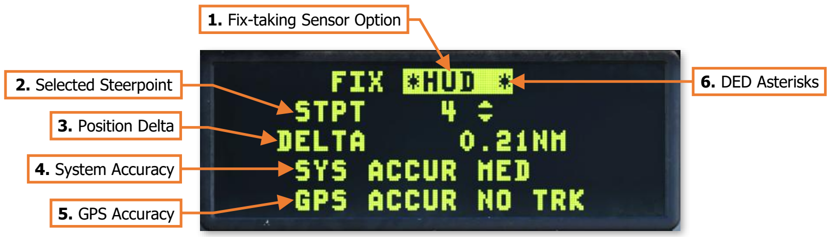
Manual Altitude Calibration

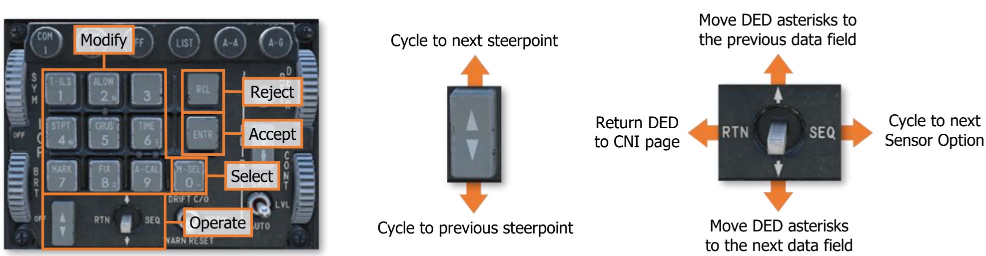
In the figure above on the right, the pilot presses the **9/A-CAL** button on the ICP keypad when the CNI page is displayed on the DED in preparation for performing a manual altitude calibration and sets the sensor option on the MAN ACAL DED page to "FCR". The pilot then sets the FCR to Ground Map (GM) mode, assigns the FCR MFD format as the Sensor-Of-Interest (SOI), uses the RDR CURSOR/ENABLE switch on the throttle grip to slew the Navigation cursor until the FCR crosshairs on the FCR MFD format are directly over the radar-reflective object at the steerpoint location, and presses TMS Forward to enter Fixed Target Track (FTT) and freeze the altitude delta as measured by the FCR.

When the FCR entered FTT and the altitude delta was frozen, the INS-only altitude was 3,627 feet MSL, which would equate to 2,476 feet AGL, assuming the steerpoint elevation was accurate. However, based on the FCR track and associated calculations, the aircraft altitude was 2,395 feet AGL, which produced a delta of -84 feet. When the pilot presses the **ENTR** button on the ICP keypad, the delta of -84 feet is used to update the INS-only altitude to 3,543 feet MSL, reflecting the true aircraft altitude above sea level.

FIX DED Page

The Fix DED page is accessed by pressing the **8/FIX** button on the ICP keypad when the CNI page is displayed on the DED. This page allows the pilot to correct horizontal errors within the INS-only navigation solution using one of several methods. The page may only be accessed when the master mode is set to NAV.





1. **Fix-taking Sensor Option.** Displays the sensor that will be used to obtain a position fix of the selected steerpoint location. The next available option may be selected by momentarily positioning the DCS ("Dobber" switch) to the SEQ position. If the data field is not highlighted, the selected sensor is not available to obtain a position fix (e.g., if a targeting pod is not installed and powered, "TGP" won't be highlighted).

   - **HUD.** The HUD Diamond symbol may be slewed to the selected steerpoint location to obtain a position fix. (See Performing a Position Fix using HUD for more information.)
   - **FCR.** The fire control radar will be used to obtain a position fix on the selected steerpoint location when set to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes on the FCR MFD format. (See Performing a Position Fix using FCR for more information.)
   - **TGP.** The targeting pod will be used to obtain a position fix on the selected steerpoint location when set to Air-to-Ground (A-G) mode on the TGP MFD format. (See Performing a Position Fix using TGP for more information.)

     NOTE: Although it is not required to fire the TGP's laser designator/ranger when performing a position fix, it will increase the accuracy of the delta, particularly when at low altitude and/or shallow look-down angles.
   - **OFLY.** The aircraft position itself will be used to obtain a position fix using a direct overflight of the selected steerpoint location. (See Performing a Position Fix using OFLY for more information.)

2. **Selected Steerpoint.** Displays the selected steerpoint that is being used as a reference location for obtaining a position fix. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint. The selected steerpoint can also be changed by placing the DED asterisks over the data field and input the steerpoint number using the ICP keypad and then pressing ENTR.

3. **Position Delta.** Displays the difference, or "delta", between the current INS-only navigation solution, referenced to the selected steerpoint location, and the selected fix-taking sensor, in nautical miles (NM). For reference, 0.05 NM = 300 feet (91 meters).

4. **System Accuracy.** Displays an overall estimate of the system navigation accuracy, which will be derived from either a blended solution or an INS-only solution, depending on the filter mode setting on the NAV COMMANDS DED page. The status will not be displayed if a system navigation solution is unavailable.

    - **HIGH.** The system navigation accuracy is estimated to be <300 feet. A blended solution using GPS-aiding is required to achieve this level of accuracy. A position fix is neither required nor recommended.
    - **MED.** The system navigation accuracy is estimated to be >300 feet but <6000 feet. A position fix may be performed if feasible to improve system accuracy.
    - **LOW.** The system navigation accuracy is estimated to be >6000 feet. A position fix should be performed when able to improve system accuracy.

5. **GPS Accuracy.** Displays an overall estimate of the GPS-solution accuracy. The status will not be displayed if the GPS is not fully initialized or is powered off.

    - **HIGH.** The onboard GPS receiver is tracking 4 GPS satellites. The estimated horizontal position error of the GPS-solution is <300 feet.
    - **LOW.** The onboard GPS receiver is tracking less than 4 GPS satellites or the estimated horizontal position error of the GPS-solution is >300 feet.
    - **NO TRK.** The onboard GPS receiver is not tracking any GPS satellites.

    NOTE: GPS will only be available if the DCS mission date is 28 March 1994 or later. In addition, GPS precision will be degraded unless USA is one of the countries assigned to the player's coalition within the DCS mission. However, these limitations may be overridden if *both* of the following conditions are true:

    - **Unrestricted SATNAV** is enabled in the player's GAMEPLAY options or is enforced as enabled in the Mission Options for the mission being played.
    - **Unrestricted SATNAV** is not enforced as disabled in the Mission Options for the mission being played.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Performing a Position Fix using HUD

The Diamond symbol may be slewed within the HUD field-of-view to obtain a position fix of the selected steerpoint location when the "HUD" sensor option is selected on the FIX DED page.

NOTE: If the HUD Diamond symbol is being used to perform a position fix, accuracy will be hindered when performed at low-altitudes or under conditions in which the selected steerpoint location is closer to the horizon, due to the linear perspective. Steeper look-down angles will provide better conditions to adequately ascertain whether the Diamond symbol is properly aligned over the selected steerpoint location.

To perform a position fix using the HUD Diamond symbol, perform the following:

1. ICP Keypad – Press **8/FIX**.

2. ICP DCS Switch – **SEQ** to select HUD in the sensor option data field.

3. DMS Forward-Short – Press to select the HUD as SOI.

4. RDR CURSOR/ENABLE switch (Throttle) – Slew the Diamond symbol to the correct location within the HUD field-of-view that corresponds with the selected steerpoint.

5. ICP Keypad – **ENTR** to accept the position delta and update the INS position.

NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta.

Performing a Position Fix using FCR

The FCR may be used to obtain a position fix of the selected steerpoint location when set to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes on the FCR MFD format, in Fixed Target Track (FTT) or Moving Target Track (MTT), and the "FCR" sensor option is selected on the FIX DED page.

To perform a position fix using the FCR, perform the following:

1. ICP Keypad – Press **8/FIX**.

2. ICP DCS Switch – **SEQ** to select FCR in the sensor option data field.

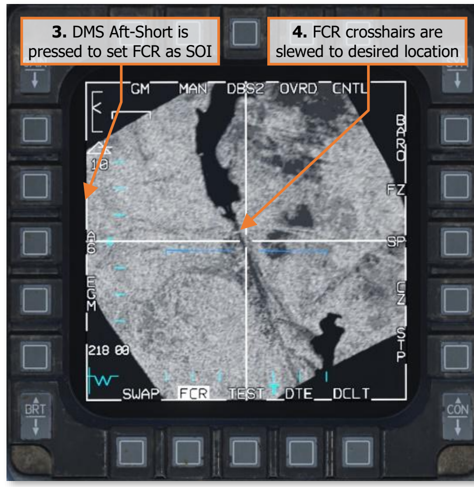
3. DMS Aft-Short – Press as necessary to select the FCR as SOI on the applicable MFD.

4. RDR CURSOR/ENABLE switch (Throttle) – Slew the FCR crosshairs to the correct location that corresponds with the selected steerpoint.

5. TMS Forward-Short (Stick) – Press to switch the FCR to Fixed Target Track (FTT).

6. ICP Keypad – **ENTR** to accept the position delta and update the INS position.

NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta.



Performing a Position Fix using TGP

The TGP may be used to obtain a position fix of the selected steerpoint location when set to Air-to-Ground (A-G) mode on the TGP MFD format, in AREA or POINT track modes, and the "TGP" sensor option is selected on the FIX DED page.

To perform a position fix using the TGP, perform the following:

1. ICP Keypad – Press **8/FIX**.

2. ICP DCS Switch – **SEQ** to select TGP in the sensor option data field.

3. DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.

4. RDR CURSOR/ENABLE switch (Throttle) – Slew the TGP line-of-sight crosshairs to the correct location that corresponds with the selected steerpoint.

5. TMS Right-Short (Stick) – Press to switch the TGP to AREA track.

6. **(Optional)** LASER ARM Switch (MISC panel) – Set to **LASER ARM** position, if necessary.

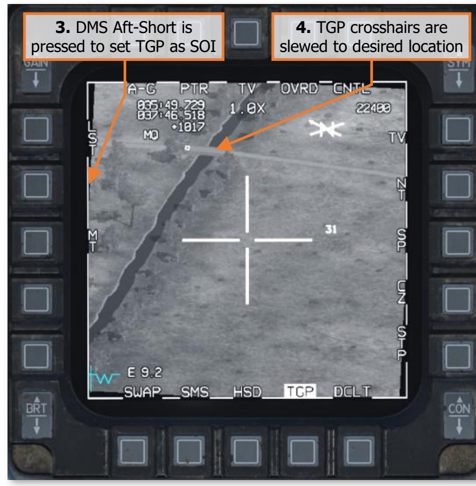
7. **(Optional)** Trigger (Stick) – Pull and hold to gain accurate range data.

NOTE: Although it is not required to fire the TGP's laser designator/ranger, it will increase the accuracy of the delta, particularly when at low altitude and/or shallow look-down angles.

8. ICP Keypad – **ENTR** to accept the position delta and update the INS position.

NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta.

9. Trigger (Stick) – Release.



Performing a Position Fix using OFLY

A position fix may be obtained by directly overflying the selected steerpoint location when the "OFLY" sensor option is selected on the FIX DED page. However, it is worth noting that a direct overflight is the least accurate method of obtaining a position fix, particularly at higher speeds and/or altitudes, due to needing to freeze the position delta precisely as the aircraft passes over the selected steerpoint location.

NOTE: If OFLY is displayed in the sensor option data field on the FIX DED page, TMS Forward-Short will designate the aircraft position as the selected steerpoint location regardless of the selected SOI.

To perform a position fix using a direct overflight of the selected steerpoint location, perform the following:

1. ICP Keypad – Press **8/FIX**.
2. ICP DCS Switch – **SEQ** to select OFLY in the sensor option data field.
3. Maneuver the aircraft as necessary to ensure the flight path will take it over location that corresponds with the selected steerpoint.
4. TMS Forward-Short (Stick) – Press to freeze the position delta when directly overhead the correct location that corresponds with the selected steerpoint.
5. **(Optional)** TMS Aft-Short (Stick) – Press to reject the frozen position delta, return to step 3, and attempt another overflight, if necessary.
6. ICP Keypad – **ENTR** to accept the position delta and update the INS position.

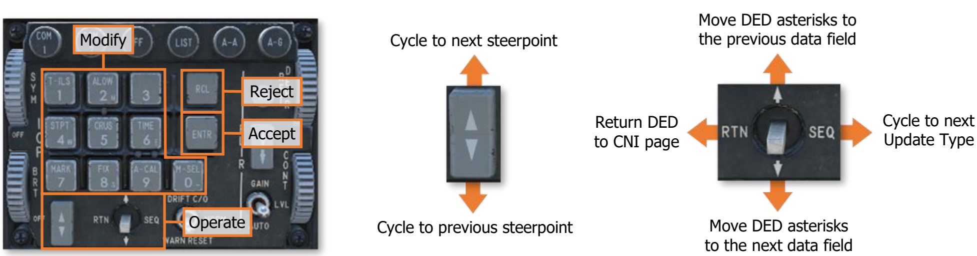
   NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta.

MAN ACAL DED Page

The Altitude Calibration DED page is accessed by pressing the **9/A-CAL** button on the ICP keypad when the CNI DED page is displayed. The MAN ACAL DED page allows the pilot to manually correct vertical errors within the INS-only altitude using one of several methods. When the MAN ACAL sub-mode is selected, the MMC blended system altitude is disabled and the INS-only altitude will be utilized as system altitude, even if GPS or DTS data is available. If necessary, the pilot may also selectively or simultaneously correct horizontal errors within the INS-only navigation solution from the MAN ACAL DED page in lieu of performing a position fix from the FIX DED page.

NOTE: The AUTO ACAL page is the default ACAL sub-mode. However, MAN ACAL sub-mode may be selected, if necessary. If the AUTO ACAL sub-mode is displayed, MAN ACAL sub-mode may be selected by momentarily pressing the DCS switch to the SEQ position.

(See AUTO ACAL DED page for more information.)



1. **Altitude Sensor Option.** Displays the sensor that will be used to perform a calibration of the INS-only altitude. The next available option may be selected by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field. If the data field is not highlighted, the selected sensor is not available to perform a calibration (e.g., if a targeting pod is not installed and powered, "TGP" won't be highlighted).

   - **RALT.** The Combined Altitude Radar Altimeter (CARA) will be used to calibrate the INS-only altitude using a direct overflight of the selected steerpoint location. (See Performing an Altitude Calibration using RALT for more information.)

   - **FCR.** The fire control radar will be used to calibrate the INS-only altitude using the selected steerpoint location when set to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes on the FCR MFD format. (See Performing an Altitude Calibration using FCR for more information.)

     NOTE: An altitude calibration using the FCR is limited to a slant range of 10 NM (F010.0) or less. If the slant range exceeds 10 NM, the altitude calibration can still be performed, but the altitude delta will remain at 0 after entering Fixed Target Track regardless of whether an altitude delta actually exists.

   - **HUD.** The HUD Diamond symbol may be slewed to the selected steerpoint location to calibrate the INS-only altitude. (See Performing an Altitude Calibration using HUD for more information.)

   - **TGP.** The targeting pod will be used to calibrate the INS-only altitude using the selected steerpoint location when set to Air-to-Ground (A-G) mode on the TGP MFD format. (See Performing an Altitude Calibration using TGP for more information.)

2. **Update Type Option.** Displays which INS solution(s) will be updated when a manual altitude calibration is performed. The next available option may be selected by momentarily positioning the DCS ("Dobber" switch) to the SEQ position.
    - **ALT.** The INS-only altitude will be updated. The INS-only navigation solution will not be updated.
    - **BOTH.** The INS-only altitude and INS-only navigation solution will be updated.
    - **POS.** The INS-only navigation solution will be updated. The INS-only altitude will not be updated.
3. **Manual Calibration.** Indicates the altitude calibration of the system altitude (SALT) is set to Manual sub-mode. Automatic sub-mode may be selected to by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field.
4. **Reference Elevation.** Displays the reference elevation for the selected steerpoint, in feet (FT). The reference elevation used for altitude calibration may be momentarily modified by placing the DED asterisks over the data field and inputting the steerpoint elevation using the ICP keypad and then pressing ENTR.

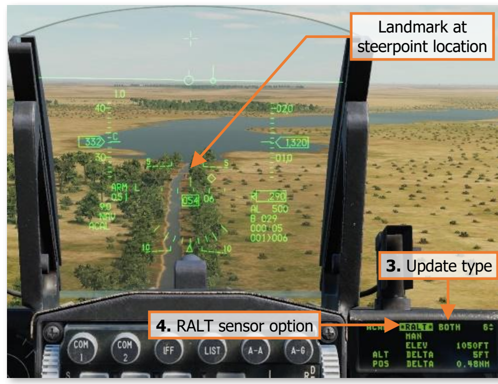
    NOTE: Modifying the reference elevation on the MAN ACAL DED page does not change the elevation of the selected steerpoint. If the selected steerpoint is changed, the modified reference elevation entered on the MAN ACAL DED page for the previous steerpoint will be erased.
5. **Altitude Delta.** Displays the difference, or "delta", between the current INS-only altitude, referenced to the selected steerpoint elevation, and the selected altitude calibration sensor, in feet (FT).
6. **Position Delta.** Displays the difference, or "delta", between the current INS-only navigation solution, referenced to the selected steerpoint location, and the selected altitude calibration sensor, in nautical miles (NM). For reference, 0.05 NM = 300 feet (91 meters).
7. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
8. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Performing an Altitude Calibration using RALT

The INS-only altitude may be updated using the Combined Altitude Radar Altimeter (CARA) by directly overflying the selected steerpoint location when the "RALT" sensor option is selected on the MAN ACAL DED page. However, it is worth noting that a direct overflight is the least accurate method of performing an altitude calibration, particularly at higher speeds and/or altitudes, due to needing to freeze the altitude and/or position delta(s) precisely as the aircraft passes over the selected steerpoint location.

NOTE: If RALT is displayed in the sensor option data field on the MAN ACAL DED page, TMS Forward-Short will freeze the altitude and/or position delta(s) regardless of the selected SOI.

To perform a manual altitude calibration using a direct overflight of the selected steerpoint location, perform the following:



1. ICP Keypad – Press **9/A-CAL**.
2. ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.
3. ICP DCS Switch – **SEQ** to select the type of update to be performed.
   - INS-only altitude – ALT.
   - INS-only altitude and position – BOTH.
   - INS-only position – POS.
4. ICP Keypad – Press any button **1-9** to select RALT in the sensor option data field.
5. Maneuver the aircraft as necessary to ensure the flight path will take it over location that corresponds with the selected steerpoint.
6. TMS Forward-Short (Stick) – Press to freeze the altitude and/or position delta(s) when directly overhead the correct location that corresponds with the selected steerpoint.
7. **(Optional)** TMS Aft-Short (Stick) – Press to reject the frozen altitude and/or position delta(s), return to step 5, and attempt another overflight if necessary.
8. ICP Keypad – **ENTR** to accept the altitude and/or position delta(s) and update the INS-only altitude and/or INS-only position.

   NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta(s).

Performing an Altitude Calibration using FCR

The FCR may be used to update the INS-only altitude using the selected steerpoint location when set to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes on the FCR MFD format, in Fixed Target Track (FTT) or Moving Target Track (MTT), and the "FCR" sensor option is selected on the MAN ACAL DED page.

To perform a manual altitude calibration using the FCR, perform the following:

1. ICP Keypad – Press **9/A-CAL**.

2. ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.

3. ICP DCS Switch – **SEQ** to select the type of update to be performed.

- INS-only altitude – ALT.
- INS-only altitude and position – BOTH.
- INS-only position – POS.

4. ICP Keypad – Press any button **1-9** to select FCR in the sensor option data field.

5. DMS Aft-Short – Press as necessary to select the FCR as SOI on the applicable MFD.

6. RDR CURSOR/ENABLE switch (Throttle) – Slew the FCR crosshairs to the correct location that corresponds with the selected steerpoint.

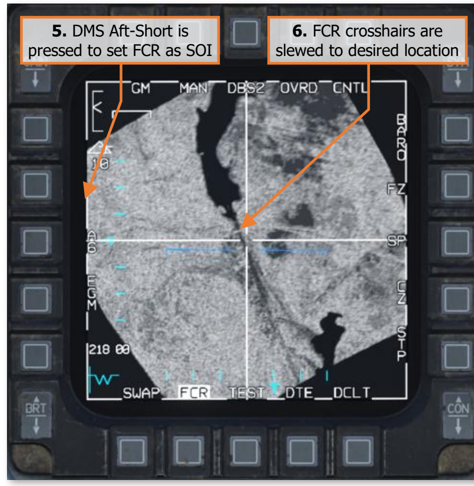
7. TMS Forward-Short (Stick) – Press to switch the FCR to Fixed Target Track (FTT).

NOTE: An altitude calibration using the FCR is limited to a slant range of 10 nautical miles (F010.0) or less. If the slant range exceeds 10 NM, the altitude calibration can still be performed, but the altitude delta will remain at 0 after entering Fixed Target Track regardless of whether an altitude delta actually exists.

8. **(Optional)** TMS Aft-Short (Stick) – Press to reject Fixed Target Track, return to step 6, and adjust the FCR crosshairs if necessary.

9. ICP Keypad – **ENTR** to accept the altitude and/or position delta and update the INS-only altitude and/or INS-only position.

NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta(s).



Performing an Altitude Calibration using HUD

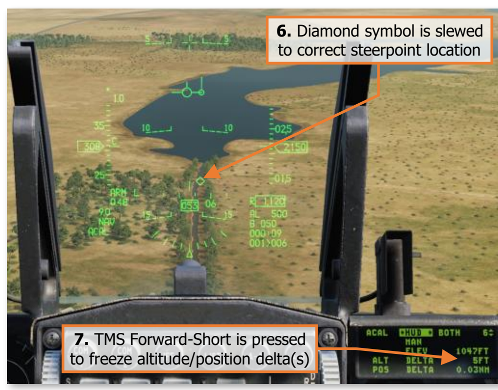
The Diamond symbol may be slewed within the HUD field-of-view to update the INS-only altitude of the selected steerpoint location when the "HUD" sensor option is selected on the MAN ACAL DED page.

NOTE: If the HUD Diamond symbol is being used to perform an altitude calibration, accuracy will be hindered when performed at low-altitudes or under conditions in which the selected steerpoint location is closer to the horizon, due to the linear perspective. Steeper look-down angles will provide better conditions to adequately ascertain whether the Diamond symbol is properly aligned over the selected steerpoint location.

To perform a manual altitude calibration using the HUD Diamond symbol, perform the following:

1. ICP Keypad – Press **9/A-CAL**.
2. ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.
3. ICP DCS Switch – **SEQ** to select the type of update to be performed.
   - INS-only altitude – ALT.
   - INS-only altitude and position – BOTH.
   - INS-only position – POS.
4. ICP Keypad – Press any button **1-9** to select HUD in the sensor option data field.
5. DMS Forward-Short – Press to select the HUD as SOI.
6. RDR CURSOR/ENABLE switch (Throttle) – Slew the Diamond symbol to the correct location within the HUD field-of-view that corresponds with the selected steerpoint.
7. TMS Forward-Short (Stick) – Press to freeze the altitude and/or position delta(s).
8. **(Optional)** TMS Aft-Short (Stick) – Press to reject the frozen altitude and/or position delta(s), return to step 6, and adjust the Diamond symbol if necessary.
9. ICP Keypad – **ENTR** to accept the altitude and/or position delta(s) and update the INS-only altitude and/or INS-only position.

   NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta(s).



Performing an Altitude Calibration using TGP

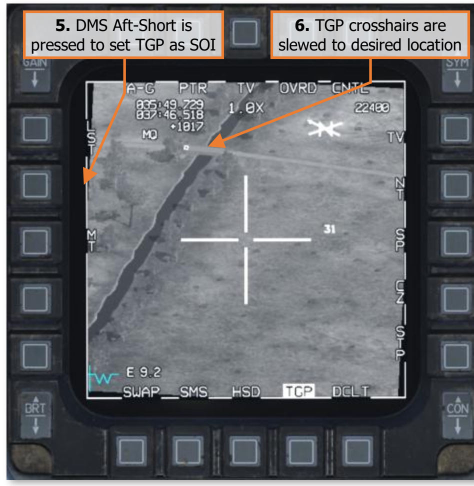
The TGP may be used to update the INS-only altitude using the selected steerpoint location when set to Air-to-Ground (A-G) mode on the TGP MFD format, in AREA or POINT track modes, and the "TGP" sensor option is selected on the MAN ACAL DED page.

To perform a manual altitude calibration using the TGP, perform the following:

1. ICP Keypad – Press **9/A-CAL**.
2. ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.
3. ICP DCS Switch – **SEQ** to select the type of update to be performed.
   - INS-only altitude – ALT.
   - INS-only altitude and position – BOTH.
   - INS-only position – POS.
4. ICP Keypad – Press any button **1-9** to select TGP in the sensor option data field.
5. DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.
6. RDR CURSOR/ENABLE switch (Throttle) – Slew the TGP line-of-sight crosshairs to the correct location that corresponds with the selected steerpoint.
7. TMS Right-Short (Stick) – Press to switch the TGP to AREA track.
8. **(Optional)** LASER ARM Switch (MI SC panel) – Set to **LASER ARM** position, if necessary.
9. **(Optional)** Trigger (Stick) – Pull and hold to gain accurate range data.

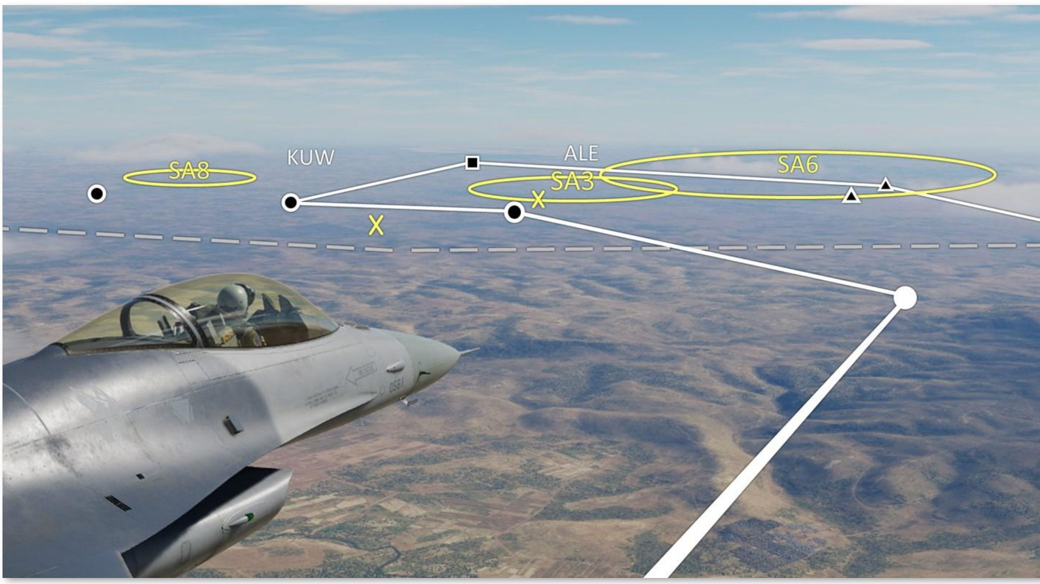
   NOTE: Although it is not required to fire the TGP's laser designator/ranger, it will increase the accuracy of the delta(s), particularly when at low altitude and/or shallow look-down angles.
10. TMS Forward-Short (Stick) – Press to freeze the altitude and/or position delta(s).
11. Trigger (Stick) – Release.
12. **(Optional)** TMS Aft-Short (Stick) – Press to reject AREA track, return to step 6, and adjust the TGP line-of-sight crosshairs if necessary.
13. ICP Keypad – **ENTR** to accept the altitude and/or position delta(s) and update the INS-only altitude and/or INS-only position.

    NOTE: The DED asterisks must be placed around the sensor option data field to accept the delta(s).



NAVIGATION DATABASE

The F-16C's navigation database consists of 127 unique steerpoints, many of which may be uploaded from a removable Data Transfer Cartridge (DTC) prior to a mission. These steerpoints serve as geographical coordinates for navigation and routing, displaying geographic lines or reference points used for maintaining situational awareness, plotting known or suspected locations of hostile air defenses, and storing markpoints or ground target locations received from other aircraft over the datalink.



Steerpoints within the navigation database are stored in one of seven partitions, depending on their type. Most steerpoints are uploaded from the DTC, but some types may be added or edited from within the cockpit as well.

Navigation	Markpoints	Geographic Lines	Pre-planned Threats	Datalink	Destinations	Extended Datalink
1-25	26-30	31-55	56-70	71-80	81-99	100-127

Steerpoint Partitions

- **Navigation partition.** Navigation steerpoints/routes and steerpoints input using MGRS coordinates.
- **Markpoints partition.** Markpoints stored using ownship sensors or direct overflight of locations of interest.
- **Geographic Lines partition.** Geographic lines for depicting areas of the battlefield or airspace boundaries.
- **Pre-planned Threats partition.** Hostile air defense locations that need to be avoided or used as targets for pre-planned HARM engagements, along with corresponding threat engagement rings.
- **Datalink partition.** Markpoints or SPI locations transmitted from other flight members.
- **Destinations partition.** Airbases, divert airfields, or other reference points used for orientation.
- **Extended Datalink partition.** SEAD targets transmitted from other flight members or ground/surface surveillance tracks transmitted from AWACS.

Steerpoints

All steerpoints consist of at least four elements of information, which are the index number of the steerpoint within the database, the latitude coordinates of the steerpoint, the longitude coordinates of the steerpoint, and the steerpoint elevation above sea level. Depending on the database partition within which the steerpoint resides, additional data may be included with the steerpoint, such as a desired Time Over Steerpoint (TOS), whether the steerpoint is part of a navigation route or part of a geographic line, if the steerpoint marks the location of an air defense threat.

Steerpoints 1-25 may be assigned up to two offset aimpoints, defined by a fixed distance and direction relative to their parent steerpoint, and an elevation above mean sea level.

MGRS coordinates may be used to input the locations of steerpoints 21-25 within the cockpit, which are subsequently converted to latitude/longitude for use by the avionics. This may be necessary when receiving target locations from friendly ground forces, which typically use MGRS coordinates instead of latitude/longitude.

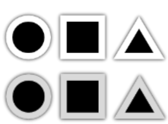
Steerpoint Symbols

Steerpoint locations are primarily displayed using symbols on the HSD and HAD MFD formats. However, the HUD, HMCS, and the FCR MFD format may also display symbols representing the steerpoint currently selected for navigation, of which the type of symbol will vary depending on the selected master modes and/or sub-modes. (See Navigation by Steerpoints for more information.)

Navigation Steerpoint

Steerpoints 1-25 are intended to be used for primary navigation. As such, only steerpoints within this range may be assigned to one of the three navigation routes when uploaded from the Data Transfer Cartridge (DTC) and may be displayed as one of three steerpoint sub-types: a navigation steerpoint (STPT) is displayed as a circle, an initial point (IP) is displayed as a square, and a target (TGT) is displayed as a triangle.

Selected Steerpoint. The steerpoint selected for navigation steering is displayed as a solid white circle, square, or triangle on the HSD and HAD formats and as a white "wedding cake" symbol on the FCR format when the FCR is set to CRM mode.



Steerpoint. Any steerpoint that is not selected for navigation steering is displayed as a hollow white circle, square, or triangle on the HSD and HAD formats if part of the active navigation route, or a hollow gray circle, square, or triangle on the HSD and HAD formats if part of an inactive navigation route.

The selected steerpoint is represented by either a Steerpoint Diamond or a Target Designator Box within the HUD and HMCS symbology. (See Sighting Points within the Tactical Employment chapter for more information.)

Ownship Markpoint

Steerpoints 26-30 are used for storing ownship markpoints. Markpoints are steerpoints that may be stored during the mission for the purposes of navigation at some point later in the mission, recording a location of interest during reconnaissance, or for follow-on targeting of sensors and/or weapons.

Ownship Markpoint. Markpoints stored by the ownship will be displayed as a small yellow X symbol on the HSD and HAD formats. (See Storing a Markpoint for more information.)

Pre-planned Threat Steerpoint

Steerpoints 56-70 are used for displaying locations of known air defense threats. Pre-planned threats are displayed using up to three alphanumeric characters and an optionally-displayed ring that corresponds to the approximate Weapon Engagement Zone (WEZ) of the air defense threat.

Pre-planned Threat. Pre-planned threats are displayed with yellow text that identifies the nature of the threat and a yellow circular threat ring. If the ownship is within the radius of threat ring, the text and ring will be displayed in red and the ownship can expect to be engaged by the air defense system. The threat ring may be selectively hidden or shown as desired.

Datalink Markpoint

Steerpoints 500 and above are used for storing markpoints received through the datalink. Datalink markpoints are steerpoints corresponding to another flight member's selected steerpoint or System-Point-of-Interest (SPI) and may be used to coordinate reconnaissance or attacks against locations on the battlefield.

Datalink Markpoint. Markpoints received via the datalink will be displayed as a large white X symbol on the HSD and HAD formats. (See the Tactical Net Datalink chapter for more information.)

Destination Steerpoint

Steerpoints 81-99 are used for displaying locations of airfields, reference points, tactical areas of interest, or any other location that may have relevance to the mission. Destination steerpoints are displayed using up to three alphanumeric characters.

Destination. Destinations are displayed with white text that identifies the airfield, reference point, or tactical area of interest (e.g., "INK" may be used as an abbreviation for Incirlik airbase).

Datalink SEAD Target

Steerpoints 107-127 are used for storing SEAD targets received through the datalink. Datalink SEAD targets are steerpoints corresponding to an air defense radar threat designated by another flight member and may be used to coordinate attacks against enemy air defenses on the battlefield.

Datalink SEAD Target. SEAD targets received via the datalink will be displayed as yellow text with a slash on the HSD and HAD formats. The type of threat is indicated by the character(s) that comprise the symbol itself. (See the Tactical Net Datalink chapter for more information.)

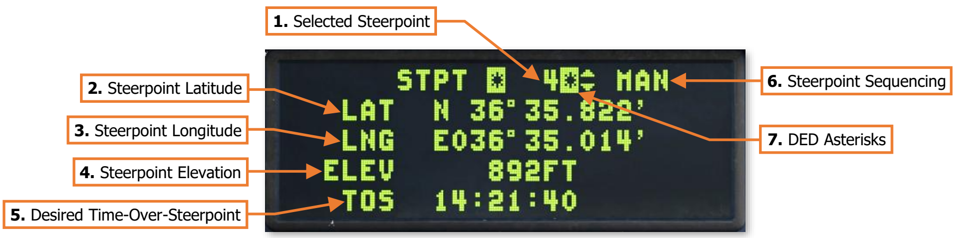
Editing a Steerpoint

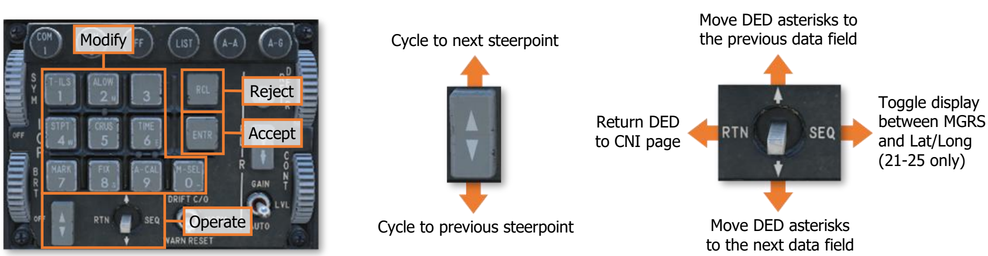
Steerpoints may be edited using the Integrated Control Panel (ICP) while the STPT or DEST pages are displayed on the DED. The STPT page allows the pilot to edit the latitude, longitude, elevation, and desired Time-Over-Steerpoint of the currently selected steerpoint only. If the pilot intends to edit a steerpoint that is *not* the selected steerpoint for navigation, or the offset aimpoints of any steerpoint within the range of 1-25, these edits must be performed using the DEST DED page.

When working in conjunction with ground forces or other aircraft that primarily relay coordinates using the Military Grid Reference System (MGRS), which is a UTM-derived coordinate system, steerpoints 21-25 may be initially input using MGRS and then converted to the Latitude/Longitude coordinate format used by the F-16 navigation system. When the DEST DED page is initially accessed, it will default to a UTM DEST page, providing an immediate an efficient method for inputting MGRS coordinates as a steerpoint location.

STPT DED Page

The Steerpoint DED page is accessed by pressing the **4/STPT** button on the ICP keypad when the CNI DED page is displayed. This page displays the position and elevation of the currently selected steerpoint, along with the desired Time-Over-Steerpoint (TOS), all of which can be modified from this page.





1. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.

2. **Steerpoint Latitude.** Displays the latitude (in DD° MM.MMM' format) of the selected steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value in DDMMMMM format using the ICP keypad, and pressing ENTR.

3. **Steerpoint Longitude.** Displays the longitude (in DDD° MM.MMM' format) of the selected steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value in DDDMMMMM format using the ICP keypad, and pressing ENTR.

4. **Steerpoint Elevation.** Displays the elevation (in feet above Mean Sea Level, MSL) of the selected steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value (in feet) using the ICP keypad, and pressing ENTR.

5. **Desired Time-Over-Steerpoint.** Displays the desired Time-Over-Steerpoint (TOS) of the selected steerpoint. May be modified by placing the DED asterisks over the data field, inputting a time in HHMMSS format using the ICP keypad, and pressing ENTR. An invalid TOS may be entered in -HHMMSS format by pressing the 0/M-SEL button to input a minus (-) symbol before inputting the TOS value.

6. **Steerpoint Sequencing.** Displays the steerpoint sequencing mode. May be toggled between MAN and AUTO by pressing the 0/M-SEL button on the ICP while the DED asterisks are over the data field and the selected steerpoint is 1-20. If the selected steerpoint is 21 or greater, this data field will not be selectable.

    - **MAN.** The selected steerpoint must be manually changed by the pilot. Manual sequencing is the default sequencing mode.

    - **AUTO.** The selected steerpoint will be automatically sequenced to the next steerpoint in the current navigation route when the aircraft is within 2 nautical miles of the selected steerpoint and the range to the selected steerpoint is increasing. The selected steerpoint may be manually changed by the pilot.

      Automatic steerpoint sequencing will only be functional when the selected steerpoint is 1-20. Automatic steerpoint sequencing will be disabled if the selected steerpoint is 21 or higher, if the master mode is set to Air-to-Ground (A-G), if the FIX DED page is displayed, or if the MAN ACAL DED page is displayed.

7. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

STPT Page – MGRS coordinate format

If the selected steerpoint is within the range of 21-25, the STPT page may be toggled to the Military Grid Reference System (MGRS) coordinate format by momentarily pressing the DCS "Dobber" switch to the SEQ position. After a 3-second delay, the MGRS grid zone designator, square, and easting/northing coordinates of the steerpoint location will be displayed, along with the steerpoint elevation.

STPT Page – Latitude/Longitude format (Left) and MGRS format (Right)

All steerpoints must be in Latitude/Longitude (degrees/minutes/decimal) format to be stored within the navigation database. However, steerpoints 21-25 may be input using the MGRS coordinate format and then converted to Latitude/Longitude. Alternatively, steerpoints 21-25 may be input using the Latitude/Longitude coordinate format and the corresponding MGRS coordinates of the location may be viewed for pilot reference or relayed to other forces over the radio.

MGRS coordinates may be input using the STPT or DEST DED pages. In either case, after the MGRS coordinates have been input, a conversion to the equivalent Latitude/Longitude coordinate format must be manually commanded by moving the DED asterisks around the CNVRT data field and pressing ENTR on the ICP keypad. When the conversion is complete, the DED asterisks will be placed around the steerpoint data field automatically. The elevation (ELEV) data field is not required to contain data other than 0 for the conversion to occur.

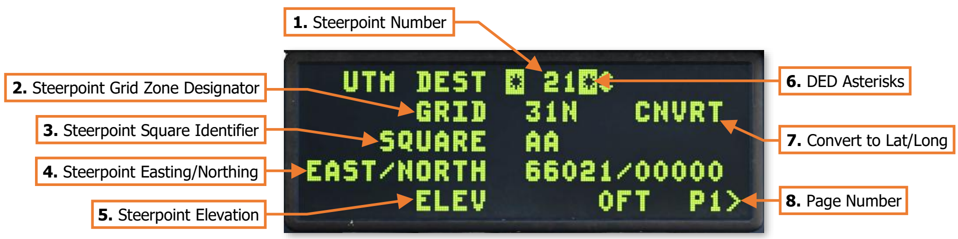
NOTE: If a conversion is not completed before the STPT or DEST pages are sequenced to another DED page, or the DED is otherwise set to any other DED page, the conversion will not complete and the MGRS coordinates that were input will not be stored for that steerpoint.

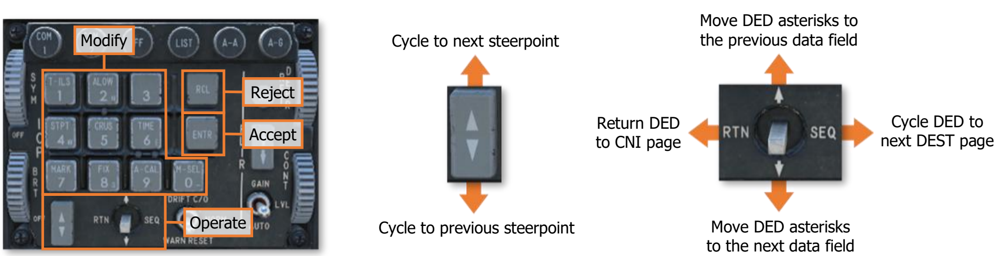
The Military Grid Reference System (MGRS) is described later within this chapter. For more information regarding inputting steerpoints 21-25 using the MGRS coordinate format, see Converting MGRS to Latitude/Longitude.

UTM DEST DED Page

The Destination DED pages are accessed by pressing the **1/T-ILS** button on the ICP keypad when the LIST DED page is displayed. The first DEST DED page is the UTM Destination page, which display steerpoints 21-25 for the purposes of MGRS coordinate entry. The Military Grid Reference System is a UTM-derived coordinate system used as an alternative to Latitude/Longitude and is the primary coordinate system used by many military ground forces.

All steerpoints must be in Latitude/Longitude format to be stored within the navigation database. If a steerpoint is input using MGRS, then a conversion to Latitude/Longitude must be commanded. If a conversion is not commanded before the DED page is changed or a different steerpoint is selected, the MGRS coordinates that were input will not be stored for that steerpoint and the Latitude/Longitude coordinates will not correctly correspond with the MGRS location. (See Converting MGRS to Latitude/Longitude for more information.)

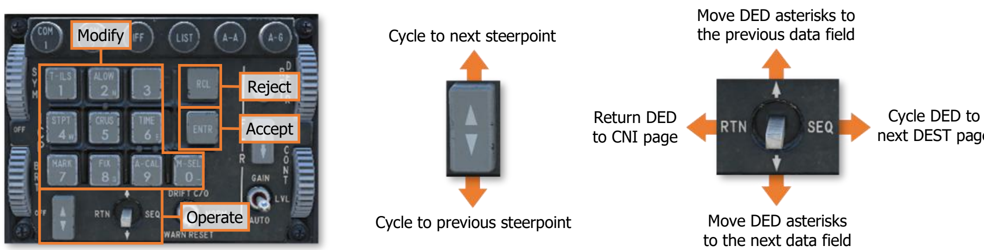




1. **Steerpoint Number.** Displays the destination steerpoint number. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint (21-25), or the DED asterisks may be placed over the data field and a steerpoint number between 21 and 25 may be input using the ICP keypad followed by ENTR.
2. **Steerpoint Grid Zone Designator.** Displays the MGRS Grid Zone Designator of the destination steerpoint. May be modified using the ICP keypad and Increment/Decrement rocker.
3. **Steerpoint Square Identifier.** Displays the MGRS Square Identifier of the destination steerpoint. May be modified using the Increment/Decrement rocker.
4. **Steerpoint Easting/Northing.** Displays the MGRS Easting & Northing of the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a 10-digit number using the ICP keypad, and pressing ENTR.
5. **Steerpoint Elevation.** Displays the elevation (in feet) of the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.
6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.
7. **Convert to Lat/Long.** Converts the MGRS coordinates to the equivalent Latitude/Longitude format.
8. **Page Number.** Displays the DED page number and indicates that additional pages may be viewed.

DEST DIR DED Page

The second DEST DED page is the Destination Direct page. This page is similar to the STPT DED page, in that it displays the position, elevation, and TOS of steerpoints within the navigation database. However, unlike the STPT page, the DEST DIR page permits review and modification of steerpoint data fields without selecting that steerpoint for navigation.



1. **Steerpoint Number.** Displays the destination steerpoint number. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.

2. **Steerpoint Latitude.** Displays the latitude (in DD° MM.MMM' format) of the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value in DDMMMMM format using the ICP keypad, and pressing ENTR.

3. **Steerpoint Longitude.** Displays the longitude (in DDD° MM.MMM' format) of the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value in DDDMMMMM format using the ICP keypad, and pressing ENTR.

4. **Steerpoint Elevation.** Displays the elevation (in feet) of the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

5. **Desired Time-Over-Steerpoint.** Displays the desired Time-Over-Steerpoint (TOS) of the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a time in HHMMSS format using the ICP keypad, and then pressing ENTR. An invalid TOS may be entered in -HHMMSS format by pressing the 0/M-SEL button to input a minus (-) symbol before inputting the TOS value.

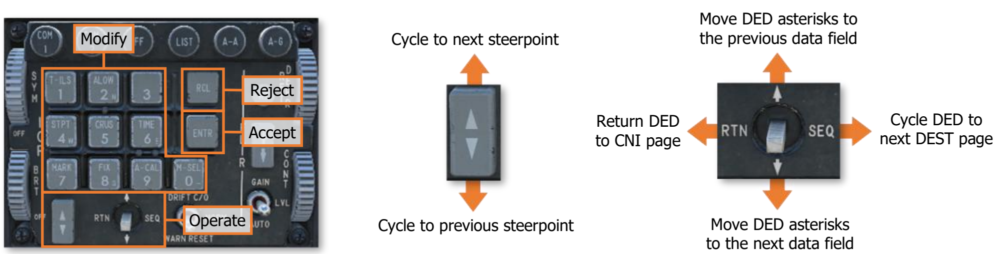
6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

7. **Page Number.** Displays the DED page number and indicates that additional pages may be viewed.

DEST OA1 & OA2 DED Pages

The Destination Offset Aimpoint DED pages display the relative distance, direction, and elevation of the destination steerpoint's offset aimpoints, which are maintained relative to their parent steerpoint. If the steerpoint coordinates are modified, or if the steerpoint is slewed to a different location, the offset aimpoint will be re-positioned accordingly. Each offset aimpoint and its respective values may be modified from these pages.

NOTE: Offset aimpoint symbols will only be displayed in the HUD and HMCS when selected as the current sighting point on the FCR or TGP MFD formats. However, if VRP or VIP modes are enabled for the selected steerpoint, both offset aimpoint symbols will be displayed in HUD and HMCS regardless of the selected sighting point.



1. **Steerpoint Number.** Displays the destination steerpoint number. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.
2. **Relative Range.** Displays the relative distance (in feet) of the offset aimpoint from the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. The following values may be used for conversion to feet.
   - 1 Nautical Mile (NM) = 6,076 feet
   - 1 Kilometer (km) = 3,280 feet

   NOTE: If the range value is set to zero, the offset aimpoint will not be displayed in the HUD and HMCS and cannot be selected as a sighting point on the FCR and TGP MFD formats.
3. **Relative Bearing.** Displays the relative bearing (in degrees, true) of the offset aimpoint from the destination steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.
4. **Offset Aimpoint Elevation.** Displays the elevation (in feet) of the offset aimpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.
5. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.
6. **Page Number.** Displays the DED page number and indicates that additional pages may be viewed.

Editing a Steerpoint

Steerpoints may be edited from the DEST DIR DED page, which is accessed by pressing the **1/T-ILS** button on the ICP keypad when the LIST DED page is displayed. Steerpoints may also be edited from the STPT DED page in the same manner as the described below; however, selecting a different steerpoint on the STPT page will also change the selected steerpoint for navigation.

To edit a steerpoint, perform the following:

1. ICP DCS Switch – **SEQ** to cycle to the DEST DIR DED page (P2>).

2. ICP **Keypad** – Input the steerpoint number.

or

2. ICP **Increment/Decrement** Rocker – Select the steerpoint number.

3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

LAT

4. ICP DCS Switch – **Down** to move DED asterisks around LAT data field.

5. ICP Keypad – Input **2** for North or **8** for South.

6. ICP **Keypad** – Input latitude in Degrees-Minutes-Decimals format of DD°MM.MMM', which is input as DDMMMMM in a continuous string of seven numbers.

7. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

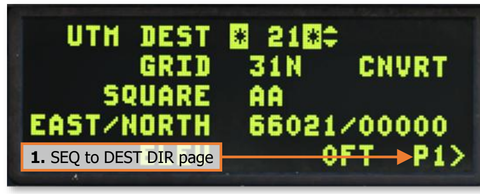
LON

8. ICP DCS Switch – **Down** to move DED asterisks around LON data field.

9. ICP Keypad – Input **6** for East or **4** for West.

10. ICP **Keypad** – Input longitude in Degrees-Minutes-Decimals format of DDD°MM.MMM', which is input as DDDMMMMM in a continuous string of eight numbers, to include a leading zero if necessary.

11. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.



ELEV

12. ICP DCS Switch – **Down** to move DED asterisks around ELEV data field.

13. ICP **Keypad** – Input the elevation in feet.

14. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

TOS

15. **(Optional)** ICP DCS Switch – **Down** to move DED asterisks around TOS data field.

16. ICP **Keypad** – Input the desired time in a 24-hour time format of HH:MM:SS, which is input as HHMMSS in a continuous string of six numbers.

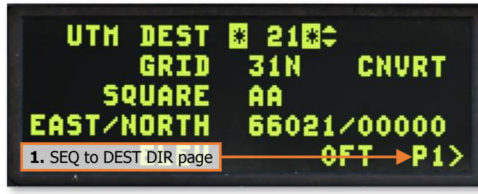
17. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

Modifying an Offset Aimpoint

Offset aimpoints may be modified from the DEST OA1 & DEST OA2 DED pages, which are accessed by pressing the **1/T-ILS** button on the ICP keypad when the LIST DED page is displayed. Only steerpoints 1-25 may be modified with offset aimpoints, with up to two independently referenced offset aimpoints for each steerpoint.

To modify an offset aimpoint, perform the following:

1. ICP DCS Switch – **SEQ** to cycle to the DEST DIR page (P2>).



2. ICP **Keypad** – Input the steerpoint number.

or

2. ICP **Increment/Decrement** Rocker – Select the steerpoint number.

3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

4. ICP DCS Switch – **SEQ** to cycle to the DEST OA1 page (P3>) or the DEST OA2 page (P4>).

RNG

5. ICP DCS Switch – **Down** to move DED asterisks around RNG data field.

6. ICP **Keypad** – Input the offset aimpoint range from the steerpoint in feet.

7. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

BRG

8. ICP DCS Switch – **Down** to move DED asterisks around BRG data field.

9. ICP **Keypad** – Input the offset aimpoint true bearing from the steerpoint in Degrees-Decimal format of DD.D° or DDD.D°, which is input as either DDD or DDDD in a continuous string of numbers.

10. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

ELEV

11. ICP DCS Switch – **Down** to move DED asterisks around ELEV data field.

12. ICP **Keypad** – Input the offset aimpoint elevation in feet.

13. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

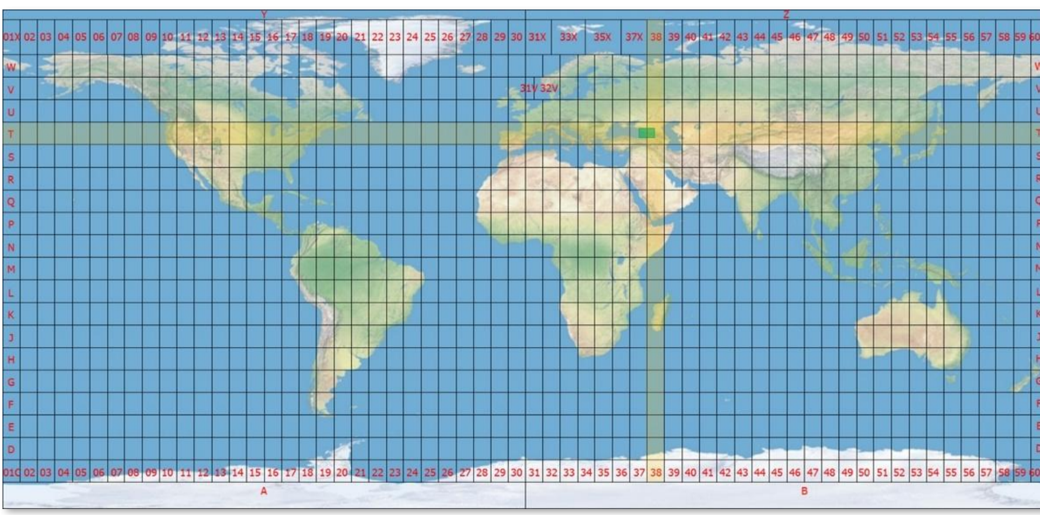
Converting a Steerpoint from MGRS

Although the majority of the F-16C steerpoints are displayed in Latitude/Longitude coordinates in degrees/minutes/decimal format, steerpoints 21-25 may also be displayed in MGRS format. Additionally, these steerpoints may be input using MGRS coordinates, and then converted to Latitude/Longitude coordinates.

Steerpoints 26-30 are reserved for ownship markpoints and may only be stored via aircraft sensors or edited using the Latitude/Longitude coordinates; they cannot be input and converted from MGRS. However, they will display the equivalent MGRS coordinate formats on the MARK DED page for pilot reference. (See MARK DED Page for more information.)

Military Grid Reference System (MGRS)

The Military Grid Reference System is a coordinate system used as an alternative to Latitude/Longitude and is the primary coordinate system used by many military ground forces. MGRS is derived from the Universal Transverse Mercator system which divides a Mercator-projection map of the Earth into 60 zones that are numbered from 01 starting from the 180° meridian and moving eastward. Each UTM zone number is then further sub-divided into 20 zone designators starting from the south pole and moving northward, with the south pole itself split between zone designators A and B and the north pole itself split between zone designators Y and Z. In addition, several non-uniform UTM zones are in northern Europe and the Norwegian and Barents Seas.



Universal Transverse Mercator (UTM) Zones

MGRS further sub-divides the UTM zones into 100×100 kilometer squares identified by a pair of letters, and then each 100 kilometer square is further broken down to 1 meter resolution grid coordinates that are numerically incremented eastward and northward.

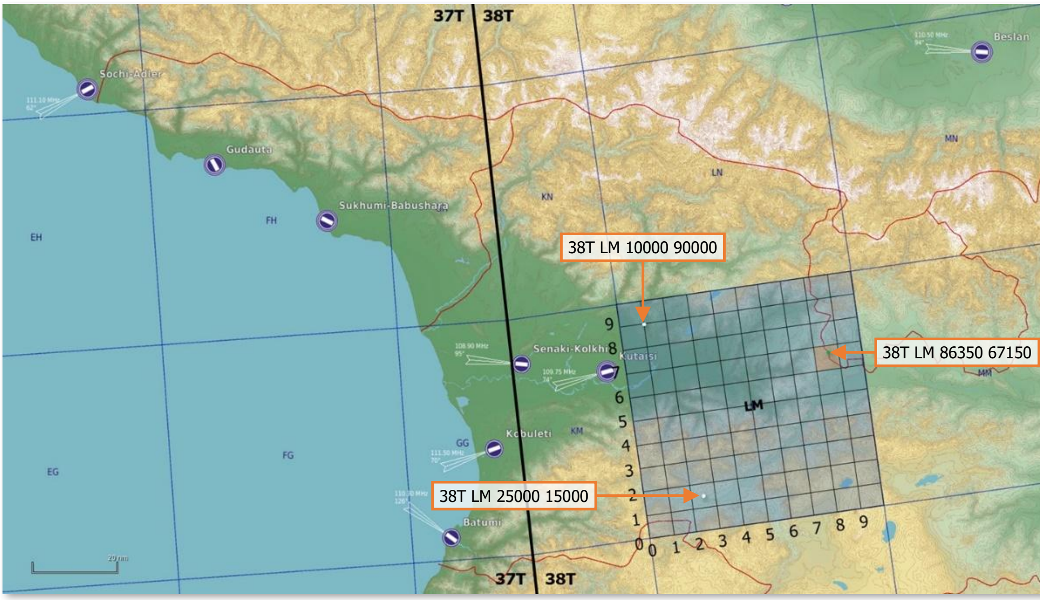
In the image above, a portion of the Caucasus region along the western coast of the Black Sea is highlighted in green. The green highlighted area (expanded on the following page) straddles grid zone designators 37T and 38T. Within that region along the border of South Ossetia is a position on the ground that is identified by the MGRS grid coordinates below.

Grid Zone Designator 38T LM 86350 67150

Square Identifier Easting Northing

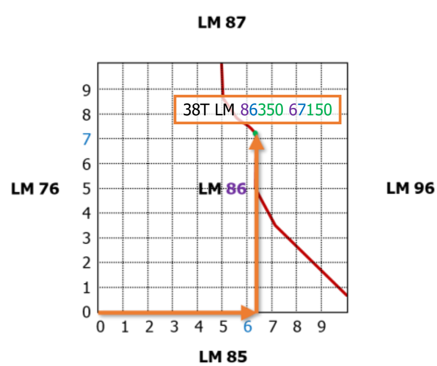
The expanded map in the image below is split between the grid zone designators of 37T and 38T, with the area of interest located within the 100×100 kilometer square identified as LM (Blue Shade), and marked by a green dot. Each 100 km square is further sub-divided into a 100,000×100,000 meter grid.

Note that since the Earth is a sphere and cannot contain a perfect grid of adjacent geometric squares, the 100 km squares that run along the east and west borders of each grid zone designator will not actually be 100 km in width, but will be truncated to account for the curve of the Earth and the difference in east-west circumference between the equator and the polar regions across each numbered UTM zone.



Military Grid Reference System (MGRS)

Within the LM square, the first digit of the easting is attained by proceeding from zero and moving eastward in intervals of 10 kilometers, and then moving northward in the same manner. The grid section containing the green dot, LM86 (Orange Shade), is further expanded in the figure on the right.



As each grid is sub-divided further, the coordinate resolution of the corresponding location becomes more precise.

- 10-kilometer precision – 38T LM 8 6 (2-digit grid)
- 1-kilometer precision – 38T LM 86 67 (4-digit grid)
- 100-meter precision – 38T LM 863 671 (6-digit grid)
- 10-meter precision – 38T LM 8635 6715 (8-digit grid)
- 1-meter precision – 38T LM 86350 67150 (10-digit grid)

It is important to understand that all grid coordinates must contain an even number of digits to be valid, in that the easting and northing must be referenced using the same level of precision.

When inputting MGRS coordinates into the F-16C, a 10-digit grid coordinate format must be utilized. During instances in which the 10-digit precision of a location is not known, such as if ground forces were to relay that their position was "38T LM 863 671", the coordinates would be input as 38T LM 86300 67100, with zeros added to the easting and northing as needed to adhere to the required input format.

Converting MGRS to Latitude/Longitude

MGRS coordinates may be input to steerpoints 21-25 using the UTM DEST DED page, which is accessed by pressing the **1/T-ILS** button on the ICP keypad when the LIST DED page is displayed. MGRS coordinates may also be input using the STPT DED page in the same manner as the described below; however, selecting a different steerpoint on the STPT page will also change the selected steerpoint for navigation.

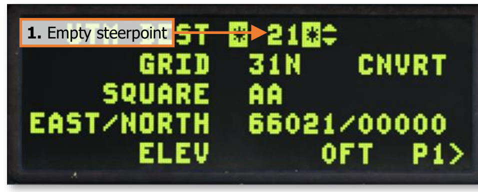
To input a steerpoint location using MGRS coordinate format, perform the following:

1. ICP **Keypad** – Input the steerpoint number.

or

1. ICP **Increment/Decrement** Rocker – Select the steerpoint number.

2. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.



GRID

3. ICP DCS Switch – **Down** to move DED asterisks around GRID data field.

4. ICP **Keypad** – Input the 2-digit grid zone.

5. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

6. ICP **Increment/Decrement** rocker – Select the letter of the grid zone designator.

7. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

SQUARE

8. ICP DCS Switch – **Down** to move DED asterisks around SQUARE data field.

9. ICP **Increment/Decrement** rocker – Select the first letter of the square as necessary.

10. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

11. ICP **Increment/Decrement** rocker – Select the second letter of the square as necessary.

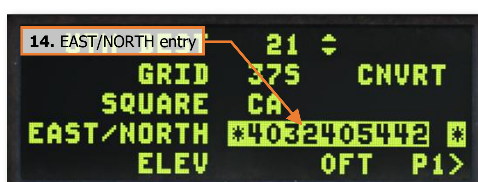
12. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

EAST/NORTH

13. ICP DCS Switch – **Down** to move DED asterisks around EAST/NORTH data field.

14. ICP **Keypad** – Input the 10-digit easting and northing as a continuous string.

15. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.



ELEV

16. ICP DCS Switch – **Down** to move DED asterisks around ELEV data field.

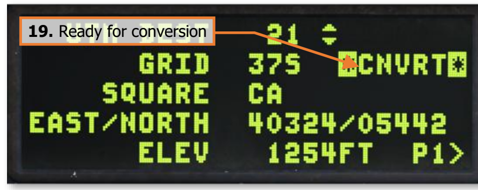
NOTE: Elevation data is not required for the conversion process to successfully complete, and may be input separately or not at all.

17. ICP **Keypad** – Input the elevation in feet.

18. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

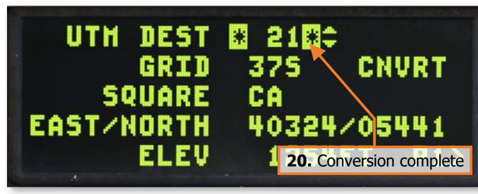
CNVRT

19. ICP DCS Switch – **Down** to move DED asterisks around CNVRT data field.



20. ICP Keypad – Press **ENTR** to initiate the conversion to Latitude/Longitude format. When the conversion is complete, the DED asterisks will be placed around the steerpoint data field automatically.

After the conversion is complete, the UTM DEST page may be sequenced to the DEST DIR page to review the converted Latitude/Longitude coordinates as described in the remaining steps below.



21. ICP DCS Switch – **SEQ** to cycle to the DEST DIR page (P2>).

22. ICP **Keypad** – Input the number of the steerpoint (21-25) that was entered via MGRS coordinates.

23. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject.

NOTE: If the STPT DED page is used to input MGRS coordinates, the ICP DCS switch may be momentarily set to the SEQ position to sequence the STPT page directly back to the Latitude/Longitude coordinate format for the current steerpoint after the conversion is complete.

Storing a Markpoint

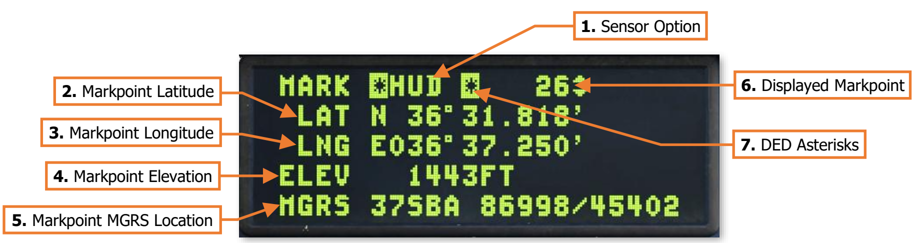
Markpoints are steerpoints that may be stored during the mission for the purposes of navigation later in the mission, recording a location of interest during reconnaissance, or for follow-on targeting of sensors and/or weapons. Markpoints are stored within the steerpoint range of 26-30, using one of four methods best suited to the current tactical situation and the available sensors onboard the aircraft.

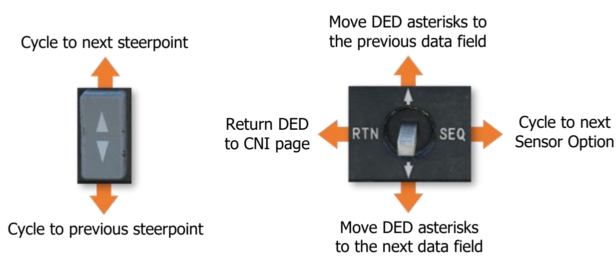
- **HUD**. The markpoint location is based on the HUD Mark Cue, which is slewed to the desired markpoint location within the HUD or HMCS field-of-view.
- **FCR.** The markpoint location is based on the System-Point-of-Interest (SPI) derived from the FCR in Fixed Target Track (FTT) or Moving Target Track (MTT) modes.
- **TGP.** The markpoint location is based on the System-Point-of-Interest (SPI) derived from the targeting pod in POINT track mode.
- **OFLY.** The markpoint location is based on the aircraft position during an overflight of the desired location.
- **Manual entry.** The markpoint location is directly input via the ICP keypad using Latitude/Longitude coordinate format.

See the APG-68 Fire Control Radar and AAQ-33 Advanced Targeting Pod chapters for more information regarding the use of the FCR and TGP for targeting and designation.

MARK DED Page

The Markpoint DED page is accessed by pressing the **7/MARK** button on the ICP keypad when the CNI page is displayed on the DED. When accessed, this page displays the position and elevation of the most recently stored markpoint. However, the Increment/Decrement rocker may be used to display other markpoint data if desired.





1. **Sensor Option.** Displays the sensor that will be used to store the location of the next markpoint. The next available option may be selected by momentarily positioning the DCS ("Dobber" switch) to the SEQ position.
   - **HUD.** The HUD Mark Cue may be slewed to the desired indication prior to storing the markpoint. When the MARK DED page is displayed with HUD as the selected sensor option, VIS sub-mode will be entered, the HUD will automatically be selected as SOI, and the FCR will enter AGR mode for accurate ranging. (See Storing a Markpoint using HUD or Storing a Markpoint using HMCS for more information.)

- **FCR.** The fire control radar may be used to store the markpoint location when set to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes on the FCR MFD format. If the FCR is already in Fixed Target Track (FTT) or Moving Target Track (MTT) when the MARK DED page is accessed, the FCR sensor option will be automatically selected. (See Storing a Markpoint using FCR for more information.)
- **TGP.** The targeting pod may be used to store the markpoint location when set to Air-to-Ground (A-G) mode on the TGP MFD format. If the targeting pod is already in POINT track when the MARK DED page is accessed, the TGP sensor option will be automatically selected. (See Storing a Markpoint using TGP for more information.)
- **OFLY.** The aircraft position itself may be used to store the markpoint location using a direct overflight. (See Storing a Markpoint using OFLY for more information.)

  NOTE: OFLY will be the only functional sensor option if the master mode is set to A-A, MSL, or DGFT.

2. **Markpoint Latitude.** Displays the latitude (in DD° MM.MMM' format) of the displayed markpoint. May be modified by placing the DED asterisks over the data field, inputting a value in DDMMMMM format using the ICP keypad, and pressing ENTR.
3. **Markpoint Longitude.** Displays the longitude (in DDD° MM.MMM' format) of the displayed markpoint. May be modified by placing the DED asterisks over the data field, inputting a value in DDDMMMMM format using the ICP keypad, and pressing ENTR.
4. **Markpoint Elevation.** Displays the elevation (in feet) of the displayed markpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.
5. **Markpoint MGRS Location.** Displays the MGRS location of the displayed markpoint. May be modified using the ICP keypad.
6. **Displayed Markpoint.** Displays the steerpoint number that corresponds with the Latitude/Longitude and MGRS coordinates currently displayed on the DED. When a new markpoint is stored, this number will automatically increment up to the next steerpoint number. Markpoints can only be stored in steerpoints 26-30, in sequential order. If a markpoint is already stored in steerpoint 30, the next markpoint will be stored in 26, overwriting the previous markpoint coordinates. Each subsequent markpoint that is stored will overwrite steerpoints 26-30 in a cyclic fashion.
7. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Any time the markpoint displayed on the MARK DED page is also the selected steerpoint, a highlighted STPT label will appear in the top right corner of the DED. The displayed markpoint may be set as the selected steerpoint by setting the DED asterisks around the Sensor Option data field and pressing the 0/M-SEL button.

NOTE: After designating a markpoint using the TGP or FCR in NAV master mode or A-G master mode (when set to a pre-planned weapon delivery sub-mode), it may be necessary to use the Cursor Zero (CZ) command to remove any slews of the Navigation cursor. This can be commanded by pressing CZ (OSB 9) on the TGP or FCR MFD formats, or CZ (OSB 10) on the HSD MFD format.

Storing a Markpoint using HUD

The HUD Mark Cue may be used to designate a location on the ground for storing a markpoint. When the "HUD" sensor option is selected on the MARK DED page, VIS sub-mode will be entered, the HUD will be selected as SOI, and the FCR will enter AGR mode for accurate ranging.

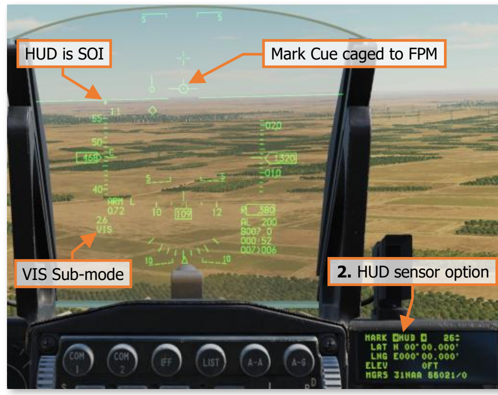
If DMS Aft-Short is used to select a different SOI, VIS mode will be exited and the avionics will return to the previous sub-mode. To re-enable the HUD Mark Cue, the sensor option on the MARK page must be cycled back to HUD by momentarily and repeatedly pressing the DCS switch to the SEQ position.

To store a markpoint using the HUD Mark Cue, perform the following:

1. ICP Keypad – Press **7/MARK**.
2. ICP DCS Switch – **SEQ** to select HUD in the sensor option data field.
3. RDR CURSOR/ENABLE switch (Throttle) – Slew the Mark Cue to the desired location within the HUD field-of-view.
4. TMS Forward-Short (Stick) – Press to ground stabilize the Mark Cue.
5. **(Optional)** RDR CURSOR/ENABLE switch (Throttle) – Adjust the Mark Cue, as necessary.
6. TMS Forward-Short (Stick) – Press to designate the location as a markpoint.

   or

6. TMS Aft-Short (Stick) – Press to cage the Mark Cue to the HUD FPM without designating the markpoint.



Storing a Markpoint using HMCS

As an extension of the HUD, the HMCS may be used to position the HUD Mark Cue to designate a location on the ground outside of the HUD field-of-view for storing a markpoint. As such, it uses the same logic as the HUD. When the "HUD" sensor option is selected on the MARK DED page, VIS sub-mode will be entered, the HUD will be selected as SOI, and the FCR will enter AGR mode for accurate ranging. Pressing TMS Forward-Long will slave the Mark Cue to the HMCS Aiming Cross.

To return the Mark Cue to the HUD, the Mark Cue must be caged back to the HMCS Aiming Cross using TMS Aft-Short if the Mark Cue has already been ground stabilized. If the Mark Cue is already caged back to the HMCS Aiming Cross, pressing TMS Aft-Short will return the Mark Cue to the HUD FPM.

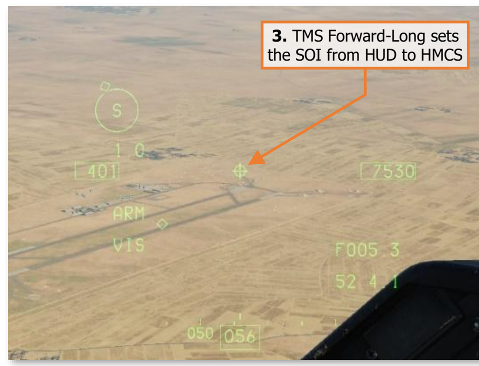
If DMS Aft-Short is used to select a different SOI, VIS mode will be exited and the avionics will return to the previous sub-mode. To re-enable the HUD Mark Cue, the sensor option on the MARK page must be cycled back to HUD by momentarily and repeatedly pressing the DCS switch to the SEQ position.

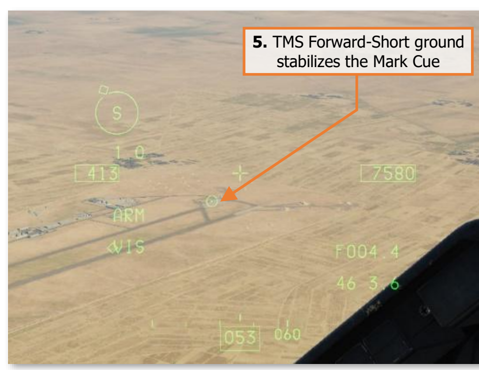
To store a markpoint using the HUD Mark Cue through the HMCS, perform the following:

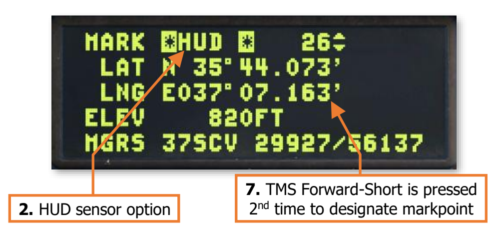
1. ICP Keypad – Press **7/MARK**.
2. ICP DCS Switch – **SEQ** to select HUD in the sensor option data field.
3. TMS Forward-Long (Stick) – Press to select the HMCS as SOI.
4. Place the HMCS Aiming Cross over the desired location by head movement.
5. TMS Forward-Short (Stick) – Press to ground stabilize the Mark Cue.
6. **(Optional)** RDR CURSOR/ENABLE switch (Throttle) – Adjust the Mark Cue, as necessary.
7. TMS Forward-Short (Stick) – Press to designate the location as a markpoint.

   or

7. TMS Aft-Short (Stick) – Press to cage the Mark Cue to the HMCS Aiming Cross without designating the markpoint.







Storing a Markpoint using FCR

The FCR may be used to designate a location on the ground for storing a markpoint when set to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes on the FCR MFD format, in Fixed Target Track (FTT) or Moving Target Track (MTT), and the "FCR" sensor option is selected on the MARK DED page.

To store a markpoint using the FCR, perform the following:

1. DMS Aft-Short – Press as necessary to select the FCR as SOI on the applicable MFD.

2. RDR CURSOR/ENABLE switch (Throttle) – Slew the FCR crosshairs to the desired location on the FCR MFD format.

3. TMS Forward-Short (Stick) – Press to switch the FCR to Fixed Target Track (FTT).

4. ICP Keypad – Press **7/MARK**.

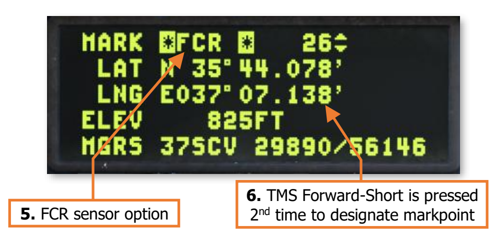
NOTE: If the FCR is already in FTT when the MARK DED page is displayed, the sensor option is automatically set to "FCR" and step 5 is not required.

5. ICP DCS Switch – **SEQ** to select FCR in the sensor option data field, if necessary.

6. TMS Forward-Short (Stick) – Press to designate the FTT location as a markpoint.

or

6. TMS Aft-Short (Stick) – Press to reject Fixed Target Track (FTT) without designating the markpoint.



Storing a Markpoint using TGP

The TGP may be used to designate a location on the ground for storing a markpoint when when set to Air-to-Ground (A-G) mode on the TGP MFD format, in POINT track, and the "TGP" sensor option is selected on the MARK DED page.

To store a markpoint using the TGP, perform the following:

1. DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.

2. RDR CURSOR/ENABLE switch (Throttle) – Slew the TGP line-of-sight crosshairs to the desired location on the TGP MFD format.

3. TMS Forward-Short (Stick) – Press and release to switch the TGP to POINT track.

or

3. TMS Right-Short (Stick) – Press to switch the TGP to AREA track.

4. ICP Keypad – Press **7/MARK**.

NOTE: If the TGP is already in POINT track when the MARK DED page is displayed, the sensor option is automatically set to "TGP" and step 5 is not required.

5. ICP DCS Switch – **SEQ** to select TGP in the sensor option data field, if necessary.

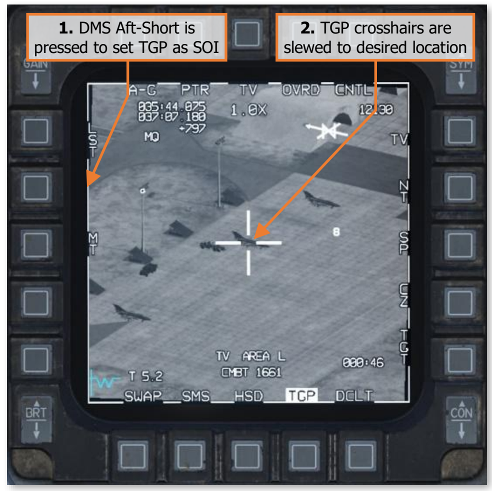
6. **(Optional)** LASER ARM Switch (MISC panel) – Set to **LASER ARM** position, if necessary.

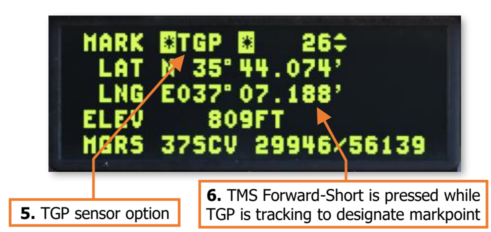
7. **(Optional)** Trigger (Stick) – Pull and hold to gain accurate range data.

NOTE: Although it is not required to fire the TGP's laser rangefinder/designator when storing a markpoint, it will increase the accuracy of the markpoint position, particularly when at low altitude and/or shallow look-down angles.

8. TMS Forward-Short (Stick) – Press to designate the TGP location as a markpoint.

9. Trigger (Stick) – Release.





Storing a Markpoint using OFLY

A markpoint may be stored by directly overflying the intended location and using the aircraft's current position to designate the markpoint location when the "OFLY" sensor option is selected on the MARK DED page.

NOTE: If OFLY is displayed in the sensor option data field on the MARK DED page, TMS Forward-Short will designate a markpoint regardless of the selected SOI.

To designate a markpoint at the current aircraft position, perform the following:

1. ICP Keypad – Press **7/MARK**.
2. ICP DCS Switch – **SEQ** to select OFLY in the sensor option data field.

   NOTE: OFLY will be the only functional sensor option if the master mode is set to A-A, MSL, or DGFT.
3. Maneuver the aircraft as necessary to ensure the flight path will take it over the intended markpoint location.
4. TMS Forward-Short (Stick) – Press to designate the location as a markpoint as the aircraft passes directly overhead the intended location.

Modify a markpoint using manual entry of latitude/longitude coordinates and elevation

A markpoint may be manually created on the MARK DED page by inputting latitude, longitude, and elevation data using the ICP. This procedure functions identically to manual data entry on the STPT or DEST DED pages. Additionally, position data of existing markpoints that have already been stored may be edited in a similar manner, if necessary.

NOTE: MGRS coordinates cannot be converted to Latitude/Longitude on the MARK DED page. As such, a markpoint cannot be manually input via MGRS. Only steerpoints 21-25 can be input via MGRS and subsequently converted to Latitude/Longitude format. (See Converting MGRS to Latitude/Longitude for more information.)

NAVIGATION ROUTES

The F-16C navigation system can be configured with up to three unique navigation routes, composed of sequential steerpoints within the Navigation partition of the database. Each steerpoint within the range of 1-25 may be assigned to a single navigation route, the sequence of which is driven by the steerpoint numbers themselves. However, navigation steering is always referenced to the selected steerpoint on the DED, regardless of whether the steerpoint is part of a navigation route or whether the steerpoint is within the Navigation partition of 1-25.

Navigation routes are composed during pre-mission planning, in which steerpoints within the Navigation partition are assigned to one or none of the three navigation routes. When planning a mission, it is useful to have multiple ingress and/or egress routes to and from the objective area. Although navigation routes may be created to correspond to a flight plan, they should not be exclusively considered as such; but rather avenues to reach the objective(s), a means of flight coordination and timing to or from mission objective(s), or a method to plan for contingencies such as egressing along an alternate route or navigating to a divert airfield for landing.

The steerpoints that compose a navigation route only determine the order by which steerpoints are automatically sequenced as each steerpoint within the route is passed. If steerpoint sequencing is set to AUTO on the STPT DED page, the next steerpoint in the navigation route sequence will automatically be selected when the aircraft is within 2 nautical miles of the currently selected steerpoint and the range to the selected steerpoint begins to increase. However, automatic sequencing will only be performed from steerpoints 1-20.

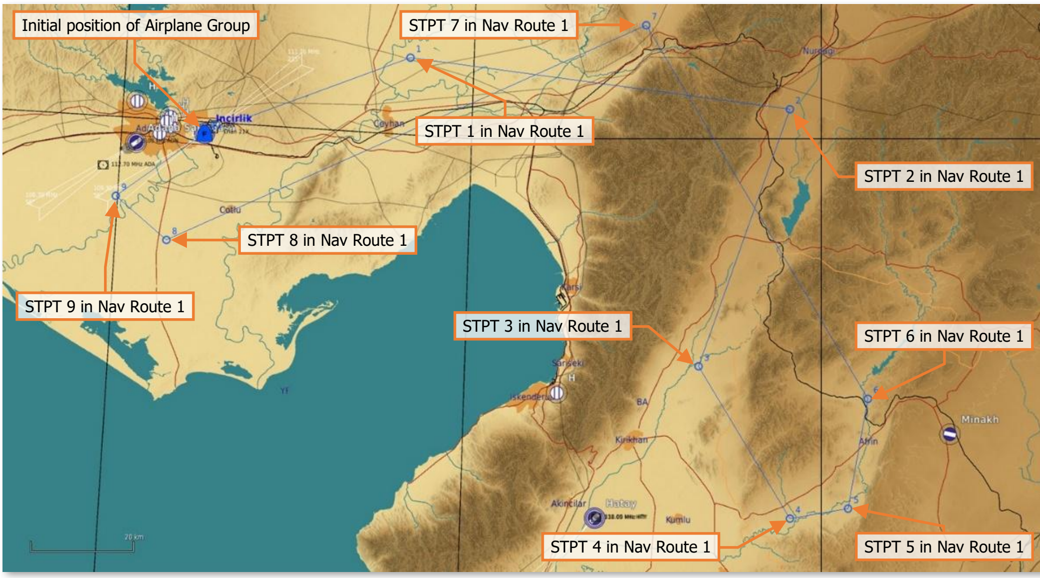
Automatic sequencing will be suspended under any of the following conditions.

- The master mode is set to Air-to-Ground (A-G).
- The FIX DED page is displayed.
- The MAN ACAL DED page is displayed.

Under such conditions, automatically sequencing to the next steerpoint in the navigation route may disrupt an air-to-ground attack, such as laser designating a target for a precision munition while overflying a target steerpoint, or if performing an update to the Inertial Navigation System (INS).

Creating a Navigation Route using the Mission Editor

When using the Mission Editor, waypoints placed on the map from the Airplane Group's Route tab will autopopulate into the DCS: F-16C Viper as steerpoints. Each waypoint following the initial Airplane Group position (waypoint 0) will be displayed as a steerpoints on the HSD as part of Navigation Route 1, and will be numbered in accordance with their sequence within the Mission Editor.



Mission Editor – Airplane Group Route

Steerpoints within the F-16C's navigation database are input and displayed in three dimensions, therefore it is typically advisable to set the altitude of all waypoints for the player's Airplane Group within the Mission Editor to the minimum value, which corresponds with ground level; especially if intended to mark a specific location, landmark, or target. However, under certain circumstances it may be useful to place steerpoints at altitudes above ground if such steerpoints are to be used for navigation, such as building 3-dimensional instrument approaches during low-visibility conditions.

NOTE: The waypoint altitudes for AI-only Airplane Groups must be set at the altitude at which they are intended to fly. However, if a steerpoint is to be used for orienting the player aircraft's sensors for the purposes of targeting or performing corrections to the navigation system through the use of surface landmarks, the waypoint altitudes should be placed at ground level. (See Sighting Points and Cursor Slews in the Tactical Employment chapter for more information.)

Navigation by Steerpoints

Navigation by steerpoints is the primary method of navigation during a mission. Information regarding the selected steerpoint is displayed at multiple locations within the cockpit, including the HUD, MFDs, and the EHSI.

Steerpoint Navigation Information

The Head-Up Display (HUD) overlays virtual symbols and navigation information within the pilot's forward view, permitting the pilot to maintain a "heads-out" view from the cockpit. This is particularly useful when avoiding terrain during low-level flight maneuvers, when approaching a target location that is marked by a steerpoint, or when maintaining formation near other friendly aircraft.

As an extension of the HUD, the Helmet-Mounted Cueing System (HMCS) provides some of the same information, allowing the pilot to visually identify the steerpoint location through the canopy at any viewing angle.

The Multi-Function Displays (MFD) include several formats that display steerpoint navigation information.

- The Horizontal Situation Display (HSD) format provides the most navigation information, particularly a graphical representation of navigation route(s) and steerpoint locations, along with many other symbology elements that illustrates where the aircraft is located within the battlespace at any point during the mission.
- The HARM Attack Display (HAD) format is similar to the HSD format and provides the same presentation of navigation route(s) and steerpoint locations.
- The Fire Control Radar (FCR) format displays the selected steerpoint location when set to Combined Radar Modes (CRM), allowing the pilot to see where radar tracks are located in relation to fixed geographical reference point.

The Electronic Horizontal Situation Display (EHSI) allows the pilot to precisely navigate along any course while using steerpoints, TACAN, or ILS as the source of navigation, even if the HUD and/or MFDs are inoperative.

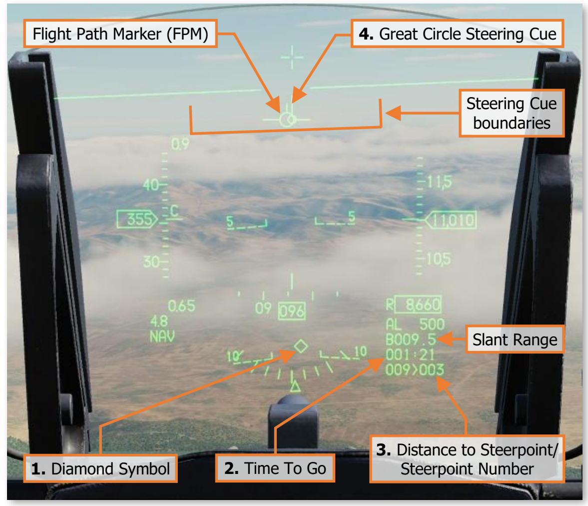
Head-Up Display (HUD)

In addition to the Heading Scale and Flight Path Marker (FPM), the following HUD symbology elements are used when navigating by steerpoints.

1. **Diamond Symbol.** Displays the 3-dimensional position of the selected steerpoint within the HUD field-of-view. An X is superimposed across the symbol itself any time it is outside the HUD field-of-view.

2. **Time to Go.** Displays the time that is estimated to elapse before arriving at the selected steerpoint, based on the current ground speed.

3. **Distance to Steerpoint/Steerpoint Number.** The distance to the selected steerpoint is displayed to the left of the chevron in 1 nautical mile increments. The selected steerpoint number is displayed to the right of the chevron.

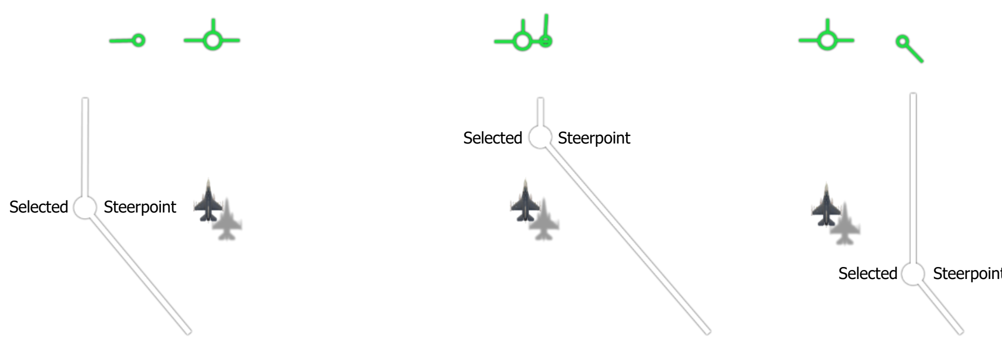


HUD Navigation Information

NOTE: The Slant Range data field displayed above the Time To Go indicates the direct, straight-line distance from the aircraft's 3-dimensional position to the selected steerpoint, target, or SPI location. The Distance to Steerpoint indicates the 2-dimensional navigational range from the aircraft's position across the ground.

4. **Great Circle Steering Cue.** Provides a lateral steering indication to the selected steerpoint. The steering cue functions using the great circle method, in that the most direct route across a 3-dimensional sphere is used to determine the course to the destination instead of a fixed heading across a 2-dimensional surface.

   The position of the steering cue is stabilized to a horizontal plane adjacent to the Flight Path Marker (FPM) and aligned to the horizon, and indicates the direction that the pilot must turn toward the selected steerpoint. If the virtual position of the steerpoint (as seen through the HUD) is beyond the lateral displacement boundaries of the steering cue, the steering cue will remain pinned to left or right edge of the boundary.



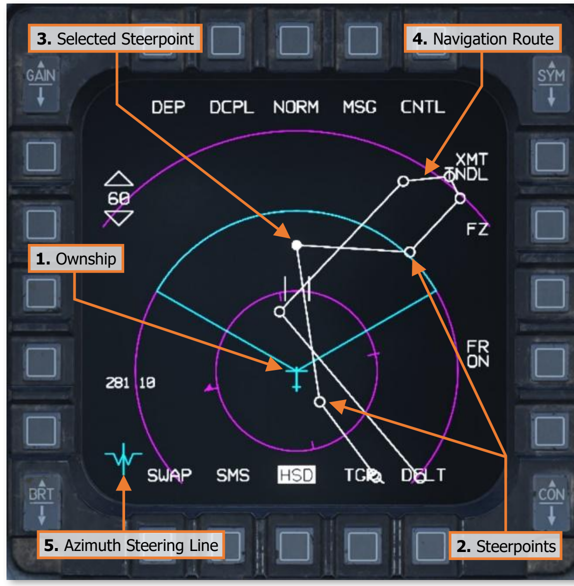
Great Circle Steering Cue

The line extending from the cue indicates the relative bearing to the selected steerpoint from the nose. If the line is pointed to the 12 o'clock, the steerpoint is directly ahead of the aircraft. If the line is pointed to the 3 or 9 o'clock, the steerpoint is 90° to the right or left of the aircraft, respectively. If the line is pointed to the 6 o'clock, the steerpoint is behind the aircraft.

Horizontal Situation Display (HSD)

The HSD MFD format provides a birds-eye view of the battlespace surrounding the aircraft, to include steerpoints and the navigation route(s).

1. **Ownship.** Depicts the location of the ownship.
2. **Steerpoints.** Steerpoints that are not the selected for navigation are displayed as hollow white circles.
3. **Selected Steerpoint.** The steerpoint selected for navigation is displayed as a solid white circle.
4. **Navigation Route.** The active navigation route is displayed as a solid white line linking sequential steerpoints.
5. **Azimuth Steering Line.** Displays the alignment of the aircraft heading relative to the selected steerpoint, SPI, or weapon release solution. If the line is offset left or right from the center of the watermark, the pilot must turn towards the steering line until centered on the watermark.



HSD Navigation Information

Electronic Horizontal Situation Indicator (EHSI)

The EHSI is a color liquid-crystal display that provides a top-down orientation of the navigation situation centered on the aircraft. The EHSI allows the pilot to precisely navigate along any course relative to a steerpoint, TACAN station, or ILS localizer, even if the HUD and MFDs are inoperative. (See TACAN or ILS for more information.)

1. **Bearing Pointer.** Indicates the bearing to the selected navigation source, depending on the selected mode. If the Instrument mode is set to NAV, the pointer will indicate the bearing to the selected steerpoint. If the Instrument mode is set to TCN or TCN/PLS, the pointer will indicate the bearing to the selected TACAN station if receiving a valid bearing signal.
2. **Lubber Lines.** Indicate relative azimuths around the aircraft in relation to the aircraft's heading independently of the magnetic heading compass, in 45° increments.
3. **Range Indicator.** Displays the range in nautical miles (NM) to the selected navigation source, depending on the selected mode. If the Instrument mode is set to NAV, the range to the selected steerpoint is displayed. If the Instrument mode is set to TCN or TCN/PLS, the range to the selected TACAN station is displayed if receiving valid DME (Distance Measuring Equipment) signals. The fourth digit of the range indicator (highlighted in white) provides a range resolution of 0.1 NM.
4. **Magnetic Heading Compass.** Displays the magnetic heading reference around the Aircraft symbol. Cardinal directions and numerals to the nearest tens value are placed every 30° of azimuth, major tick marks are placed at every 10° of azimuth, and minor tick marks are placed at every 5° of azimuth.
5. **Heading Marker.** Indicates the desired heading reference as set by the Heading Set knob. If the Autopilot ROLL switch on the MISC panel is set to the HDG SEL position, the aircraft will turn toward and maintain this heading value. (See Autopilot for more information.)
6. **Course Indicator.** Displays the desired course as set by the Course Set/Brightness knob.
7. **To-From Indicator.** Indicates the hemispherical position of the selected TACAN station in relation to the desired course. If the To-From indicator is pointed in the same direction as the Course Pointer, the pilot will be flying to the TACAN station if proceeding along the desired course. If the To-From indicator is pointed in the opposite direction as the Course Pointer, the pilot will be flying away from the TACAN station if proceeding along the desired course.
8. **Course Pointer.** Indicates the desired course direction as set by the Course Set/Brightness knob.
9. **Course Deviation Scale.** Provides a reference scale relative to the Course Pointer along which the Course Deviation Indicator is displaced. The scale of deviation is dependent on the selected mode.

   If the Instrument mode is set to NAV or TCN, the inner white dots correspond to a 5° lateral separation from the desired course line and the outer white dots correspond to a 10° lateral separation from the desired course line.

   If the Instrument mode is set to NAV/PLS or TCN/PLS and receiving a valid localizer signal, the inner white dots correspond to a 1.25° lateral separation from the ILS localizer and the outer white dots correspond to with a 2.5° lateral separation from the ILS localizer.
10. **Course Deviation Indicator.** Indicates the lateral deviation from the desired course line along the Course Deviation Scale relative to the Course Pointer. If the indicator is aligned with the course pointer, the aircraft is aligned with the desired course. If the indicator is offset to either side, the aircraft has laterally deviated from the desired course.
11. **New Mode Indicator.** When the selected Instrument mode is changed, the newly selected mode is displayed in front of the Aircraft symbol for 1 second. If the Heading Set or Course Set/Brightness knobs are depressed, the "ADJ HDG" or "BRT" messages will be displayed to indicate their respective alternate functions are enabled.
12. **Aircraft Symbol.** Provides a top-down orientation reference of the navigation situation around the aircraft, around which the Magnetic Heading Compass rotates.
13. **Heading Set Knob.** Sets the position of the Heading Marker around the Magnetic Heading Compass. If depressed while the INU is set to Attitude (ATT) mode, the knob may be used to manually adjust the Magnetic Heading Compass while "ADJ HDG" is displayed. After 2 seconds of inactivity, the knob will revert to its normal function and "ADJ HDG" will be removed.

14. Course Set/Brightness Knob. Sets the desired course as displayed by the Course Indicator and Course Pointer. If depressed, the knob may be used to increase/decrease the intensity of the EHSI display itself while "BRT" is displayed. After 2 seconds of inactivity, the knob will revert to its normal function.

If the EHSI Instrument mode is set to NAV/PLS or TCN/PLS modes, the EHSI course will be synced to the ILS course on the T-ILS DED page but may be modified by rotating the Course Set/Brightness knob.

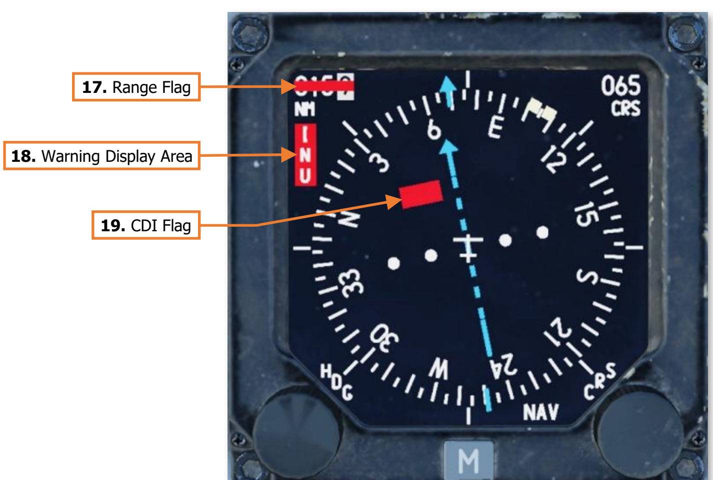
15. Instrument Mode Selector. Switches through the available Instrument Modes of the EHSI in a cyclic, repeating sequence of NAV, NAV/PLS, TCN, TCN/PLS, back to NAV, and so on.

16. Selected Instrument Mode. Displays the navigation source to which the EHSI is providing bearing, course, and range indications.

- **NAV.** The EHSI will provide bearing and range indications to the selected steerpoint. Course deviation indications will be based on the desired course direction to the selected steerpoint as set by the Course Set/Brightness knob.
- **NAV/PLS.** The EHSI will provide bearing and range indications to the selected steerpoint. Course deviation indications will be based on the desired course direction to the selected steerpoint as set by the Course Set/Brightness knob.

  If the ILS receiver is enabled by the ILS Power/Volume knob on the AUDIO 2 control panel and an ILS localizer frequency is entered on the T-ILS DED page, any localizer signals that are received on corresponding frequency will take precedence over the selected steerpoint. Course deviation indications will be based on ILS localizer signals regardless of the course set by the Course Set/Brightness knob.
- **TCN.** The EHSI will provide bearing indications to the selected TACAN station. Course deviation indications will be based on the desired course direction to the selected TACAN station as set by the Course Set/Brightness knob. Range indications will be provided if DME signals are received.
- **TCN/PLS.** The EHSI will provide bearing indications to the selected TACAN station. Course deviation indications will be based on the desired course direction to the selected TACAN station as set by the Course Set/Brightness knob. Range indications will be provided if DME signals are received.

  If the ILS receiver is enabled by the ILS Power/Volume knob on the AUDIO 2 control panel and an ILS localizer frequency is entered on the T-ILS DED page, any localizer signals that are received on corresponding frequency will take precedence over the selected steerpoint. Course deviation indications will be based on ILS localizer signals regardless of the course set by the Course Set/Brightness knob.



17. Range Flag. Displayed when range to the selected steerpoint or the selected TACAN station is not available.

18. Warning Display Area. Displays a message indicating a loss in INU data or degraded mode of operation.

- **INU.** The INU is powered off, is not aligned, or has malfunctioned or failed in some manner.
- **ATT.** The INU is set to Attitude (ATT) mode.

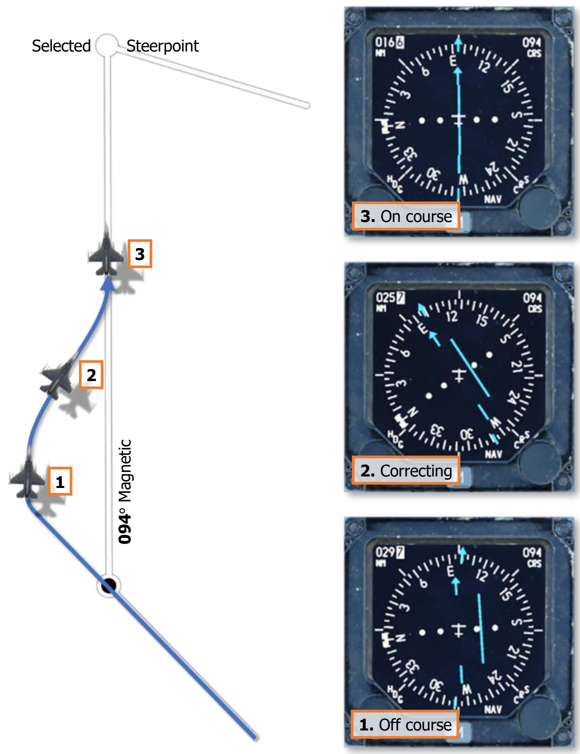
19. CDI Flag. Displayed when course deviation indications are unavailable. The Course Deviation Indicator will be centered within the Course Pointer and dashed.

EHSI Navigation (NAV) Mode

When set to NAV mode, the EHSI allows the pilot to set a desired course to the selected steerpoint and precisely navigate that course in the event the HUD or MFDs are inoperable.

In the example on the right, the pilot has overflown steerpoint 2 and turned toward steerpoint 3 after deviating from the planned navigation route.

1. The Course Deviation Indicator on the EHSI indicates the desired course line between steerpoints 2 and 3 is 6° to the right of the aircraft's current position.
2. The pilot turns right toward the Course Deviation Indicator to correct the deviation and re-intercept the desired course line of 094° (magnetic) to steerpoint 3. As the aircraft approaches the desired course line, the Course Deviation Indicator moves back toward the center.
3. As the Course Deviation Indicator approaches the center of the Course Deviation Scale, the pilot starts to turn back toward the steerpoint. If properly timed, the pilot will roll back to a level attitude on the desired course just as the Course Deviation Indicator reaches the center of the Course Deviation Scale, in line with the Aircraft Symbol.



EHSI Navigation Mode

In this example, the pilot performed a course correction by hand-flying the aircraft. However, if desired, the pilot may utilize the autopilot functions on the MISC panel to assist with navigation and course corrections.

- With the Autopilot PITCH switch set to the ALT HOLD position and the Autopilot ROLL switch set to the ATT HOLD position, roll inputs may be made with the stick to re-intercept and maintain the course.
- The Heading Set knob may be rotated to align the Heading Marker on the EHSI to the desired intercept heading and the Autopilot ROLL switch may be set to the HDG SEL position, which will allow the autopilot to turn the aircraft to re-intercept the course.
- The Heading Set knob may be rotated to align the Heading Marker on the EHSI to the course as the aircraft approaches the course line, which will allow the autopilot to turn the aircraft back on-course.
- The Autopilot ROLL switch may be set to the STRG SEL position after re-intercepting the course, which will allow the autopilot to maintain course to the selected steerpoint.

Selecting a Steerpoint

A steerpoint may be selected for navigation from the STPT DED page, which is accessed by pressing the **4/STPT** button on the ICP keypad when the CNI DED page is displayed. The ICP Increment/Decrement rocker may be used to sequentially cycle through steerpoints within the navigation database any time the current DED page displays the selected steerpoint in the top right corner of the DED itself and the Increment/Decrement symbol is placed adjacent to the selected steerpoint data field.

To select a steerpoint using the Upfront Controls, perform the following:

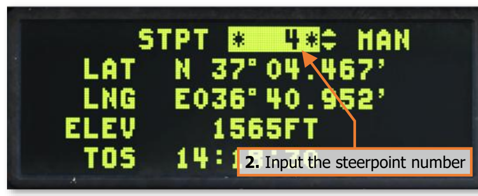
1. ICP **Increment/Decrement** Rocker – Select the steerpoint number.

or

1. ICP Keypad – Press **4/STPT** to display the STPT DED page.

2. ICP **Keypad** – Input the steerpoint number.

3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.



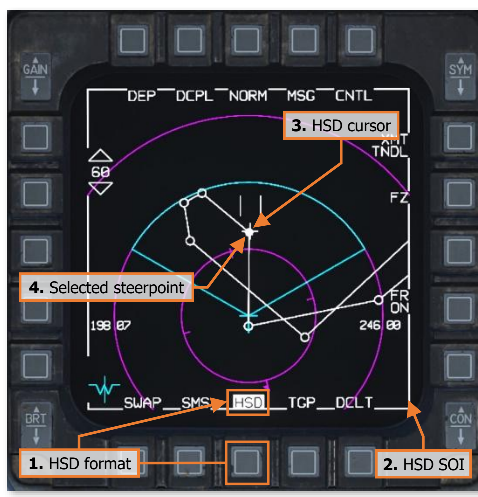
To select a steerpoint using the Hands-On Controls, perform the following:

1. DMS Left or DMS Right – Press as necessary to display the HSD format on either MFD.

2. DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HSD MFD format.

3. RDR CURSOR/ENABLE Switch – Slew the HSD cursor to the symbol of the steerpoint that is intended to be used for navigation.

4. TMS Up-Short – Press to select the steerpoint symbol.



TACTICAL AIR NAVIGATION (TACAN)

The Tactical Air Navigation system is a radio-based navigation system used primarily by military aircraft. TACAN is similar to VOR (Very high frequency Omnidirectional Range) navigation stations in that a TACAN station employs a unique radio signal to provide bearing and distance measurement from aircraft to the station itself, and is dependent on line-of-sight between the aircraft and the station antenna. However, unlike VOR stations that operate on VHF frequencies, TACAN operates on UHF frequencies, offers increased precision and range, and includes an inherent DME (Distance Measuring Equipment) function.

Although terrestrial TACAN stations are often co-located and combined with VOR stations, referred to as VORTAC stations, TACAN is also used by naval vessels such as aircraft carriers to enable aircraft to navigate to their location for approach and landing. TACAN beacons operate across 126 channels, split between two bands (X and Y), for a total of 252 usable navigation channels to prevent interference between multiple stations.

Three TACAN modes of operation may be selected through the F-16's Upfront Controls (UFC).

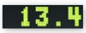
- **Receive-only (REC).** Bearing to the selected TACAN station. Distance measurement is not provided.
- **Transmit/Receive (T/R).** Bearing and distance measurement to the selected TACAN station.
- **Air-Air Transmit/Receive (A/A T/R).** Distance measurement between two TACAN-equipped aircraft.

The Multifunction Information Distribution System (MIDS) on F-16C Block 50 aircraft provides both tactical datalink and TACAN capabilities. As such, the MIDS Low Volume Terminal must be powered on the AVIONICS POWER control panel to enable TACAN functions through the UFC and enable bearing and range indications on the Electronic Horizontal Situation Indicator (EHSI).

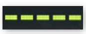
Tuning a TACAN Station

If the MIDS LVT knob is set to ON, TACAN-related information will be displayed at the bottom right corner of the CNI DED page. If the MIDS LVT knob is set to OFF, this data field will be blank.

TACAN is powered and set to **REC** or **T/R** mode. The selected TACAN channel and band (X/Y) are displayed.



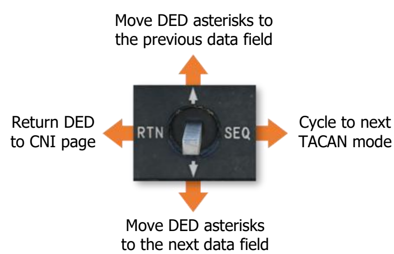
TACAN is powered and set to **A/A T/R** mode. Distance measurement is displayed between 00.1 and 99.9 NM.



TACAN is powered and set to **A/A T/R** mode. Distance measurement is not available.

T-ILS DED page (TACAN)

The TACAN-ILS DED page is accessed by pressing the **1/T-ILS** button on the ICP keypad when the CNI page is displayed on the DED. This page allows the pilot to configure TACAN or ILS (Instrument Landing System) settings for radio-based navigation procedures. (See Instrument Landing System for more information.)



1. **TACAN Mode.** Displays the selected TACAN mode of operation. The mode may be cycled between REC, T/R, and A/A T/R by momentarily positioning the DCS ("Dobber" switch) to the SEQ position.

   NOTE: If the MIDS LVT is powered off, the TCN Mode will be replaced by OFF in an enlarged font.

2. **Beacon Identification.** Displays the 3-character identification received from the selected TACAN station. (e.g., "DAN" corresponds with the TACAN station located at Incirlik Air Base).

3. **TACAN Channel.** Displays the selected TACAN channel. May be modified by placing the DED asterisks over the data field, inputting a value between 1 and 126 using the ICP keypad, and pressing ENTR.

4. **TACAN Band.** Displays the selected TACAN band. May be toggled between X and Y by pressing the ICP 0/M-SEL button and then pressing the ENTR button.

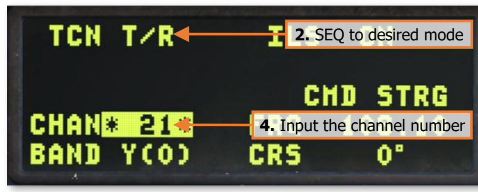
5. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

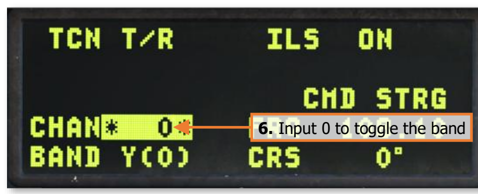
Tuning a TACAN Station

The TACAN mode of operation, channel, and band may be modified from the T-ILS DED page, which is accessed by pressing the **1/T-ILS** button on the ICP keypad when the CNI DED page is displayed.

To tune a TACAN station, perform the following:

1. ICP Keypad – Press **1/T-ILS**.
2. ICP DCS Switch – **SEQ** to select the desired TACAN mode of operation, as necessary.
   - **REC** or **T/R** – Select when tuning a ground- or naval-based TACAN station.
   - **A/A T/R** – Select when employing the TACAN in an Air-to-Air mode.
3. ICP DCS Switch – **Down** to move DED asterisks around CHAN data field.
4. ICP **Keypad** – Input the TACAN channel (1-126), which is input with no leading zeros.
5. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
6. ICP Keypad – Press **0/M-SEL** as necessary to toggle the band between X and Y.
7. ICP Keypad – Press **ENTR** to accept the selected TACAN band or **RCL** to reject it.
8. Verify the BCN data field displays the correct 3-character identifier for the TACAN station that is intended to be used for navigation.
9. **(A/A T/R mode only)** ICP DCS Switch – **RTN** to display the CNI page as desired to view the distance measurement to the paired TACAN receiver.





Identifying a TACAN Station

TACAN stations typically broadcast a unique, 3-character identifier using Morse code, which allows any receiving aircraft to confirm the station to which they have tuned their TACAN receiver is the correct station that they intend to use for navigation. When a valid TACAN signal is received, the T-ILS DED page will automatically display the identifier in the BCN data field.

However, if desired, the pilot may listen to the raw Morse code audio signal received from the tuned TACAN station by rotating the TACAN knob clockwise on the AUDIO 2 control panel.

Once a TACAN station has been tuned and identified, the EHSI must be configured for TACAN navigation, as described on the following pages.

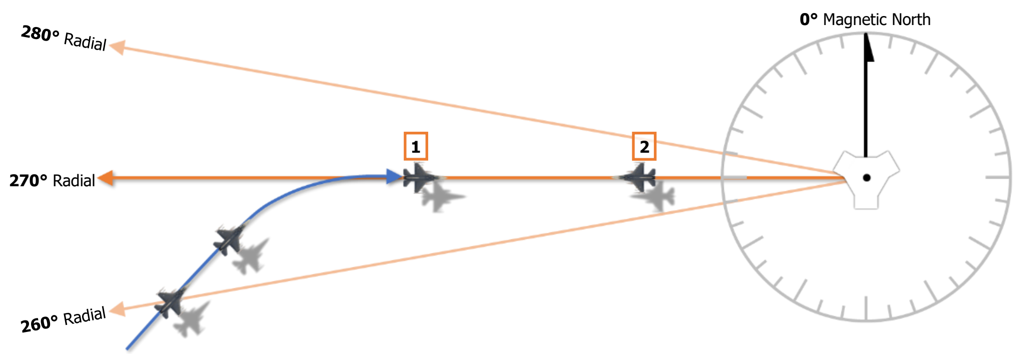
Radio Navigation by TACAN

Navigation by TACAN radio signals may be used during operations under Instrument Flight Rules (IFR); or if the Inertial Navigation system (INS) has malfunctioned in such a manner that it is no longer reliable for navigation and the aircraft must be recovered to a friendly airfield. Once a TACAN station has been tuned and identified through the Upfront Controls (as described on the previous page), the EHSI must be set to TCN mode by pressing the Instrument Mode Selector button on the EHSI itself, after which bearing and distance to the selected TACAN station may be displayed. (See Electronic Horizontal Situation Display (EHSI) for more information.)

It is worth noting that unlike an INS, TACAN signals require line-of-sight between the aircraft and the TACAN stations themselves. TACAN signals are generally considered reliable for up to 130 nautical miles, but under some circumstances may be less, especially at low altitudes.

Radials

Navigation to and from TACAN stations is typically performed along lines known as "Radials", which protrude outward from the TACAN station like spokes of a bicycle wheel and are identified by their corresponding compass direction relative to magnetic north. In the example below, the 270-degree Radial starts at the location of the TACAN station itself and runs directly west, or 270°, relative to the local magnetic north.



TACAN Radials

Radials are not to be confused with an aircraft's *course*. In the example above, two aircraft are established on the 270° Radial, with one flying inbound toward the TACAN and the other flying outbound from the TACAN.

The aircraft on the left [**1**] was initially flying a course of 045° to intercept the 270° Radial, and then turned to a course of 090° *to* the TACAN station once established inbound *along* the 270° Radial.

The aircraft on the right [**2**] is flying a course of 270° *from* the TACAN station and is established outbound *along* the 270° Radial.

In both cases, the Bearing Pointer indicates the bearing to the TACAN station independently of the Course Pointer.

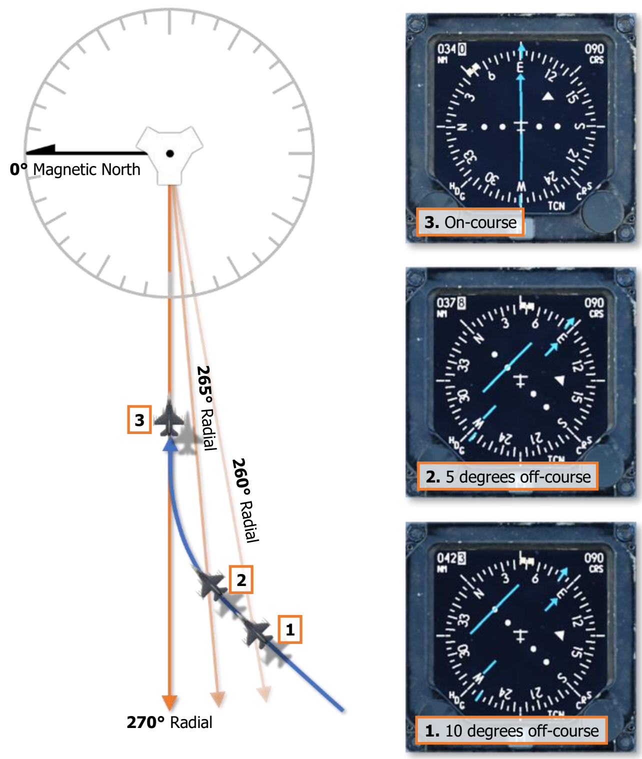
The To/From Indicator provides an indication as to whether the course set by the pilot corresponds with an inbound course toward the TACAN station or an outbound course from the TACAN station.

EHSI TACAN (TCN) Mode

When set to TCN mode, the EHSI allows the pilot to set a desired course to the selected TACAN station and precisely navigate along that course.

In the example on the right, the pilot has set the desired inbound course to the selected TACAN station as 090° while approaching the 270° Radial.

1. The aircraft is approaching the desired course at an intercept angle. The Course Deviation Indicator on the EHSI indicates the desired course line is 10° to the left of the aircraft's current position.
2. The Course Deviation Indicator on the EHSI indicates the desired course line is 5° to the left of the aircraft's current position.
3. As the Course Deviation Indicator approaches the center of the Course Deviation Scale, the pilot begins a right turn toward the Course Pointer. If properly timed, the pilot will roll back to a level attitude on the desired course just as the Course Deviation Indicator reaches the center of the Course Deviation Scale, in line with the Aircraft Symbol.



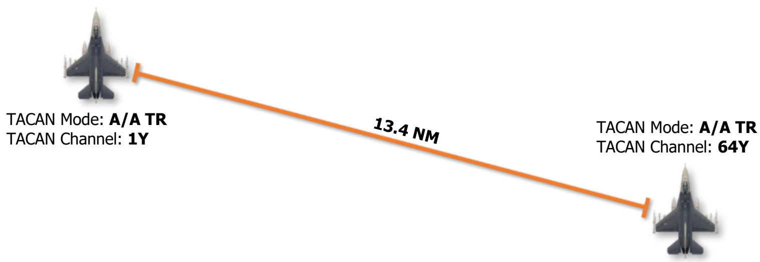
EHSI TACAN Mode

In this example, the pilot performed a course correction by hand-flying the aircraft. However, if desired, the pilot may utilize the autopilot functions on the MISC panel to assist with navigation and course corrections.

- With the Autopilot PITCH switch set to the ALT HOLD position and the Autopilot ROLL switch set to the ATT HOLD position, roll inputs may be made with the stick to intercept and maintain the course.
- The Heading Set knob may be rotated to align the Heading Marker on the EHSI to the desired intercept heading and the Autopilot ROLL switch may be set to the HDG SEL position, which will allow the autopilot to turn the aircraft to re-intercept the course.
- The Heading Set knob may be rotated to align the Heading Marker on the EHSI to the course as the aircraft approaches the course line, which will allow the autopilot to turn the aircraft back on-course.

Air-to-Air TACAN

Although primarily used to provide bearing and distance to ground- or naval-based TACAN stations, the distance measuring function of TACAN may be used in an "air-to-air" mode to calculate the slant range between two TACAN-equipped aircraft. When the TACAN receivers on board each aircraft are set to A/A TR mode, and the TACAN channels are set precisely 63 channels apart and in the same band (X or Y), the range to the opposite aircraft is displayed in each aircraft, in nautical miles (NM). (See Tuning a TACAN Station for more information)



Air-to-Air TACAN

Since each pair of TACAN channels may also be utilized across either the X or Y bands, 126 possible TACAN pairings may be chosen. However, these channel selections must remain deconflicted from any channels in use by ground- or naval-based TACAN stations within the region to avoid interference or erroneous signals.

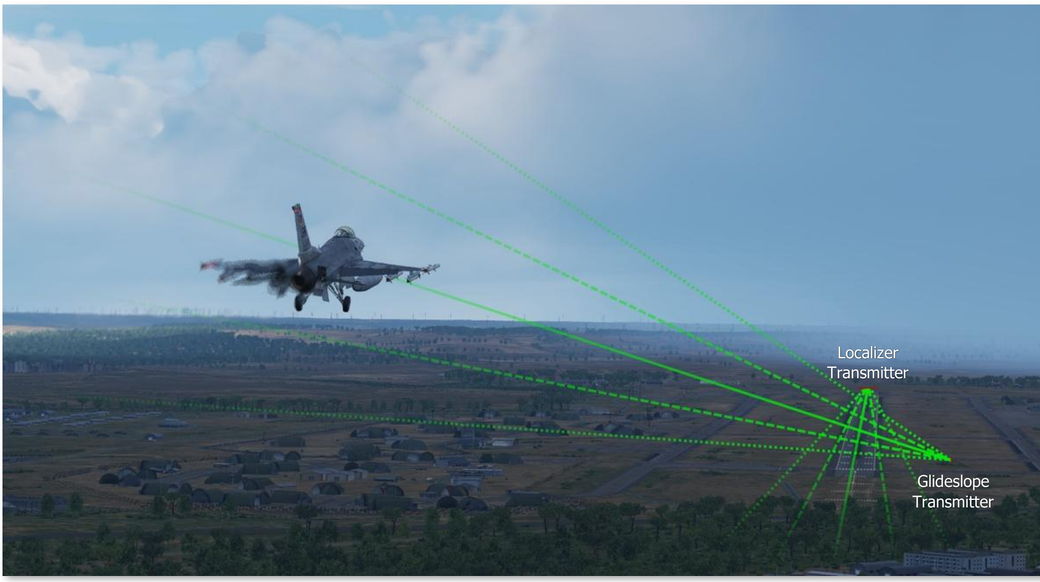
Air-to-Air TACAN – Paired channels

1 ↔ 64	8 ↔ 71	15 ↔ 78	22 ↔ 85	29 ↔ 92	36 ↔ 99	43 ↔ 106	50 ↔ 113	57 ↔ 120
2 ↔ 65	9 ↔ 72	16 ↔ 79	23 ↔ 86	30 ↔ 93	37 ↔ 100	44 ↔ 107	51 ↔ 114	58 ↔ 121
3 ↔ 66	10 ↔ 73	17 ↔ 80	24 ↔ 87	31 ↔ 94	38 ↔ 101	45 ↔ 108	52 ↔ 115	59 ↔ 122
4 ↔ 67	11 ↔ 74	18 ↔ 81	25 ↔ 88	32 ↔ 95	39 ↔ 102	46 ↔ 109	53 ↔ 116	60 ↔ 123
5 ↔ 68	12 ↔ 75	19 ↔ 82	26 ↔ 89	33 ↔ 96	40 ↔ 103	47 ↔ 110	54 ↔ 117	61 ↔ 124
6 ↔ 69	13 ↔ 76	20 ↔ 83	27 ↔ 90	34 ↔ 97	41 ↔ 104	48 ↔ 111	55 ↔ 118	62 ↔ 125
7 ↔ 70	14 ↔ 77	21 ↔ 84	28 ↔ 91	35 ↔ 98	42 ↔ 405	49 ↔ 112	56 ↔ 119	63 ↔ 126

The air-to-air mode of TACAN functions independently of the selected EHSI mode, in that the Selected Instrument Mode on the EHSI may be set to NAV or PLS without affecting the function.

INSTRUMENT LANDING SYSTEM (ILS)

The Instrument Landing System is a radio-based navigation system used by aircraft to make a precision approach to a runway during low-visibility, which includes hours of darkness or instrument meteorological conditions (IMC). ILS employs a pair of directional radio signals that are detected by dedicated radio receivers onboard the aircraft which provide horizontal and vertical steering guidance to the pilot via cockpit instruments.



Each ILS system includes two radio transmitters strategically placed near the runway, one that emits a VHF localizer signal another that emits a UHF glideslope signal.

- **Localizer.** The localizer provides horizontal approach guidance and is aligned with the ILS approach course. The localizer transmitter is located at the opposite end of the runway from the intended approach direction.
- **Glideslope.** The glideslope provides vertical approach guidance and is aligned with the ILS approach angle. The glideslope transmitter is located to the side of the runway near the touchdown area.

Some airfields include a series of radio transmitters called "marker beacons" that provide audio and/or visual cockpit alerts as to when the aircraft has reached a specified distance from the runway touchdown threshold.

- **Outer Marker.** The outer marker is typically used to identify the location at which the aircraft intercepts the glideslope and should initiate a descent along the ILS approach course.
- **Middle Marker.** The middle marker is typically used to identify the point along the glideslope at which a missed approach procedure should be executed if the runway is not in sight (≥200 feet AGL).
- **Inner Marker.** The inner marker is typically used in the same manner as the middle marker for ILS approach procedures that permit a lower missed approach point (<200 feet AGL), subject to specific requirements.

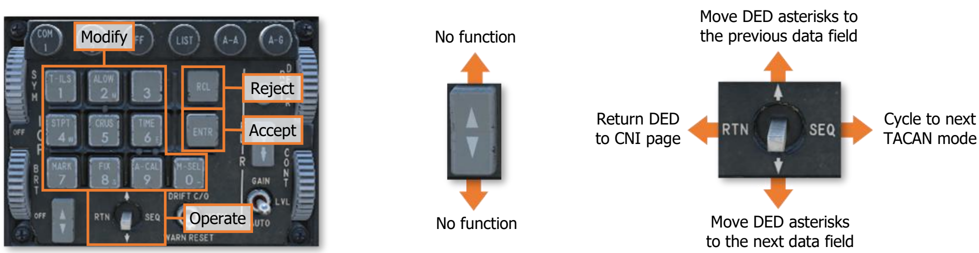
The ILS receiver is powered by rotating the ILS power/volume knob on the AUDIO 2 control panel clockwise from the OFF position. If the ILS power/volume knob is set to OFF, the ILS localizer frequency cannot be edited on the T-ILS DED page.

Tuning an ILS Localizer

If the ILS power/volume knob clockwise from the OFF position, an ILS localizer frequency may be entered into the T-ILS DED page. ILS localizer frequencies occupy 40 VHF channels between 108 and 112 MHz, separated in 5 kHz intervals and allocated to only those frequencies with an "odd" kHz interval, such as 108.10, 108.15, 108.30, 108.35, etc., up to a maximum frequency of 111.95 MHz. Each localizer frequency is paired with a corresponding glideslope frequency, which is automatically tuned by the ILS receiver based on the selected localizer frequency and does not require pilot interaction.

T-ILS DED Page (ILS)

The TACAN-ILS DED page is accessed by pressing the **1/T-ILS** button on the ICP keypad when the CNI page is displayed on the DED. This page allows the pilot to configure TACAN (Tactical Air Navigation) or ILS settings for radio-based navigation procedures. (See Tactical Air Navigation for more information.)



1. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.
2. **ILS Status.** Displays the state of the ILS receiver as ON or OFF.
3. **Command Steering Status.** Indicates that a localizer signal is being received and command steering to the corresponding runway is available if the EHSI Instrument mode is set to NAV/PLS or TCN/PLS. If the data field is not highlighted, a localizer signal is not being received over the selected ILS frequency.
4. **ILS Frequency.** Displays the selected localizer frequency. May be modified by placing the DED asterisks over the data field, inputting an appropriate localizer frequency using the ICP keypad, and pressing ENTR.
5. **ILS Approach Course.** Displays the selected approach course. May be modified by placing the DED asterisks over the data field, inputting a magnetic course between 0° and 360° using the ICP keypad, and pressing ENTR.

   If the EHSI Instrument mode is set to NAV/PLS or TCN/PLS modes, the EHSI course will be synced to the ILS course in this data field but may be modified by rotating the Course Set/Brightness knob on the EHSI itself or by editing the ILS course on the DED. If the EHSI Instrument mode is set to NAV or TCN, the ILS course may be modified independently of the course set on the EHSI.

Tuning an ILS Localizer

The ILS localizer frequency and course may be modified from the T-ILS DED page, which is accessed by pressing the **1/T-ILS** button on the ICP keypad when the CNI DED page is displayed.

To tune an ILS localizer in preparation for performing a precision approach, perform the following:

1. ILS Knob (AUDIO 2 control panel) – Rotate clockwise out of the OFF position as necessary.
2. ICP Keypad – Press **1/T-ILS**. Verify the ILS status data field displays ILS ON.
3. ICP DCS Switch – **Down** to move DED asterisks around FRQ data field.
4. ICP **Keypad** – Input the localizer frequency, which is input as a continuous string of five numbers with no leading zeros.
5. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
6. ICP DCS Switch – **Down** to move DED asterisks around CRS data field.
7. ICP **Keypad** – Input the approach course, which is input as degrees magnetic with no leading zeros.
8. ICP Keypad – Press **ENTR** to accept the selected TACAN band or **RCL** to reject it.

Identifying an ILS Localizer

Localizer antennas typically broadcast a unique, 3-character identifier using Morse code, which allows any receiving aircraft to confirm the localizer to which they have tuned their ILS receiver corresponds to the correct airfield and runway for an approach and landing. When a valid localizer signal is received, the CMD STRG data field on the T-ILS DED page will be highlighted.

However, if desired, the pilot may listen to the raw Morse code audio signal received from the localizer transmitter by rotating the ILS knob clockwise on the AUDIO 2 control panel.

Once an ILS localizer has been tuned, the EHSI must be configured to enable ILS guidance indications.

ILS Approach in Low-Visibility Conditions

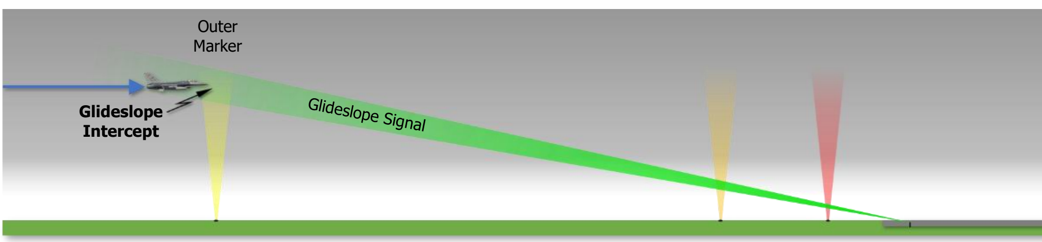
Under circumstances in which a pilot cannot visually navigate to an airfield runway for landing while remaining clear of terrain or other obstacles, the ILS allows the pilot to use cockpit instrumentation to safely and reliably perform an approach to a runway during nighttime or inclement weather conditions. ILS is used to guide aircraft in a controlled descent, clear of obstacles and terrain, to a lower altitude where the pilot can transition from cockpit instruments to visual recognition of the runway environment just prior to touchdown at an airfield.

Unlike TACAN stations, which may be used for navigation across long distances, ILS radio signals are limited to short distances along a narrow approach corridor to a corresponding runway. However, guidance signals transmitted by ILS are more precise, permitting pilots to safely descend to lower altitudes near the destination airfield, increasing the likelihood of visually spotting the intended runway before it becomes necessary to abort the approach and divert to another airfield.

Glideslope Intercept

Steerpoints or TACAN stations are required to navigate to a 3-dimenisonal position in the sky near the destination airfield from where the ILS localizer signal is being transmitted. Once the localizer signal on the selected frequency is received by the onboard ILS receiver, the pilot will receive course guidance to the center of the ILS approach course in a manner similar to intercepting a TACAN radial. However, when initially acquiring the localizer signal during an ILS approach procedure, it is likely the aircraft will have not yet intercepted the glideslope.

The most common method of intercepting the glideslope is from below, in which the pilot maintains level flight along the localizer approach course, at the glideslope intercept altitude, while approaching the glideslope approach path. The standard glideslope angle is 3°, but the angle may vary depending on obstacles or terrain in the approach path or the prevalence of specific types of aircraft that frequently operate from the airfield.



ILS Glideslope Intercept

The altitudes (in feet) above the runway elevation at which the glideslope is intercepted are shown in the table below, rounded to the nearest hundred feet (ft), based on the glideslope angle and slant distance to the runway.

SLANT DISTANCE	15 NM	14 NM	13 NM	12 NM	11 NM	10 NM	9 NM	8 NM	7 NM	6 NM	5 NM
GS 3.5°	+5,600	+5,200	+4,800	+4,500	+4,100	+3,700	+3,300	+3,00	+2,600	+2,200	+1,900
GS 3.0°	+4,800	+4,500	+4,100	+3,800	+3,500	+3,200	+2,900	+2,500	+2,200	+1,900	+1,600
GS 2.5°	+4,000	+3,700	+3,400	+3,200	+2,900	+2,700	+2,400	+2,100	+1,900	+1,600	+1,300

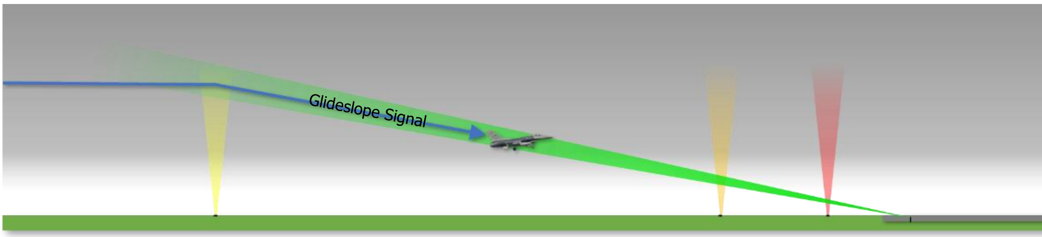
Once the glideslope signal has been acquired and the applicable cockpit instruments indicate the aircraft is approaching glideslope alignment, the pilot initiates a descent.

Outer marker beacon. Outer markers in the United States are typically used to identify the location at which the aircraft should intercept the glideslope and initiate the descent along the approach path. However, the locations of outer marker beacons relative to the runway, and their intended use, may vary in other regions of the world.

Outer markers generate a 400 Hz audio tone in a repeating "dash" (**— — —**) Morse code pattern and illuminate the Marker Beacon light to the right of the EHSI.

Glideslope Descent

Once glideslope alignment has been achieved, the pilot should attempt to maintain a constant descent rate, which will vary depending on the glideslope angle and the ground speed during the approach. Small adjustments of the throttle will be necessary to adjust the descent rate in order to remain centered within the glideslope signal.



ILS Glideslope Descent

The descent rates (in feet per minute, or fpm) that are required to maintain glideslope alignment are shown in the table below, rounded to the nearest ten feet per minute, based on the glideslope angle and aircraft ground speed (in knots) during the approach.

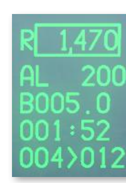
GROUND SPEED	200	190	180	170	160	150	140	130	120	110
GS 3.5°	-1170	-1110	-1050	-990	-930	-880	-820	-760	-700	-640
GS 3.0°	-1000	-950	-900	-850	-800	-750	-700	-650	-600	-550
GS 2.5°	-830	-790	-750	-710	-670	-630	-580	-540	-500	-460

As the wind conditions may change throughout the approach, which can affect the ground speed relative to the approach airspeed that is being maintained during descent, the pilot will need to adjust the descent rate as needed to account for variations in the aircraft's ground speed.

As the aircraft nears the runway and the localizer and glideslope radio lobes become more narrow, adjustments to the aircraft's course and descent rate should be made with care to avoid "chasing the needles" on the HUD and ADI, which will become more sensitive to any deviations. In addition, during this final phase of the descent, pilots should avoid becoming distracted with the increased sensitivity of the ILS indications, otherwise they may inadvertently descend through the Decision Height (see the following page).

MSL FLOOR. The MSL FLOOR altitude alert on the ALOW DED page may be used to trigger a voice warning message when passing through the Decision Height. If the value of the Decision Height is added to the runway surface elevation near the touchdown zone, and then input as the MSL FLOOR value on the ALOW DED page, the "Altitude…altitude" voice warning message will alert the pilot when passing through the Decision Height. For example, if the runway elevation is 160 feet and the Decision Height is 200 feet, the MSL FLOOR value would be set to 360 feet.

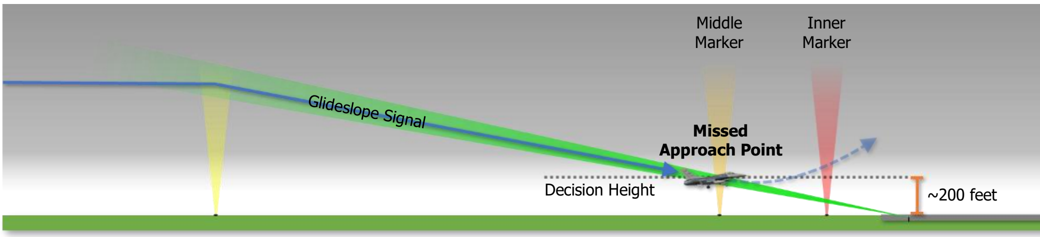
CARA ALOW. The CARA ALOW altitude alert on the ALOW DED page may be used to trigger a visual indication in the HUD when passing through the Decision Height. If the value of the Decision Height is input as the CARA ALOW value on the ALOW DED page, the Altitude Low indication will flash in the HUD. For example, if the Decision Height is 200 feet, a value of 200 is input into the CARA ALOW data field, which will be displayed below the Radar Altitude indication as "AL 200". When the radar altimeter measures the altitude above ground is below 200 feet, "AL 200" will flash.



Note that the "Altitude…altitude" voice warning message that normally accompanies a violation of the CARA ALOW setting is inhibited when the landing gear is deployed. It is also worth noting that if the terrain in the runway approach path is higher or lower than the runway elevation near the touchdown zone, the Altitude Low indication may flash before the Decision Height is reached or after the aircraft has already descended below it.

Decision Height

As the aircraft approaches the Decision Height (DH), which is typically no lower than 200 feet above the runway surface near the touchdown zone, the pilot should attempt to visually recognize the runway approach lighting system or the runway surface itself.



ILS Decision Height

Once the aircraft descends through the Decision Height, the pilot must abort the approach if the runway approach lighting system or the runway surface are not visible, or the aircraft is not in a position to perform a safe landing. This may be the case if the aircraft is too far left or right of the runway surface and does not have sufficient time to maneuver over the runway and land with enough runway remaining for braking to a stop. At this point, known as the Missed Approach Point (MAP), the pilot executes the missed approach procedure if the approach lighting system or runway could not be seen; and may need to divert to another airfield with weather conditions that are more favorable for landing.

Middle marker beacon. Middle markers in the United States are typically used to identify the point along the approach at which the aircraft is passing through the decision height and should execute a missed approach if the runway is not in sight. However, the locations of middle marker beacons relative to the runway, and their intended use, may vary in other regions of the world.

Middle markers generate a 1300 Hz audio tone in an alternating "dot dash" (● ▬ ● ▬) Morse code pattern and illuminate the Marker Beacon light to the right of the EHSI.

Inner marker beacon. Inner markers in the United States are typically used to identify a lower decision height along the approach. Performing an ILS approach to a decision height that is below 200 feet above the runway elevation usually requires specific aircrew qualifications and equipment/instrumentation onboard the aircraft.

Inner markers generate a 3000 Hz audio tone in a rapidly repeating "dot" (● ● ●) Morse code pattern and illuminate the Marker Beacon light to the right of the EHSI.

EHSI Precision Landing System (PLS) Mode

Once an ILS localizer has been tuned through the Upfront Controls, the EHSI must be set to either NAV/PLS or TCN/PLS modes by pressing the Instrument Mode Selector button on the EHSI itself. This will enable ILS guidance indications on the EHSI, the ADI, and within the HUD when localizer and glideslope signals are received.

When a localizer signal on the selected frequency is received by the ILS receiver, the EHSI course indications will transition from displaying course deviation to the selected steerpoint (NAV/PLS) or the selected TACAN station (TCN/PLS) to course deviation along the tuned localizer course. However, the Bearing Pointer will remain referenced to the selected steerpoint (NAV/PLS) or the selected TACAN station (TCN/PLS), independently of the Course Deviation Indicator.

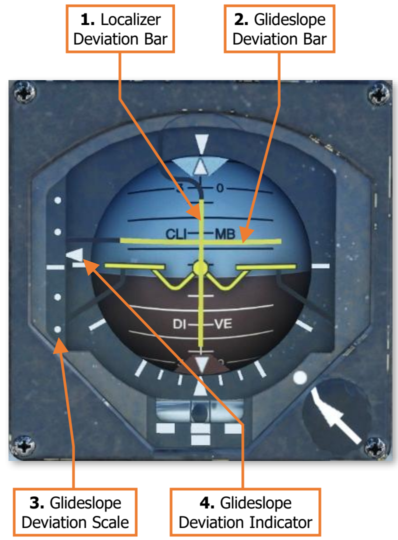
It is worth noting that when receiving a localizer signal while the EHSI is set to NAV/PLS or TCN/PLS modes, the Course Pointer and Course Deviation Indicator will be displayed left or right along the Course Deviation Scale based on the deviation from the center of the localizer signal itself, regardless of the course set on the EHSI.

(See Electronic Horizontal Situation Display (EHSI) for more information.)

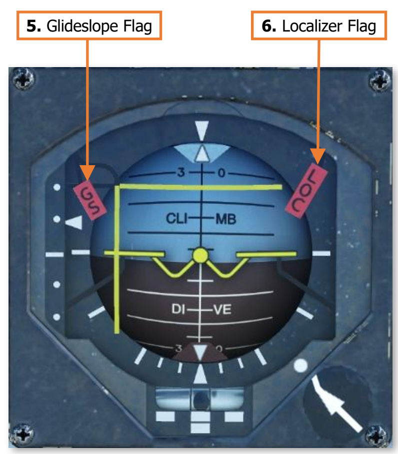
Attitude Director Indicator (ADI)

The Attitude Director Indicator, or ADI, displays the aircraft pitch and roll attitude as supplied by the Inertial Navigation System, or INS. When performing an ILS approach, the ADI displays localizer and glideslope indicators.

(See the Cockpit Overview section for more information regarding the ADI.)



1. **Glideslope Deviation Indicator.** Indicates the relative position of the glideslope along the Glideslope Deviation Scale when performing an ILS approach. If the indicator is aligned with the center tick mark, the aircraft is on glideslope.
2. **Glideslope Deviation Scale.** Provides a vertical reference of relative aircraft position above or below the glideslope when tuned to an ILS approach frequency and roughly aligned with the approach path for the associated landing area. Each white dot corresponds with a 2.5° vertical separation from the glideslope. If the Glideslope Indicator is aligned with the top or bottom white dot of the Glideslope Deviation Scale, the aircraft is 5° above or 5° below the glideslope, respectively.
3. **Glideslope Deviation Bar.** Indicates the position of the glideslope relative to the Aircraft Symbol when performing an ILS approach. If the deviation bar is aligned with the "wings" of the Aircraft Symbol, the aircraft is on the glideslope. If the deviation bar is above the Aircraft Symbol, the aircraft is below the glideslope. If the deviation bar is below the Aircraft Symbol, the aircraft is above the glideslope.
4. **Localizer Deviation Bar.** Indicates the position of the localizer relative to the Aircraft Symbol when performing an ILS approach. If the deviation bar is aligned with the center dot of the Aircraft Symbol, the aircraft is aligned with the runway. If the deviation bar is left of the Aircraft Symbol, the aircraft is to the right of the runway centerline. If the deviation bar is right of the Aircraft Symbol, the aircraft is to the left of the runway centerline.

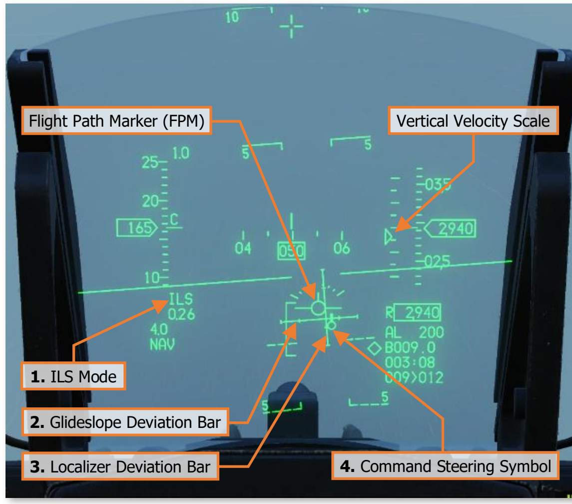


5. **Glideslope Flag.** Displayed when a glideslope (GS) signal is not being received.
6. **Localizer Flag.** Displayed when the selected localizer (LOC) signal is not being received.

Head-Up Display (HUD)

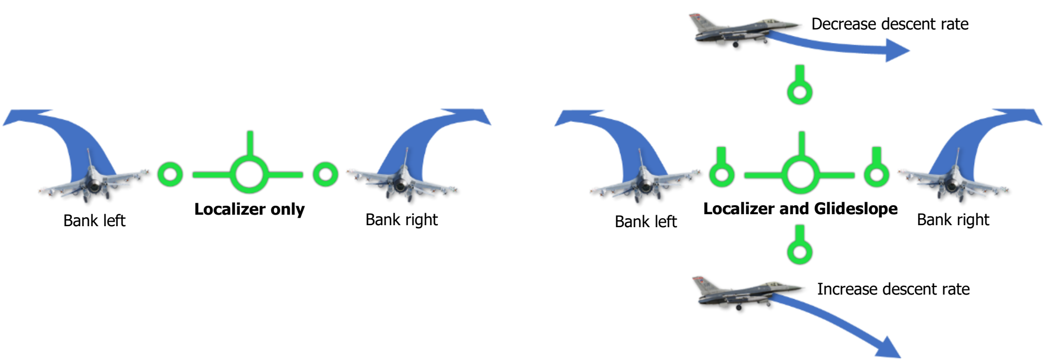
The following HUD symbology elements will be displayed when performing an ILS approach.

1. **ILS Mode.** Displayed when the EHSI Instrument mode is set to NAV/PLS or TCN/PLS.
2. **Glideslope Deviation Bar.** Indicates the position of the glideslope relative to the Flight Path Marker (FPM). If the deviation bar is aligned with the FPM, the aircraft is on the glideslope. If the deviation bar is above the FPM, the aircraft is below the glideslope. If the deviation bar is below the FPM, the aircraft is above the glideslope.
3. **Localizer Deviation Bar.** Indicates the position of the localizer relative to the Flight Path Marker (FPM). If the deviation bar is aligned with the FPM, the aircraft is aligned with the runway. If the deviation bar is left of the FPM, the aircraft is to the right of the runway centerline. If the deviation bar is right of the FPM, the aircraft is to the left of the runway centerline.



HUD ILS Information

4. **Command Steering Symbol.** Provides lateral and vertical steering indication to intercept and maintain alignment with the ILS localizer and/or glideslope. The lateral displacement of the Command Steering symbol corresponds with the required bank angle that is necessary to achieve a turn rate for localizer intercept. If the Command Steering symbol is displaced left or right from the FPM, the pilot should bank towards the Command Steering symbol until the symbol is aligned with the FPM.



Command Steering Symbol

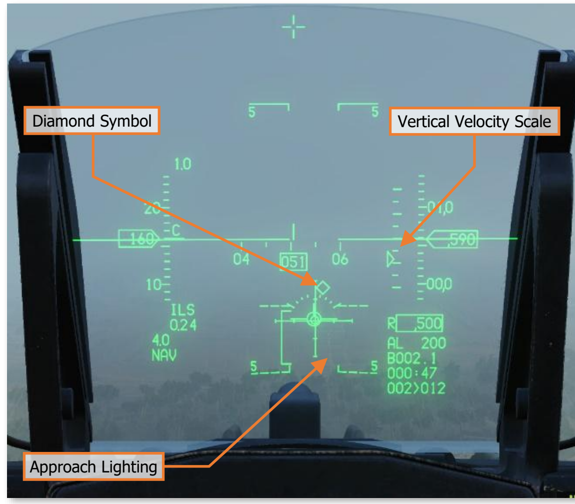
The vertical displacement of the Command Steering symbol corresponds with the required vertical velocity that is necessary to achieve the descent rate for glideslope intercept. If the Command Steering symbol is displaced above or below the FPM, the pilot should adjust throttle to drive the FPM upwards or downwards toward the Command Steering symbol until the symbol is aligned with the FPM.

If the tick mark on the Command Steering symbol is not displayed, the ILS receiver is not receiving a glideslope signal and command steering is only available from the ILS localizer.

Once established inbound on the ILS approach course, it may be helpful to set the Scales switch on the HUD Control Panel to the VV/VAH position prior to intercepting the glideslope. This will display the Vertical Velocity Scale to provide an indication of the descent rate directly within the HUD. Each major tick mark on the Vertical Velocity Scale represents 1000 feet per minute, and each minor tick mark represents 500 feet per minute. The major tick mark adjacent to the Altitude indication corresponds to 0 feet per minute, or level flight.

If a steerpoint is located at the destination airfield, the Diamond symbol within the HUD may be useful in maintaining awareness of the aircraft's course and orientation relative to the airfield in low-visibility conditions. However, the pilot should be aware that the steerpoint may not necessarily indicate the location of the runway nor the touchdown zone to where the ILS glideslope is providing guidance.

In addition, the steerpoint at the destination airfield may be useful in providing the remaining distance indication to the airfield. Alternatively, if a TACAN station is located at the airfield, the Range Indicator on the EHSI may also provide remaining distance indication to the airfield, which may be outlined as part of the ILS approach procedure on the applicable approach charts. However, just as in the case of the Diamond Symbol, the pilot should be aware that the distance indication from the steerpoint or the TACAN station may not be to the runway itself.



Approach Lighting System

As the aircraft approaches the decision height (as shown in the image above), the pilot should attempt to visually recognize the runway approach lighting system or the runway surface itself. The approach lighting system will typically be easier to recognize due to the distinct light pattern, which may include a rapidly pulsing series of strobe lights called the Runway Alignment Indicator Lights (RAIL), also known as the "rabbit" lights.

If desired, the MAN RNG/UNCAGE knob may be depressed to the UNCAGE position to declutter the lower portion of the HUD to aid in visual recognition of the approach lighting or the runway surface. When this occurs, the Heading Tape will be repositioned to the top portion of the HUD, the Roll Indicator (if displayed) and ILS Localizer and Glideslope Deviation Bars will be removed. However, the Command Steering Symbol will remain.

Once the approach lighting or the runway is in sight, proceed visually in accordance with the Landing procedure, beginning at step 2.

Otherwise, upon passing the Decision Height, execute a missed approach. Increase throttle, arrest the descent rate, and begin a climb. When a positive rate of climb is established, retract the landing gear. Ensure the landing gear is fully retracted with the gear doors closed before exceeding 300 KCAS.

HUD decluttered at Decision Height

RADIO COMMUNICATIONS

USAF Photo
by TSgt Christopher Boitz

RADIO COMMUNICATIONS

The F-16C is equipped with two radios, a UHF radio and a VHF radio, which primarily function as the pilot's voice communications system with other flight members, allied aircraft, ground forces, and air traffic control. Each radio is also capable of transmitting and receiving datalink messages relayed through its secure, modem-based datalink system (SMDL).

AN/ARC-164 & AN/ARC-222 Radio Antenna Locations

The AN/ARC-164 UHF AM radio provides two-way line-of-sight communications over UHF-AM frequencies between 225.000 and 399.975 MHz, and includes a separate GUARD receiver tuned to 243.000 MHz. The radio is capable of HAVE QUICK frequency-hopping as an electronic counter-countermeasures (ECCM) capability, and transmissions may be selectively routed through either the upper or lower UHF antennas, mounted to the center fuselage, which are shared with the AN/APX-113 Advanced IFF transponder/interrogator system. (See ANT SEL switches for more information.)

The AN/ARC-222 VHF AM/FM radio provides two-way line-of-sight communications over VHF-AM frequencies between 116.000 and 151.975 MHz or VHF-FM frequencies between 30.000 MHz and 87.975 MHz. The radio is also capable of receiving VHF-AM radio signals between 108.000 and 115.975 MHz. The VHF radio includes two antennas embedded within the leading edge of the vertical tail surface; one antenna for transmitting/receiving VHF-AM radio signals and the other for transmitting/receiving VHF-FM radio signals.

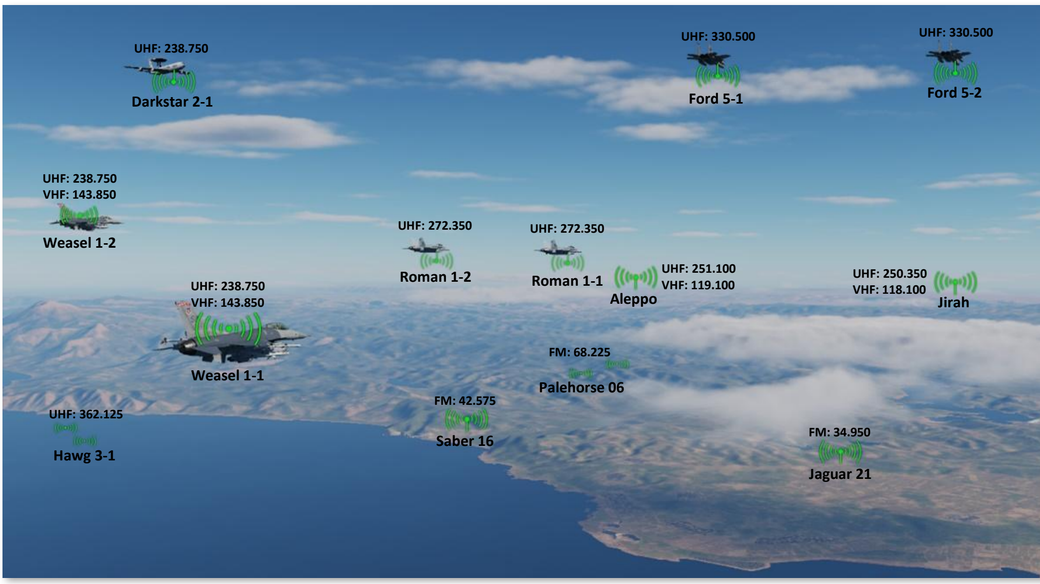
Both radios in the F-16C may be connected to a KY-58 module for secure radio encryption, and both may be programmed with up to 20 unique radio channels for efficient communications. However, manually tuning either radio to individual, non-programmed frequencies is also possible, if necessary.

The primary radio interface for both radio systems is through the Upfront Controls (UFC), with a dedicated DED page for each radio system. However, in the event of a main power failure or a failure within the UFC itself, the UHF radio may also be controlled through a backup control panel located on the left console.

NOTE: Radio encryption, frequency hopping, and SMDL functions are not implemented in DCS: F-16C Viper.

Communications Management

Communications is an important aspect of all aviation operations, but it takes on an even greater significance during a tactical mission, especially as a team member within a larger "mission package" of many aircraft. Whether it be coordinating with a wingman in an aerial dogfight, requesting information from a command and control asset, or receiving a request for air support from ground forces, communications play a key role in ensuring teamwork and unity of effort among friendly forces and distributing critical information regarding the battlespace to the units or personnel that need it.



Throughout each phase of the mission, the frequencies to which either radio is tuned may need to be changed in order to contact different aircraft or units. These may include other friendly aircraft within the same "mission package", AWACS command and control aircraft, aerial refueling tankers, ground forces such as Joint Terminal Attack Controllers (JTAC), or airfield air traffic control (ATC). However, with only two radios onboard, strategic management of frequencies must be performed to ensure communications is maintained with the correct units at the correct time during the mission.

Although the radios in the F-16C may be rapidly re-tuned to a different frequency through the Upfront Controls, the most efficient means of managing the onboard radios is through preset radio channels. By assigning frequencies that are relevant to the current mission to one of the 20 preset channels for either radio, the pilot can rapidly switch between frequencies without needing to input the entire frequency each time.

Frequencies that are required to successfully perform a mission are typically noted in the mission briefing and should be programmed into the aircraft radios before the mission. Prior to takeoff or while en-route to the mission area or objective, it may be wise to verify the frequencies assigned to each preset radio channel to ensure they are set appropriately.

The UHF Backup control panel is not typically used during normal operations after the engine is started and the aircraft is operating on generator power. However, during final checks prior to entering the combat area, it may be wise to configure this panel to a preset channel and/or manual frequency that would be necessary to request assistance, direct your wingman to provide support, receive a bearing to the nearest tanker, or receive a bearing to your home airfield. If there was some sort of main power loss and the aircraft were to revert to battery power after a malfunction or taking damage from hostile fire, the UHF radio control would revert to the UHF Backup control panel and the corresponding radio settings.

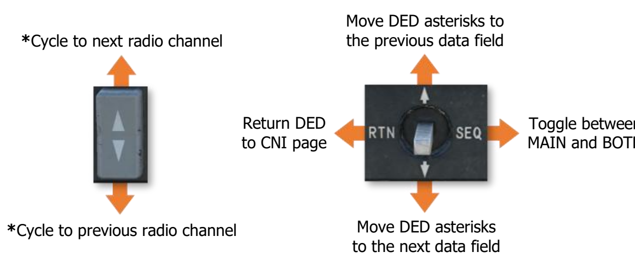
Upfront Controls

The Upfront Controls are available when the C & I knob is set to the UFC position on the IFF control panel. During normal operations, the UFC is used for communications functions. In the event there is a failure with the UFC, the C & I knob can be set to the BACK UP position, which allows control of the UHF radio through the use of the UHF Backup control panel.

If the aircraft is operating on battery power only, control of the UHF radio will revert to the UHF Backup control panel, regardless of whether the C & I knob is set to the UFC position. The UHF radio is commonly used to communicate with the appropriate air traffic control (ATC) agencies prior to engine start.

UHF DED Page

The UHF radio DED page may be accessed by pressing the COM 1 override button on the ICP, regardless of the DED page currently displayed. Pressing the COM 1 button a second time will return to the previous DED page. This page allows the pilot to immediately tune a preset UHF channel, edit a preset UHF channel, or manually input a frequency into the UHF radio.



* Cycles the Preset Channel Number data field to the next/previous preset radio channel for editing the assigned frequency of that preset. However the radio will not be tuned to that preset channel or frequency.

1. **Active Channel/Frequency.** Displays the preset radio channel or the manual radio frequency to which the radio is currently tuned.

2. **Preset Channel Number.** Displays the preset channel number that corresponds with the frequency in the Preset Frequency data field below. The ICP Increment/Decrement rocker may be used to cycle to a different preset channel, or the DED asterisks may be placed over the data field and a channel number between 1 and 20 may be input using the ICP keypad followed by ENTR.

3. **Preset Frequency.** Displays the frequency that is assigned to the preset channel number in the data field above. May be modified by placing the DED asterisks over the data field, inputting a frequency using the ICP keypad, and pressing ENTR. Modifying this data field does not change the tuned UHF frequency.

4. **Radio Mode/Power Status.** Displays the current mode and power status of the UHF radio. The mode may be cycled between MAIN and BOTH by momentarily placing the ICP DCS to the SEQ position.

   - **OFF.** The COMM 1 power/volume knob on the AUDIO 1 control panel is set to OFF, removing power from the UHF radio.
   - **MAIN.** The UHF radio is operating on the selected preset channel/radio frequency. The auxiliary GUARD receiver of the UHF radio is disabled.
   - **BOTH.** The UHF radio is operating on the selected preset channel/radio frequency. The auxiliary receiver of the UHF radio is enabled to monitor 243.0 MHz (GUARD).

     NOTE: The UHF radio may be immediately tuned to the international distress frequency of 243.0 MHz (GUARD) by rotating the COMM 1 mode knob on the AUDIO 1 control panel to the GD positon.

5. **Scratchpad.** This data field is used to input a preset channel number or radio frequency to tune the UHF radio. May be modified by placing the DED asterisks over the data field, inputting a preset channel number or frequency using the ICP keypad, and pressing ENTR. Valid channel entries range from 1 to 20. Valid frequencies range from 225.000 to 399.975, entered in a continuous string without the final digit.

   When a valid preset channel number or radio frequency is accepted into the Scratchpad using the ENTR button, the DED will return to the previous page prior to pressing the COM 1 override button.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

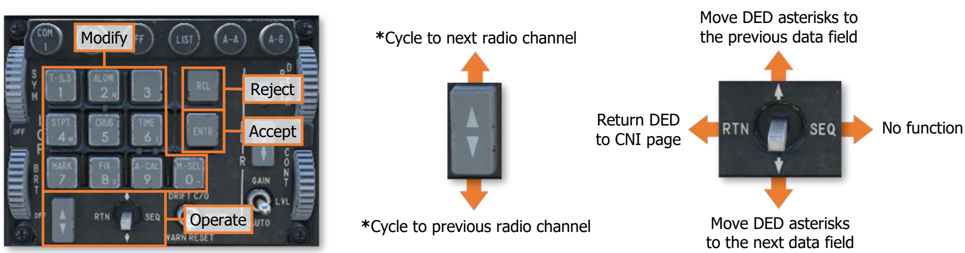
7. **Receiver Band.** Displays the bandwidth setting of the radio. May be toggled between NB (narrow) and WB (wide) by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field. (N/I)

When the C & I knob is set to the BACK UP position on the IFF control panel, control of the UHF radio will revert to UHF Backup control panel.

The UHF DED page may still be accessed by pressing the COM 1 override button on the ICP. However, the page will be displayed in the BACKUP format and the ICP will have no effect on the function of the UHF radio. The page will indicate the currently tuned UHF frequency and preset channel (if applicable).

VHF DED Page

The VHF radio DED page may be accessed by pressing the COM 2 override button on the ICP, regardless of the DED page currently displayed. Pressing the COM 2 button a second time will return to the previous DED page. This page allows the pilot to immediately tune a preset VHF channel, edit a preset VHF channel, or manually input a frequency into the VHF radio.



* Cycles the Preset Channel Number data field to the next/previous preset radio channel for editing the assigned frequency of that preset. However, the radio will not be tuned to that preset channel or frequency.

1. **Active Channel/Frequency.** Displays the preset radio channel or the manual radio frequency to which the radio is currently tuned.

2. **Preset Channel Number.** Displays the preset channel number that corresponds with the frequency in the Preset Frequency data field below. The ICP Increment/Decrement rocker may be used to cycle to a different preset channel, or the DED asterisks may be placed over the data field and a channel number between 1 and 20 may be input using the ICP keypad followed by ENTR.

3. **Preset Frequency.** Displays the frequency that is assigned to the preset channel number in the data field above. May be modified by placing the DED asterisks over the data field, inputting a frequency using the ICP keypad, and pressing ENTR. Modifying this data field does not change the tuned VHF frequency.

4. **Power Status.** Displays the power status of the VHF radio.
   - **OFF.** The COMM 2 power/volume knob on the AUDIO 1 control panel is set to OFF, removing power from the VHF radio.
   - **ON.** The VHF radio is operating on the selected preset channel/radio frequency.

5. **Scratchpad.** This data field is used to input a preset channel number or radio frequency to tune the VHF radio. May be modified by placing the DED asterisks over the data field, inputting a preset channel number or frequency using the ICP keypad, and pressing ENTR. Valid channel entries range from 1 to 20. Valid frequencies range from 30.00 to 87.975 and 108.000 to 151.975, entered in a continuous string without the final digit.

   When a valid preset channel number or radio frequency is accepted into the Scratchpad using the ENTR button, the DED will return to the previous page prior to pressing the COM 2 override button.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

7. **Receiver Band.** Displays the bandwidth setting of the radio. May be toggled between NB (narrow) and WB (wide) by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field. (N/I)

When the COMM 2 mode knob on the AUDIO 1 control panel is set to the GD position, the VHF radio is tuned to the international distress frequency of 121.5 MHz (GUARD).

The VHF DED page may still be accessed by pressing the COM 2 override button on the ICP. However, the page will be displayed in the AM GUARD format and the ICP will have no effect on the function of the VHF radio.

Tuning a Preset Frequency using Upfront Controls

A preset UHF or VHF frequency may be tuned by inputting a preset channel number into the Scratchpad data field on the applicable UHF or VHF DED pages.

To tune a preset frequency using the UHF DED page or VHF DED page, perform the following:

1. ICP **COM 1** Button – Press to access the UHF DED page.

or

1. ICP **COM 2** Button – Press to access the VHF DED page.

2. ICP **Keypad** - Input the 1- or 2-digit preset channel number (1-20).

3. ICP Keypad – Press **ENTR** to accept the channel number or **RCL** to reject it.

If the entered number is valid, the radio will be tuned to the corresponding preset channel and the DED will return to the previous page prior to pressing the COM 1 or COM 2 override button.

Alternatively, if the applicable radio is already tuned to a preset channel, the radio may be cycled incrementally through the 20 preset channels on the CNI DED page.

To select a preset frequency using the CNI DED page, perform the following:

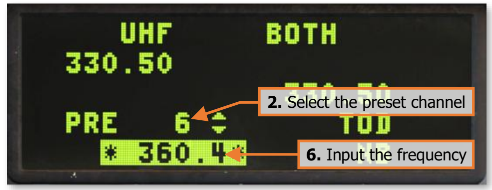
1. ICP DCS Switch – **Up/Down** to move the Increment/Decrement symbol adjacent to the UHF or VHF data field, as necessary.

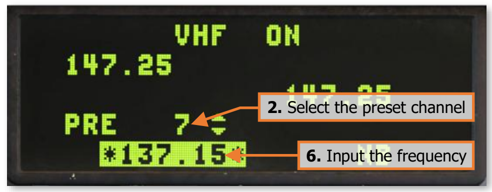
2. ICP **Increment/Decrement** Rocker – Press as necessary to select the desired preset channel.

Editing a Preset Frequency using Upfront Controls

Preset UHF or VHF frequencies may be edited by inputting a different preset frequency on the applicable UHF or VHF DED pages.

To edit a preset frequency using the UHF DED page or VHF DED page, perform the following page:





1. ICP **COM 1** Button – Press to access the UHF DED page.

or

1. ICP **COM 2** Button – Press to access the VHF DED page.

2. ICP **Increment/Decrement** Rocker – Select the preset channel to be edited. (Skip to step 5)

or

2. ICP DCS Switch – **Up/Down** to move the DED Asterisks around the Preset Channel Number data field.

3. ICP **Keypad** - Input the 1- or 2-digit preset channel number (1-20) to be edited.

4. ICP Keypad – Press **ENTR** to accept the channel number or **RCL** to reject it.

5. ICP DCS Switch – **Up/Down** to move the DED Asterisks around the Preset Channel Frequency data field.

6. ICP **Keypad** - Input the 4- or 5-digit frequency in a continuous string without leading zeros.

7. ICP Keypad – Press **ENTR** to accept the frequency or **RCL** to reject it.

Tuning a Manual Frequency using Upfront Controls

A manual UHF or VHF frequency may be tuned by inputting a valid frequency into the Scratchpad data field on the applicable UHF or VHF DED pages.

To tune a manual frequency using the UHF DED page or VHF DED page, perform the following:

1. ICP **COM 1** Button – Press to access the UHF DED page.

or

1. ICP **COM 2** Button – Press to access the VHF DED page.

2. ICP **Keypad** - Input the 4- or 5-digit frequency in a continuous string without leading zeros.

3. ICP Keypad – Press **ENTR** to accept the frequency or **RCL** to reject it.

If the entered frequency is valid, the radio will be tuned to the corresponding frequency and the DED will return to the previous page prior to pressing the COM 1 or COM 2 override button.

UHF Backup Control Panel

Communication functions are normally controlled through the Upfront Controls, however a backup radio control panel is also available if a malfunction of the ICP and/or DED has occurred. The UHF Backup control panel may be used on battery power, and as such is the only radio that can be used prior to engine start.

1. **Preset Channel Card & Access Door.** The top of the access door displays the frequencies that correspond with each preset selection. Lifting the access door allows the UHF radio presets and anti-jam functions to be programmed. (N/I)
2. **TEST DISPLAY Button.** Illuminates all display segments within the Frequency Status/Display and CHAN Display windows for a functional test.
3. **CHAN Display.** If Mode knob is set to PRESET, displays the currently selected frequency preset. If Mode knob is set to MNL, the display will be blank.
4. **CHAN Knob.** Selects the desired frequency preset.
5. **Frequency Status/Display.** Displays the manual frequency that has been selected using the Manual Frequency Knobs.
6. **STATUS Button.** When this button is depressed, the frequency that the UHF radio is tuned to will be momentarily shown in the Frequency Status/Display. This allows the pilot to verify the frequency of the currently selected preset when the Mode Knob is set to PRESET.
7. **A-3-2 Knob.** Selects anti-jamming or single-frequency functionality of the UHF radio.
   - **A.** Selects AJ (Anti-Jam) function of the radio. (N/I)
   - **3.** When the Mode knob is set to MNL, sets the 1st digit of the frequency to 3 (e.g., 325.000 MHz).
   - **2.** When the Mode knob is set to MNL, sets the 1st digit of the frequency to 2 (e.g., 225.000 MHz).
8. **Manual Frequency Knobs.** When Mode knob is set to MNL, permits manual tuning of the frequency in 0.025 MHz increments from 225.000 MHz to 399.975 MHz.
9. **Function Knob.** Selects the functional mode of operation of the UHF radio.
   - **OFF.** Power is removed from UHF Backup control panel. If the UHF radio is powered by the battery bus or the C & I knob on the IFF control panel is set to BACK UP, this knob position also removes power from the UHF radio itself.

- **MAIN.** If COMM 1 power/volume knob on the AUDIO 1 control panel is not set to OFF, the UHF radio is operating on the selected preset/frequency. UHF GUARD auxiliary receiver is disabled.
- **BOTH.** If COMM 1 power/volume knob on the AUDIO 1 control panel is not set to OFF, the UHF radio is operating on the selected preset/frequency. UHF GUARD auxiliary receiver is enabled to monitor 243.0 MHz.
- **ADF.** No function.

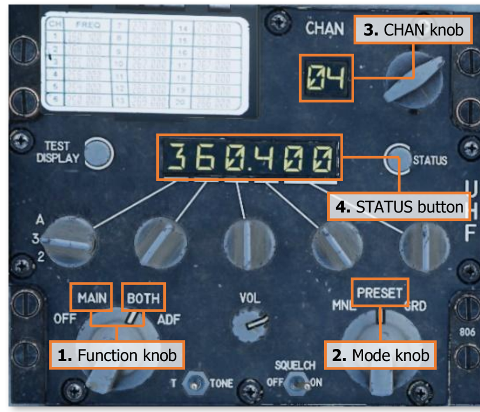
10. **Mode Knob.** Selects the tuning mode of the UHF radio.
    - **MNL.** The UHF radio is tuned to the frequency displayed in the Frequency Status/Display window. Frequency is tuned using the Manual Frequency knobs.
    - **PRESET.** The UHF radio is tuned to the frequency that corresponds with the preset displayed in the CHAN Display. Preset frequency is selected using the CHAN knob.
    - **GRD.** The UHF radio is tuned to 243.0 MHz and the dedicated GUARD receiver is disabled.
11. **TONE Button.** Interrupts radio reception and transmits a tone on the current frequency. (N/I)
12. **VOL Knob.** No Function.
13. **SQUELCH Switch.** Enables/Disables the squelch function.

Tuning a Preset Frequency using the UHF Backup Control Panel

A preset UHF frequency may be tuned by setting the UHF Backup control panel to PRESET mode and selecting the desired preset channel.

To tune a preset UHF frequency using the UHF Backup Control Panel, perform the following:

1. Function Knob – Set to **MAIN** or **BOTH**.
2. Mode Knob – Set to **PRESET**.
3. **CHAN** Knob – Rotate until the desired preset channel is displayed in the CHAN Display indicator.
4. **(Optional)** STATUS Button – Press to verify the frequency assigned to the selected preset channel within the FREQUENCY STATUS/DISPLAY indicator.

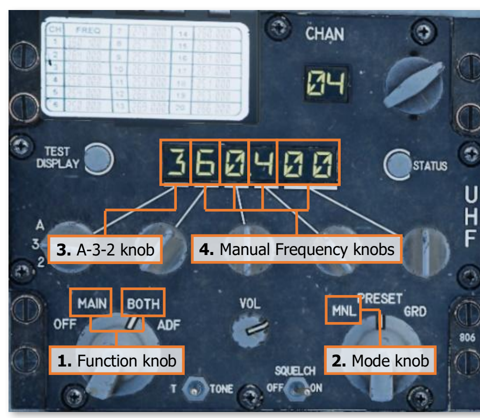


Tuning a Manual Frequency using the UHF Backup Control Panel

A manual UHF frequency may be tuned by setting the UHF Backup control panel to MNL mode and setting the desired frequency.

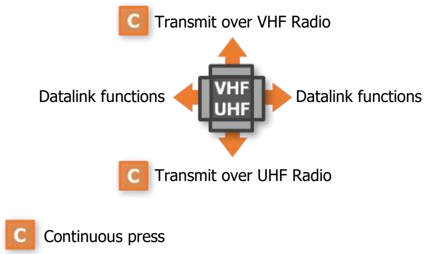
To tune a manual frequency using the UHF Backup Control Panel, perform the following:

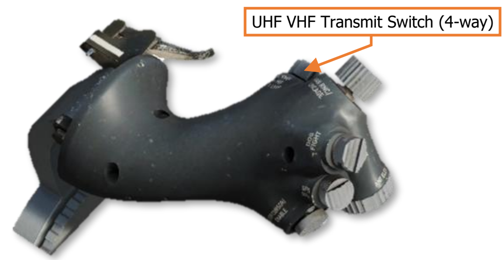
1. Function Knob – Set to **MAIN** or **BOTH**.
2. Mode Knob – Set to **MNL**.
3. **A-3-2** Knob – Rotate until the first digit of the desired frequency is displayed in the FREQUENCY STATUS/DISPLAY indicator.
4. **Manual Frequency** Knobs – Rotate until the remaining four digits of the desired frequency are displayed in the FREQUENCY STATUS/DISPLAY indicator.



HANDS-ON CONTROLS

The UHF VHF Transmit switch on the Throttle initiates voice communications over the UHF and VHF radios. The UHF VHF Transmit switch is 4-way switch that continuously transmits over either voice radio when held to the Forward (VHF transmit) or Aft (UHF transmit) positions, in a Push-To-Talk (PTT) manner.





In DCS World, when sending commands or requests to other units, either switch position must be utilized to open the **Call Radio menu** for the correct radio. When communicating with the ground crew, you may use the intercom system to issue requests using the **Communication menu** command. The corresponding keyboard commands for accessing these menus are below.

- Transmit switch – VHF (call radio menu) **[RCtrl + \]**
- Transmit switch – UHF (call radio menu) **[RAlt + \]**
- Communication menu **[\]**

As an example, if your wingmen are tuned to a VHF frequency, you must also be tuned to the same frequency on your VHF radio and open the VHF call radio menu to issue them commands. This is the more realistic mode and requires you to know the correct frequencies for each unit you intend on communicating with during your mission, such as wingmen, AWACS, refueling tankers, or ground units. Each radio call will need to be transmitted over the correct radio while tuned to the correct frequency.

However, for more casual players that do not desire as in-depth of a radio management simulation, there is an option available under the DCS Options GAMEPLAY Tab labeled "Easy Communication".

Easy Communication Option

The radio communications menu is accessed by pressing the backslash key **[\]** (for US keyboards; other language keyboards may vary). A list of radio recipients will be displayed along with the function key (**[F1]** through **[F10]**) required to issue the corresponding command or view a sub-menu command list.

When the radio communications menu is displayed, recipients are color-coded as follows:

- Recipients on a frequency to which at least one of the player's radios is tuned are colored white.
- Recipients on a frequency to which at least one of the player's radios may be tuned, but are not currently on the same frequency as the player's radio(s), are colored gray.
- Recipients that cannot be contacted due to range or line-of-sight limitations, such as terrain obstructions or are over the horizon, are colored black.

The frequency that each recipient is monitoring will be displayed next to recipient entry. When a recipient is selected, the appropriate radio will be automatically tuned to the required frequency in order to communicate with that recipient.

TACTICAL EMPLOYMENT

USAF Photo
by SSgt Vernon Young

F-16C TACTICAL EMPLOYMENT OVERVIEW

The F-16C is an all-weather, multi-role, tactical fighter aircraft. The F-16C is capable of a variety of air-to-air and air-to-surface missions such as Combat Air Patrol (CAP), Offensive Counter-Air (OCA), Defensive Counter-Air (DCA), Air Interdiction (AI), and Close Air Support (CAS). However, the most notable of the F-16C's missions has been to replace the F-4G as the U.S. Air Force's dedicated "Wild Weasel" platform for performing SEAD (Suppression of Enemy Air Defenses).

The F-16C's cockpit layout and fire control avionics are optimized for operation by a single-pilot, presenting the most important information on the HUD and forward instrument panel, with numerous fire control and weapon functions accessible via buttons and switches mounted directly onto the side stick and throttle grip. This cockpit design allows the pilot to remain focused outside as much as possible, taking advantage of the all-around visibility afforded by the F-16's bubble canopy. The F-16's mission systems and HUD symbology facilitate accurate low-level strikes against ground targets, even when its navigation system has degraded in position quality. The avionics and sensors are equally capable of pinpoint strikes against pre-planned targets or against targets of opportunity that have been visually identified by the pilot.

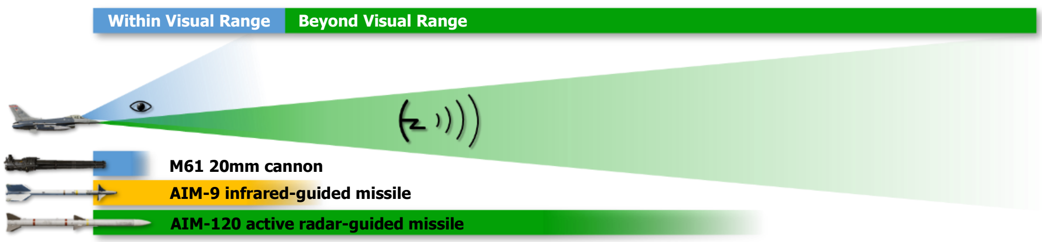
Regardless of the type of mission the F-16 is performing, pre-mission planning is the most important part of any successful combat mission, particularly when performing an air-to-surface strike on a target protected by hostile air defense systems. As in the case with other military aircraft, factors such as terrain, weather, and threat locations should be considered when planning ingress and egress routes; and the speeds and altitudes to be flown. Routes and altitudes should be selected to maximize survivability, reduce the probability of detection by threat weapon systems, and, when necessary to fly through the Weapon Engagement Zone (WEZ) of enemy air defense systems, minimize the time spent within the WEZ of such systems.

In addition, the desired weapon effects against the assigned target(s) will typically determine which munition types will be appropriate for the mission, which in turn may determine the nature of the ingress routes and the speed and altitudes that are utilized when conducting the attack itself. Conversely, the defenses surrounding the target may preclude the use of specific routing and/or munition types, which may drive the planning process to consider alternative routes and altitudes in order to achieve the same weapon effects.

Air-to-Air Missions

Air-to-air missions rely on effective communication and coordination between flight members, situational awareness, and a firm understanding of Air Combat Maneuvers (ACM). Regardless of the specific mission that is being performed, the flight leader must retain the initiative by anticipating what the enemy may do while simultaneously maneuvering the flight in a manner to gain and maintain an advantage in position and energy state.

Air-to-air engagements are divided into two distinct phases of combat: Beyond Visual Range (BVR) and Within Visual Range (WVR).



Air-to-Air Engagement Ranges

Beyond Visual Range (BVR) Combat

BVR is the phase in which the majority of modern-day air-to-air engagements begin. The key to BVR combat is termed as "first look, first shot, first kill", which is the ability to detect, shoot, and kill hostile air threats before they can achieve the same opportunity. This is dependent on detecting the presence of enemy aircraft as soon as possible, positioning the flight in a manner in which long-range air-to-air missiles may be employed against the enemy aircraft at the furthest range that is tactically feasible, and successfully defeating any counterattack that is taken against the flight.

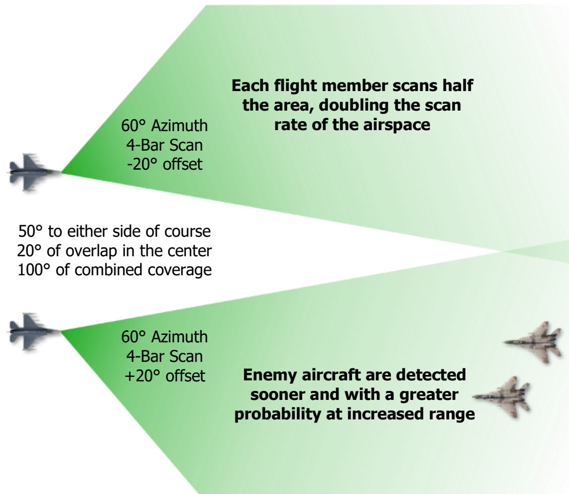
Detection

BVR combat is typically reliant on the use of radar for detection, tracking, and missile guidance against enemy aircraft at long range. However, in some cases electro-optical sensors such as telescopic cameras or infrared search & track (IRST) systems may be utilized. In addition, electronic datalinks may also be incorporated to enhance the collective situational awareness of each flight member by sharing sensor data across networks of multiple aircraft.

Like most sensors, radar has some key advantages and disadvantages. Radar can detect the presence of aircraft at ranges well beyond that which the pilot can visually see with the unaided eye, and can calculate the precise position, altitude, and velocity of detected aircraft. Unfortunately, radar alone cannot determine the allegiance of an aircraft, which is referred to using the brevity term "bogey" to describe an aircraft of unknown identity or affiliation. However, in the case of the F-16C, the APG-68 Fire Control Radar (FCR) incorporates a function known as Non-Cooperative Target Recognition (NCTR) to identify the specific type of aircraft, along with the APX-113 Advanced Identification-Friend-or-Foe (AIFF) interrogator to determine if a detected aircraft is potentially hostile, which is referred to using the brevity term "bandit". Further, the APG-68 FCR is limited to the forward sector only, and requires several moments to mechanically scan the airspace within its entire scan volume.

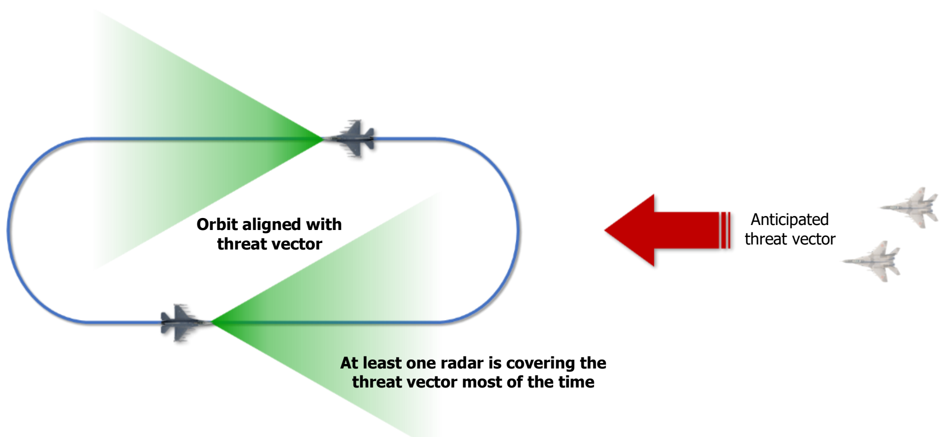
When operating as a flight, radar coverage may be allocated to each flight member using azimuth and/or altitude sectors, which allows each flight member to scan a smaller volume of airspace. Since each flight member is responsible for a smaller scan volume, each sector is scanned faster and more frequently, increasing the probability of detection within the total volume of radar coverage amongst the flight. Increasing the scan rate of a given volume of airspace increases the likelihood of detecting enemy aircraft at further range, allowing the flight to decide on a course of action earlier and act accordingly. This can be especially advantageous when performing a fighter sweep across a large area of airspace.

Alternatively, when patrolling an area where the flight must maintain a position within an assigned area, such as a combat air patrol orbit, it will often be necessary to split the flight to opposing sides of the patrol orbit, with the orbit itself aligned with the anticipated vector from which enemy aircraft are expected to approach.



Radar Sector Delineation

In such a situation in which the flight consists of two aircraft, at least one aircraft will maintain their radar oriented toward the anticipated threat vector while the other is on the opposite side of the orbit. This sequence allows the anticipated threat vector to be monitored by at least one flight member's radar, with only brief periods of time in which the threat vector is not being monitored as both aircraft are in a turn. When performed with a flight of four, each 2-ship element may be staggered to permit uninterrupted radar coverage.

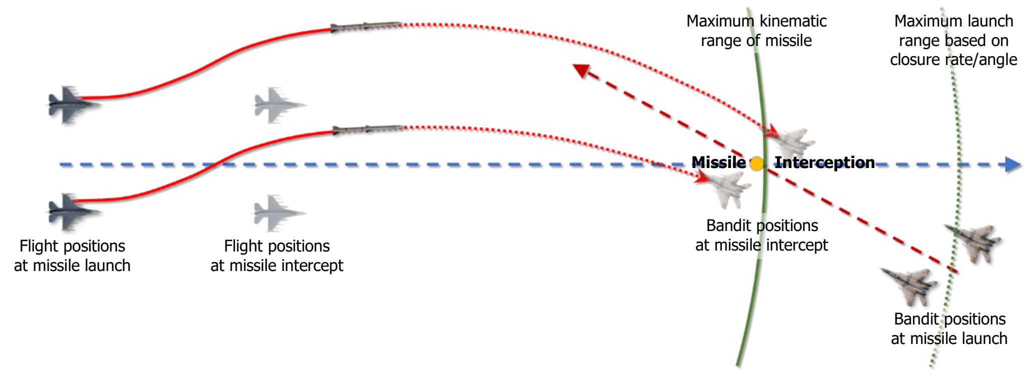


Patrol orbit aligned with threat vector

Even when supported by AWACS aircraft such as the E-3, the flight should not solely rely on the surveillance information provided by the datalink network for detection of enemy aircraft. AWACS or other contributing sensors on the datalink network may not have the same line-of-sight or proximity to potential threats compared to one's own flight. Rather, datalink information should be utilized to augment the collective situational awareness of the flight members or provide early warning beyond the range of the flight's own sensors.

Committing to the Engagement

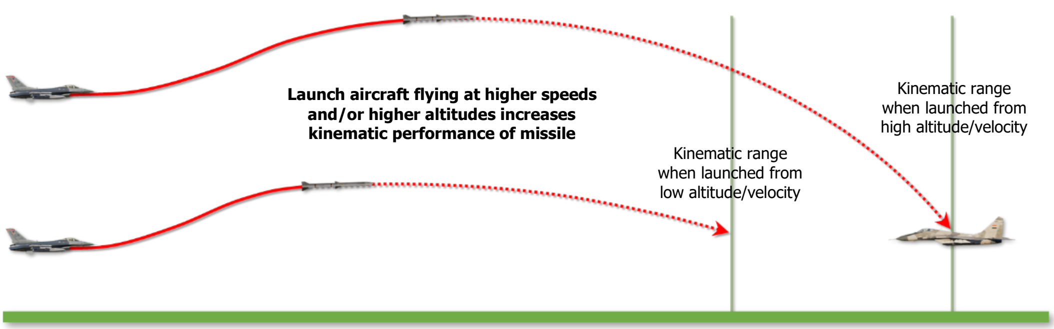
Once aircraft are detected and determined to be hostile ("bandits") and the Flight Lead has decided to commit to an engagement, the flight must orient themselves appropriately to ensure they are in the most advantageous position and energy state for the impending engagement. The flight should align their course with an appropriate intercept vector that will allow them to engage the bandits from the desired aspect angle for the given tactical situation. If intending to engage the bandits from an aspect angle that will guarantee the maximum kinematic performance of their missiles, the flight should align to an approximate intercept vector that will place the bandit aircraft directly in front of the flight when the onboard missiles would achieve their maximum range, thereby minimizing the course corrections the missiles must perform after launch.



Intercept vector for maximum missile performance

The Flight Lead should consider the formation of the flight itself, in that each flight member's position, spacing, and altitude relative to one other is properly set for a BVR engagement. When entering a BVR engagement, the Flight Lead should select a formation that best suits the tactical situation, which maximizes firepower where it is needed without sacrificing the ability for the flight to provide mutual support or maneuver defensively if necessary.

The Flight Lead should also consider the flight's altitude and velocity. Launching a missile from higher altitudes and higher speeds will increase the kinematic performance of the missile. Conversely, launching a missile at lower altitudes where the air density is higher will result in increased drag on the missile, and launching from a lower speed will result in the missile attaining less total kinetic energy before its rocket motor is depleted.



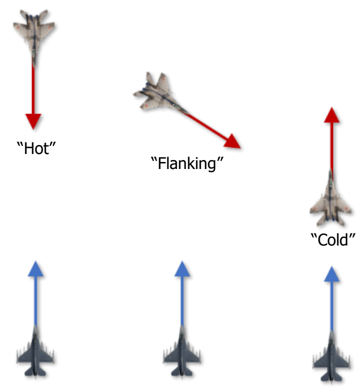
Missile kinematic range at launch

By positioning the flight at higher altitudes and increasing velocity prior to launch, enemy aircraft may be engaged from a greater distance. However, inducing a radar look-down situation may also have a negative effect on the flight's own radar performance, depending on the bandit's range, aspect, relative altitude, and radar cross section (RCS). Additionally, a higher closure rate will compress the engagement timeline, forcing the Flight Lead to make decisions faster and requiring the flight as a whole to react quickly to an evolving tactical situation.

Engagement

The tactics and techniques of conducting a BVR engagement will vary greatly depending on the tactical situation, the composition of the flight, the weapons load amongst the flight members, and the type of enemy aircraft the flight is expecting to encounter, especially with consideration to the sensor and weapon capabilities of the enemy aircraft. In the case of the F-16C, the only type of weapon that may be employed in a beyond visual range engagement is the AIM-120, which is an active radar-homing missile that permits simultaneous engagements of multiple targets by autonomously tracking its target using an onboard active radar seeker for terminal guidance.

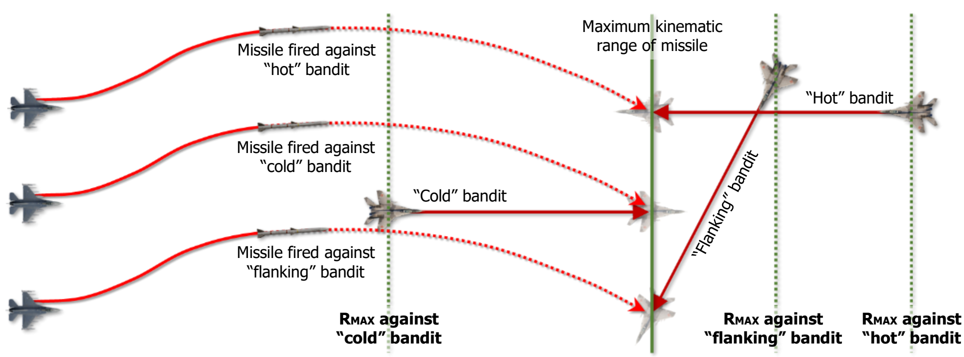
As mentioned above, the kinematic performance of the missile will be affected by the launching aircraft's altitude and velocity at the moment of launch. However, the maximum range at which a target may be engaged will be determined by a combination of the missile's kinematic performance and the aspect angle and closure rate of the targeted aircraft relative to the launching aircraft. If the targeted aircraft is approaching from a head-on or "hot" aspect, the target may be engaged at a greater range. If the targeted aircraft is flying away in a tail-on or "cold" aspect, the target must be engaged from a closer range.



Aspect Angle

Further, if the targeted aircraft is approaching from a "hot" aspect but is flying at a low speed, the target must be engaged from a closer range due to the reduced closure rate with the missile. If the targeted aircraft is flying away in a "cold" aspect but is flying at a low speed, the target may be engaged at a greater range due to the increased closure rate the missile will have to catch up to the target. These two factors, aspect angle and relative closure rate, will determine the maximum launch range of a missile against a target, also known as R_{MAX}, for a given set of launch conditions.

In the figure below, each bandit is flying at the same velocity, and each missile that is fired is being launched under identical conditions with the same kinematic range. However, due to the aspect angle of each bandit, the range (R_{MAX}) at which each target can actually be engaged will be drastically different solely based on the aspect angle. In the same scenario, if the "Hot" bandit were to increase velocity, the R_{MAX} would also increase; but if the "Cold" bandit were to increase velocity, the R_{MAX} would inversely *decrease*.

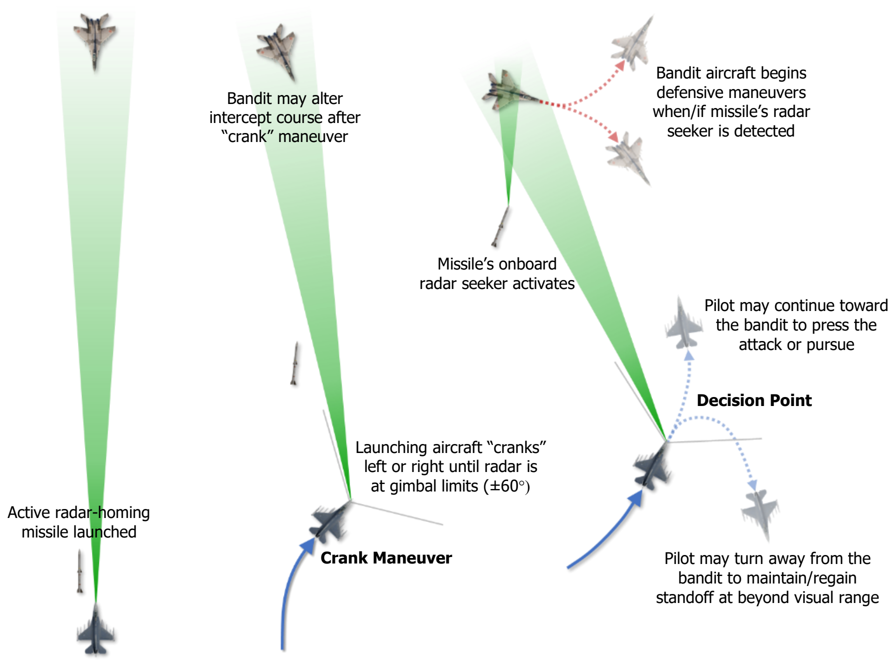


Missile maximum launch range (R_{MAX}) based on aspect angle

In addition, if the bandit aircraft were to defensively maneuver after the missile is launched, the missile would be required to expend kinematic energy to adjust its course to a new intercept vector. If a bandit is flying directly toward the flight ("hot" aspect) and is engaged at the absolute maximum range, the missile may be kinematically defeated if the bandit simply changes its aspect. Therefore, the Flight Lead must anticipate the possibility of such an action when considering engagement tactics.

Conversely, aspect angle may be exploited by the ownship *after* a missile is launched at the enemy aircraft. After missile launch, the ownship may turn, or "crank", to one side until the ownship radar is near its antenna gimbal limit. This maneuver will reduce the ownship's closure rate with the bandit, allowing the ownship to prolong standoff range from the bandit and potentially complicate the employment of enemy missiles against the ownship, especially if the bandit aircraft is equipped with missiles that have a shorter range compared to the AIM-120.

It is worth noting that if the targeted bandit is simultaneously attempting to engage the ownship, performing a crank maneuver may cause the bandit to adjust course as well. This may reduce the kinematic range of the ownship's missile while in flight as it will need to alter its course to maintain an optimal intercept vector on the targeted bandit. If the ownship's missile was launched at the absolute maximum kinematic range, the crank maneuver itself could reduce the probability of a successful engagement, depending on the relative closure rates.



Post-launch "Crank" maneuver

Once the missile's onboard radar seeker activates to begin terminal tracking of the enemy aircraft, the radar signals emitted from the missile seeker itself may alert the targeted bandit to the attack, resulting in the bandit aircraft initiating defensive maneuvers and/or employing countermeasures in an attempt to defeat the missile. At this point in the engagement, the Flight Lead must make a decision as to how to continue the engagement.

The launching aircraft could turn toward the bandit to be in a position to continue with the engagement in the event the bandit survives the missile encounter. Alternatively, the launching aircraft could turn away from the bandit to maintain standoff and keep the engagement at beyond visual range. If the wingman or second element of the flight were following at a staggered distance behind the launching aircraft, the remainder of the flight could continue the engagement while the launching aircraft turns away to maintain standoff.

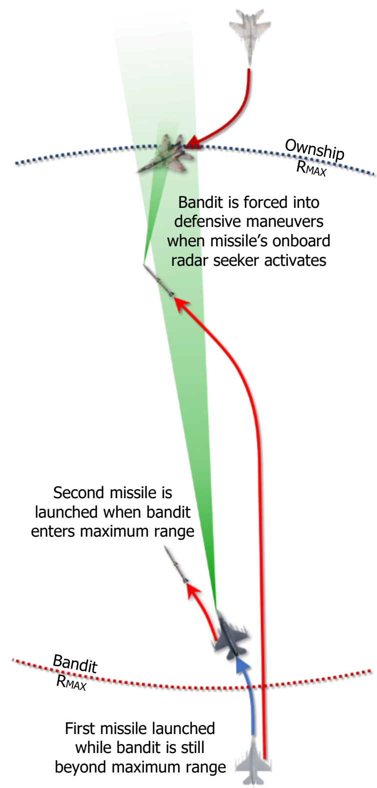
Turning away from the bandit may also ensure a kinematic advantage against any missiles that may have been launched by the bandit aircraft before it was forced to initiate defensive maneuvers. Although the bandit will likely be forced to maneuver in a manner that results in losing a radar lock on the ownship, thereby defeating any semi-active radar-homing missiles that were launched by the bandit, any active radar-homing missiles launched by the bandit may have already begun terminal guidance. If that is the case, the enemy active radar-homing missile(s) will now be at a kinematic disadvantage in a tail chase.

In some instances, it may be advantageous to launch a long-range radar-guided missile even if the bandit aircraft is not yet within maximum launch range, with the intent to force the bandit into defensive maneuvers or break up a formation of several enemy aircraft.

By launching in advance, the radar signals emitted from an incoming active radar-homing missile in terminal guidance may prompt the bandit to initiate defensive maneuvers in an attempt to defeat the missile. This may disrupt an impending attack from the bandit (especially critical if the bandit aircraft is equipped with missiles that have superior engagement range over the AIM-120), giving the ownship additional time to reduce the range to the extent that a follow-up missile may be launched with a higher probability of successful interception. In addition, if multiple bandit aircraft were operating together in a formation, forcing one or more bandits to defensively maneuver may allow the flight to regain the initiative, prevent the bandits from mutually supporting one another for a brief time, or more easily target individual enemy aircraft.

If forced to perform defensive maneuvers, the bandit will also likely need to expend significant energy by sacrificing airspeed and/or altitude during the maneuvers themselves. This may grant a temporary kinematic advantage to the ownship flight while imposing a kinematic disadvantage on the bandit. However, as noted before, although an altitude advantage does provide a kinematic advantage during a BVR missile engagement, inducing a radar look-down situation may also have a negative effect on the flight's own radar performance, depending on the bandit aircraft's range, aspect, relative altitude, and radar cross section (RCS).

It is also worth noting that, depending on the total quantity of long-range missiles that are available within the flight, deliberately expending missiles in an opening engagement with a low probability of success may not be advisable. If the number of opposing bandit aircraft meets or exceeds one's own flight, the Flight Lead should consider the tactical implications of expending missiles in such a manner.



Long-range offensive missile engagement

Defense

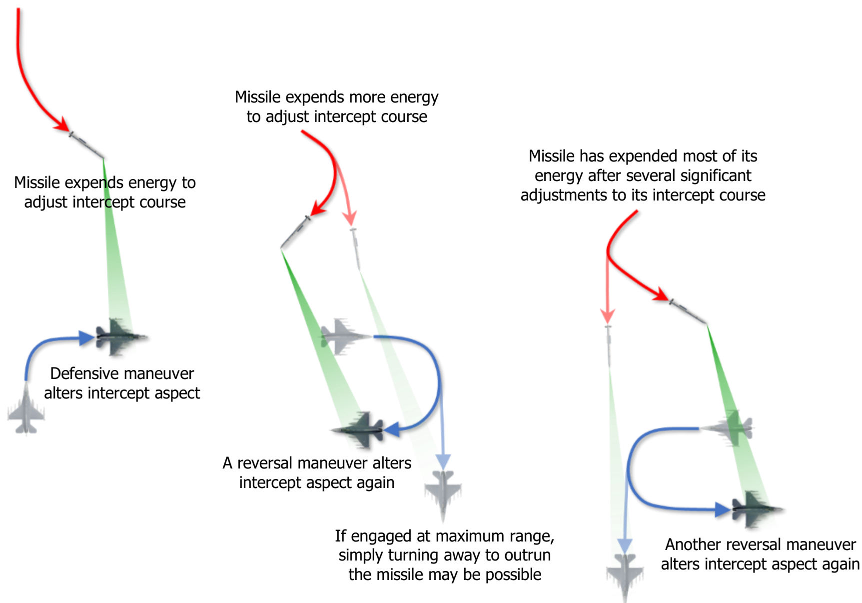
When under attack by long-range missiles launched from enemy aircraft, defensive actions may be taken to either electronically defeat the guidance of the missile with countermeasures or to kinematically defeat the missile itself.

In the case of the former, the missile guidance may be disrupted by expending chaff cartridges to degrade the tracking solution of the bandit aircraft's radar (in the case of semi-active radar-homing missiles) or the missile's onboard radar seeker (in the case of active radar-homing missiles); or electronic "jamming" emissions against the radar may be employed. However, such defensive measures may be negated if the bandit's radar or the missile itself possesses counter-countermeasures in the form of chaff rejection algorithms or "home-on-jam" capabilities, especially when facing an enemy with modern, sophisticated aircraft or weapons.

In the case of the latter, the missile may be kinematically defeated by forcing the missile to expend energy by altering its course and/or descending to lower altitudes to increase the total drag acting against the missile body and control surfaces. Once a missile's rocket motor is depleted, it must rely on its remaining kinetic energy for maneuvering. If the missile needs to change its flight path, it must use its control surfaces to alter the angle-of-attack against its external airfoils and missile body. Like any airfoil, increasing the angle-of-attack of the airflow against the airfoil itself will also increase the aerodynamic drag acting upon it. Therefore, the more maneuvers a missile must perform, the more drag will be incurred, reducing the missile's kinetic energy. When launched from higher altitudes, or if the missile performs a post-launch "loft" maneuver, the missile can leverage the force of gravity to convert its potential energy (i.e., altitude) to kinetic energy, thereby gaining additional kinematic range.

However, unlike a missile, an aircraft has the advantage of an onboard engine, or engines, that allows it to maintain or gain energy for maneuvers. This grants an aircraft kinematic *sustainment* that can be used to delay or eventually defeat an enemy missile, which is otherwise limited to a finite amount of kinematic energy.

If the targeted aircraft aggressively alters its course, the missile must recalculate a new intercept trajectory and then alter its own course accordingly. This maneuver incurs drag which causes the missile to lose kinetic energy. If the targeted aircraft alters its course again, the missile must once more expend kinetic energy to alter its own course to maintain an intercept. Contrarily, the targeted aircraft may use engine thrust to maintain its kinetic energy during moderate maneuvers or regain kinetic energy following aggressive maneuvers. This means that for every defensive maneuver the aircraft performs in which it drastically alters its flight path, the total kinematic advantage the missile may have over the aircraft is incrementally reduced.



Defensive maneuvers against long-range missile attack

If the enemy missile is forced to expend enough kinetic energy, the missile will eventually slow down to the point it will not be able to achieve a successful intercept, or even maintain stable flight, and will simply fall from the sky. When engaged from long range, only a few defensive maneuvers by the targeted aircraft have the potential to reduce the missile's kinematic range to an extent that it cannot achieve an intercept, and the targeted aircraft simply needs to turn away from the missile, resulting in a tail chase that the missile cannot overcome.

Another method of reducing a missile's kinematic range is by decreasing altitude. By descending into thicker regions of the atmosphere, the increased air density will increase the total drag acting upon the missile, further reducing its kinetic energy. This may also induce a radar look-down situation which may degrade the radar tracking solution from the bandit aircraft or an active radar-homing missile's onboard radar seeker. However, it is worth noting that this will also grant the bandit an altitude advantage for subsequent attacks, so the necessity of such a defensive tactic must be weighed between defeating the immediate threat posed by a launched missile versus the potential threat posed by a subsequent attack.

Within Visual Range (WVR) Combat

WVR combat is one of the most challenging environments a fighter pilot may encounter and requires significant skill and proficiency. Close range aerial combat is very dynamic, and mistakes or miscalculations can result in lethal consequences within seconds. If BVR is a game of chess, WVR is hand-to-hand combat in which offense and defense must be performed simultaneously, instantly, and instinctively, in which either pilot may find themselves gaining or losing the upper hand at any moment.

Many advantages provided by sophisticated sensors and weapons – or even stealth – are negated by the fact that close-range aerial combat places one's own aircraft in a position to be engaged by any of the enemy aircraft's weapon systems, such as highly-maneuverable short-range air-to-air missiles, and compresses the reaction time to deploy countermeasures or defensive maneuvering to nearly zero. Even when facing an enemy aircraft with inferior maneuverability and a lower thrust-to-weight ratio, granting an enemy pilot an opportunity to engage one's own aircraft in a maneuvering "dogfight" is a tactical risk that should be avoided if possible.

During air-to-air combat within visual range, fighter pilots must employ elements of BFM and ACM.

Basic Fighter Maneuvers (BFM). BFM is characterized as maneuvering one's own aircraft to exploit positional and attack geometry in order to place the enemy aircraft, or "bandit", within the weapons envelope of one's own aircraft while simultaneously preventing the bandit from doing the same thing.

Air Combat Maneuvers (ACM). ACM is characterized as two friendly aircraft employing BFM while working as a team to engage or avoid one or more bandits; or to extend and escape from WVR combat altogether, if possible.

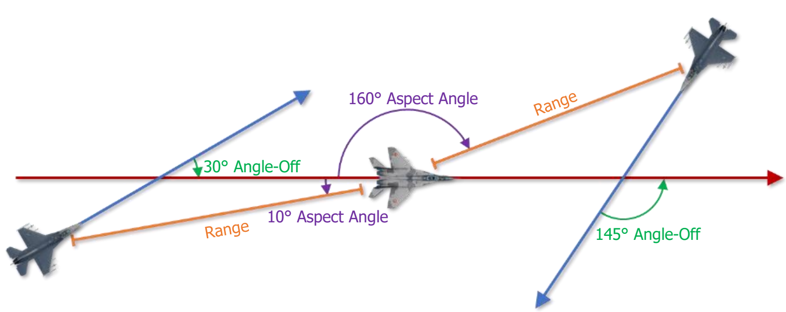
Positional Geometry

The position and orientation of one's own aircraft in relation to the bandit can be expressed using the factors of aspect angle, angle-off, and range.

- **Aspect Angle.** The position of the attacking aircraft in relation to the targeted aircraft's tail, where an aspect angle of 0° would mean the attacking aircraft is directly behind the target and 180° would mean the attacking aircraft is directly in front of the target. In practical terms, as the aspect angle increases, the relative closure rate will tend to increase and the time within which a bandit will be within the weapons envelope of the ownship will decrease.

- **Angle-Off.** The relative heading of each aircraft, where an angle-off of 0° would mean the nose of each aircraft are pointed in the same direction and 180° would mean the nose of each aircraft is pointed in opposing directions. In practical terms, as the angle-off increases, the flight paths of the aircraft will diverge and the amount of aiming "lead" that will be required to employ weapons against a bandit will increase, which will complicate a gun engagement and may reduce the probability of a successful missile engagement.

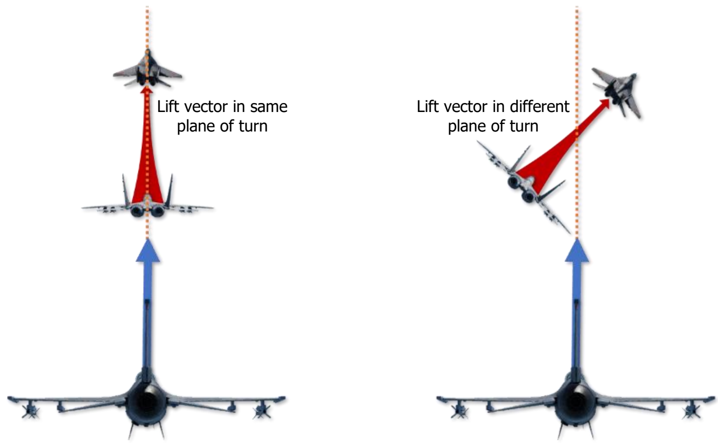
- **Range.** The straight-line distance between each aircraft. In practical terms, as the range increases, the time within which a bandit will be within the weapons envelope of the ownship will increase, which may improve the probability of a successful missile engagement but will greatly complicate a gun engagement due to the increased time-of-flight and trajectory compensation that must be performed.



Positional Geometry

Attack Geometry

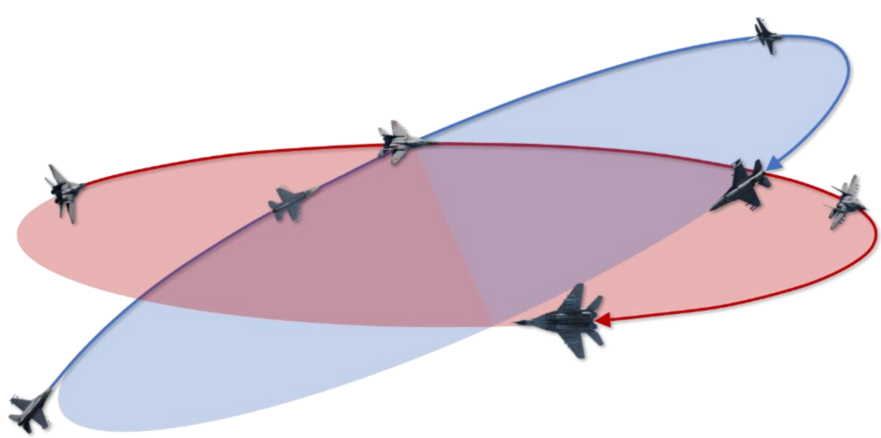
The flight path that is utilized to gain more favorable positional geometry, known as the pursuit course, is determined by either the ownship's lift vector or the ownship's nose position relative to the bandit, depending on whether the ownship is within the same plane of turn as the bandit.



Lift vector relative to bandit's plane of turn

The plane of turn can be thought of as a 2-dimensional disk around which an aircraft maneuvers. As any aircraft maneuvers within a 3-dimensional volume of airspace, the flight path is determined by the forces of aerodynamic lift and gravity. When maneuvering in a positive-G turn, the pilot directs the lift vector using roll and pulls aft on the stick to induce a positive pitch motion, which alters the flight path using aerodynamic lift.

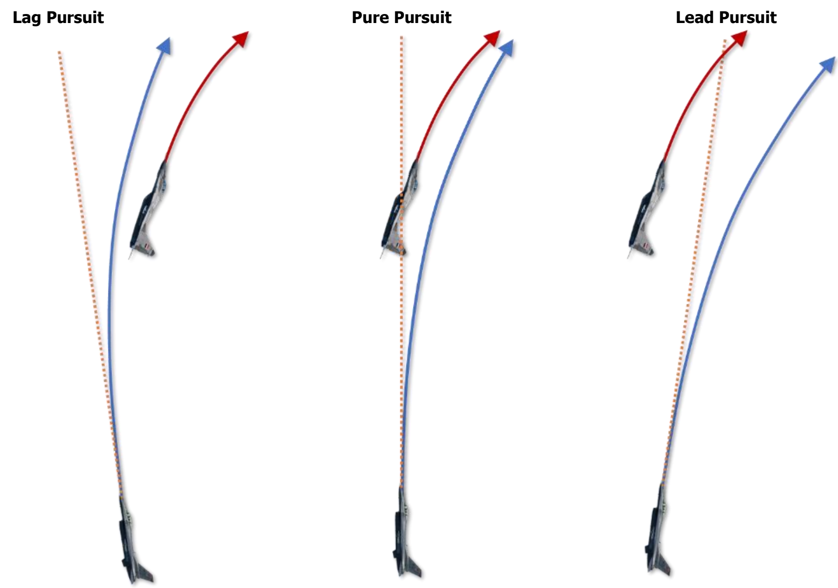
When maneuvering in a different plane of turn compared to the bandit, the pursuit course is determined by the lift vector of the ownship. In this situation, the lift vector diverges from the bandit's plane of turn and the ownship is maneuvered into a 3-dimensional pursuit course in relation to the bandit's plane of turn. This can be particularly useful if intending to use gravity to maintain or regain kinetic energy, to lengthen one's own flight path away from the bandit to extend the range before employing a weapon, or to tighten one's own turning radius to attain an optimum position for employing a weapon.



Pursuit course outside the bandit's plane of turn

When maneuvering within the same plane of turn as the bandit, the pursuit course is determined by the nose position of the ownship relative to the bandit itself.

- **Lag Pursuit.** If the nose position is behind the bandit, the ownship is in a lag pursuit course. In practical terms, a lag pursuit may be employed if the aspect angle is too high and the ownship does not have enough kinetic energy to maintain the required turn rate to keep the nose on the bandit, or the ownship requires more turning room than what the current range or closure rate allows.
- **Pure Pursuit.** If the nose position is on the bandit itself, the ownship is in a pure pursuit course. In practical terms, a pure pursuit may be employed if the aspect angle is low enough and the ownship has enough kinetic energy to maintain the required turn rate and within the required turning room to keep the nose on the bandit. A pure pursuit can be useful in achieving an optimum position for weapons employment at low aspect angles.
- **Lead Pursuit.** If the nose position is ahead of the bandit, the ownship is in a lead pursuit course. In practical terms, a lead pursuit may be employed to reduce the ownship's turning radius within the bandit's turn circle, or to increase the closure rate and/or reduce the range to the bandit. However, this requires that the ownship has enough kinetic energy and/or engine thrust to maintain the required turn rate and within the required turning room to keep the nose ahead of the bandit. A lead pursuit can be useful in achieving an optimum position for weapons employment at higher aspect angles, particularly if employing the gun, but doing so with a positive closure rate will likely require a constantly increasing turn rate that eventually results in being forced into a lag pursuit outside the bandit's turn radius.



Pursuit course within the bandit's plane of turn

Although a bandit may be engaged from outside the bandit's plane of turn, the attack geometry will be more complex and attaining the required targeting solution will likely be fleeting in nature. Particularly when engaging a bandit with the gun, entering the same plane of turn as the bandit will simplify the targeting solution required to achieve hits on the bandit.

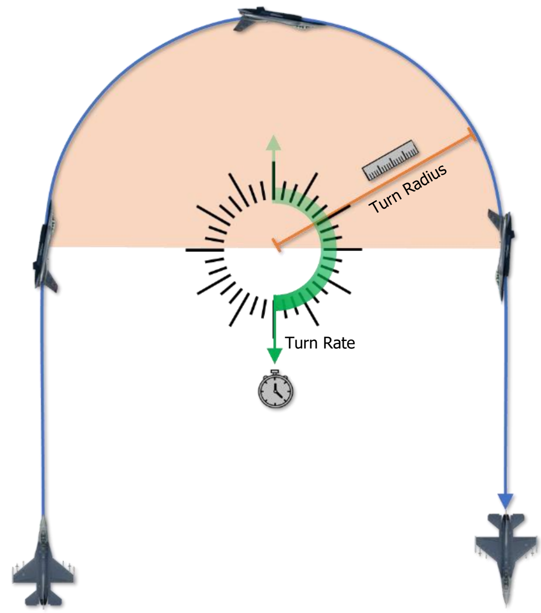
Conversely, when attempting to avoid a gun attack from a bandit, significantly changing one's own plane of turn will also complicate the bandit's targeting solution, forcing the bandit to adjust nose position and lift vector before an acceptable targeting solution for a gun attack can be attained.

Turn Rate versus Turn Radius

When employing attack geometry to achieve more favorable positional geometry for weapons employment, the turn performance of each opposing aircraft must be considered, which are expressed by the factors of turn rate and turn radius.

- **Turn Rate.** The time that is required for an aircraft to alter its flight path to a new direction is its turn rate. In practical terms, this is an expression of how *quickly* the aircraft can turn to point the nose in a different direction.
- **Turn Radius.** The space that is required for an aircraft to alter its flight to a new direction is its turn radius. In practical terms, this is an expression of how *tightly* the aircraft can turn to point the nose in a different direction.

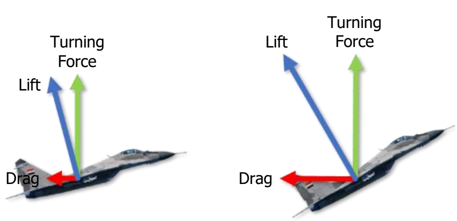
Both factors must be considered together, in that achieving the maximum turn rate for a given speed may not result in the minimum turn radius, nor will the minimum turn radius for a given speed result in the maximum turn rate. The pilot must consider what is more desirable throughout BFM: being able to turn the aircraft within a metric of time or being able to turn the aircraft within a metric of physical distance.



Turn Rate vs Turn Radius

Airspeed plays an important role in determining an aircraft's turn performance. Since an aircraft must utilize aerodynamic lift to alter its flight path, and aerodynamic lift is generated by air flowing across an airfoil, sufficient airspeed must be attained to achieve the desired turn performance. As an aircraft performs a positive pitch motion to increase the angle-of-attack (AoA, or "alpha"), the aerodynamic lift generated by the airfoils will increase, tightening the turn. However, increasing the AoA will also increase aerodynamic drag, which will cause the aircraft to slow down. This is overcome by increasing engine thrust during the turn; however, if the AoA is high enough in that more drag is produced than the thrust from the engine can overcome, the aircraft will slow down.

At higher speeds, a given turn rate will result in higher G-forces. Once the aircraft reaches the maximum allowable G-force that can be sustained, the turn radius will increase with airspeed. Conversely, if airspeed decreases, the turn radius will also decrease. However, if the airspeed continues to decrease, so too will the aerodynamic lift and the turn performance of the aircraft. Once the airspeed drops below a certain threshold, the aircraft will no longer be capable of achieving the maximum allowable G-force. This threshold, at which the turn performance is at its highest, is known as "corner velocity".

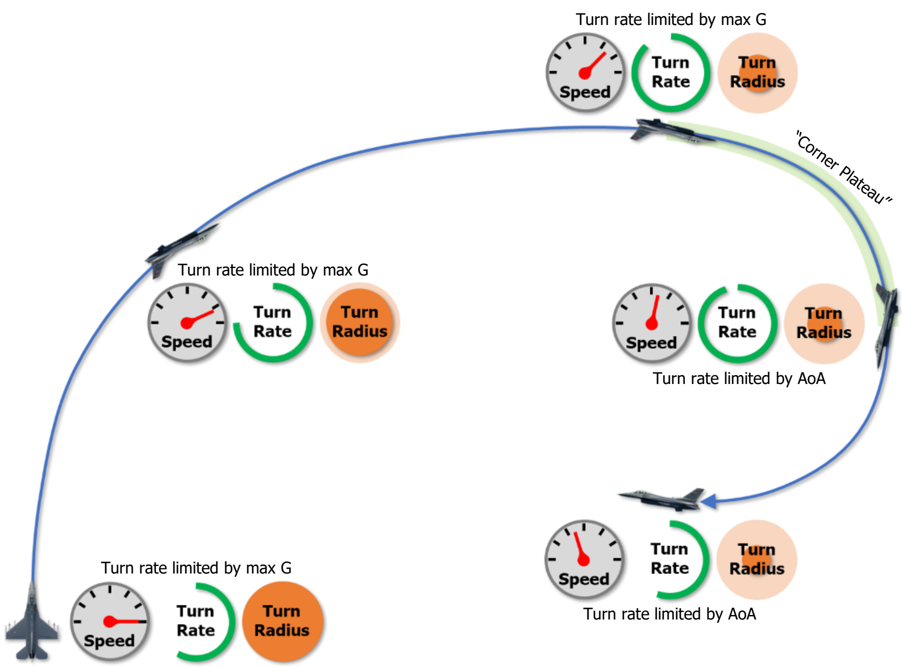


Drag at high Angles-of-Attack

It is worth mentioning that some aircraft are designed with "high-alpha" (high angle-of-attack) maneuverability in mind. However, as already mentioned, increasing AoA will also increase aerodynamic drag, and "high-alpha" conditions will generate aerodynamic drag to an extent that such maneuvers can only be maintained for a few moments before the energy state of the aircraft is depleted. Although high-alpha maneuverability in itself permits a significantly higher turn rate, allowing the pilot to bring the nose to bear on an enemy aircraft for a "snapshot" engagement opportunity, doing so will place the aircraft at an energy disadvantage.

The Flight Control System (FLCS) limits the F-16 turn performance based on angle-of-attack (AoA) and G-force in such a manner that the F-16 does not have a specific corner velocity, but rather a "corner plateau" between 330 and 440 knots airspeed. This also means that the F-16 is not capable of employing high-alpha maneuvers.

- At higher airspeeds, the limiting factor of the F-16's turn performance is G-force. The turn rate and turn radius will increase and decrease accordingly with airspeed, based on a maximum G-force of 9 G. Once the airspeed drops below approximately 440 KCAS (knots, calibrated airspeed), the limiting factor of the F-16's turn performance becomes angle-of-attack.
- As the airspeed is reduced from approximately 440 to 330 KCAS (the "corner plateau"), the turn radius will decrease slightly while the turn rate will increase.
- As the airspeed is reduced below approximately 330 KCAS, the turn radius will remain roughly the same, but the turn rate will decrease.



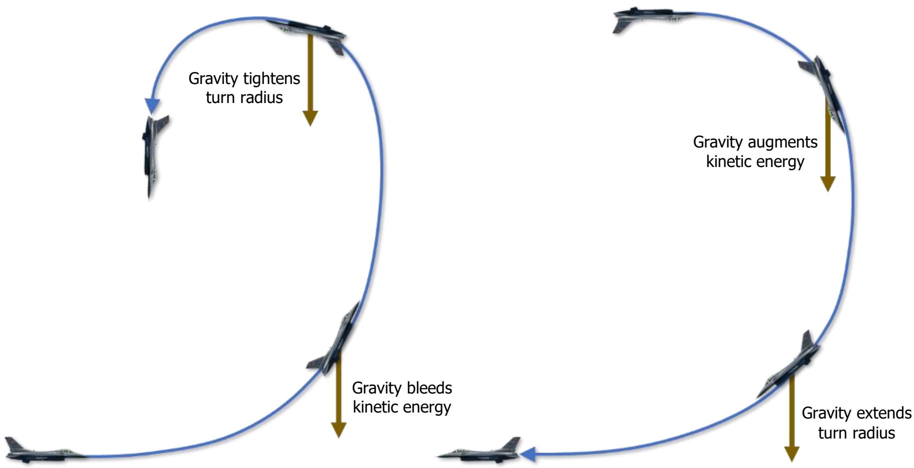
Turn Performance

It is worth noting that turn performance is greatly affected by gross weight and air density. At higher gross weights, greater AoA will be necessary to generate the required aerodynamic lift to redirect the aircraft's inertia and alter the flight path. Accordingly, the increased AoA will generate more aerodynamic drag, requiring more thrust from the engine to maintain the energy state of the aircraft. At higher altitudes and/or temperatures, lower air densities will result in reduced aerodynamic lift, which will likewise require additional AoA.

As a result, the turn performance of the aircraft will decrease at higher altitudes and gross weights. Under such conditions, the turn rate that may be sustained at maximum engine thrust may not reach the maximum G or maximum AoA limits of the aircraft. The pilot may still elect to utilize the full turn performance of the aircraft in this case, knowing that the current energy state cannot be maintained due to insufficient engine thrust, but doing so should be done with consideration to the tactical situation. For example, a more aggressive turn may be momentarily employed to achieve an optimum position for weapons employment, or to temporarily deny a bandit the same opportunity, with the knowledge that doing so will expend energy and cause the airspeed to decrease. However, such an action may prove tactically advantageous in that moment if the energy can be recovered.

The force of gravity itself will also affect the turning radius of the aircraft when the plane of turn is not parallel with the surface of the Earth. When ascending and the flight path passes the vertical, gravity will pull the aircraft in the same direction as the lift vector. This augments the aerodynamic lift with which the aircraft is turning, tightening the turn itself and reducing the turn radius.

When descending and the flight path passes the vertical, gravity will pull the aircraft in the opposite direction from the lift vector. This counteracts the aerodynamic lift with which the aircraft is turning, extending the turn itself and increasing the turn radius.



Vertical Turn Radius

In addition, altitude may be traded for airspeed, or vice versa. As altitude is potential energy and airspeed is kinetic energy, one may be exchanged for the other during aerial maneuvers, as necessary.

If the pilot must perform a turn for which the engine thrust cannot maintain the current airspeed, the aircraft will slow down. However, if sufficient altitude (potential energy) is available and the pilot incorporates a descent throughout the turn, the force of gravity may be used to augment the engine thrust to maintain or regain airspeed (kinetic energy). Thus, potential energy is traded for kinetic energy.

Alternatively, if the pilot must gain altitude and the engine thrust cannot maintain the current airspeed throughout the ascent, the aircraft will slow down. However, if sufficient airspeed (kinetic energy) is available, aircraft inertia may be used to augment the engine thrust to gain altitude (potential energy). Thus, kinetic energy is traded for potential energy.

Entering the Merge

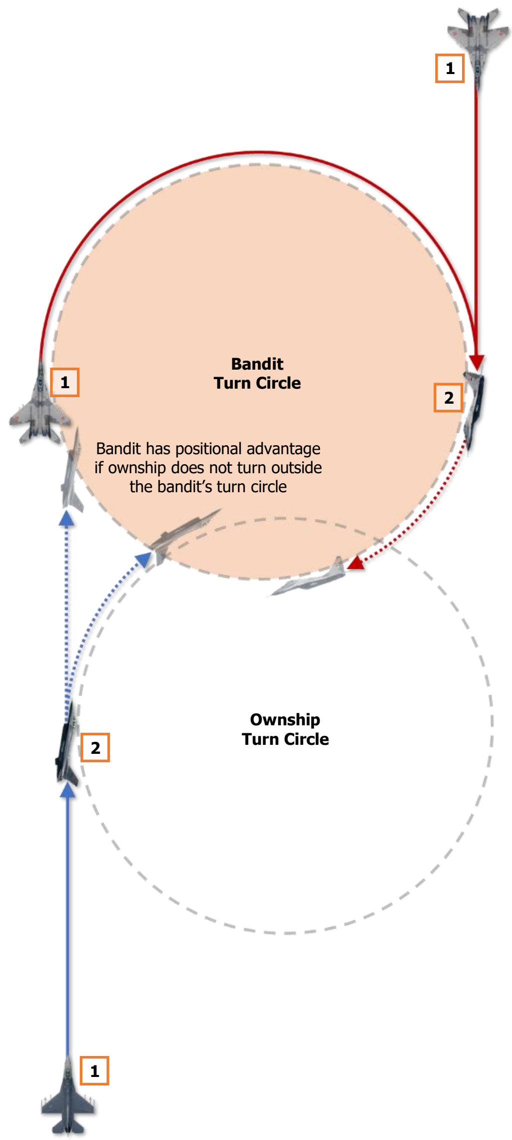
The tactics and techniques of conducting a close-range WVR engagement will vary greatly depending on the tactical situation, the positional geometry as the flight merges with an enemy aircraft, and the type of aircraft with which the flight has merged, especially with consideration to the maneuverability and weapon capabilities of the enemy aircraft. Of particular note are whether the enemy aircraft's strengths lie within its turn performance, its thrust-to-weight ratio, and whether it has the capability to perform "high-alpha" maneuvers or employ high-off-boresight missiles. These factors should drive how the enemy aircraft are engaged in close combat, in order to leverage the strengths of one's own aircraft while exploiting the weaknesses of the enemy aircraft.

Once two opposing aircraft have entered into close-range BFM combat, this is referred to as becoming "merged". Prior to the merge itself, it is important to develop a plan for how to maneuver, attack, defend against, and ultimately defeat the bandit with respect to one's own flight and the capabilities and tactics that will likely be employed by the enemy aircraft. The most important thing to remember is to *avoid losing sight of the bandit.* In many cases during close-range combat, the bandit will be outside of the FCR gimbal limits, any position updates of an enemy aircraft received via datalink will not be received fast enough, and the radar warning receiver cannot be relied upon to warn of an impending attack from IR-guided missiles or guns.

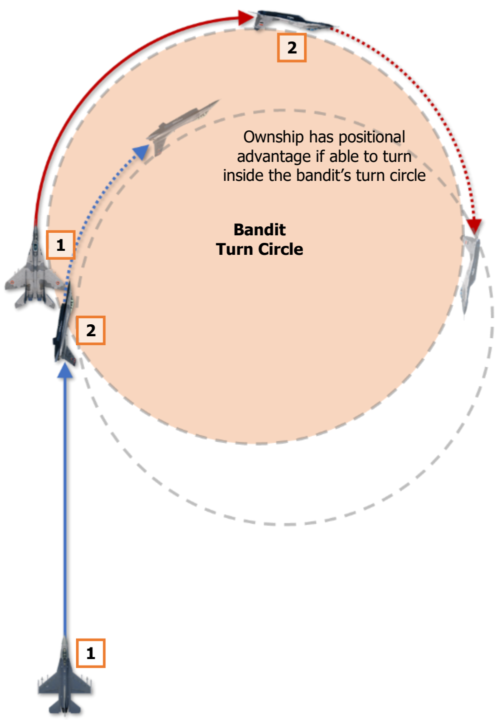
When entering into a merge, performing a turn into the bandit before actually passing the bandit aircraft, which is known as a lead turn, can be used to reduce the angle-off and aspect angle. However, it is likely the bandit will also attempt a lead turn against the ownship. In this situation, the opposing aircraft will enter what is known as a "two circle fight".

A two circle fight may also occur if the ownship is in an offensive position behind the bandit, the bandit turns to increase the ownship's aspect angle and angle-off, and the ownship enters a pursuit turn in the same direction as the bandit. If the bandit can sufficiently increase the aspect angle before the ownship can enter the bandit's turn circle, the ownship must avoid granting the bandit positional advantage by either turning into the bandit and entering a two circle fight or accelerate and extend the range to deny the bandit an opportunity to employ a weapon against the ownship.

As the two aircraft pass, a high aspect missile shot may be taken if equipped with an appropriate missile type. However, one should be prepared for the bandit to attempt the same, especially if the bandit is equipped with all-aspect IR-guided missiles. Particularly when positioned on opposing sides of the respective circles, one should be prepared for brief opportunities to employ missiles, especially if equipped with high-off-boresight missiles such as the AIM-9X. Likewise, if the bandit is equipped with high-off-boresight missiles as well, or is capable of high-alpha maneuvers, one should be prepared for the bandit to attempt the same.



BFM Two-Circle Fight



Two Circle Fight

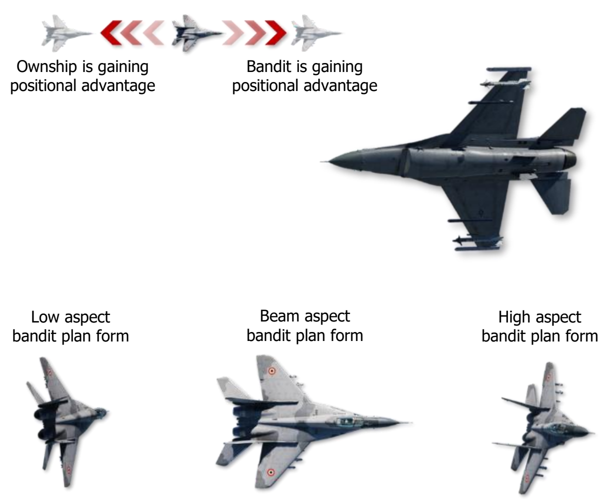
When the ownship is in an offensive position behind the bandit and at a range that permits the ownship to enter the bandit's turn circle before the bandit can react, the ownship may gain positional advantage with favorable aspect angle and angle-off. However, if the bandit recognizes this, the bandit may perform a turn reversal to force the engagement into a one circle fight.

If the ownship is able to enter the bandit's turn circle in a two circle fight, the objective will be to utilize a smaller turn radius and higher turn rate to gain positional advantage over the bandit until an optimum position for weapons employment can be achieved. The pilot must manage the energy state of the aircraft using AoA, engine thrust, and *patience*. If the pilot depletes the energy state of the aircraft in an attempt to hastily employ a weapon, the bandit may easily turn the tables, so to speak, if the weapon fails to impact the bandit aircraft.

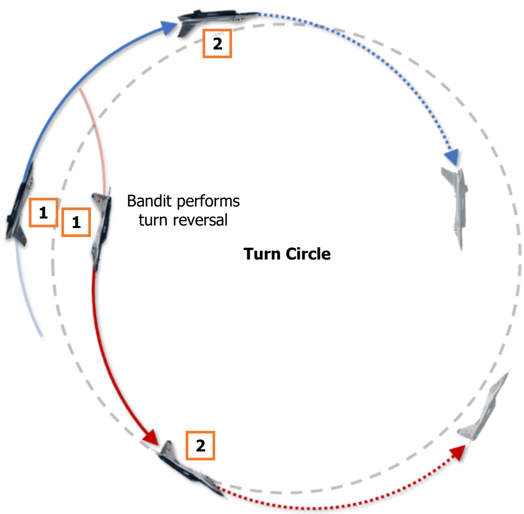
Even if positional advantage is not yet ideal for a gun shot, a high aspect missile shot may be taken if equipped with high-off-boresight missiles such as the AIM-9X. However, just as in the scenario illustrated on the previous page, one should be prepared for the bandit to attempt the same if the bandit is equipped with high-off-boresight missiles as well. Additionally, if the bandit is capable of high-alpha maneuvers, the bandit may not need to employ a high-off-boresight missile if the bandit is able to achieve sufficient positional advantage to permit such an attempt.

As the opposing aircraft continue in the two circle fight, the positional geometry must be continually assessed to determine whether positional advantage is being gained or lost, whether a weapon may be successfully employed, and when to be prepared to defend against a weapon employed by the bandit.

- If the bandit appears to be moving toward the nose of the ownship, the ownship is gaining positional advantage over the bandit.
- If the bandit appears to be moving toward the tail of the ownship, the bandit is gaining positional advantage over the ownship.
- If the aspect angle is low, the position is ideal for weapon employment due to the low crossing rate and requires less lead.
- If the aspect angle is at the beam, the position is not ideal for weapon employment due to the high crossing rate and requires large amounts of lead.
- If the aspect angle is high, one should be prepared to defend against a weapon employed by the bandit.



Assessing positional geometry from the bandit



One Circle Fight

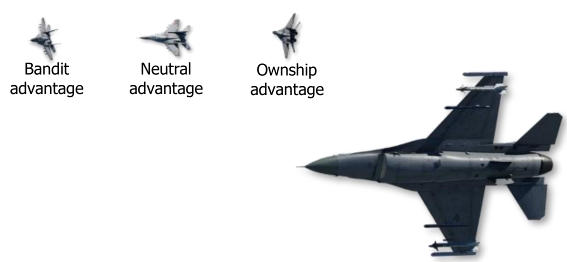
If either aircraft turns away from the other, whether it be at the merge or if performing a turn reversal from a two circle fight, the opposing aircraft will enter what is known as a "one circle fight".

When entering a one circle fight, the opposing aircraft will be on opposite sides of the same turn circle, with a high aspect pass completing the circle. As the two aircraft pass, a high aspect missile shot may be taken if equipped with an appropriate missile type. However, such opportunities will typically be more fleeting compared to a two circle fight and one should be prepared for the bandit to attempt the same, especially if the bandit is equipped with all-aspect IR-guided missiles. Particularly when the ownship has a superior aspect angle advantage, one should be prepared for brief opportunities to employ missiles, especially if equipped with high-off-boresight missiles such as the AIM-9X. Likewise, if the bandit is equipped with high-off-boresight missiles as well, or is capable of high-alpha maneuvers, one should be prepared for the bandit to attempt the same.

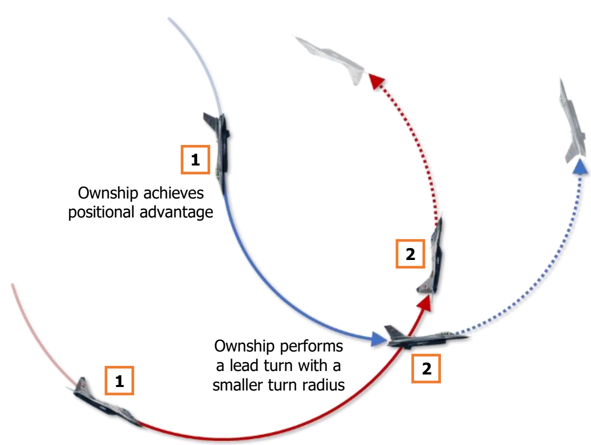
Leading up to each high aspect pass, the positional geometry must be assessed to determine which aircraft has positional advantage, when to be prepared to defend against a weapon employed by the bandit, or when to transition back to a two circle fight.

- If the bandit's aspect angle is low when abeam the ownship, the ownship has positional advantage and may transition to a two circle fight.
- If the bandit's aspect angle appears to be a mirror image when abeam the ownship, neither aircraft have positional advantage.
- If the bandit's aspect angle is high when abeam the ownship, the bandit has positional advantage and the ownship should be prepared to defend against a weapon employed by the bandit.

During a one circle fight, the ownship must utilize a smaller turning radius to attain positional advantage. If sufficient positional advantage can be achieved, the ownship can perform a lead turn behind the bandit and attempt to transition back to a two circle fight. However, if the bandit performs another turn reversal and turns back toward the ownship, the engagement will be forced back into a one circle fight. Accordingly, if the bandit has positional advantage, the bandit may similarly attempt to transition to a two circle fight.



Assessing positional geometry from the bandit

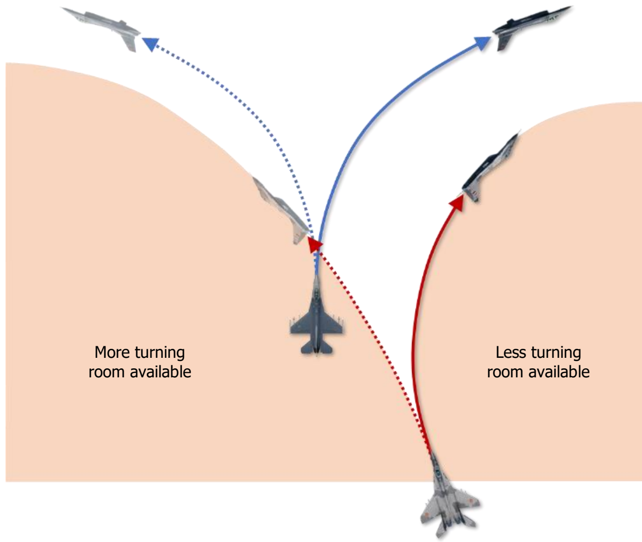


Transition from One Circle to Two Circle Fight

When the bandit is in an offensive position behind the ownship, the ownship can exploit the available turning room to *increase* a bandit's aspect angle and angle-off relative to the ownship to deny or complicate the employment of a weapon from the bandit against one's own aircraft.

In the example to the right, a bandit is approaching from the 5 o'clock position, with a low aspect angle and low angle-off relative to the F-16's heading. If the F-16 were to turn away from the bandit, the aspect angle and angle-off would be further *reduced*, simplifying the targeting solution for the bandit and granting more turning room.

If the F-16 turns into the bandit, the aspect angle and angle-off will be *increased*, restricting the turning room within which the bandit must use. This will complicate the bandit's targeting solution and may force the bandit to overshoot outside the F-16's turn circle.



Turning Room

Engaged Fighter and Supporting Fighter

During Air Combat Maneuvers (ACM) in which two friendly aircraft are working as a team, one aircraft is designated as the engaged fighter and the other is designated as the supporting fighter.

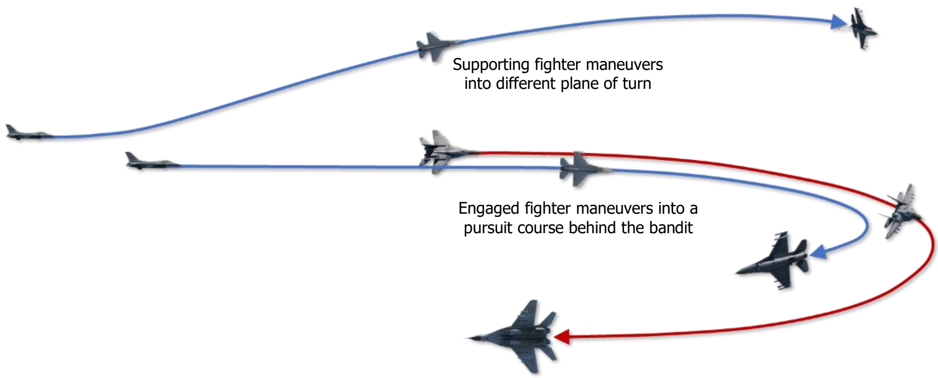
- **Engaged Fighter.** When maneuvering offensively against a bandit, the engaged fighter is the aircraft that is actively maneuvering to employ a weapon. When maneuvering defensively against a bandit, the engaged fighter is the aircraft that is being engaged by the bandit.

- **Supporting Fighter.** When the engaged fighter is maneuvering offensively against a bandit, the supporting fighter maintains a visual on the engaged fighter and tally on the bandit while remaining clear of the fight itself but remains ready to employ a weapon against the bandit, if necessary, in coordination with the engaged fighter and without endangering the engaged fighter itself. When the engaged fighter is maneuvering defensively against a bandit, the supporting fighter employs weapons against the bandit in coordination with the engaged fighter and without endangering the engaged fighter itself.

  In addition, the supporting fighter will also need to keep the engaged fighter informed of any other threats to the flight (to include other enemy aircraft as well as ground- or naval-based air defense systems) and be prepared to direct and cover the engaged fighter's egress from the fight, if necessary. During close-range aerial combat, the engaged fighter will be solely focused on the bandit and reliant on the supporting fighter to maintain situational awareness of the battlespace beyond the immediate close-range fight.

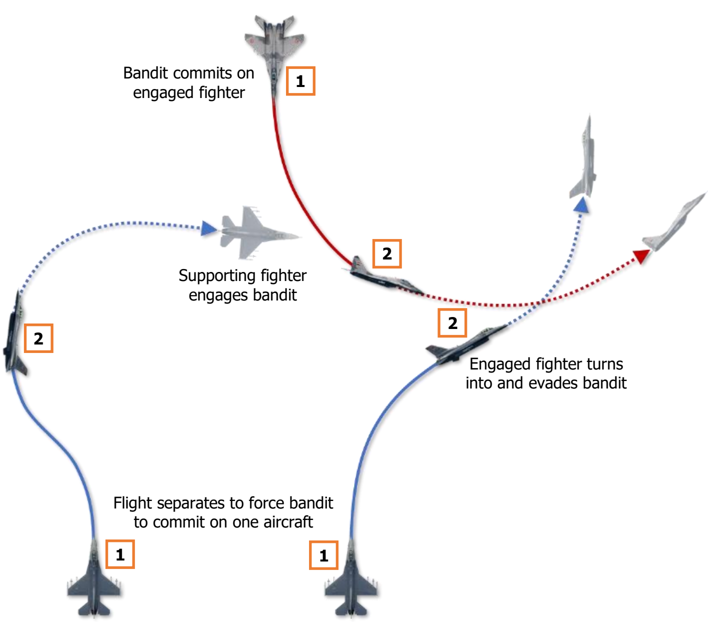
It is important to note that any aircraft within the flight may become the engaged fighter, and that in the course of a close-range WVR engagement the engaged and supporting fighter may change, and may in fact change more than once. As mentioned above, it is important to develop a plan for how to employ the flight to maneuver, attack, defend against, and ultimately defeat the bandit. When initiating an attack against an enemy aircraft, the engaged fighter will typically be the flight lead with the wingman as the supporting fighter. However, when a bandit is maneuvering against the flight, whether initiating an attack against the flight or if responding to the flight's attack against itself, the bandit may choose to engage the supporting fighter. In this instance, the roles of engaged fighter and supporting fighter will swap.

It is critical that the supporting fighter maneuver to attain positional advantage against the bandit while not impeding the ability for the engaged fighter to do the same. This can be accomplished by maneuvering within a different plane of turn, extending from the fight to gain separation, or lagging slightly behind and offset from the engaged fighter, depending on the positional geometry that would prevent placing oneself in danger of being engaged by the bandit.



Supporting fighter offset into separate plane of turn

In the example below, the flight is approaching a merge with a bandit and breaks away from each other in opposite directions. At this point, the bandit is forced to commit on one or the other, therefore the choice that the bandit makes will be the determining factor regarding which flight member becomes the engaged fighter or the supporting fighter. Once the engaged fighter is recognized, the engaged fighter will maneuver to attain positional advantage against the bandit while the supporting fighter maneuvers to defend the engaged fighter.



Merge into ACM Engagement

Air-to-Surface Missions

Air-to-surface missions can be demanding missions to undertake. Any successful strike mission requires detailed planning to ensure that all the appropriate factors are considered. In addition, all flight members must ensure they have a thorough understanding of the mission and their respective duties at each phase of the mission before climbing into the cockpit.

Mission Objective

The first four factors that should be considered when planning the mission are related to the objective of the mission itself.

- The nature of the objective (the targets and the desired weapon effects against them)
- The location of the objective (proximity to friendly units, distance from airfield, surrounding terrain)
- The timing of the objective (the time at which the desired weapon effects must be achieved)
- The on-station time over the objective (the duration of the desired weapon effects, if applicable)

These four factors will determine the selection of munitions that may be used to achieve the desired weapon effects, the quantity of the given munitions the flight must employ to achieve the desired weapon effects, and the required amount of fuel the flight must have onboard when committing to the objective. In addition, the time of day at which the mission is undertaken may further refine what weapons or sensors may be used during the attack itself.

Enemy Threats

The next set of factors that should be considered are related to the enemy's ability to prevent the flight from achieving the mission objective.

- Air defense threats surrounding the objective.
- Air defense threats that may be encountered while enroute to the objective.
- Airborne threats that may be encountered over the objective.
- Airborne threats that that may be encountered while enroute to the objective.

These four factors will determine the selection of munitions that may be used to defend the flight against such threats while over or enroute to the objective, the quantity of such munitions the flight must carry to ensure their survival, and the configuration of the defensive countermeasures the flight should employ against such threats. In addition, these factors may further dictate the required amount of fuel the flight must have onboard when committing to the objective (for defensive maneuvering) and whether an external ECM pod must be carried.

Terrain and Weather

The third set of factors that should be considered are related to the environment the flight is expecting to encounter while enroute to or from the objective, as well as at the objective itself.

- Terrain surrounding the objective.
- Terrain that will be encountered while enroute to the objective.
- Weather conditions that are expected over the objective.
- Weather conditions that may be encountered while enroute to the objective.

These four factors may limit the selection of munitions that may be successfully employed, or the specific attack patterns that may be used to employ them. In addition, the terrain may be used to mitigate air defense or airborne threats that may threaten the flight while enroute to the objective or when conducting the attack itself.

Once a tentative attack plan has been generated that has the highest likelihood of achieving the mission objectives given the assessed factors, "backwards planning" techniques are used to plan each preceding event leading up to the strike itself, which will include the ingress strategy and, by extension, the egress strategy. This will ensure the flight arrives at the mission objective within the required timeline, with the required munitions to achieve the mission objectives, and sufficient fuel remaining to return to base.

High Altitude Attack Profiles

High altitude attack profiles allow the flight to avoid most short-range air defense systems such as AAA or IR-guided weapons such as MANPADS. However, this will also place the flight within the engagement range of long-range/high-altitude air defense systems and increase the probability of detection by early warning systems or hostile aircraft.

High altitude flight will reduce the workload of flight members, allowing pilots to maintain a higher degree of situational awareness and providing more time to acquire their target prior to weapons release. Navigation is also simplified when there is no risk of colliding with terrain, but weather and visibility may play a more significant factor in target acquisition.

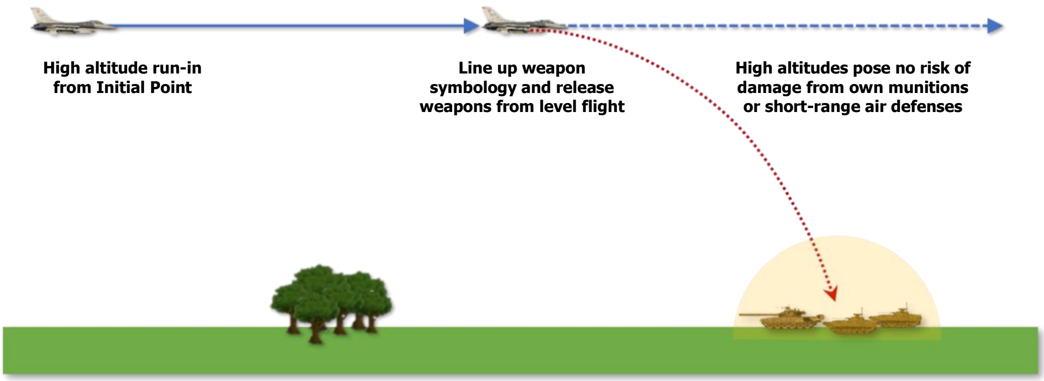
Fuel consumption when flying at high altitudes will be significantly lower, allowing the flight to increase their station time over an objective, attack targets at further ranges into enemy territory, or retain additional fuel reserves for contingencies or defensive maneuvers.

High altitude flight will also provide an advantage when faced with airborne threats, especially if such hostile aircraft are launched in response to the flight's approach to the designated target area. In this situation, hostile aircraft will be at an energy disadvantage while climbing to meet the incoming strike package. Additionally, air-to-air missiles may be employed at longer ranges against airborne threats.

High Altitude Level Bombing

Performing level-bombing from high-altitude exposes the flight to the least amount of risk over the target area and is the simplest attack technique to perform. However, this type of attack technique will typically require some form of precision targeting to increase the likelihood of striking the intended target, which could take the form of an onboard targeting pod to aid in target acquisition and designation; or an external source of targeting and designation could be provided (such as another aircraft or ground force in vicinity of the target).

Multiple sensors may be used to acquire the target, such as radar, electro-optical targeting pods, night-vision goggles, or even visual acquisition using the unaided eye. However, weather and time of day will play an important factor in determining which sensors are required to find the target.

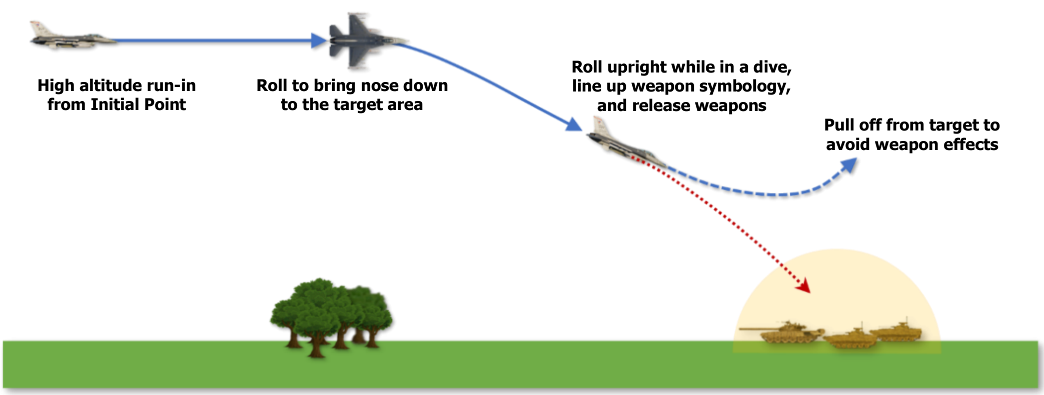


High Altitude Level Bombing

High Altitude Dive Bombing

Dive bombing from high altitudes may expose the flight to additional risk by potentially entering the engagement ranges of short-range air defenses or by colliding with terrain while pulling off following weapons release. However, dive bombing increases the accuracy of delivering unguided weapons onto a target by engaging from a closer range and reduces the dispersion by releasing the weapons from a vertical angle.

Dive bombing may also mitigate the effects of poor visibility over the target area by allowing the flight members to visually acquire targets below the cloud layers prior to weapons release. But this carries with it the added risk of colliding with terrain and should only be performed if each flight member has a thorough understanding of the terrain contours and elevations surrounding the target and has implemented appropriate criteria of when to abort the attack sequence if visual contact with the surface cannot be achieved.



High Altitude Dive Bombing

Low Altitude Attack Profiles

Low altitude attack profiles allow the flight to avoid long-range/high-altitude air defense systems, delay detection by early warning systems or hostile aircraft, and minimize the reaction time of short-range air defenses. However, this will also place the flight within the engagement range of a greater number of threat weapon systems.

Such low-altitude flight is more demanding, carries additional risk, and requires a higher degree of skill and proficiency to avoid becoming "task saturated"; especially when performed at night. Situational awareness is hindered due to the increased time the flight members spend avoiding terrain and obstacles instead of scanning outside for threats or each other, or cross-checking cockpit displays and sensor information.

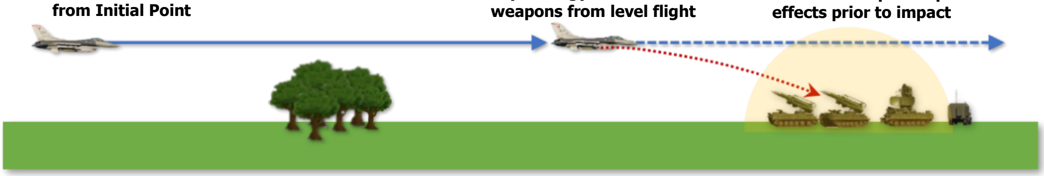
Fuel consumption when flying at low altitudes will be significantly higher. Because of this, the time spent at low altitudes should be minimized to ensure the flight retains enough fuel for egress or defensive maneuvering as necessary. Performing aerial refueling prior to committing to a low-level strike should be considered, if feasible, to provide additional options for any contingencies encountered during the mission.

Low altitude flight will also incur a disadvantage when faced with airborne threats, especially if such hostile aircraft are directed to intercept the flight as they approach the designated target area. In this situation, hostile aircraft will be at an energy advantage while intercepting the incoming strike package. Additionally, air-to-air missiles will have reduced ranges against airborne threats.

Low Altitude Level/Retarded Bombing

Performing level-bombing from low-altitude exposes the flight to the most amount of risk over the target area, exposes the flight to potential damage incurred from their own weapons as well as weapons fire from the enemy, and will typically require the most accurate intelligence regarding the location of the intended target and its surroundings. However, this type of attack technique will minimize the time spent within the Weapon Engagement Zone (WEZ) of enemy air defense systems in vicinity of the target area, does not necessarily require precision targeting to the same degree as high-altitude bombing, and is unlikely to be impacted by weather over the target area.

Such attack techniques will typically require some form of deconfliction between each aircraft's attack sequence to ensure that the weapon effects from each flight member does not cause damage to their own aircraft. In addition, munitions with some sort of retarding device may be required in the form of the Mk15 "Snakeye" petals or the BSU-49 inflatable "ballute" tail kits, to ensure that the delivering aircraft has time to escape the effects of their own weapons.

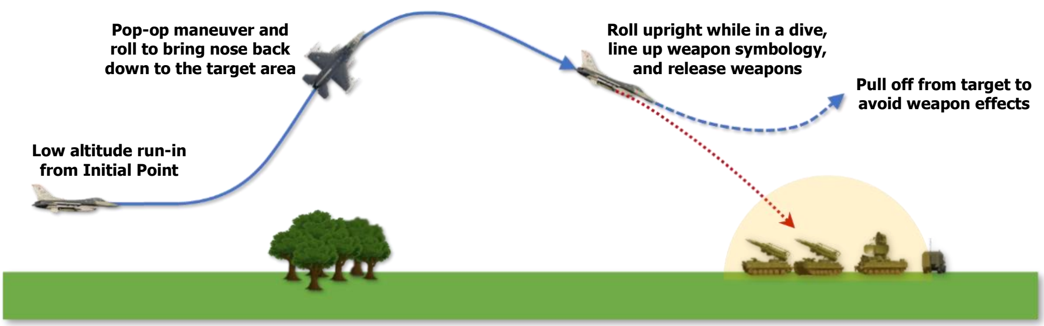


Low Altitude Level/Retarded Bombing

Low Altitude Pop-Up Dive Bombing

Pop-up dive bombing from low altitudes allows the flight to take advantage of a low-altitude attack profile while providing the pilots additional time to acquire the intended target prior to weapons release, reduces the dispersion of unguided weapons by releasing the weapons from a vertical angle, and also makes the flight pattern unpredictable when being targeted by short-range air defenses. However, this is the most complex attack technique to perform and is the most demanding on flight members.

By performing a pop-up from low altitude before reaching the target, pilots will have additional time to acquire their intended targets prior to weapons release if the precise location or disposition of their targets are unknown; or if the position quality of their navigation system is in question. But this carries with it the added risk of colliding with terrain when pulling off following weapons release; and it may momentarily expose the flight to additional enemy weapon systems in the target area by silhouetting themselves against the sky.



Low Altitude Pop-Up Dive Bombing

Standoff Attack Profiles

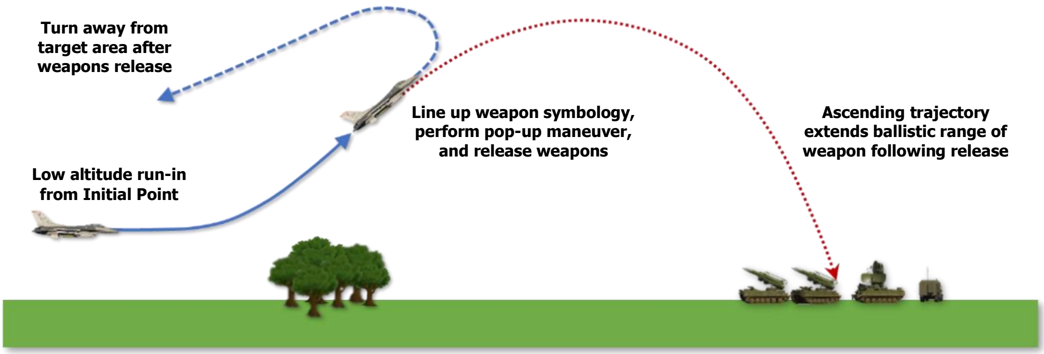
Using "standoff" to engage targets from longer range allows the flight to minimize the time spent within the WEZ of enemy air defense systems, or avoid the WEZ altogether. This can be particularly beneficial when attacking heavily defended targets, or when attempting to maintain an element of surprise by avoiding overflight and subsequent detection by nearby enemy units.

Using standoff attacks will typically be driven by the available munitions that are in use, which in turn may be dictated by the nature of the target and the desired weapon effects, the time of day, or the weather conditions in vicinity of the target.

Toss Bombing

Toss bombing is an alternative to performing a level bomb delivery and uses the additional kinematics of releasing a munition while in an ascending flight path to increase the ballistic range that the weapon can achieve following release from the aircraft. Although toss bombing can be utilized from any altitude, it is more commonly used in conjunction with a low-altitude pop-up maneuver, except the bomb is released during the pop-up climb itself rather than during a subsequent dive onto the target.

Unfortunately, toss bombing increases the dispersion of unguided munitions within the target area. Additionally, when performed from low altitudes, accurate intelligence regarding the location of the intended target and its surroundings is required if the target is not acquired by the pilot prior to initiating the attack itself. However, these disadvantages can be mitigated by using precision munitions and other sources of targeting or designation.



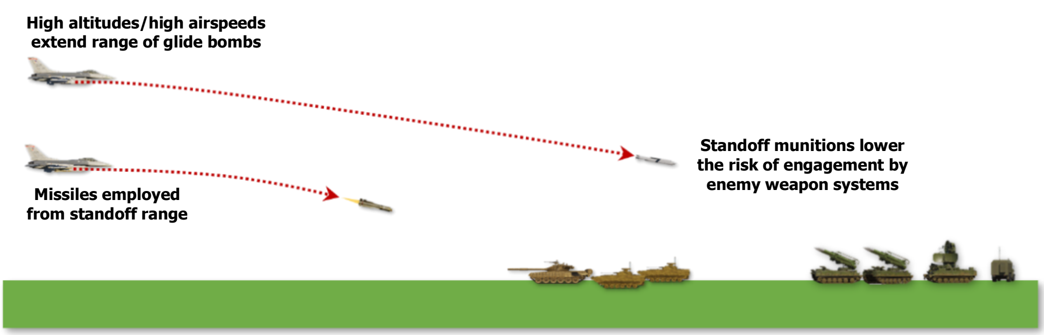
Low Altitude Pop-Up Toss Bombing

Missile/Glide Bomb Delivery

Employing precision munitions such as missiles or glide bombs allows the flight to attack targets from extended ranges with a high probability of striking the intended target. These munitions may typically be employed from a variety of altitudes or attack profiles; but the primary limiting factors of these types of munitions are the range at which the launching aircraft or the munition itself can acquire its target, or the range that the munition can travel from the point of weapons release.

Employing missiles or glide bombs from high altitudes will improve the ability of the pilot to acquire the target and will extend the kinematic range from which these weapons may be released. This will allow the launching aircraft to release the munitions from a greater distance from the target, decreasing the likelihood of the flight of being engaged by enemy weapon systems surrounding the target. However, this will also increase the chances of detection by early warning systems and hostile aircraft; and it may place the flight in the WEZ of long-range/high-altitude air defense systems.

Employing missiles or glide bombs from low altitudes will hinder the ability of the pilot to acquire the target (depending on the nature of terrain surrounding the target area) and will reduce the kinematic range from which these weapons may be released. This may force the launching aircraft to release the munitions from a closer distance to the target, increasing the likelihood of the flight of being engaged by enemy weapon systems in the target area. However, this will also decrease the chances of detection by early warning systems and hostile aircraft; and it may allow the flight to avoid the WEZ of long-range/high-altitude air defense systems.



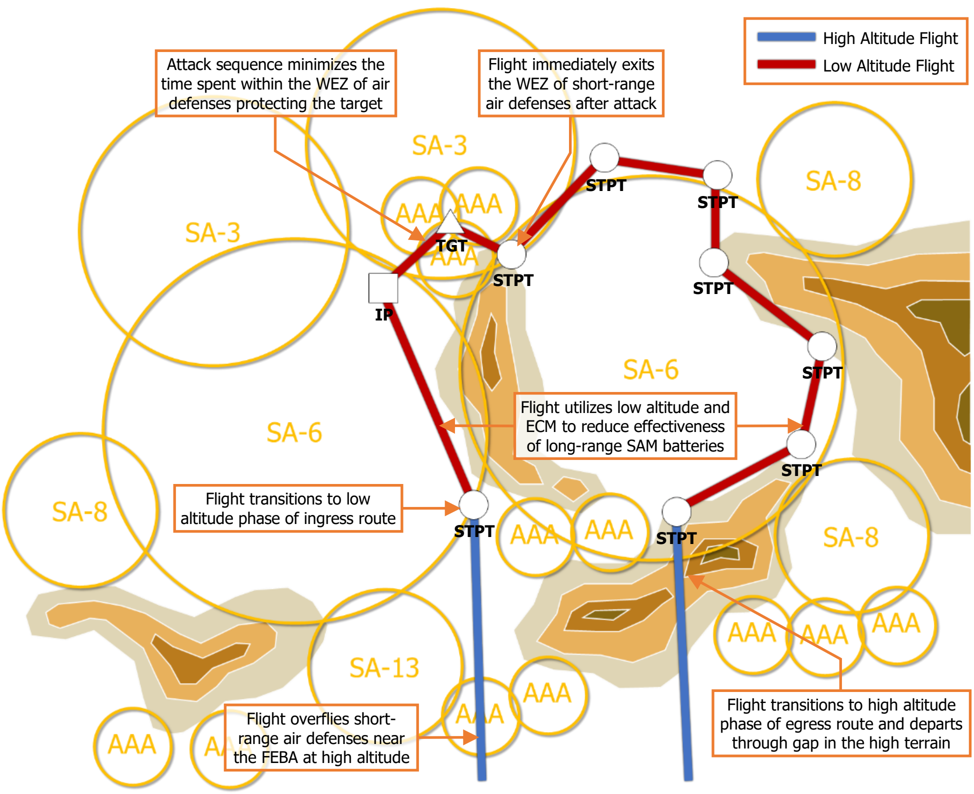
Missile/Glide Bomb Delivery

Ingress and Egress Strategies

Planning appropriate ingress and egress routes are just as important as the attack itself. The routes should avoid known air defenses as much as possible while minimizing the chances of detection for as long as possible. At times, it may be necessary for the flight to fight their way to and from the target area by engaging enemy threats along the route to ensure the flight's survival and ensure the target area can be reached to initiate the attack.

A combination of high and low altitudes may be utilized at different phases of the route as appropriate, along with terrain masking, ECM jamming, and unpredictable flight patterns to have a collective effect in degrading or defeating the enemy's ability to successfully engage the strike package.

In the example below, a strike is planned against a heavily defended target in enemy territory, such as an airfield or a command center. The initial portion of the ingress begins at high altitude when crossing the FEBA, where there are likely substantial numbers of tactical ground units equipped with heavy machine guns, light AAA, and MANPADS. After these units are overflown and the flight approaches the Weapons Engagement Zone (WEZ) of long-range/high-altitude SAM batteries, the flight descends to low altitude and uses a combination of threat avoidance, terrain masking, and ECM to avoid engagement. Once the strike is complete, the flight egresses along a different route and again uses low altitude, threat avoidance, terrain masking, and ECM to avoid an enemy engagement. When feasible, the flight climbs back to high altitude for the remainder of the flight back to base.



Ingress and Egress Planning

The scenario above is just one example; each mission may require various techniques for ingress and egress. Some missions may need to be flown entirely at low altitude or entirely at high altitude, or a combination of each as shown above. When threats cannot be avoided or engaged with the flight's own weapons, it may be necessary to rely on other flights within a "strike package" for fighter escort or suppression of enemy air defenses.

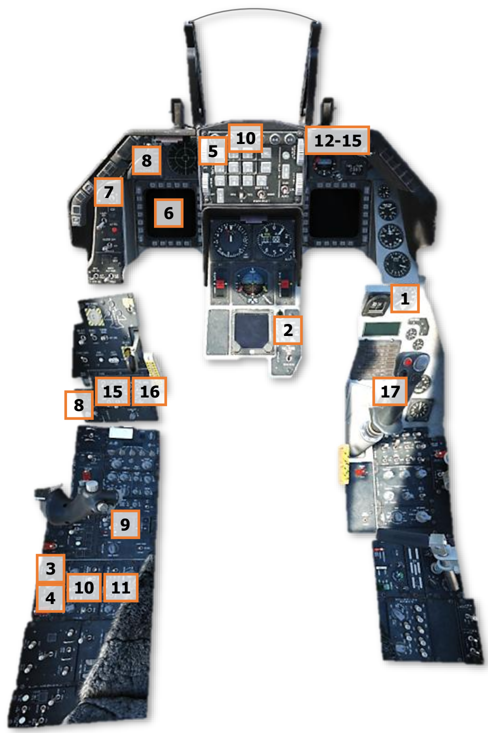
Pre-Combat Checks

When approaching the combat area, flight members should conduct pre-combat checks and ensure their aircraft are ready to employ weapons and defensive countermeasures as needed. This is commonly referred to as the "Fence Check". Many of the systems may already be appropriately configured during the initial run-up prior to departure or while enroute, but the final Fence Check allows each pilot to confirm their respective aircraft is ready for combat.

The Flight Lead may direct each flight member to perform one final Fence Check prior to entering the combat area using the brevity term "Fence In". Conversely, the Flight Lead may direct each flight member to perform a Fence Check after exiting the combat area using the brevity term "Fence Out".

Fence Check

Fuel



1. Total fuel quantity – Check.
2. FUEL QTY SEL knob – Check balance between tanks.
3. ENGINE FEED knob – Set to NORM.
4. TANK INERTING switch – Set to TANK INERTING.

Emitters

5. TACAN – Set A/A T/R settings or configure as necessary.
6. FCR – Set mode and scan volume.
7. RF switch – Set as required.
8. RWR – Configure as necessary.
9. ECM control panel – Configure as necessary.
10. IFF – Set modes & codes; configure as necessary. (N/I)
11. EXT LIGHTING control panel – Set MASTER knob to OFF (or as appropriate).

Navigation

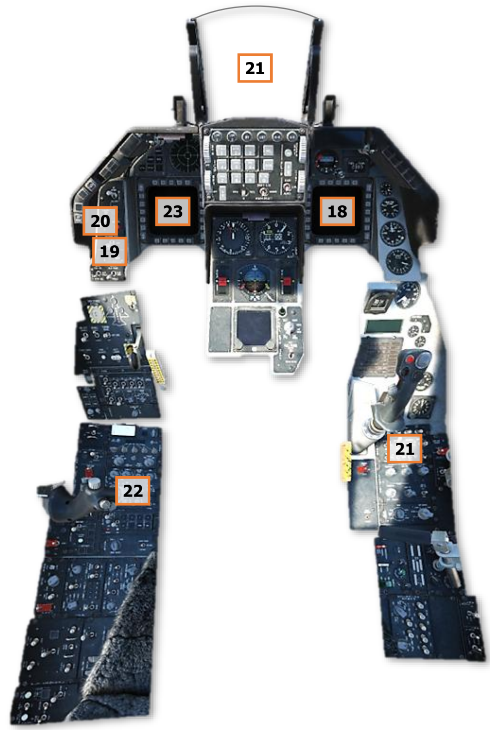
12. STPT/DEST pages – Verify steerpoint data.
13. NAV page – Verify SYS ACCUR and GPS ACCUR are HIGH.
14. FIX/A-CAL pages – Perform updates as necessary.

Chaff/Flares

15. CMDS settings – Configure as necessary on CMDS control panel and CMDS DED page.
16. CMDS MODE knob – Set to MAN, SEMI, or AUTO as required.
17. CMS switch – Press to Aft position to confirm consent in SEMI/AUTO modes; or press to Right position to revoke consent in SEMI/AUTO modes.

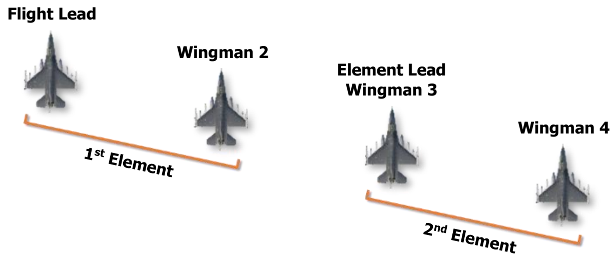
Employment

18. SMS – Check weapon profiles and settings in each master mode (A-A, A-G, MSL, DGFT)
19. MASTER ARM switch – Set as required.
20. LASER ARM switch – Set as required.
21. HUD control panel – Configure as desired; confirm correct symbology and indications are displayed.
22. AUDIO 1 & AUDIO 2 control panels - Set volume levels as desired.
23. SOI – Confirm or set as desired.



Flight Formations

U.S. Air Force F-16 squadrons typically consist of 15-24 aircraft. However, tactical missions are commonly assigned to 4-ship combat formations called "flights", which consist of two 2-ship fighting units called "elements". Each 4-ship flight is commanded by a Flight Lead, with the second element within the flight commanded by a 2-ship Element Lead. The Flight Lead is responsible for ensuring the success of the flight's mission and will direct the actions of the other flight members accordingly.



Structure of 4-ship Flight

When approaching the combat area, flight members should conduct pre-combat checks and ensure their aircraft are ready to employ weapons and defensive countermeasures as needed. Accordingly, wingmen should adjust their formation and flight patterns to those which are best suited for the tactical situation, routing, and speeds they intend to fly. In particular, flying in close formation can drastically hinder the collective situational awareness of the flight if each wingman is solely focused on maintaining a specific formation spacing close to each other, instead of focusing on their respective cockpit sensors and displays, such as the Fire Control Radar, Threat Warning Azimuth Indicator, the HARM Attack Display, or the Horizontal Situation Display. In addition, close formations impede the ability of the flight leader or wingmen to perform immediate combat maneuvers in response to hostile aircraft or surface-to-air weapons fire; at the risk of a mid-air collision.

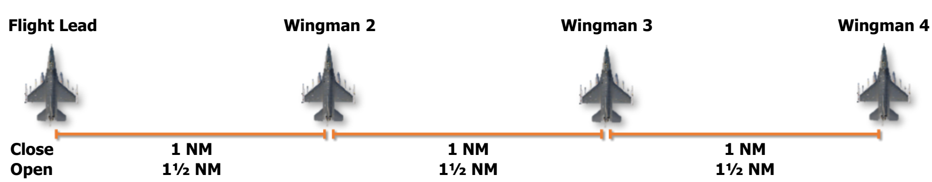
Formation Types

Several types of formations may be employed by the Flight Lead, each with a pre-briefed "Close" or "Open" distance between each flight member. Each formation type has its own advantages and disadvantages, depending on the tactical situation or maneuvers the flight is undertaking.

Line Abreast

This formation allows the Flight Lead to maximize the firepower of the formation toward the forward sector, especially when faced with hostile aircraft approaching from the 12 o'clock. This formation also provides mutual support to flight members if engaged from the sides or from the rear of the formation, while complicating the ability for the enemy to visually acquire the entire flight.

However, this formation may also complicate the ability of the Flight Lead to rapidly reorient the flight toward a different direction while maintaining formation. In these instances, it may take time for the flight to regain their assigned positions following a change in heading, with larger course changes requiring additional time to regain proper position and spacing.

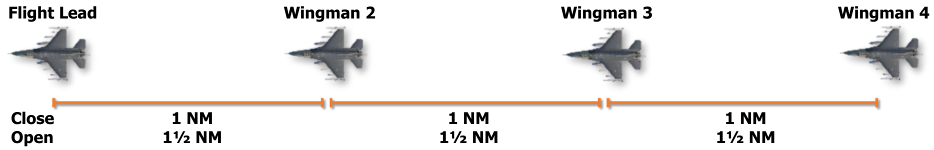


Line Abreast Formation

Trail

This formation simplifies the ability of the remaining flight members to maneuver relative to the Flight Lead when operating under night-vision goggles (NVGs) or amongst restrictive terrain during low-level flight. This formation also provides mutual support to flight members if engaged from the sides of the formation and allows any flight member to immediately perform defensive maneuvers in response to threats.

However, this formation hinders the ability of the Flight Lead to maximize the firepower of the formation toward the forward sector while increasing the ability for hostile aircraft to visually acquire the entire flight, especially when faced with hostile aircraft approaching from the 12 o'clock.

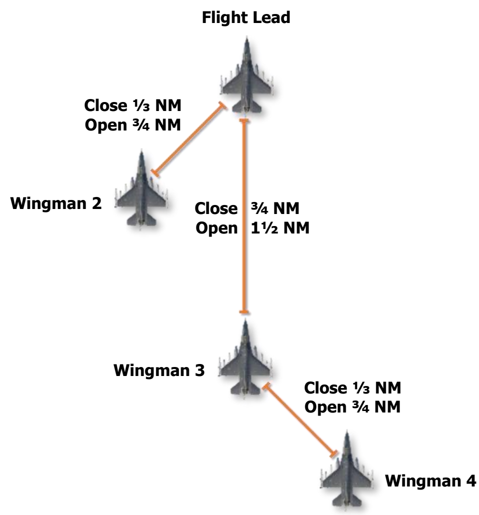


Trail Formation

Wedge

This formation allows the Flight Lead to maintain an offensive posture against hostile aircraft in the forward hemisphere. This formation also simplifies the ability of the remaining flight members maneuver relative to the Flight Lead when operating in limited visibility (night or bad weather) or amongst restrictive terrain during low-level flight.

However, this formation may also complicate the ability of the flight members to respond to threats from the 6 o'clock. In addition, depending on the relative approach aspect, it may be easier for hostile aircraft to visually acquire the entire flight.

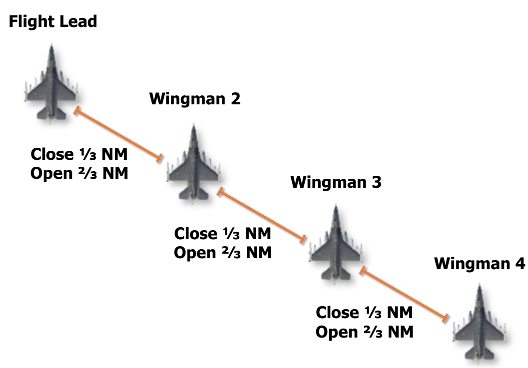


Wedge Formation

Echelon (Left/Right)

This formation allows the Flight Lead to maintain an offensive posture against hostile aircraft in the forward sector and simplifies the ability of each flight member in maintaining visual contact with the preceding wingman.

However, this formation compounds the workload of each successive wingman when performing course changes, especially when the Flight Lead must turn toward the formation. This formation also complicates the ability of the flight members to respond to threats from the 6 o'clock; and the relative proximity between flight members increases the ability for hostile aircraft to visually acquire the entire flight.

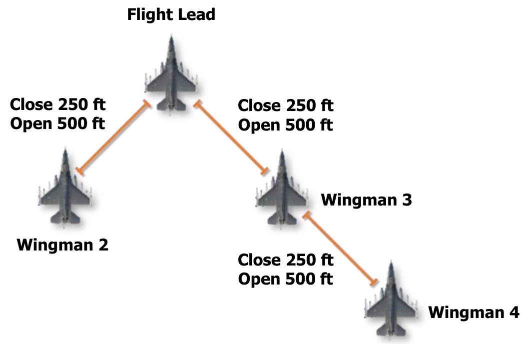


Echelon Formation

Finger Four

This formation simplifies the ability of the remaining flight members to maneuver relative to the Flight Lead when operating in limited visibility (night or bad weather) or amongst restrictive terrain during low-level flight.

However, this formation may degrade the situational awareness of the wingmen by requiring them to perform more frequent cross-checks of their positions when in close proximity instead of focusing on their sensors and displays. This formation also complicates the ability of the flight members to respond to threats from the 6 o'clock; and the relative proximity between flight members increases the ability for hostile aircraft to visually acquire the entire flight.

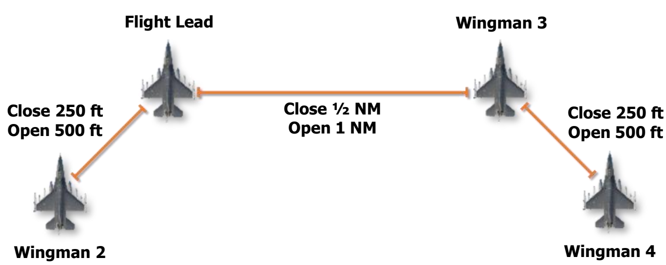


Finger Four Formation

Spread Four

Similar to the Line Abreast formation, this formation allows the Flight Lead to maximize the firepower of the formation toward the forward sector, especially when faced with hostile aircraft approaching from the 12 o'clock. This formation also simplifies the ability of Wingman 2 and 4 to maneuver relative to the Flight Lead and Element Lead, respectively.

However, like Line Abreast, this formation may complicate the ability of the second element to maintain position relative to the first element during large course changes. In addition the relative proximity between flight members may complicate the ability of the flight members to perform defensive maneuvers in response to threats; as well as increase the ability for hostile aircraft to visually acquire the entire flight.



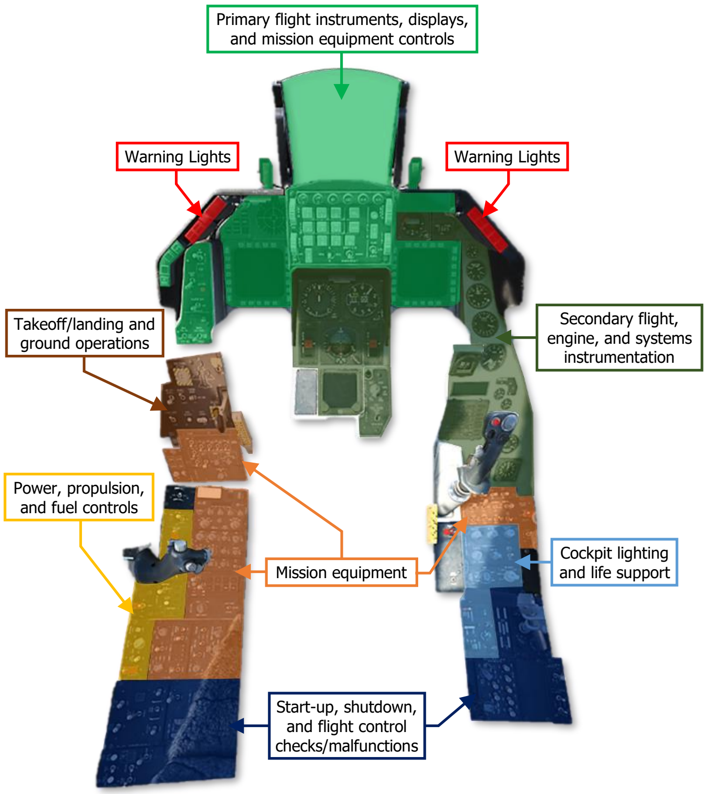
Spread Four Formation

COCKPIT AND AVIONICS INTERFACE

The F-16C's cockpit layout and avionics are designed to maximize single-pilot tactical efficiency and minimize pilot workload in combat. Essential information is presented on the Head-Up Display (HUD), two Multifunction Displays (MFD), and the Data Entry Display (DED). These four displays, along with the placement of the Integrated Control Panel (ICP) and Threat Warning Azimuth Indicator, allow the pilot to remain focused outside the aircraft as much as possible and, when necessary to look down inside the cockpit, minimize the time required to be "heads down".

Most targeting and weapons controls are placed on the Side Stick Controller (SSC) and Throttle grip to allow the pilot to maintain hands on the flight controls during high-performance maneuvers in combat. Panels and switches that are rarely used once airborne on the aft consoles within the cockpit; while controls that interact with mission equipment such as auxiliary communications or defensive systems are located close to the flight controls for immediate access. In addition, the majority of mission equipment panels are placed along the left console near the throttle to permit the pilot to maintain positive control of the aircraft using the SSC.

The aircraft sensors, which include the fire control radar, targeting pod, and HARM Targeting System, are managed by the Modular Mission Computer (MMC) through pilot-selectable master modes. When operating in their respective air-to-ground modes, each of the sensors are focused onto a single geographic location in the battlespace known as the System-Point-of-Interest (SPI).



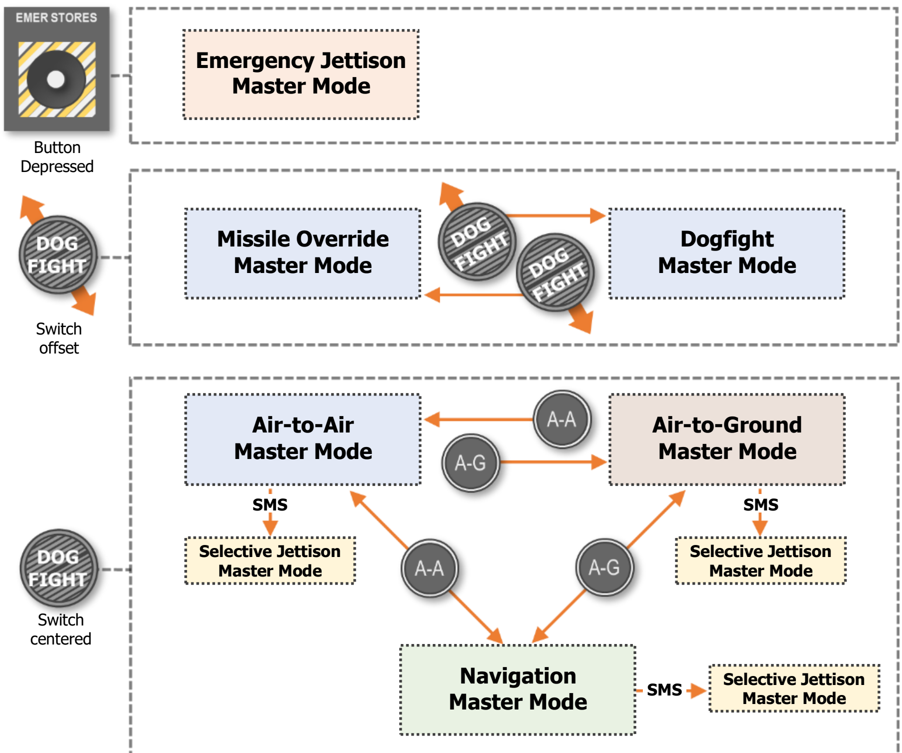
Cockpit Workflow

The pilot may interact with only one aircraft sensor at a time, known as the Sensor-Of-Interest (SOI). Many functions of the Hands-On Controls will be contextually dependent on the current SOI selection, the state of that sensor, the current weapon delivery sub-mode, and the selected SMS weapon profile. In addition, some MFD formats (such as the HSD) may be designated as SOI to facilitate interaction through the Hands-On Controls.

MASTER MODES

The F-16C's sensors, avionics, and fire control configurations are managed by the Modular Mission Computer (MMC) through the use of pilot-selectable master modes. There are 7 master modes in total, with multiple weapon delivery sub-modes to accommodate various methods of targeting, designation, and weapons employment.

When the pilot switches from one master mode to another, avionics settings and MFD states are retained within the previous master mode. This allows the pilot to configure specific avionics settings for each master mode prior to the mission for efficient cockpit management when in the mission area; or to return to a previous task if forced to switch to a different master mode abruptly. This can be especially useful if engaged by hostile fighters during a strike mission, in which case the pilot would need to rapidly re-configure the FCR, SMS, and MFDs for aerial combat. In the F-16C, this can be accomplished with a push of a button or thumb press of a switch on the throttle, allowing the pilot to immediately respond to changes in the tactical situation as they occur.



Master Mode Selection Hierarchy

The three primary MMC master modes are Navigation (NAV), Air-to-Air (A-A), and Air-to-Ground (A-G), which are accessed using the A-A and A-G master mode buttons on the Integrated Control Panel (ICP). Two secondary master modes are Dogfight (DGFT) and Missile Override (MSL), which are accessed using the DOG FIGHT switch on the throttle grip. (See Hands-On Controls for more information.)

Two additional master modes are Selective Jettison (S-J) and Emergency Jettison (E-J). The former may be entered from NAV, A-A, or A-G master modes by accessing the SMS Selective Jettison (S-J) page. The latter is entered when the Emergency Jettison button on the Left Auxiliary Console is pressed and held.

Navigation (NAV) Mode

Navigation master mode is the default master mode that is entered when the avionics are initialized. NAV mode is used for takeoff, landing, navigation, and when performing navigation position updates.

When NAV mode is entered, the following changes will take effect:

- The FCR will default to CRM mode but may be changed to any air-to-air or air-to-ground mode.
- The HUD will display navigation-related symbology only.
- "NAV" will be displayed in the HUD Master Mode Status.
- MFD formats and format selections will be displayed as last set for NAV mode.

The TGP and HTS pods may be used while in NAV mode (including firing the laser rangefinder/designator or designating radar threats on the HAD MFD format), but weapons employment will not be possible.

The default MFD formats for each MFD when the aircraft is set to NAV mode are shown to the right. However, these may be changed at any time during the mission and will be retained during master mode switchovers.

Air-to-Air (A-A) Mode

Air-to-Air master mode is used for employing air-to-air missiles in Air-to-Air Missile (AAM) sub-mode or the M61 cannon in Gun (GUN) sub-mode, which may be toggled by pressing OSB 1 on the SMS MFD format. A-A master mode is entered by pressing the A-A button on the ICP if the master mode is set to either NAV or A-G, after which the last selected sub-mode (AAM or GUN) will be recalled. Pressing the A-A master mode button when already in A-A will set the master mode to NAV.

When A-A mode is entered, the following changes will take effect:

- The FCR will default to CRM mode but may be changed to any other air-to-air mode.
- The HUD will display missile- or gun-related symbology, based on the selected missile type or gun.
- The HUD Master Mode Status will display "MRM", "SRM", or "HOB" along with the missile quantity of that type, depending on the type which was last selected in AAM sub-mode; or "EEGS" if in GUN sub-mode. If no air-to-air missiles are loaded, "AAM" will be displayed in AAM sub-mode.
- MFD formats and format selections will be displayed as last set for A-A mode.

Note that a specific missile type may be set on the SMS for each air-to-air master mode (A-A, MSL, or DGFT). By simply switching between these modes, a different missile type will be automatically selected.

The default MFD formats for each MFD when the aircraft is set to A-A mode are shown to the right. However, these may be changed at any time during the mission and will be retained during master mode switchovers.

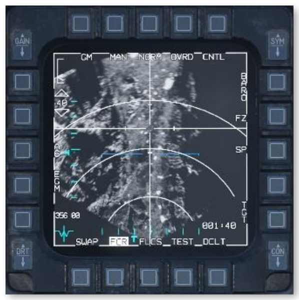
Air-to-Ground (A-G) Mode

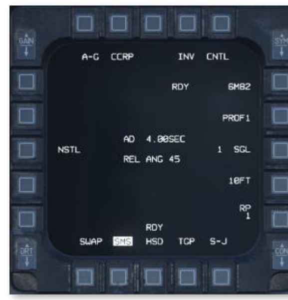
Air-to-Ground mode is used for delivering munitions against ground targets. A-G mode is entered by pressing the A-G button on the ICP if the master mode is set to either NAV or A-A. Pressing the A-G button when already in A-G will set the master mode to NAV.

When A-G mode is entered, the following changes will take effect:

- If a "Pre-planned" weapon delivery sub-mode is entered, the FCR will default to GM but may be changed to GMT or SEA modes. If a "Visual" weapon delivery sub-mode is entered, the FCR will enter AGR mode and cannot be changed.
- The HUD will display weapon delivery symbology, based on the SMS weapon profile and the selected weapon delivery sub-mode, which will be displayed in the HUD Master Mode Status.
- MFD formats and format selections will be displayed as last set for A-G mode.

The default MFD formats for each MFD when the aircraft is set to Air-to-Ground master mode are shown to the right. However, these may be changed at any time during the mission and will be retained during master mode switchovers.





Missile Override (MSL) Mode

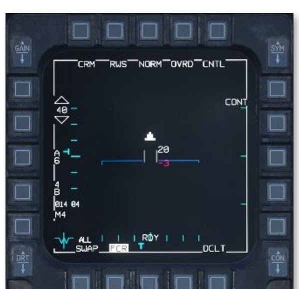
Missile Override mode is used to rapidly configure the aircraft for aerial combat directly from the flight controls by moving the DOG FIGHT switch to the inboard position on the throttle. MSL mode will take precedence over the previous master mode, with the exception of Emergency Jettison. Returning the DOG FIGHT switch to the center position will return to the previous master mode prior to entering MSL.

When MSL mode is entered, the following changes will take effect:

- The FCR will default to CRM mode but may be changed to any air-to-air mode.
- The HUD will display missile-related symbology, based on the selected missile type.
- The HUD Master Mode Status will display "MRM", "SRM", or "HOB" along with the missile quantity of that type, depending on the type which was last selected in MSL mode.
- If the MASTER ARM switch is set to ARM, AIM-9 seekers on air-to-air missile stations will be cooled.
- MFD formats and format selections will be displayed as last set for MSL mode.

Note that a specific missile type may be set on the SMS for each air-to-air master mode (A-A, MSL, or DGFT). By simply switching between these modes, a different missile type will be automatically selected.

The default MFD formats for each MFD when the aircraft is set to MSL mode are shown to the right. However, these may be changed at any time during the mission and will be retained during master mode switchovers.



Dogfight (DGFT) Mode

Dogfight mode is used to rapidly configure the aircraft for aerial combat directly from the flight controls by moving the DOG FIGHT switch to the outboard position on the throttle. DGFT mode will take precedence over the previous master mode, with the exception of Emergency Jettison. Returning the DOG FIGHT switch to the center position will return to the previous master mode prior to entering DGFT.

When DGFT mode is entered, the following changes will take effect:

- The FCR will default to ACM mode but may be changed to any air-to-air mode.
- The M61 cannon will be enabled along with AIM-9 missiles if any are loaded. If no AIM-9 missiles are loaded, the missile type will default to AIM-120 if any are loaded. If both missile types are loaded, the selected missile type will return to the type that was last selected while in DGFT mode.
- The HUD will be decluttered and optimized for close-range aerial combat maneuvers, EEGS-related symbology will be displayed, and the Velocity Scale will automatically revert to calibrated airspeed (CAS) regardless of the Velocity switch position on the HUD Control Panel.
- "DGFT" will be displayed in the HUD Master Mode Status
- If the MASTER ARM switch is set to ARM, AIM-9 seekers on air-to-air missile stations will be cooled.
- MFD formats and format selections will be displayed as last set for DGFT mode.

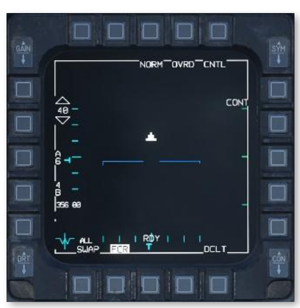
Note that a specific missile type may be set on the SMS for each air-to-air master mode (A-A, MSL, or DGFT). By simply switching between these modes, a different missile type will be automatically selected.

The default MFD formats for each MFD when the aircraft is set to Dogfight mode are shown to the right. However, these may be changed at any time during the mission and will be retained during master mode switchovers.

Selective Jettison (JETT) Mode

Selective Jettison mode is used to jettison individual weapons and/or weapon stations from the underwing pylons without arming the weapons themselves. Selective Jettison (S-J) mode is entered by pressing OSB 11 on the SMS MFD format. Pressing OSB 11 when already in S-J mode will set the master mode back to the previous selection.

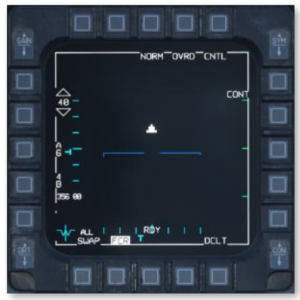
The default MFD formats for each MFD when the aircraft is set to S-J mode are shown to the right. However, these may be changed at any time during the mission and will be retained during master mode switchovers.



Emergency Jettison (JETT) Mode

Emergency Jettison mode is used to jettison all weapons (except for air-to-air missiles) and fuel tanks from underwing stations 3 through 7. Emergency Jettison (E-J) mode is entered by pressing and holding the Emergency Jettison button on the Left Auxiliary Console, which will override all other master modes. Releasing the Emergency Jettison button will set the master mode back to the previous selection.

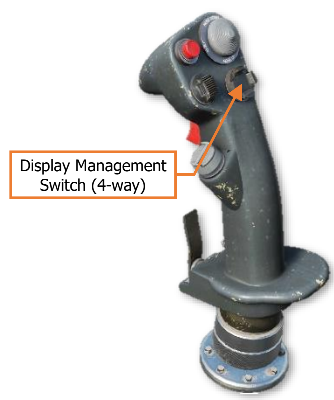
The default MFD formats for each MFD when the aircraft is set to E-J mode are shown to the right.



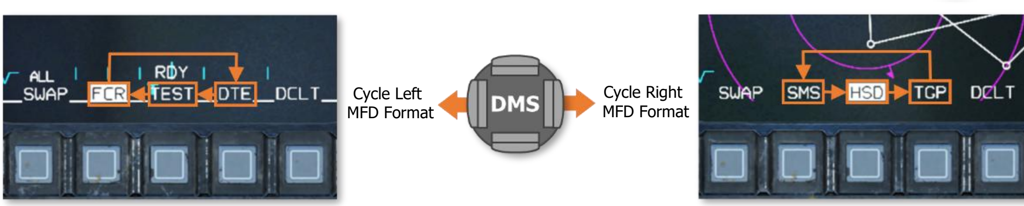
Cycling MFD Formats using the Side Stick Controller

Each MFD is assigned three formats for each master mode. These formats can be selected for display by pressing the corresponding Format Select OSB below the format label. The assigned format for each Format Select button can be re-assigned at any time during the mission. (See Multi-Function Displays for more information.)

The MFD format can also be cycled using the Display Management Switch (DMS) on the Side Stick Controller (SSC), allowing the pilot to seamlessly select a different MFD format while maintaining hands on the flight controls. This can be especially useful during high-G maneuvers that might preclude reaching out to an MFD to press the OSB directly, or when needing to quickly assign the Sensor-Of-Interest to an MFD format that is not current displayed. See Sensor-Of-Interest (SOI) on the following page for more information.



When the DMS switch is pressed left or right, the corresponding MFD will cycle to the next assigned format in an outwards fashion. If one of the Format Select buttons have been assigned to the BLANK MFD format, that button will be skipped in the sequence, and will simply toggle between the two remaining formats. If two of the Format Select buttons have been assigned to the BLANK MFD format, DMS will have no effect on that MFD.

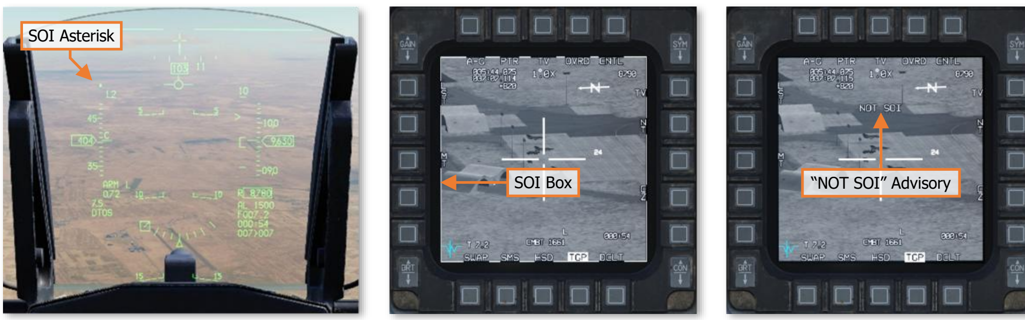


MFD Format cycle logic using Display Management Switch

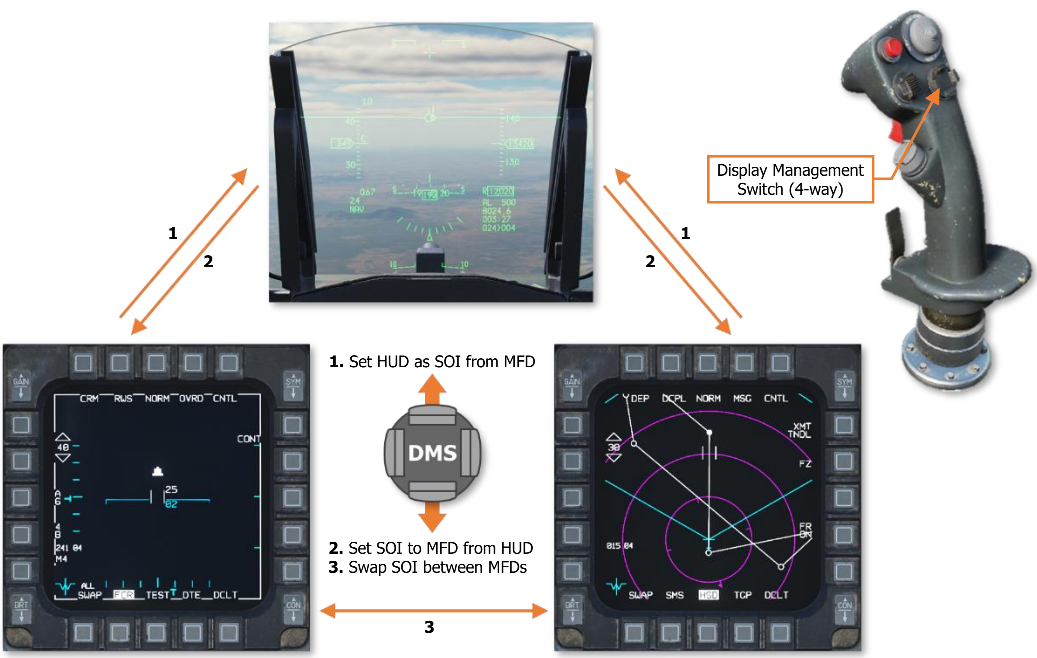
SENSOR-OF-INTEREST (SOI)

The Sensor-Of-Interest is the sensor or display to which the hands-on controls are currently assigned. The controls on the Side Stick Controller (SSC) and throttle grip, such as the Target Management Switch (TMS), Expand/FOV button, or RDR CURSOR/ENABLE switch, will only affect the sensor that is currently assigned as SOI.

The SOI can be identified by a white box around the MFD screen or an asterisk in the top left of the HUD. Additionally, when an MFD is displaying a format that may be assigned as SOI, but is not SOI at the present time, a "NOT SOI" advisory message will be displayed in the upper portion of the MFD.



The SOI is assigned to the HUD or either MFD by the Display Management Switch (DMS) on the SSC. The MFD formats that can be assigned as SOI are FCR, TGP, WPN, HSD, and HAD. If either MFD format can be set as SOI, the priority MFD format for the current master mode will be set as SOI when re-assigning SOI from the HUD.



SOI assignment cycle logic using Display Management Switch

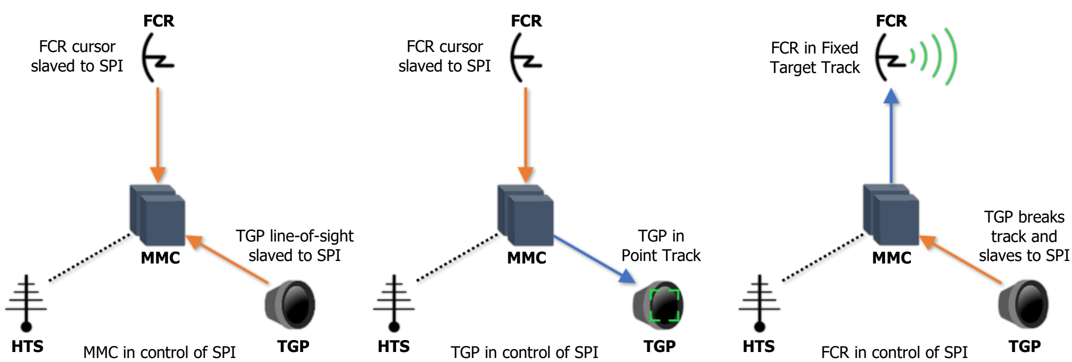
SYSTEM-POINT-OF-INTEREST (SPI)

The System-Point-of-Interest (SPI) is a singular aimpoint to which the F-16's sensors are directed. The location to which the SPI is assigned is predicated on the selected MMC master mode, the current air-to-ground weapon delivery sub-mode (when in A-G master mode), and the selected sighting point (when in NAV or A-G master modes). The SPI itself may only be controlled by a single source, which is either the Modular Mission Computer (MMC) or one of the aircraft sensors when in a "tracking" state.

When the MMC is in control of the SPI, the 3-dimensional location of the SPI is maintained relative to the aircraft's navigation solution. As such, if the SPI is assigned to the location of a steerpoint, the aircraft sensors will be directed toward the 3-dimensional location of the selected steerpoint based on where the navigation solution has calculated the steerpoint to be in relation to the aircraft. If the pilot uses the RDR CURSOR/ENABLE switch to slew the SPI to a different location, the MMC will slew the SPI based on the cursor inputs and the aircraft sensors will follow accordingly. In addition, if the navigation solution drifts in relation to the aircraft's true position, the SPI may appear to have shifted despite the fact the pilot has not performed any cursor slews.

When an aircraft sensor is in control of the SPI, the 3-dimensional location of the SPI is maintained by the sensor that is in a "tracking" state. When a sensor enters a tracking state, the SPI will coincide with the tracking solution of that sensor and the remaining sensors will remain slaved to the SPI. As such, only one sensor is capable of being in control of the SPI at any given time. However, if a different sensor is subsequently commanded into a tracking state, that sensor will assume control of the SPI and the previously tracking sensor will break track and become slaved to the SPI.

In the figure below on the left, the MMC is initially in control of the SPI. If the FCR is set to an air-to-ground mode (GM, GMT, or SEA), the A-G Acquisition Cursor on the FCR MFD format is slaved to the position of the SPI. If the TGP is set to Air-to-Ground (A-G) mode, the TGP sensor line-of-sight is slaved to the 3-dimensional location of the SPI.



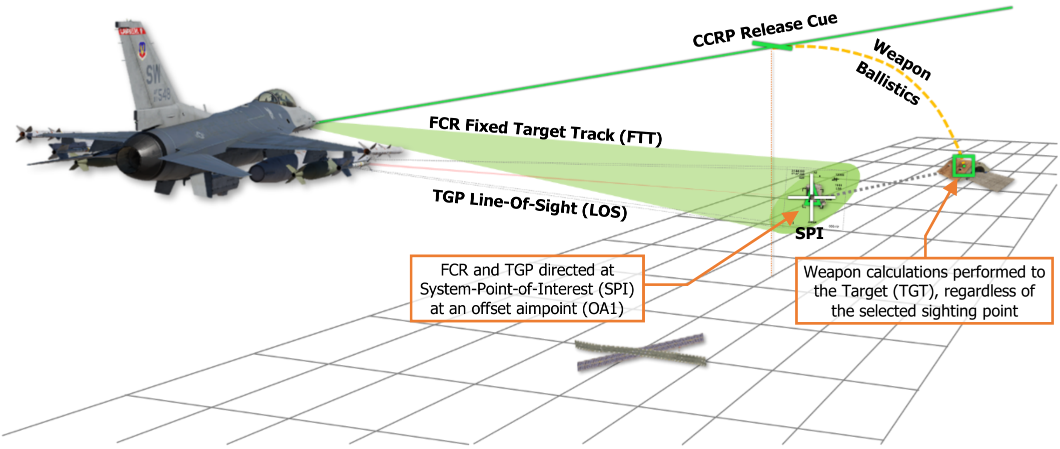
F-16C Sensor Slave & Tracking Logic

If the TGP is in A-G mode and enters a tracking state, as shown in the figure above in the center, the TGP itself will determine the position of the SPI. If the FCR is in GM, GMT, or SEA mode and was tracking a surface target or location, the FCR will break track and the A-G Acquisition Cursor on the FCR MFD format will slave to the TGP-controlled SPI. If the FCR is in GM, GMT, or SEA mode and enters a tracking state, as shown in the figure above on the right, the TGP will break track and will slave to the FCR-controlled SPI.

Accordingly, if either the FCR or TGP are in a tracking state while in their respective air-to-ground modes and an HTS-detected radar threat is designated on the HAD MFD format, the FCR and TGP will break track and slave to the HTS-controlled SPI. If the FCR or TGP subsequently enter a tracking state, the HTS designation will be dropped.

SPI assigned to Pre-Planned Sighting Point

If the weapon delivery sub-mode is set to any "Pre-planned" sub-mode (CCRP, LADD, EO-PRE, EO-BORE, PRE) or Manual (MAN), or if the selected weapon on the SMS MFD format is set to AGM-88 missiles (AG88), the SPI is assigned to the sighting point displayed at OSB 10 on the FCR and TGP MFD formats, which may be slewed via the Navigation cursor. Regardless of which sighting point is selected, weapon release parameters and symbology within the cockpit are always displayed based on calculations to the location of the Target (TGT) sighting point.



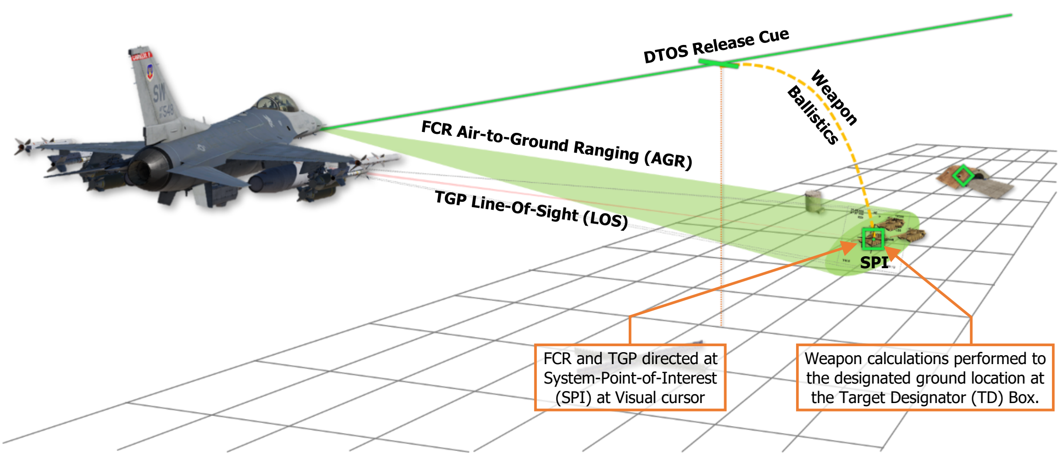
SPI assigned to the selected sighting point in "Pre-planned" sub-modes

If the Snowplow sighting method is employed while the weapon delivery sub-mode is set to any "Pre-planned" sub-mode, the SPI is assigned to the Snowplow cursor.

NOTE: When employing inertially aided munitions such as JDAM, JSOW, or WCMD, the SPI will be transferred to the weapon guidance unit as the target location, even though the release calculations are being performed to the TGT sighting point. It is imperative that the selected sighting point is confirmed prior to weapon release.

SPI assigned to Visual Designation

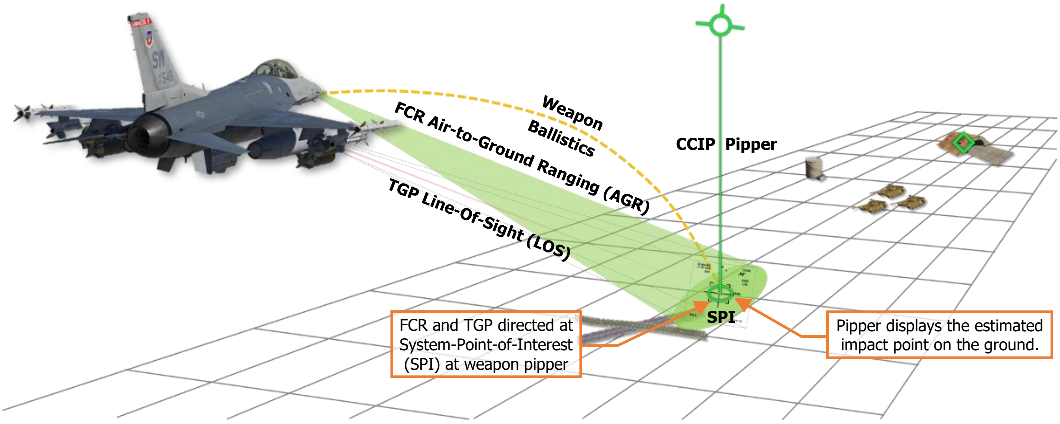
If the weapon delivery sub-mode is set to any "Visual" sub-mode that employs a ground designation (DTOS, EO-VIS, or VIS), the SPI coincides with the position of the Visual cursor.



SPI assigned to Visual cursor in DTOS, EO-VIS, and VIS sub-modes

SPI assigned to Weapon Pipper

If the weapon delivery sub-mode is set to any "Visual" sub-mode that employs a dynamic pipper within the HUD to display the estimated weapons impact point on the ground (CCIP or STRF), the SPI coincides with the calculated impact point.

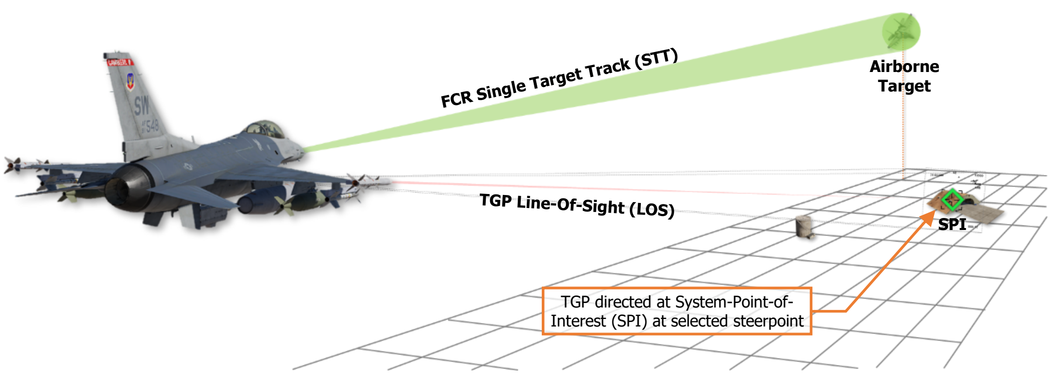


SPI assigned to weapon pipper in CCIP and STRF sub-modes

Airborne Targets

Although the F-16 is designed to employ a single SPI location to which all sensors are directed, there are certain conditions in which individual aircraft sensors may track airborne targets independently of surface locations.

- If the master mode is set to NAV, the FCR may track an airborne target in CRM or ACM radar modes while the TGP is tracking a surface target/location in A-G mode or a radar threat is designated on the HAD.
- If the master mode is set to NAV, the TGP may track an airborne target in A-A mode while the FCR is tracking a surface target/location in GM, GMT, or SEA radar modes or a radar is designated on the HAD.
- If the master mode is set to NAV, A-A, MSL, or DGFT, the FCR may track an airborne target in CRM or ACM radar modes while the TGP is independently tracking a second airborne target in A-A mode.



SPI assigned to the selected steerpoint in Navigation (NAV) master mode

WEAPON DELIVERY SUB-MODES

When conducting attacks against ground targets, a variety of weapon delivery sub-modes may be utilized by the pilot. The weapon delivery sub-modes that are available for selection may depend on the selected weapon, and whether the target is located at a known location designated by a steerpoint or acquired during the mission using onboard sensors or the pilot's eyesight. As such, these air-to-ground weapon delivery sub-modes are delineated into two categories: "Pre-planned" sub-modes and "Visual" sub-modes.

"Pre-planned" Weapon Delivery Sub-modes
Target location is designated by a steerpoint.

- **CCRP** Continuously-Computed Release Point
- **LADD** Low Altitude Drogue Delivery
- **EO-PRE** Electro-Optical Pre-planned
- **EO-BORE** Electro-Optical Boresight
- **PRE** Pre-planned
- **HARM** High-speed Anti-Radiation Missile
- **HTS** HARM Targeting System

"Visual" Weapon Delivery Sub-modes
Target is visually acquired by the pilot.

- **CCIP** Continuously-Computed Impact Point
- **DTOS** Dive/Toss
- **STRF** Strafe
- **EO-VIS** Electro-Optical Visual
- **VIS** Visual

Each category of weapon delivery sub-modes differs in how the target is designated and what type of weapon employment symbology cues are provided to the pilot. However, the pilot retains the ability to dynamically change between weapon delivery sub-modes using the Hands-On Controls at any time, even during an attack itself.

As an example, while performing a low-altitude ingress toward a target, the pilot may utilize CCRP to receive steering toward a pre-planned steerpoint located at the expected position of the target itself. Just prior to arriving at the steerpoint, the pilot performs a rapid climb to gain altitude over the target area in order to visually confirm the target location prior to weapon release. When the target is sighted, the pilot notes that the target location is several hundred meters from the steerpoint symbol within the HUD, which may be due to accumulated errors within the navigation system during the flight, inaccurate intelligence regarding the target location, or (if the target is mobile) the target may have simply moved. The pilot presses the MSL STEP button on the side stick to immediately switch to CCIP or DTOS and visually attack the target independently of the pre-planned steerpoint.

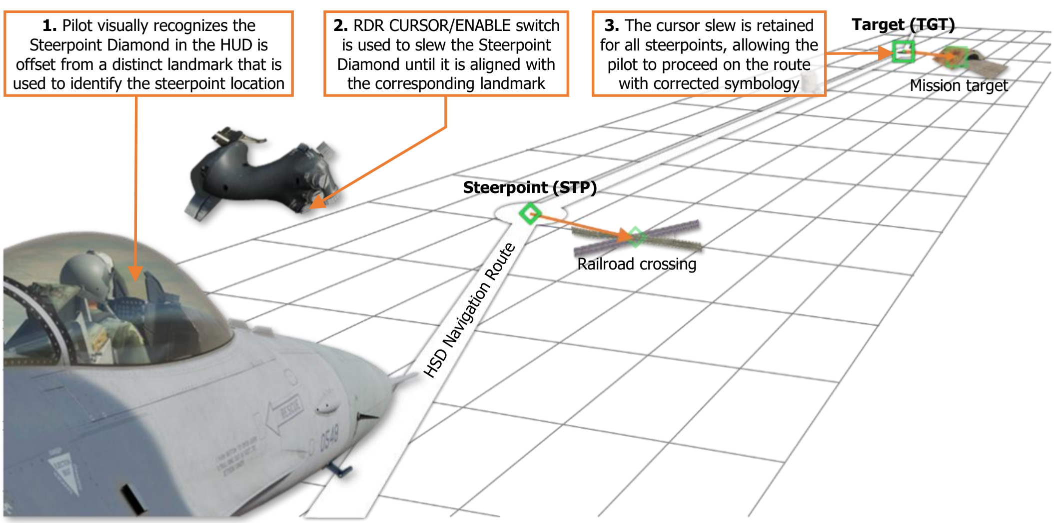
"Pre-planned" Weapon Delivery Sub-modes

Attacks against pre-planned targets are facilitated by setting a steerpoint at the location of the intended target. This target steerpoint is used by the avionics to direct the pilot to the target location, perform weapon delivery calculations, and to generate targeting symbology for the pilot during the attack sequence itself. To that end, the navigation solution of the aircraft must be accurate enough to ensure the weapon delivery calculations and the corresponding targeting symbology reflect the true location of the target up to the point of weapons release. (See the Air-to-Ground Employment chapter for more information regarding each weapon delivery sub-mode.)

Sighting Points and Cursor Corrections

Various methods may be used update the navigation solution to mitigate accumulated errors and regain the accuracy needed to reliably navigate across long distances and deliver munitions onto the intended target. However, if it is not feasible to perform a navigation update, which may be the case just prior to arriving over the intended target or if performing low-level flight in an area devoid of any useable landmarks, or if a small aiming correction is required to ensure weapon release calculations are accurate, a temporary correction may be applied by "slewing" the Navigation cursor. In this case, a navigation update is not performed, but navigation steering and weapon release calculations are adjusted to account for small inaccuracies in the system navigation solution. (See Navigation Updates in the Navigation chapter for more information.)

Since any drift within the navigation solution will affect the accuracy of the target steerpoint relative to the target's physical location, and therefore the accuracy of the weapon release calculations and corresponding symbology, the pilot may utilize "sighting points" for confirming or correcting the alignment of the weapon delivery symbology over the target. Sighting points typically consist of steerpoints and their corresponding offset aimpoints (if used). If the selected sighting point is not aligned with the physical location to which the sighting point corresponds, corrections may be made using the RDR CURSOR/ENABLE switch on the throttle. When such adjustments are performed, the pilot is using a "cursor slew" rather than performing an actual update to the navigation system.

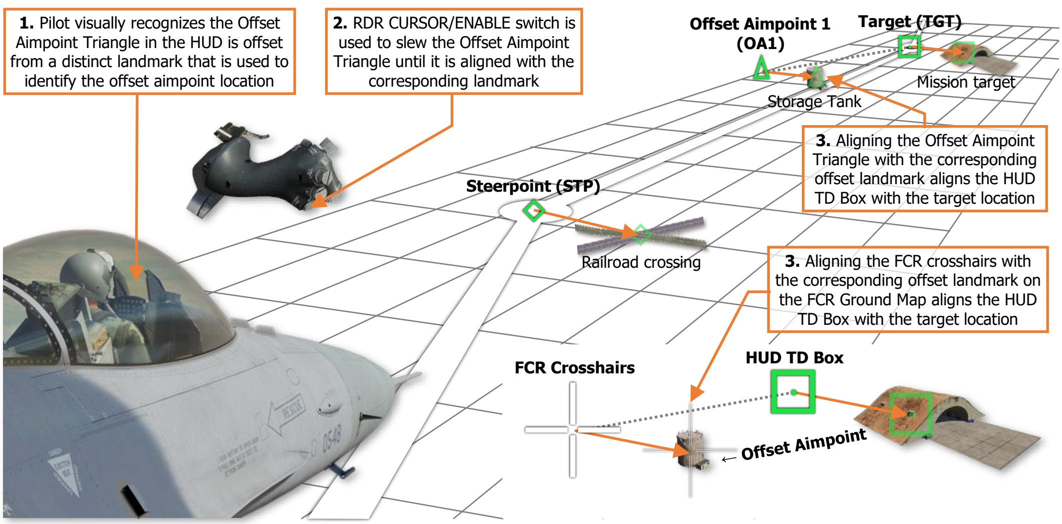


Cursor slew correction using "direct sighting" through the HUD

It is important to note that since the navigation system is not receiving a position update, the system navigation solution will not change with the cursor slew. Rather, the pilot is applying a manual adjustment to the Navigation cursor so that the Steerpoint Diamond within the HUD symbology aligns with the corresponding location or landmark seen outside the cockpit. As the pilot proceeds on the planned route through subsequent steerpoints, the cursor slew is retained so that all steerpoints receive the same corrections at once.

In the event such landmarks cannot be visually acquired by the pilot, as in the case of low-light conditions, adverse weather, or it is simply too far to be seen, the FCR or TGP may be used to perform the same corrections. However, just as is the case where the pilot must see landmarks to perform a cursor slew using the HUD symbology as a reference, the sighting point location must be detectable by the FCR to the extent it can be distinguished amongst the ground clutter, or recognizable within the TGP's optical sensors.

In such cases where a "direct sighting" of the steerpoint location cannot be performed, "offset aimpoint sighting" may be used with objects in the vicinity of the steerpoint that are easily recognizable through the HUD or within the TGP's optical sensors, or radar-detectable by the FCR in Ground Map (GM) mode. As the pilot visually acquires the physical landmark that corresponds with the offset aimpoint, a cursor slew may be applied to the Navigation cursor to align the Offset Aimpoint Triangle within the HUD symbology over the offset aimpoint location. Alternatively, if using the TGP to acquire the offset aimpoint, the pilot simply slews the TGP crosshairs over the offset aimpoint location to perform the intended correction.



Cursor slew correction using "offset aimpoint sighting" through the HUD or FCR

If using the FCR in GM mode, the radar-detectable object corresponding with the sighting point is acquired on the FCR MFD format. If the FCR crosshairs are not located at the intended sighting point as the pilot studies the ground radar map, the RDR CURSOR/ENABLE switch is used to slew the crosshairs onto the sighting point in the same manner as slewing the TGP crosshairs.

Prior to performing any cursor slew corrections, the pilot must select the intended sighting point with which to use as a reference. The current sighting point is displayed adjacent to OSB 10 on the FCR and TGP MFD formats and may be sequenced using the sighting point rotary button (OSB 10). Once the intended sighting point is selected, the pilot may perform cursor corrections as needed until the HUD symbology or sensor is aligned with the corresponding sighting point.

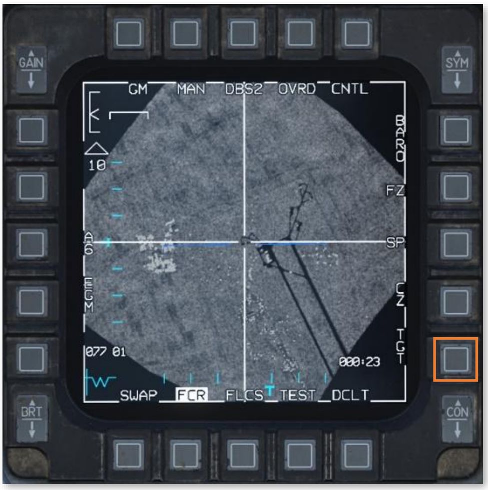
The F-16 also includes several specialized sighting modes that may be used in conjunction with "Pre-planned" weapon delivery sub-modes.

- Visual Reference Point and Visual Initial Point sighting modes allow the pilot to perform last minute corrections to the alignment of the HUD symbology with regard to expected target location, typically prior to commencing a low-level ingress to a pop-up attack maneuver.
- Snowplow sighting mode allows the pilot to rapidly reposition the SPI directly in front of the aircraft. Snowplow may also be used in Navigation master mode if the FCR is set to GM, GMT, or SEA modes.

Sighting Point Options

Sighting points may only be utilized when employing "Pre-planned" weapon delivery sub-modes. However, some sighting point options are limited to specific steerpoint ranges or are only available in VIP or VRP modes.

The pilot may select a different sighting point by pressing the sighting point rotary at OSB 10 on the FCR MFD format when the FCR is set to GM, GMT, or SEA modes, or on the TGP MFD format. Each time the sighting point rotary is pressed, the selection will advance to the next available sighting point within the list in a cyclic fashion, eventually returning to the first selection.



Sighting Point Rotary (OSB 10)

The pilot may also use TMS Right-Short when the SOI is set to HUD or FCR to advance to the next sighting point.

Steerpoint/Target (STP/TGT)

The selected steerpoint is used in a "direct sighting" method, where the physical location or target that corresponds with the steerpoint is identified by the aircraft sensors or visually by the pilot through the HUD/HMCS.

The cursor is slewed as necessary until the Steerpoint Diamond or Target Designator (TD) Box is directly over the physical steerpoint location or target to provide accurate navigation alignment or steering to the weapon release point.

STP. The steerpoint is used as a location reference and is represented by the Steerpoint Diamond within the HUD and HMCS symbology, under any of the following conditions.

- Master mode is set to NAV.
- Master mode is set to A-G and the weapon delivery sub-mode is set to MAN (Manual bombing).
- Master mode is set to A-G, the selected weapon profile on the SMS MFD format is set to AG88 (AGM-88 HARM missiles), and the HARM mode is set to HAS (HARM-As-Sensor).

TGT. The steerpoint is used as a target and is represented by the Target Designator (TD) Box within the HUD and HMCS symbology, under any of the following conditions.

- Master mode is set to A-G and the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, or PRE.
- Master mode is set to A-G, the selected weapon profile on the SMS MFD format is set to AG88 (AGM-88 HARM missiles), and the HARM mode is set to POS (Position Known).

Offset Aimpoint (OA1/OA2)

A known location near the steerpoint is used in an “offset aimpoint sighting” method, where a distinct landmark that is easily identified by the aircraft sensors or recognizable by the pilot through the HUD/HMCS is calculated to be at a precise range and bearing from the steerpoint. An Offset Aimpoint Triangle symbol is displayed at the calculated range and bearing relative to the Steerpoint Diamond or Target Designator (TD) Box.

The cursor is slewed as necessary until the Offset Aimpoint Triangle is directly over the physical landmark that corresponds with the offset aimpoint location, which will in turn ensure the Steerpoint Diamond or TD Box is directly over the physical steerpoint location or target to provide accurate navigation alignment or steering to the weapon release point.

OA1/OA2. The offset aimpoint is used as a location reference and is represented by the Offset Aimpoint Triangle when the corresponding sighting point is selected, under any of the following conditions.

- Master mode is set to NAV, S-J, or E-J.
- Master mode is set to A-G and the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN (Manual bombing).
- Master mode is set to A-G, the selected weapon profile on the MFD format is set to AG88 (AGM-88 HARM missiles), and the HARM mode is set to HAS (HARM-As-Sensor) or POS (Position Known).

OA1/OA2 are only available as sighting points for steerpoints 1-25, and only under the following conditions.

- FIX, A-CAL, and Snowplow (SP) are not selected.
- The offset aimpoint range from the steerpoint has been programmed with a value greater than “0”.

Initial Point (IP)

The selected steerpoint is a known location used as an initial point that is visually recognizable by the pilot through the HUD/HMCS during a low-level attack against a target that is calculated to be at a precise range and bearing from the steerpoint. The steerpoint is used as the IP when in Visual Initial Point (VIP) mode.

The cursor is slewed as necessary until the Steerpoint Diamond is directly over the physical steerpoint location, or the IP is overflown and designated by TMS Forward, which will in turn ensure the Target Designator (TD) Box is directly over the physical target to provide accurate steering to the weapon release point.

IP. The steerpoint is used as an initial point and is represented by the Steerpoint Diamond within the HUD and HMCS symbology, under the following conditions.

- Master mode is set to A-G, the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN, and VIP mode is enabled for the selected steerpoint.

NOTE: If the selected steerpoint is changed to a different steerpoint than that entered on the VIP-TO-TGT DED page, the Initial Point sighting point option will be removed.

Reference Point (RP)

The selected steerpoint is a known location used as a target during a low-level attack and a distinct landmark that is visually recognizable by the pilot through the HUD/HMCS is calculated to be at a precise range and bearing from the steerpoint. The landmark is used as the RP when in Visual Reference Point (VRP) mode.

The cursor is slewed as necessary until the Steerpoint Diamond is directly over the physical landmark that corresponds with the reference point location, or the RP is overflown and designated by TMS Forward, which will in turn ensure the Target Designator (TD) Box is directly over the physical target to provide accurate steering to the weapon release point.

RP. The reference point is used as a visual reference and is represented by the Steerpoint Diamond within the HUD and HMCS symbology, under the following conditions.

- Master mode is set to A-G, the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN, and VRP mode is enabled for the selected steerpoint.

NOTE: If the selected steerpoint is changed to a different steerpoint than that entered on the TGT-TO-VRP DED page, the Reference Point sighting point option will be removed.

Cursor Slewing

Any time the pilot performs a "cursor slew" in which corrections or adjustments are being made to the steerpoint location, the TD Box, or the HUD Mark Cue, the pilot is affecting one of 7 independent cursors. Only one cursor may be controlled by the pilot (using the RDR CURSOR/ENABLE switch on the throttle grip) at any given time. The cursor that is controlled by the pilot is dependent on the current master mode, weapon delivery sub-mode, and Sensor-Of-Interest (SOI).

After a cursor has been slewed, the accumulated slew inputs are retained for that cursor independently of the others through changes of the master mode or weapon delivery sub-mode. As an example, if the Navigation cursor had not been slewed prior to entering VIP mode, but the VIP cursor was subsequently slewed as the pilot approached the IP during a low-level attack, the Navigation cursor would remain unaffected with no slews applied.

In addition, if the selected steerpoint is changed while any aircraft sensor is tracking a ground target, the sensor will break track to prevent excessive cursor slews from being applied from the newly selected steerpoint. This will cause the FCR to break track if set to GM, GMT, or SEA modes, the TGP to break track if in A-G mode, or any designated radar emitter on the HAD MFD format to be undesignated.

Navigation Cursor

The Navigation cursor applies navigation corrections to all steerpoints at the same time without changing the system navigation solution or performing an update to the INS itself. (See Sighting Points and Cursor Corrections for more information.)

The Navigation cursor may be slewed when the FCR or TGP are set as SOI under any of the following conditions.

- Master mode is set to NAV, S-J, or E-J.
- Master mode is set to A-G and the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN (Manual bombing).
- Master mode is set to A-G, the selected weapon profile on the SMS MFD format is set to AG88 (AGM-88 HARM missiles), and the HARM mode is set to HAS (HARM-As-Sensor) or POS (Position Known).

VIP & VRP Cursors

The VIP and VRP cursors apply navigation corrections to the selected steerpoint when in VIP or VRP modes, respectively, without affecting the Navigation cursor or changing the navigation solution or performing an update to the INS itself. (See Visual Reference Point (VRP) & Visual Initial Point (VIP) for more information.)

The VIP cursor may be slewed when the HUD, FCR, or TGP are set as SOI under the following conditions.

- Master mode is set to A-G, Visual Initial Point (VIP) mode is enabled for the selected steerpoint, and the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN.

The VRP cursor may be slewed when the HUD, FCR, or TGP are set as SOI under the following conditions.

- Master mode is set to A-G, Visual Reference Point (VRP) mode is enabled for the selected steerpoint, and the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN.

Markpoint Cursor

The Markpoint cursor applies movement to the HUD Mark Cue within the HUD symbology when using the HUD method to create a markpoint. (See DED MARK page in The F-16C Viper chapter for more information.)

The Markpoint cursor may be slewed when the HUD is SOI under the following conditions.

- The MARK DED page is displayed the Mark method has been set to "HUD".

HMCS Cursor

The HMCS cursor applies movement to the TD Box or the HUD Mark Cue within the HMCS symbology. (See DED MARK page in the F-16C Viper chapter for more information.)

The HMCS cursor may be slewed when the HMCS is SOI under any of the following conditions.

- Master mode is set to A-G and the weapon delivery sub-mode is set to DTOS, EO-VIS, or VIS.
- The MARK DED page is displayed the Mark method has been set to "HUD".

Visual Cursor

The Visual cursor applies movement to the Target Designator (TD) Box within the HUD symbology when performing air-to-ground targeting against targets that are visually identified by the pilot through the canopy or the targeting pod sensor video, independently of pre-planned steerpoints. (See "Visual" Weapon Delivery Sub-modes for more information.)

The Visual cursor may be slewed when the HUD or TGP are SOI under the following conditions.

- Master mode is set to A-G and the weapon delivery sub-mode is set to DTOS, EO-VIS, or VIS.

Snowplow Cursor

The Snowplow cursor is located at a fixed range in front of the aircraft and is used to direct the aircraft sensors forward of the aircraft's flight path. The Snowplow cursor itself cannot be slewed by the pilot, but its position relative to the aircraft may be modified. See Snowplow Sighting Method on the following page for more information.

Cursor Zero (CZ)

Cursor slews may be removed entirely by pressing the Cursor Zero (**CZ**) button, which is displayed at OSB 9 on the FCR or TGP MFD formats, or OSB 10 on the HSD MFD format.

- If the Navigation cursor, VIP cursor, or VRP cursor have accumulated any cursor slews, the **CZ** OSB option will be displayed on the relevant MFD formats to indicate that cursor corrections have been input into the system.
- If the Navigation cursor, VIP cursor, or VRP cursor cursors have not accumulated any cursor slews, or the cursor slews are removed using Cursor Zero, the **CZ** OSB option will be removed and not displayed on the relevant MFD formats.
- The **CZ** OSB option will only zeroize the accumulated slews of the cursor that is currently being controlled by the pilot.

As an example, if the Navigation cursor was slewed prior to entering VIP mode, and the VIP cursor was subsequently slewed as the pilot approached the IP; if the pilot were to press the **CZ** OSB option, the VIP cursor would be zeroized but the Navigation cursor would remain unaffected. In this situation, if the Navigation cursor was intended to be zeroized, the pilot would need to exit VIP mode and return to a master mode and/or weapon delivery sub-mode in which the Navigation cursor is affected and then press the **CZ** OSB option.

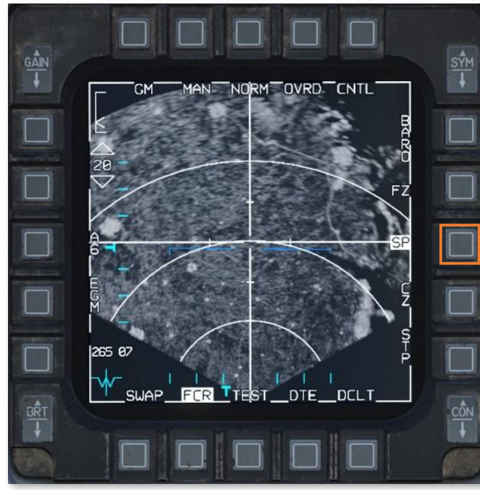
- Zeroizing the Navigation cursor removes cursor slews from all steerpoints.
- Zeroizing the VIP cursor while in VIP mode removes cursor slews from the selected VIP steerpoint.
- Zeroizing the VRP cursor while in VRP mode removes cursor slews from the selected VRP steerpoint.

Hands-On Cursor Zero

If a targeting pod is installed, powered, and operational, Cursor Zero may be alternatively commanded from the Side Stick Controller (SSC) by pressing TMS Aft when both of the following criteria are met:

- The TGP MFD format is the Sensor-Of-Interest (SOI).
- The TGP is in SLAVE mode (i.e., not in POINT or AREA track).

Snowplow Sighting Mode



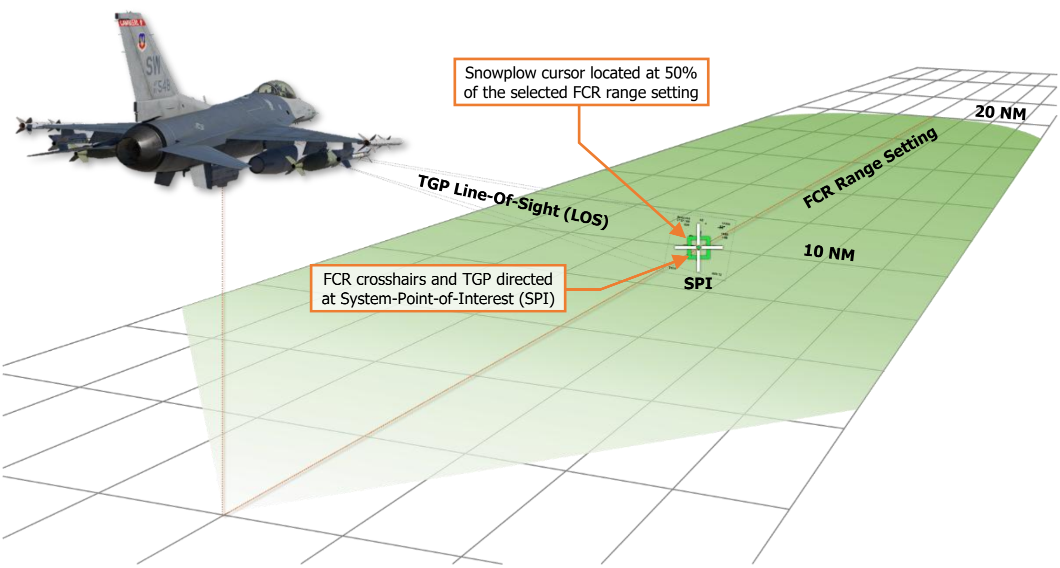
Snowplow mode allows the pilot to rapidly reposition the System-Point-of-Interest (SPI) ahead of the aircraft when using a "Pre-planned" weapon delivery sub-mode or when in Navigation master mode.

In situations when it is desirable to use a "Pre-planned" weapon delivery sub-mode against a target that is not designated by a steerpoint, Snowplow allows the pilot to hastily slew the selected steerpoint to a fixed location directly in front of the aircraft and then ground stabilize the steerpoint at its current location.

Snowplow mode may be enabled by pressing the Snowplow (**SP**) button, which is displayed at OSB 8 on the FCR and TGP MFD formats when the following criteria are met:

- Master Mode is set to NAV or A-G.
- FCR mode is set to GM, GMT, or SEA.
- VIP and VRP sighting modes are not enabled for the selected steerpoint.

When Snowplow is enabled, the SPI is assigned to the Snowplow cursor, which corresponds with a fixed location directly in front of the aircraft.



Snowplow Sighting Method

The Snowplow cursor is placed in three dimensions based on the following.

- **Aircraft Heading.** The Snowplow cursor will always remain stabilized with the aircraft centerline and cannot be changed. The Snowplow cursor (and the SPI) will turn with the aircraft nose and cannot be moved in the lateral axis.

- **Range.** The Snowplow cursor will be located along the aircraft centerline at 50% of the FCR's selected range setting, placing the SPI within the center of the MFD FCR format. The pilot may indirectly move the Snowplow cursor along the longitudinal axis by selecting a different FCR range setting, even if the FCR is in STBY mode or if the RF switch is in QUIET or SILENT positions.

  If the FCR is powered OFF on the SNSR PWR control panel, the Snowplow cursor will be placed at a range of 5 NM in front of the aircraft, which cannot be changed.
- **Elevation.** The Snowplow cursor is set to the same elevation as the selected steerpoint, independently of the actual terrain elevation below it. The pilot may indirectly move the Snowplow cursor in the vertical axis by modifying the elevation of the selected steerpoint on the STPT DED page.

  When the aircraft is weight-on-wheels, the Snowplow cursor is set to the same elevation as the aircraft.

When Snowplow is enabled in pre-designate, it may be exited with or without designating (post-designate), or will be disabled automatically if any of the following criteria are met:

- The selected steerpoint is changed.
- VIP or VRP sighting modes are entered.
- FIX or A-CAL pages are displayed on the DED.
- The FCR is set to AGR mode, which occurs automatically if a "Visual" weapon delivery sub-mode is entered, such as CCIP, STRF, DTOS, STRF, EO-VIS, or VIS; or if the MARK page is displayed on the DED with "HUD" as the selected marking method.
- The FCR is set to CRM or ACM mode, which occurs automatically when entering MSL or DGFT master modes.

Exiting Snowplow via Post-Designate

When Snowplow is enabled, the SPI may be ground stabilized by pressing TMS Forward while the HUD, FCR, or TGP is set as SOI. When this occurs, the selected steerpoint will be stabilized at that location, incurring a slew to the Navigation cursor, and the steerpoint elevation will be adjusted to the calculated terrain elevation.

Ground stabilizing the SPI in this manner will also exit Snowplow sighting mode.

Exiting Snowplow from Pre-Designate

When Snowplow is enabled, the SPI may be returned to the previous steerpoint location without designation by pressing TMS Aft while the HUD, FCR, or TGP is set as SOI; or by pressing **SP** (OSB 8) on the FCR or TGP formats. When this occurs, Snowplow mode will be exited without incurring a slew to the Navigation cursor.

Pressing **CZ** on the FCR, TGP, or HSD MFD formats while Snowplow mode is enabled will exit Snowplow sighting mode but will not zeroize any slews that had been accumulated by the Navigation cursor prior to enabling Snowplow.

"Visual" Weapon Delivery Sub-modes

Attacks against targets of opportunity, independently of steerpoints, may be performed after the pilot has visually acquired and identified the physical target within the HUD or HMCS, or via electronic sensors such as the targeting pod (TGP). In these weapon delivery sub-modes, the target location is either manually designated by the pilot using the Target Designator (TD) Box, or the computed weapon ballistics are calculated from the aircraft's current position and the aircraft is maneuvered in such a way to place the weapon ballistic solution over the target itself. (See the Air-to-Ground Employment chapter for more information regarding each weapon delivery sub-mode.)

"Visual" weapon delivery sub-modes, such as CCIP, DTOS, or STRF, rely on the pilot to visually identify the target through the canopy before maneuvering the aircraft to engage the target. Since target acquisition is not reliant on pre-planned steerpoints or the position accuracy of the system navigation solution within the INU, these sub-modes do not utilize sighting points. As such, sighting point options are not displayed at OSB 10 on the FCR and TGP MFD formats when a "Visual" weapon delivery sub-mode is in use.

VISUAL REFERENCE POINT (VRP) & VISUAL INITIAL POINT (VIP) SIGHTING MODES

Although the F-16C is quite capable of performing precision strikes against pre-planned targets designated by a steerpoint, conducting such attacks following a low-level ingress can be quite challenging in that the target may not be visible until just prior to weapons release. This is compounded by the possibility that the target itself may be concealed, camouflaged, or may be difficult to acquire during the final critical moments of a low-level pop-up maneuver. Two additional sighting modes are available that allow the pilot to use visual landmarks from which to commence the attack, perform final alignment of the targeting solution just prior to the attack, and utilize visual cues within the HUD symbology for the location and timing of the pop-up maneuver during the attack itself.

Visual Reference Point (VRP). The steerpoint is used to designate a known target location (TGT). In this sighting mode, a visually identifiable location is used as a Reference Point (RP), located relative to the TGT, as a visual cue to the pilot for aligning the aircraft flight path for the attack sequence, ensure the targeting solution is accurate prior to commencing the attack, or to aid in target acquisition during the attack itself.

A pre-planned Pull-Up Point (PUP), located relative to the TGT, may be employed to provide a visual cue to the pilot as to when to initiate a pop-up maneuver following the low-level ingress.

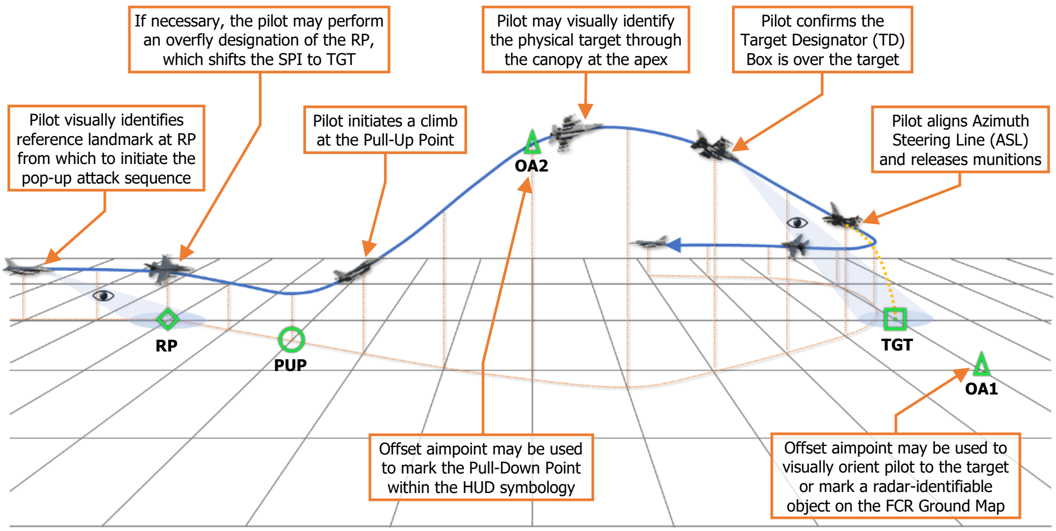
Visual Initial Point (VIP). The steerpoint is used to designate a known, visually identifiable location as the Initial Point (IP) from which to initiate an attack against a target (TGT) that may not be easily seen or detected, or which the precise location may not be known. In this sighting mode, the pilot may use the steerpoint at the IP, or offset aimpoints (OA1/OA2) relative to the IP, to ensure the targeting solution is accurate just prior to commencing the attack.

A pre-planned Pull-Up Point (PUP), located relative to the IP, may be employed to provide a visual cue to the pilot as to when to initiate a pop-up maneuver following the low-level ingress.

NOTE: VRP and VIP sighting modes may only be simultaneously enabled for separate steerpoints. Each sighting mode is mutually exclusive; enabling one sighting mode for the same steerpoint will disable the other.

Visual Reference Point (VRP) Sighting Mode

VRP is a sighting mode used in conjunction with "Pre-planned" weapon delivery sub-modes (such as CCRP or LADD) that provides the pilot with additional visual cues and hands-on designation options for performing level, toss, or pop-up dive attacks from a low-altitude ingress. A steerpoint is plotted at the target, and a landmark that is easily identifiable by the pilot while performing low-altitude flight or the pop-up maneuver itself is subsequently plotted relative to that steerpoint. The pilot may use this visual landmark for aligning the aircraft flight path for the final attack maneuvers, correcting any misalignments of the HUD symbology before committing to the attack sequence, or orienting the aircraft relative to the target to aid in target acquisition during the attack itself.



VRP Sighting Mode

VRP sighting mode is entered when all of the following criteria are met:

- The master mode is set to A-G.
- The weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, or PRE.
- The TGT steerpoint set on the TGT-TO-VRP DED page is the selected steerpoint.
- VRP is enabled on the TGT-TO-VRP DED page.

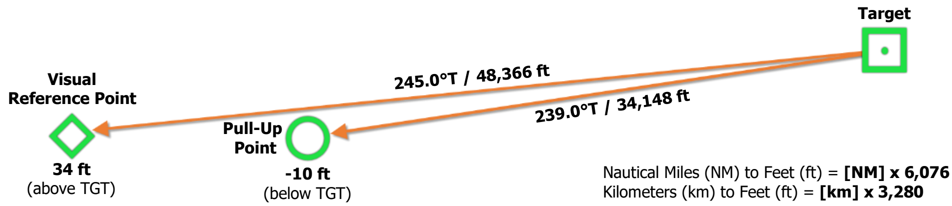
When VRP sighting mode is entered, the EHSI and Azimuth Steering Line (ASL) will display steering to the Target (TGT), the sighting point rotary will automatically be set to TGT, and the SOI will automatically move to the HUD. If the pilot intends to use the RP as a sighting point prior to the attack, RP must be manually selected.

The pilot may correct any misalignments of the HUD symbology using either of the following methods:

- Slew the Steerpoint Diamond over the landmark at the RP using the RDR CURSOR/ENABLE switch with the HUD, FCR, or TGP as SOI.
- Designate the RP using TMS Forward with the HUD as SOI while performing a direct overflight of the landmark itself. When TMS Forward is pressed, the sighting point rotary will sequence to TGT.

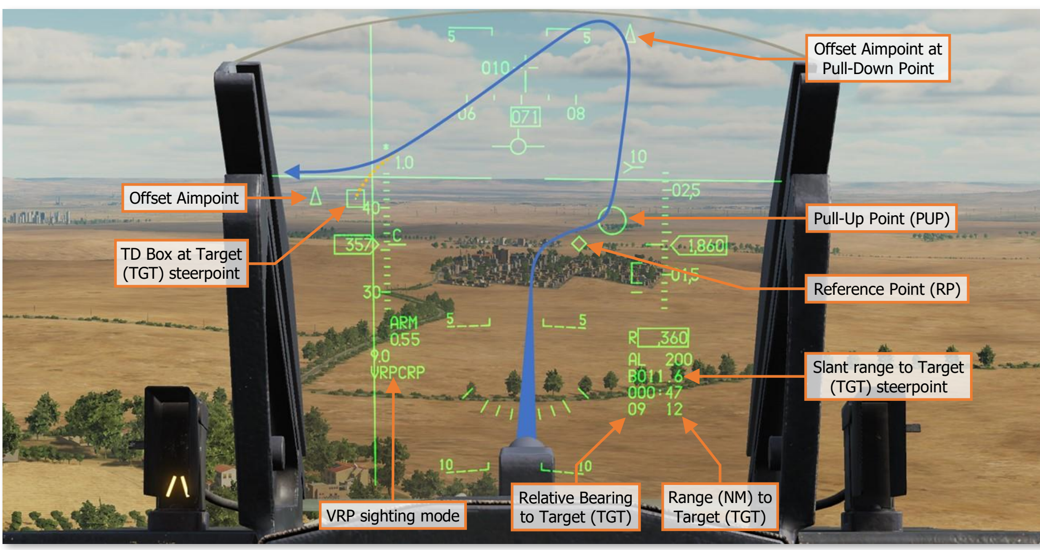
Regardless of which method the pilot uses to align the HUD symbology, any misalignments of the HUD symbology as a result of the system navigation solution will be effectively corrected. This will ensure the Target Designator (TD) Box will be placed over the corresponding target location and the weapon release symbology will be accurately calculated to the target location during the final moments of the attack sequence; assuming the Reference Point location has been accurately plotted on the TGT-TO-VRP DED page.

In the figure below and on the previous page, attack geometry has been pre-planned with the Reference Point input via the TGT-TO-VRP DED page, and an optional Pull-Up Point has been input via the TGT-TO-PUP DED page. The PUP is a location from where a pop-up diving attack is initiated from low altitude. Pull-Up Points must be plotted at a location that provides sufficient maneuver space and time for the pilot to perform the pop-up maneuver, roll over for a subsequent "pull-down" maneuver, visually acquire the target, align the aircraft for weapons release, and then perform a safe-escape maneuver prior to reaching minimum safe altitude.



Plotting TGT-to-VRP and TGT-to-PUP

When PUP is enabled and the TGT steerpoint set on the TGT-TO-VRP DED page is the selected steerpoint, a circle will be displayed within the HUD at the corresponding location. If the circle is outside of the HUD field-of-view, the circle will be displayed along the edge of the HUD symbology and will be overlayed with an ×.



When VRP sighting mode is enabled, all sighting point symbols and the pull-up point will be displayed within the HUD and HMCS symbology, regardless of the sight point that is in use.

Target (TGT), at the TGT steerpoint location.

Offset Aimpoint (OA1/OA2), as input on the DEST OA1/OA2 DED pages, for the selected steerpoint.

Reference Point (RP), as input on the TGT-TO-VRP DED page.

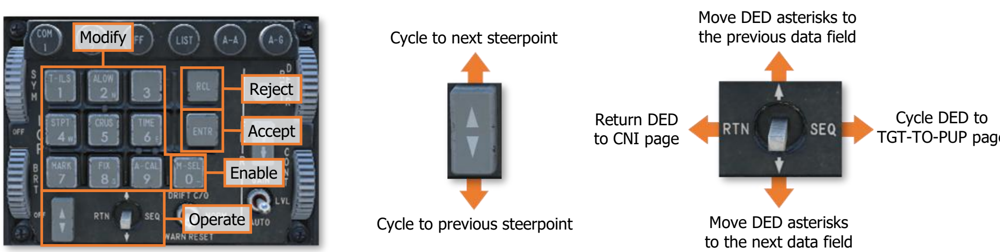
Pull-Up Point (PUP), as input on the TGT-TO-PUP DED page, if enabled.

If the selected steerpoint or master mode is changed, any cursor slews that have been accumulated by the VRP cursor will be retained. Upon returning to VRP sighting mode, an overfly designation of the RP may be performed, if necessary, regardless of whether an overfly designation had been performed prior to exiting VRP mode.

If VRP mode is disabled and then re-enabled on the TGT-TO-VRP DED page, any cursor slews that have been accumulated by the VRP cursor will be zeroed and VRP sighting mode will be reset to a pre-designate state.

TGT-TO-VRP DED Page

The Target-To-VRP DED page is accessed by pressing **9/A-CAL** on the ICP keypad when the LIST DED page is displayed. This page allows the pilot to select the TGT steerpoint and modify the position of the Visual Reference Point (VRP) relative to the location of the TGT steerpoint.



1. **VRP Mode Select.** Enables/disables VRP sighting mode by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when VRP mode is enabled.

   NOTE: Enabling VRP does not enter VRP sighting mode. VRP sighting mode will only be entered if VRP is enabled, the VRP steerpoint set on this page is the selected steerpoint, the master mode is set to A-G, and the weapon delivery sub-mode is CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN.

2. **Target Steerpoint (TGT).** Displays the steerpoint used as the Target (TGT) when VRP mode is entered. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.

   NOTE: VRP sighting cannot be simultaneously enabled for the same steerpoint as VIP. If a steerpoint is set as the TGT steerpoint *and* as the VIP steerpoint, pressing 0/M-SEL to enable VRP will disable VIP.

3. **True Bearing to VRP (TBRG).** Displays the relative bearing (in degrees true) from the TGT steerpoint to the VRP. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

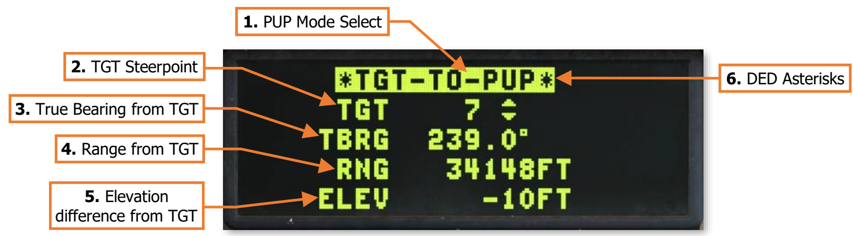
4. **Range to VRP (RNG).** Displays the range (in feet) from the TGT steerpoint to the VRP. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

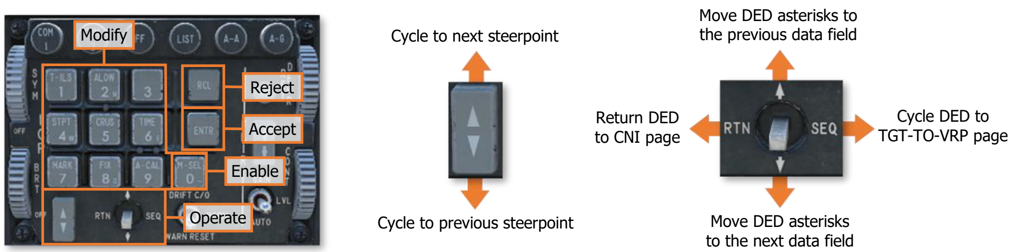
5. **Elevation difference from TGT (ELEV).** Displays the difference in elevation (in feet) of the VRP from the TGT steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. To enter a negative value, press 0/M-SEL to enter a leading zero, which will be input as a negative (–) symbol, followed by the numerical elevation difference value.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

TGT-TO-PUP DED Page

The TGT-to-Pull-Up Point DED page is accessed by pressing **9/A-CAL** on the ICP keypad when the LIST DED page is displayed, which displays the TGT-TO-VRP DED page, followed by momentarily pressing the DCS switch to the SEQ position. This page allows the pilot to select the TGT steerpoint and modify the position of the Pull-Up Point (PUP) relative to the location of the TGT steerpoint steerpoint.





1. **PUP Mode Select.** Enables/disables display of the PUP symbol by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when PUP is enabled.

2. **TGT Steerpoint.** Displays the steerpoint used as the Target (TGT) when VRP mode is entered. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.

   NOTE: VRP sighting cannot be simultaneously enabled for the same steerpoint as VIP. If a steerpoint is set as the TGT steerpoint *and* as the VIP steerpoint, pressing 0/M-SEL to enable VRP will disable VIP.

3. **True Bearing to VRP (TBRG).** Displays the relative bearing (in degrees true) from the TGT steerpoint to the PUP. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

4. **Range to VRP (RNG).** Displays the range (in feet) from the TGT steerpoint to the PUP. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

5. **Elevation difference from TGT (ELEV).** Displays the difference in elevation (in feet) of the PUP from the TGT steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. To enter a negative value, press 0/M-SEL to enter a leading zero, which will be input as a negative (–) symbol, followed by the numerical elevation difference value.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Designating the RP using Direct Overflight

If VRP sighting mode is entered and the HUD is SOI, a direct overflight and designation of the RP may be used to simultaneously align the HUD symbology for the attack and sequence the sighting point rotary to TGT.

To perform an overfly designation of the RP, ensure VRP has been enabled on the TGT-TO-VRP DED page, and perform the following:

1. ICP **Increment/Decrement** Rocker – Select the VRP steerpoint number.

or

1. ICP Keypad – Press **4/STPT** to display the STPT DED page.

2. ICP **Keypad** – Input the VRP steerpoint number.

3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

4. ICP **A-G** Button – Press to enter A-G master mode.

5. MFD format – Select **SMS**.

6. SMS OSB 6 – Select **weapon**, as desired. Verify or modify SMS profile settings for the selected weapon, as necessary.

7. SMS OSB 2 – Select pre-planned weapon delivery sub-mode, as desired (CCRP, LADD, EO-PRE, EO-BORE, or PRE).

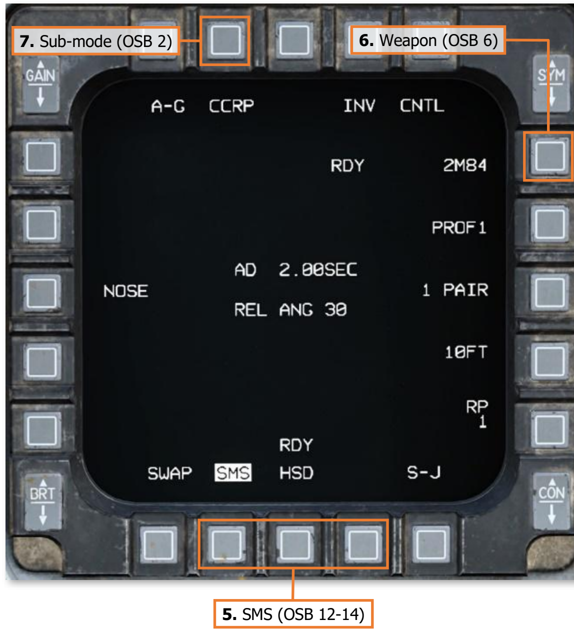
8. DMS Forward – Press to set SOI to HUD, if necessary.

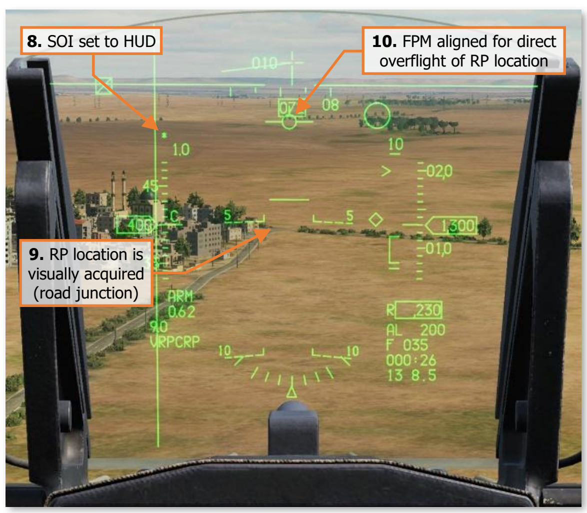
9. Visually acquire the physical landmark that corresponds with the Reference Point (RP) location.

10. Maneuver the aircraft as necessary to align the Flight Path Marker (FPM) for a direct overflight of the RP location.

11. TMS Forward-Short – Press when directly over the landmark at the RP location.

When TMS Forward-Short is pressed, the VRP cursor will be immediately slewed to place the RP directly below the aircraft, which will slew the Target (TGT) steerpoint, Pull-Up Point (PUP), and offset aimpoints (OA1/OA2) an equal distance and direction to align the HUD symbology for the attack.





Aligning the RP using VRP Cursor Slew

If VRP sighting mode is entered and the HUD, FCR, or TGP are SOI, the VRP cursor may be slewed to align the HUD symbology for the attack.

To align the HUD symbology by slewing the VRP cursor, ensure VRP has been enabled on the TGT-TO-VRP DED page, and perform the following:

1. ICP **Increment/Decrement** Rocker – Select the VRP steerpoint number.

or

1. ICP Keypad – Press **4/STPT** to display the STPT DED page.

2. ICP **Keypad** – Input the VRP steerpoint number.

3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

4. ICP **A-G** Button – Press to enter A-G master mode.

5. MFD format – Select **SMS**.

6. SMS OSB 6 – Select **weapon**, as desired. Verify or modify SMS profile settings for the selected weapon, as necessary.

7. SMS OSB 2 – Select pre-planned weapon delivery sub-mode, as desired (CCRP, LADD, EO-PRE, EO-BORE, or PRE).

8. DMS Forward – Press to set SOI to HUD, if necessary.

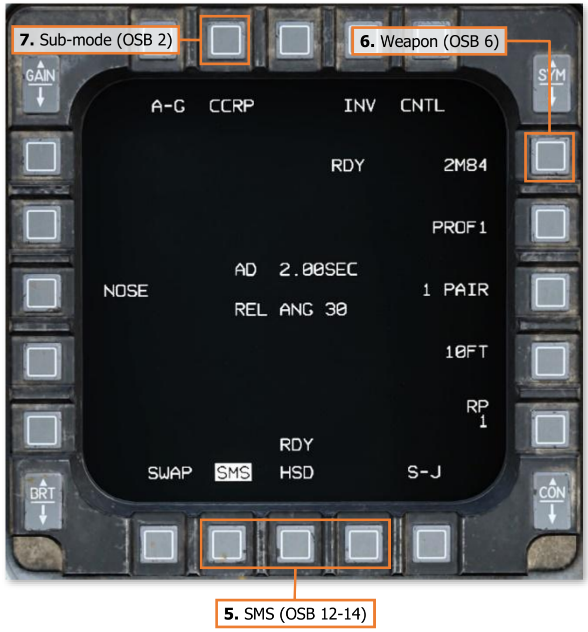
9. **(Optional)** TMS Right – Press as necessary to sequence the sighting point rotary to Reference Point (RP).

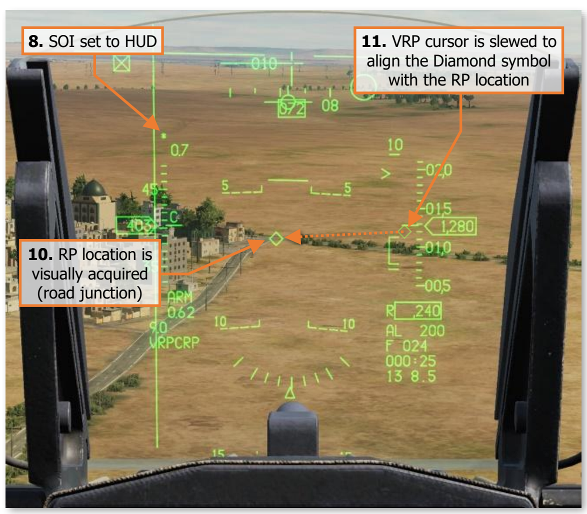
NOTE: Although it is not required to select RP as the sighting point before slewing the VRP cursor, the cursor slew rates will be scaled in a manner that will permit greater precision in aligning the Diamond symbol over the RP location.

10. Visually acquire the physical landmark that corresponds with the RP location.

11. RDR CURSOR/ENABLE Switch – Slew the VRP cursor as necessary to align the Diamond symbol over the RP location.

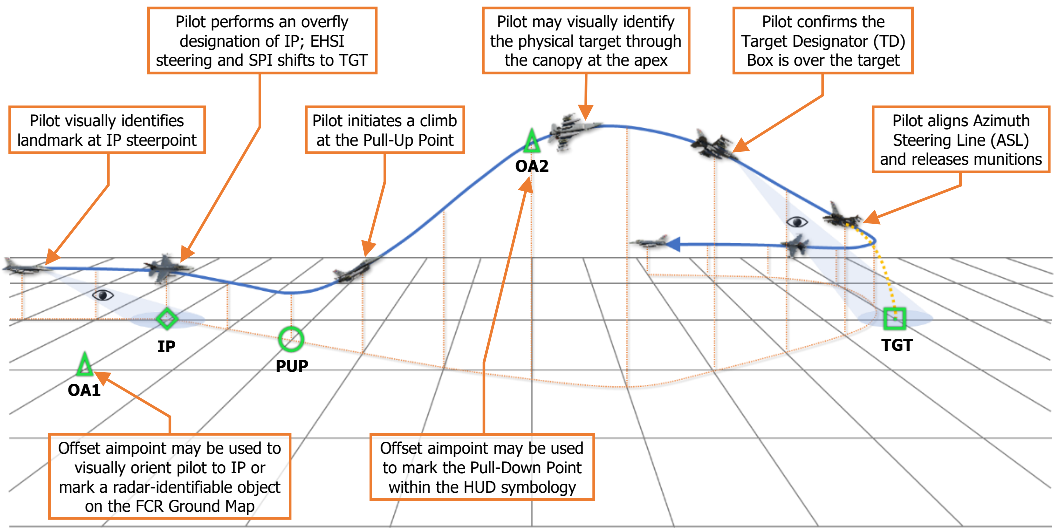
12. TMS Right – Press to sequence the sighting point rotary to TGT, if necessary.





Visual Initial Point (VIP) Sighting Mode

VIP is a sighting mode used in conjunction with "Pre-planned" weapon delivery sub-modes (such as CCRP or LADD) that provides the pilot with additional visual cues and hands-on designation options for performing level, toss, or pop-up dive attacks from a low-altitude ingress. A steerpoint is plotted at a landmark that is easily identifiable by the pilot while performing low-altitude flight, and a target location is subsequently plotted relative to that steerpoint. The pilot may use this visual landmark to align the aircraft flight path for the final attack maneuvers or to correct any misalignments of the HUD symbology before committing to the attack sequence.



VIP Sighting Mode

VIP sighting mode is entered when all of the following criteria are met:

- The master mode is set to A-G.
- The weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, or PRE.
- The VIP steerpoint set on the VIP-TO-TGT DED page is the selected steerpoint.
- VIP mode is enabled on the VIP-TO-TGT DED page.

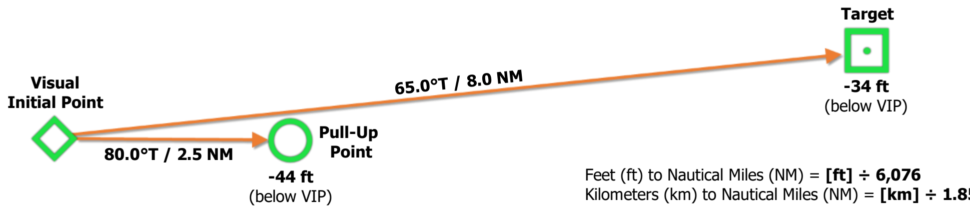
When VIP sighting mode is entered, the EHSI will display steering to the Initial Point (IP), the Azimuth Steering Line will display steering to the Target (TGT), the sighting point rotary will automatically be set to IP, and the SOI will automatically move to the HUD.

The pilot may correct any misalignments of the HUD symbology by designating the IP using TMS Forward with the HUD as SOI while performing a direct overflight of the landmark itself. When TMS Forward is pressed, the EHSI steering will switch to the Target (TGT), the sighting point rotary will sequence to TGT, and the SOI will automatically move to the FCR MFD format (if displayed).

When the IP location is accurately designated during overflight, any misalignments of the HUD symbology as a result of the system navigation solution will be effectively corrected. This will ensure the Target Designator (TD) Box will be placed over the corresponding target location and the weapon release symbology will be accurately calculated to the target location during the final moments of the attack sequence; assuming the Target location has been accurately plotted on the VIP-TO-TGT DED page.

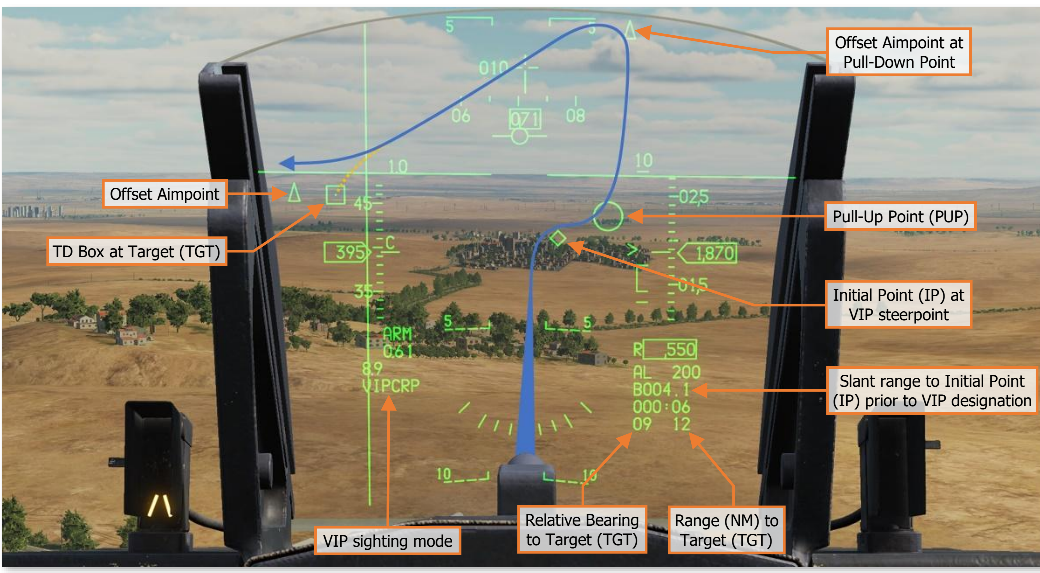
In the figures above and on the following page, attack geometry has been pre-planned with the Target input via the VIP-TO-TGT DED page, and an optional Pull-Up Point has been input via the VIP-TO-PUP DED page.

The PUP is a location from where a pop-up diving attack is initiated from low altitude. Pull-Up Points must be plotted at a location that provides sufficient maneuver space and time for the pilot to perform the pop-up maneuver, roll over for a subsequent "pull-down" maneuver, visually acquire the target, align the aircraft for weapons release, and then perform a safe-escape maneuver prior to reaching minimum safe altitude.



Plotting VIP-to-TGT and VIP-to-PUP

When PUP is enabled and the VIP steerpoint on the VIP-TO-TGT DED page is the selected steerpoint, a circle will be displayed within the HUD at the corresponding location of the Pull-Up Point. If the circle is outside of the HUD field-of-view, the circle will be displayed along the edge of the HUD symbology and will be overlayed with an **×**.



When VIP sighting mode is enabled, all sighting point symbols and the pull-up point will be displayed within the HUD and HMCS symbology, regardless of the sight point that is in use.

 **Initial Point (IP)**, at the VIP steerpoint location.

 **Target (TGT)**, as input on the VIP-TO-TGT DED page.

 **Offset Aimpoint (OA1/OA2)**, as input on the DEST OA1/OA2 DED pages, for the selected steerpoint.

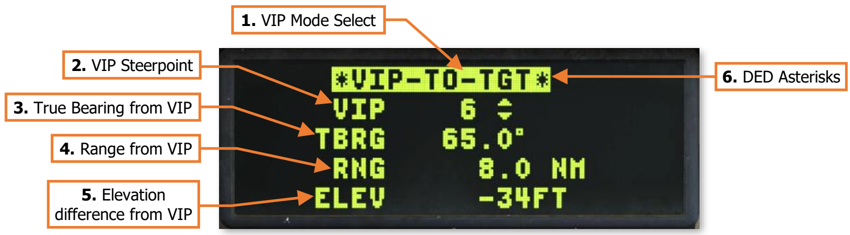
 **Pull-Up Point (PUP)**, as input on the VIP-TO-PUP DED page, if enabled.

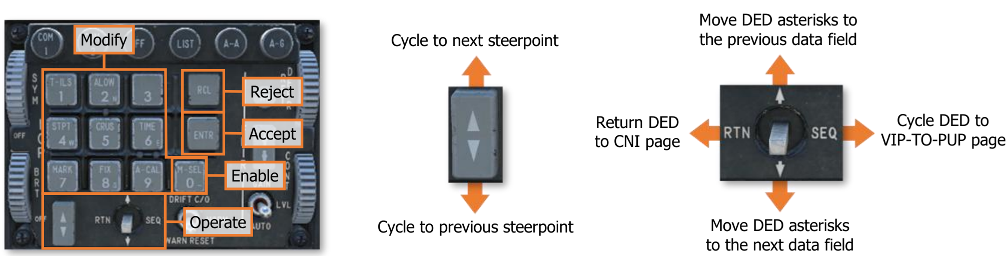
If the selected steerpoint or master mode is changed, any cursor slews that have been accumulated by the VIP cursor will be retained. Upon returning to VIP sighting mode, an overfly designation of the IP may be performed, if necessary, regardless of whether an overfly designation had been performed prior to exiting VIP mode.

If VIP mode is disabled and then re-enabled on the VIP-TO-TGT DED page, any cursor slews that have been accumulated by the VIP cursor will be zeroed and VIP sighting mode will be reset to a pre-designate state.

VIP-TO-TGT DED Page

The VIP-to-Target DED page is accessed by pressing **3** on the ICP keypad when the LIST DED page is displayed. This page allows the pilot to select the VIP steerpoint and modify the position of the Target (TGT) relative to the location of the VIP steerpoint.





1. **VIP Mode Select.** Enables/disables VIP sighting mode by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when VIP mode is enabled.

   NOTE: Enabling VIP does not enter VIP sighting mode. VIP sighting mode will only be entered if VIP is enabled, the VIP steerpoint set on this page is the selected steerpoint, the master mode is set to A-G, and the weapon delivery sub-mode is CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN.

2. **VIP Steerpoint.** Displays the steerpoint used as the Initial Point (IP) when VIP mode is entered. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.

   NOTE: VIP sighting cannot be simultaneously enabled for the same steerpoint as VRP. If a steerpoint is set as the VIP steerpoint *and* as the TGT steerpoint, pressing 0/M-SEL to enable VIP will disable VRP.

3. **True Bearing to TGT (TBRG).** Displays the relative bearing (in degrees true) from the VIP steerpoint to the TGT. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

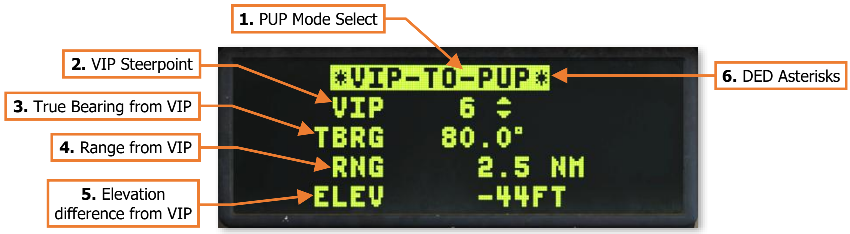
4. **Range from to TGT (RNG).** Displays the range (in nautical miles) from the VIP steerpoint to the TGT. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

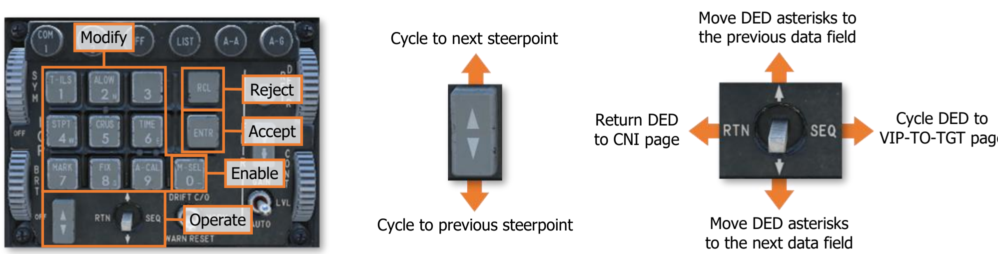
5. **Elevation difference from VIP (ELEV).** Displays the difference in elevation (in feet) of the TGT from the VIP steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. To enter a negative value, press 0/M-SEL to enter a leading zero, which will be input as a negative (–) symbol, followed by the numerical elevation difference value.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

VIP-TO-PUP DED Page

The VIP-to-Pull-Up Point DED page is accessed by pressing **3** on the ICP keypad when the LIST DED page is displayed, which displays the VIP-TO-TGT DED page, followed by momentarily pressing the DCS switch to the SEQ position. This page allows the pilot to select the VIP steerpoint and modify the position of the Pull-Up Point (PUP) relative to the location of the VIP steerpoint.





1. **PUP Mode Select.** Enables/disables display of the PUP symbol by placing the DED asterisks around the data field and pressing the 0/M-SEL button on the ICP keypad, which will highlight the text within the data field when PUP is enabled.

2. **VIP Steerpoint.** Displays the steerpoint used as the Initial Point (IP) when VIP mode is entered. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.

   NOTE: VIP sighting cannot be simultaneously enabled for the same steerpoint as VRP. If a steerpoint is set as the VIP steerpoint *and* as the TGT steerpoint, pressing 0/M-SEL to enable VIP will disable VRP.

3. **True Bearing from VIP (TBRG).** Displays the relative bearing (in degrees true) of the PUP from the VIP steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

4. **Range from VIP (RNG).** Displays the range (in nautical miles) of the PUP from the VIP steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR.

5. **Elevation difference from VIP (ELEV).** Displays the difference in elevation (in feet) of the PUP from the VIP steerpoint. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. To enter a negative value, press 0/M-SEL to enter a leading zero, which will be input as a negative (–) symbol, followed by the numerical elevation difference value.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Designating the IP using Direct Overflight

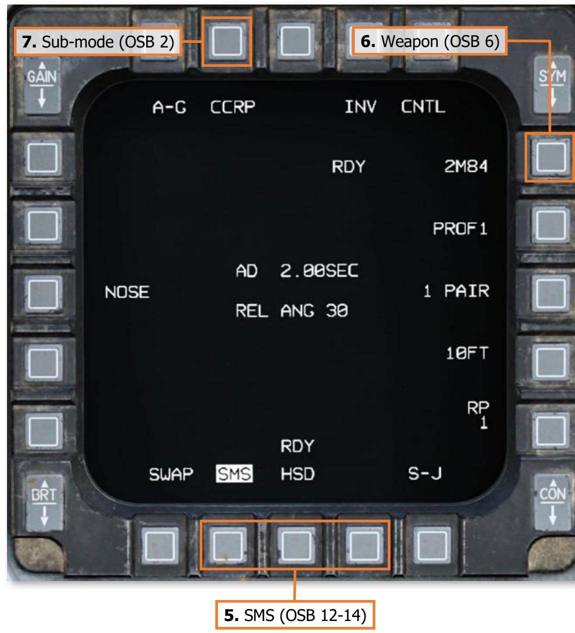
If the IP is selected as the sighting point and the HUD is SOI, a direct overflight and designation of the IP may be used to simultaneously align the HUD symbology for the attack, update EHSI steering to the target (TGT), sequence the sighting point rotary to TGT, and move the SOI to the FCR MFD format.

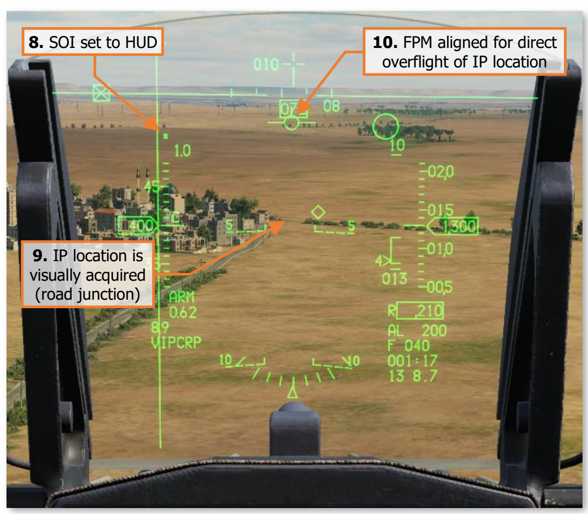
To perform an overfly designation of the IP, ensure VIP has been enabled on the VIP-TO-TGT DED page, and perform the following:

1. ICP **Increment/Decrement** Rocker – Select the VIP steerpoint number.

   or

1. ICP Keypad – Press **4/STPT** to display the STPT DED page.
2. ICP **Keypad** – Input the VIP steerpoint number.
3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.
4. ICP **A-G** Button – Press to enter A-G master mode.
5. MFD format – Select **SMS**.
6. SMS OSB 6 – Select **weapon**, as desired. Verify or modify SMS profile settings for the selected weapon, as necessary.
7. SMS OSB 2 – Select pre-planned weapon delivery sub-mode, as desired (CCRP, LADD, EO-PRE, EO-BORE, or PRE).
8. DMS Forward – Press to set SOI to HUD, if necessary.
9. Visually acquire the physical landmark that corresponds with the Initial Point (IP) location.
10. Maneuver the aircraft as necessary to align the Flight Path Marker (FPM) for a direct overflight of the IP location.
11. TMS Forward-Short – Press when directly over the landmark at the IP location.





When TMS Forward-Short is pressed, the VIP cursor will be immediately slewed to place the IP steerpoint directly below the aircraft, which will slew the Target (TGT), Pull-Up Point (PUP), and offset aimpoints (OA1/OA2) an equal distance and direction to align the HUD symbology for the attack.

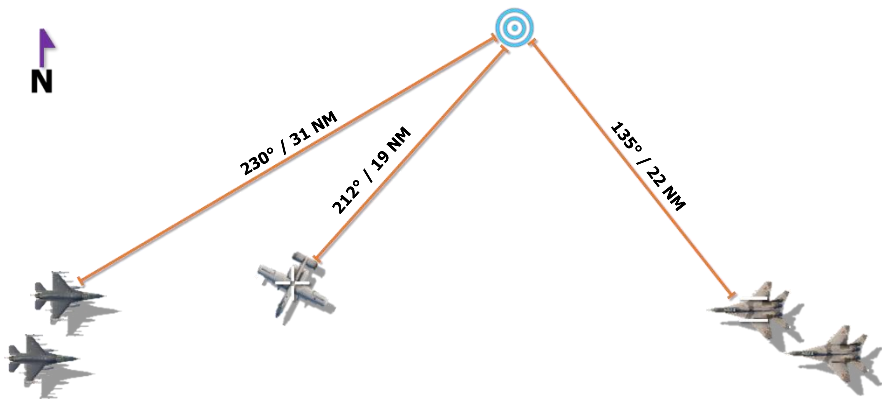
"BULLSEYE" REFERENCE POINT

"Bullseye" is a method of generating position data of aircraft, targets, threats or other locations by using a common reference point known only to allied forces. This is a method often used by AWACS controllers or friendly aircraft to ensure all aircraft operating in the area and on the same radio frequency can easily understand the tactical situation as it develops and changes.

When a Bullseye call is transmitted over the radio, the position being referenced is always the azimuth in degrees magnetic *from* the Bullseye reference, along with the distance in nautical miles. An example is shown below:

AWACS: "*Viper 1-1, Darkstar 2-1. Pop-up group, at Bullseye one-three-five, twenty-two, at nineteen thousand.*"

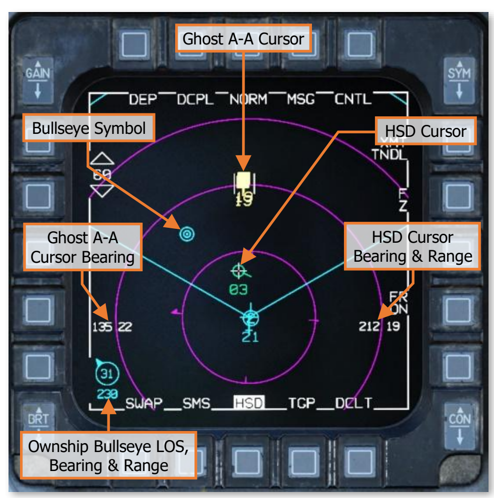
F-16C: "*Friendly aircraft at Bullseye two-one-two, nineteen, at Angels three, this is Viper 1-1. Flow southwest at low level. Viper flight engaging Bandits approaching at your 8 o'clock.*"



"Bullseye" position reference

The F-16C avionics provides several tools to the pilot to integrate Bullseye communications into the cockpit displays. Depending on the specific display in use, positions of the ownship, MFD cursor, or designated target can be displayed relative to Bullseye.

On the MFD to the right, the HSD format is displayed, depicting the same scenario as shown in the figure above. When Bullseye information is displayed, the ghost A-A and HSD cursors are referenced from the Bullseye symbol, not the selected steerpoint. In addition, the ownship's position relative to the Bullseye position is displayed in the bottom left corner of the MFD. This provides the pilot with three Bullseye references which can be used for coordination over the radio, or to maintain situational awareness within the battlespace.



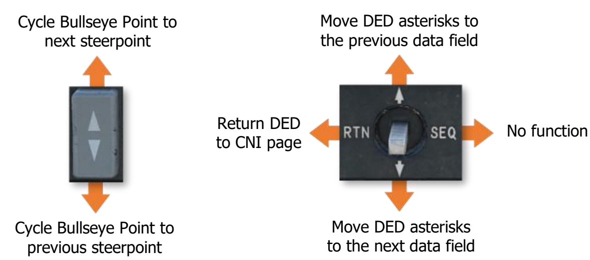
Bullseye Steerpoint

The Bullseye reference point is set by utilizing a steerpoint within the navigation database. The steerpoint normally used for Bullseye is steerpoint 25 and is automatically configured as such when a mission is loaded. However, if necessary, Bullseye can be set to a different steerpoint. Additionally, Bullseye information must be enabled for it to be displayed within the HUD or on the FCR, HSD, or HAD MFD formats.

Both of these tasks are performed on the BULL DED page.

BULL DED Page

The Bullseye DED page is accessed by pressing **8/FIX** on the ICP keypad when the MISC DED page is displayed on the DED. This page is used to enable or disable "Bullseye" position references on the HUD and MFDs, or to set a different steerpoint as the Bullseye reference point if necessary.



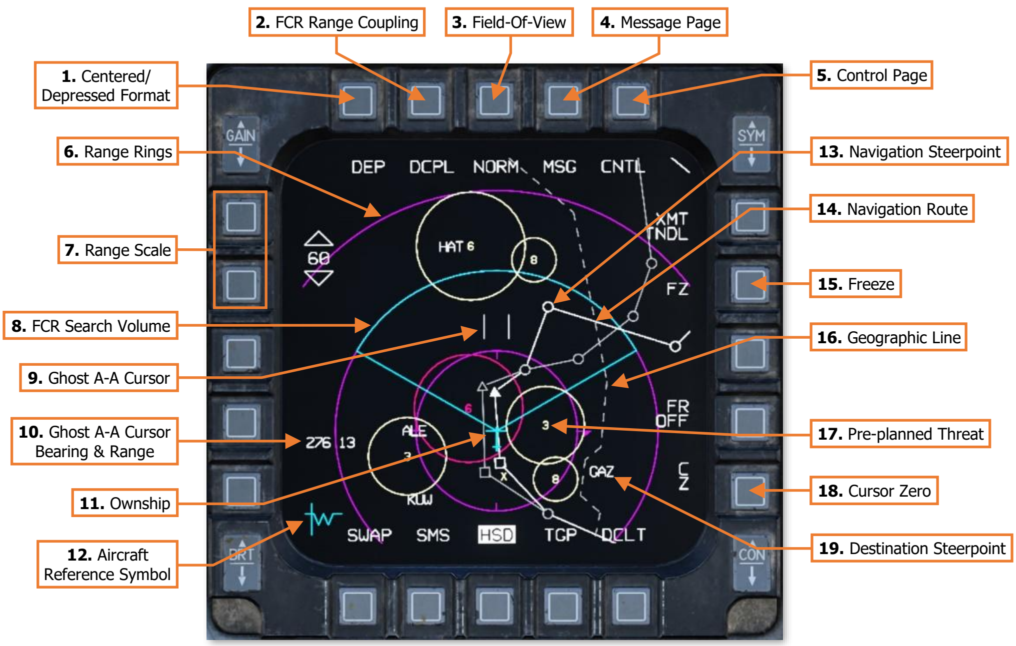
1. **Bullseye Select.** Displays the status of the Bullseye reference indications in the cockpit. When highlighted, Bullseye indications are enabled. Pressing the 0/M-SEL button when the DED asterisks are set to this data field will enable/disable the Bullseye references within the HUD and on the FCR, HSD, and HAD MFD formats.
2. **Bullseye Point.** Displays the steerpoint currently being used as the Bullseye reference point. The ICP The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint, or the DED asterisks may be placed over the data field and a steerpoint number may be input using the ICP keypad followed by ENTR.
3. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

HORIZONTAL SITUATION DISPLAY (HSD)

The Horizontal Situation Display presents a top-down, plan-view depiction of the navigation and tactical situation around the aircraft. The MMC receives navigation position data from the INS, plots pre-planned mission data in relation to the ownship position and heading, and fuses information received from the onboard fire control radar and offboard platforms through the datalink into a graphical representation of the battlespace around the aircraft.

Horizontal Situation Display (HSD) MFD Format

The HSD MFD format presents tactical symbols representing the positions of flight members, hostile aircraft, air defenses, and sensor information overlaid onto navigation information such as steerpoints and routes. Many of these symbology elements can be selectively toggled on the HSD Control page and are meant to enhance and maintain the pilot's situational awareness of the tactical environment.



1. **Centered/Depressed Format.** Toggles between Depressed (DEP) and Centered (CEN) HSD formats. When set to Depressed, the ownship is biased to the bottom portion of the HSD, allowing the HSD to primarily depict battlespace in front of the aircraft. When set to Centered, the ownship is displayed in the center of the HSD, depicting battlespace in all directions around the aircraft equally.
2. **FCR Range Coupling.** Toggles between Decoupled (DCPL) and Coupled (CPL) HSD modes. When set to Decoupled (DCPL) mode, the FCR range scale will have no effect on the HSD range scale, allowing the range scales of each MFD format to be adjusted independently of the other.

   When set to CPL, the HSD range scale will be correlated to match the FCR range scale when in Centered format or to 1.5x the range of the FCR range scale when in Depressed format (one additional magenta range ring in front of the FCR search volume). CPL mode is overridden any time the HSD is SOI, allowing the pilot to "bump" the HSD range scale independently of the FCR range scale. Once the HSD is no longer SOI, the HSD will revert to CPL mode.

3. **Field-Of-View.** Cycles the HSD between NORM, EXP1, and EXP2 fields-of-view when the HSD is SOI. The Expand/FOV button on the Side Stick Controller (SSC) may also be pressed to cycle between the HSD fields-of-view when the HSD is SOI. (See Expand Field-Of-View for more information.)

4. **Message Page (MSG).** Toggles the MFD between the HSD base page and the HSD Message page. (N/I)

5. **Control Page (CNTL).** Toggles the MFD between the HSD base page and the HSD Control page.

6. **Range Rings.** Depicts range from the ownship and the cardinal directions of north, east, south, and west (referenced from magnetic north) from the innermost range ring.

   When the HSD is set to Depressed (DEP) format, the outer ring will correspond with the HSD range scale, with two additional inner rings at ⅔ and ⅓ of the range scale. When the HSD is set to Centered (CEN) format, the outer ring will correspond with the HSD range scale, with an inner ring at ½ the range scale.

   Magnetic north is depicted as an arrow protruding outward from the innermost ring, south is depicted as a long tick mark straddling the innermost ring, and east and west are depicted as short tick marks protruding inward from the innermost ring.

7. **Range Scale.** Adjusts the scale of the HSD up or down, with the current range scale setting (in nautical miles) displayed between the arrow buttons. The HSD range scale corresponds with the outermost range ring depicted on the HSD and is scaled based on the DEP/CEN format selection. The available HSD scales are shown below:

Depressed (DEP)	15 NM	30 NM	60 NM	120 NM	240 NM
Centered (CEN)	10 NM	20 NM	40 NM	80 NM	160 NM

   When the HSD is set to its highest or lowest range scales, the upper or lower range scale arrows are removed, respectively.

8. **FCR Search Volume.** Depicts the lateral boundaries of the fire control radar scan pattern in azimuth and range, based on the current azimuth scan width, range scale, and position of the FCR Acquisition Cursor.

9. **Ghost A-A Cursor.** When the opposite MFD displays the FCR format and the FCR is set to Combined Radar Mode (CRM), the location of the FCR Acquisition Cursor relative to the ownship will be displayed on the HSD. This allows the pilot to correlate FCR target positions with the overall tactical situation depicted on the HSD.

10. **Ghost A-A Cursor Bearing & Range.** When the Ghost A-A cursor is displayed, this data field will display the bearing (in degrees magnetic) and range (in nautical miles) from the currently selected steerpoint to the Ghost A-A cursor. If Bullseye is enabled on the BULL DED page, this data field will display the bearing and range from the Bullseye steerpoint to the Ghost A-A cursor.

11. **Ownship.** Depicts the location of the ownship.

12. **Aircraft Reference Symbol.** Displays the relative alignment of the aircraft heading with the selected steerpoint, System Point-of-Interest (SPI), or weapon release solution. If the line is to the left or right of the watermark, the pilot must turn left or right respectively toward the vertical line to align the aircraft on course toward the selected steerpoint, SPI, or weapon release solution.

13. **Navigation Steerpoint.** Steerpoints 1-25 composing a navigation route are displayed as circles for normal steerpoints, squares for initial points, and triangles for targets. The steerpoint selected for navigation is displayed as a solid symbol; all other steerpoints are displayed as hollow symbols. Navigation steerpoints are displayed as white within the active navigation route and gray within the non-active navigation routes, if present.

    Navigation steerpoints that are not part of a navigation route are not displayed on the HSD unless they are the selected steerpoint.

14. **Navigation Route.** Navigation routes are displayed as solid lines linking sequential steerpoints 1-25. The active navigation route is displayed as white and the non-active navigation routes, if present, are displayed as gray. (See Navigation Routes for more information.)

15. **Freeze (FZ).** Freezes the HSD independently of the Ownship position, indicated by the highlighted "FZ" text adjacent to OSB 7. If the HSD is SOI when OSB 7 is pressed, the HSD will enter Centered (CEN) format on the location of the HSD cursor. If the HSD is not SOI when OSB 7 is pressed, the HSD will enter Centered (CEN) format on the location of the Ownship.

    A second press of OSB 7 will unfreeze the HSD. If the HSD was set to Depressed (DEP) format prior to being frozen, the HSD will revert to DEP format.

    NOTE: The Freeze (FZ) option is inhibited if the HSD is set to Expand (EXP1/EXP2) fields-of-view.

16. **Geographic Line.** Geographic lines are depicted as dashed lines linking sequential steerpoints 31-55. These lines may be used to depict airspace boundaries, kill boxes, the Forward Line of Own Troops (FLOT) or a variety of other uses. All geographic lines are displayed as gray.

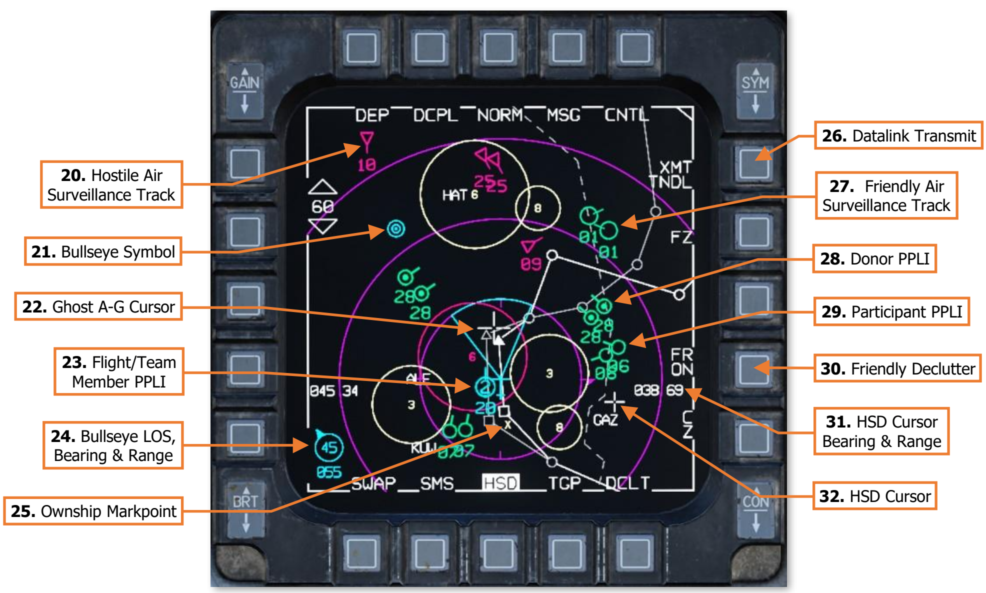
17. **Pre-planned Threat.** Locations of pre-planned air defense threats are displayed using up to three alphanumeric characters and a ring that corresponds to the approximate Weapon Engagement Zone (WEZ) of the air defense threat. Pre-planned threats and their range rings are displayed as yellow but will become red if the ownship enters the WEZ of the corresponding threat.

    The threat ring of a pre-planned threat steerpoint may be selectively hidden or shown by pressing TMS Aft or TMS forward, respectively, when the HSD is SOI and the HSD cursor is over the steerpoint text.

    NOTE: These are static locations of air defenses and do not reflect whether the air defense threat is operational or destroyed, or if any new threats have been detected.

18. **Cursor Zero (CZ).** Removes any accumulated cursor slews from the active cursor. (See Cursor Zero for more information.)

19. **Destination Steerpoint.** Steerpoints 81-99 are displayed using up to three alphanumeric characters and may be used to depict airfield locations, geographic landmarks, or other points of interest.



20. **Hostile Air Surveillance Track.** A hostile aircraft that has been detected by an AWACS aircraft and distributed across the TNDL network as an Air Surveillance track.

21. **Bullseye Symbol.** Depicts the location of the Bullseye steerpoint. The Bullseye steerppoint is normally set to steerpoint 25 but can be set to a different steerpoint on the BULL DED page.

22. **Ghost A-G Cursor.** Depicts the location of the System-Point-of-Interest (SPI) when in Air-to-Ground (A-G) master mode and the FCR is not in Standby (STBY) or Override (OVRD).

23. **Flight/Team Member PPLI.** A TNDL-participant aircraft that is set as a Flight member (1-4) or a Team member (5-8) of the ownship.

24. **Bullseye LOS, Bearing & Range.** Displays a pointer symbol that indicates the relative direction (line-of-sight or LOS) to the Bullseye steerpoint from the nose of the ownship. Displays the ownship's range (in nautical miles) and bearing (in degrees magnetic) from the Bullseye steerpoint, with the range displayed inside the pointer symbol and the bearing from Bullseye displayed below it.

25. **Ownship Markpoint.** Depicts the location of an ownship markpoint (steerpoints 26-30).

26. **Datalink Transmit (XMT).** Toggles the datalink that will be used to transmit the selected steerpoint, SPI, or SEAD target to other flight members when the VHF UHF Transmit switch on the throttle grip is pressed to the inboard IFF IN position for >0.5 seconds. (See TNDL Messages for more information.)
    - **TNDL.** The steerpoint, SPI, or SEAD target is transmitted over the Tactical Net Datalink.
    - **SMDL.** The steerpoint, SPI, or SEAD target is transmitted over the Secure Modem Datalink. (N/I)

27. **Friendly Air Surveillance Track.** A friendly aircraft that has been detected by an AWACS aircraft and distributed across the TNDL network as an Air Surveillance track.

28. **Donor PPLI.** A TNDL-participant aircraft that is set as a Donor to the ownship.

29. **Participant PPLI.** A TNDL-participant aircraft that is neither a Flight/Team member nor a Donor.

30. **Friendly Declutter.** Controls the display of PPLI symbols received over TNDL datalink. Each press will cycle through the three declutter settings.
    - **FR ON.** All PPLI symbols are displayed.
    - **FL ON.** Only Flight member (1-4), Team member (5-8), and Donor PPLI symbols are displayed. All other participant PPLI symbols are hidden.
    - **FR OFF.** All PPLI symbols are hidden.R

31. **HSD Cursor.** When the HSD is selected as the Sensor-Of-Interest (SOI), the HSD cursor will appear at the Ownship symbol if the Ghost A-A cursor is not displayed. If the Ghost A-A cursor is displayed when the HSD is selected as SOI, the HSD cursor will appear within the Ghost A-A cursor. If SOI is assigned to another MFD format or the HUD, the HSD cursor is removed.

    The HSD cursor is slewed using the RDR CURSOR/ENABLE switch on the throttle grip when the HSD is SOI and may be used to set a steerpoint, markpoint, pre-planned threat, or destination as the selected steerpoint, designate a PDLT, or used in conjunction with the Expand (EXP1/EXP2) fields-of-view.

    The HSD cursor may also be used to "bump" the range scale of the HSD itself. If the HSD cursor is slewed to the top of the HSD, the HSD range scale will increment to the next higher setting. Likewise, if the HSD cursor is slewed to the bottom of the HSD, the HSD range scale will decrement to the next lower setting.

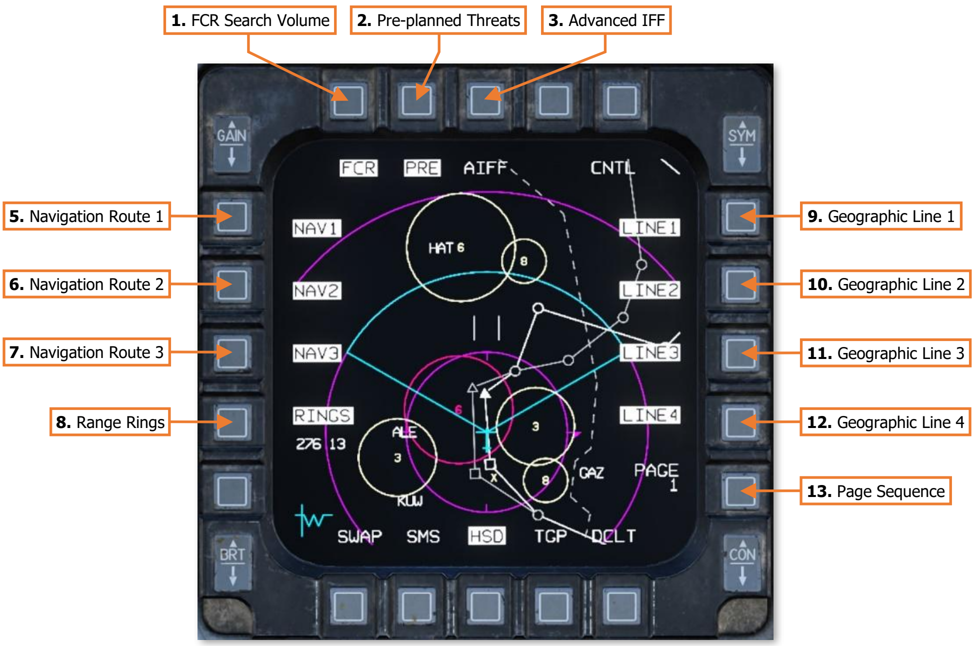
32. **HSD Cursor Bearing & Range.** When the HSD cursor is displayed, this data field will display the bearing (in degrees magnetic) and range (in nautical miles) from the currently selected steerpoint to the HSD cursor. If Bullseye is enabled on the BULL DED page, this data field will display the bearing and range from the Bullseye steerpoint to the HSD cursor.

HSD Control (CNTL) Page

The HSD Control page is accessed by pressing OSB 5 on the base page of the HSD MFD format. The Control page is used to configure which graphic elements are displayed to suit the tactical situation or individual preferences.

HSD Control Page 1

The first page presents options regarding which base level graphics uploaded from the DTC are displayed on the HSD. Enabling/disabling these options will also enable/disable the corresponding option on the HAD Control page, with the exception of PRE (OSB 2), which may be independently toggled on the HSD and HAD Control pages.



1. **FCR Search Volume (FCR).** Toggles the display of the FCR search volume.
2. **Pre-planned Threats (PRE).** Toggles the display of pre-planned threats uploaded from the DTC.
3. **Advanced Identification-Friend-or-Foe (AIFF).** Toggles the display of AIFF interrogation replies. (N/I)
4. **Navigation Route 1 (NAV1).** Toggles the display of navigation route 1 uploaded from the DTC.
5. **Navigation Route 2 (NAV2).** Toggles the display of navigation route 2 uploaded from the DTC.
6. **Navigation Route 3 (NAV3).** Toggles the display of navigation route 3 uploaded from the DTC.
7. **Range Rings (RINGS).** Toggles the display of the range rings and cardinal directions.
8. **Geographic Line 1 (LINE1).** Toggles the display of geographic line/shape 1 uploaded from the DTC.
9. **Geographic Line 2 (LINE2).** Toggles the display of geographic line/shape 2 uploaded from the DTC.
10. **Geographic Line 3 (LINE3).** Toggles the display of geographic line/shape 3 uploaded from the DTC.
11. **Geographic Line 4 (LINE4).** Toggles the display of geographic line/shape 4 uploaded from the DTC.
12. **Page Sequence.** Cycles the MFD to Page 2 of the HSD Control page.

HSD Control Page 2

The second page presents options regarding what forms of datalink information are displayed on the HSD.

13. **Engagement Status (TNDL ENG).** Not implemented.

14. **Reference Point (REF PT).** Not implemented.

15. **Primary Datalink Track Range (PDLT RNG).** Not implemented.

16. **Air Target Tracks (A TGTS).** Toggles the display of Air Target tracks received from Flight/Team members and Donors via TNDL.

17. **Air Surveillance Tracks (A SURV).** Toggles the display of Air Surveillance tracks received from AWACS aircraft via TNDL. These may include hostile aircraft, unknown aircraft, or friendly aircraft that are not TNDL capable but are visible to the AWACS radar and have been determined to be friendly.

18. **Ground Targets/Ground Surveillance Tracks (G TGTS).** Toggles the display of non-friendly ground targets received via SMDL and non-friendly Ground Surveillance tracks received via TNDL. (N/I)

19. **Ground PPLI/Ground Tracks (G FRND).** Toggles the display of TNDL-participant ground unit PPLIs and friendly ground surveillance tracks received via TNDL. (N/I)

20. **SAM Sites (SAM).** Toggles the display of SEAD targets received via TNDL or SMDL.

21. **Ships (SHIP).** Toggles the display of friendly and non-friendly ship positions received via TNDL. (N/I)

22. **Air Targets (A SMDL).** Toggles the display of Air Targets received from Flight/Team members via SMDL. (N/I)

23. **Launch Acceptability Region (LAR).** No function.

24. **Mission Planned Targets (MP).** No function.

25. **Page Sequence.** Cycles the MFD to Page 1 of the HSD Control page.

Expand (EXP) Fields-of-View

If the HSD is the Sensor-Of-Interest (SOI), the HSD Expand fields-of-view may be entered by pressing OSB 3 on the base page of the HSD MFD format or by pressing the Expand/FOV button on the Side Stick Controller (SSC).

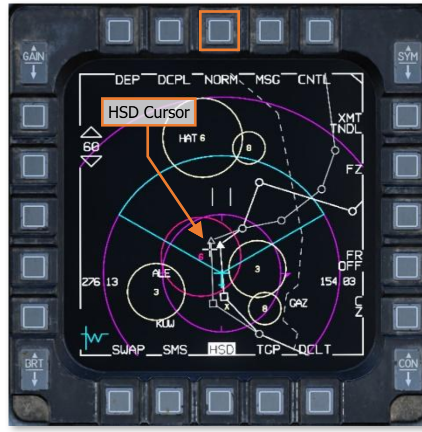
When OSB 3 or the Expand/FOV button is pressed, the HSD will advance to the next field-of-view in a cyclic manner: NORM → EXP1 → EXP2 → NORM. The current field-of-view is displayed below OSB 3.

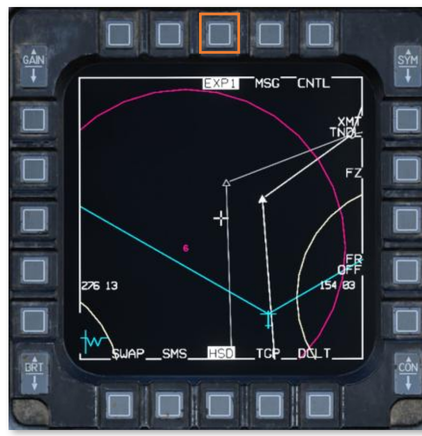
- **NORM.** The HSD is centered/depressed as selected at OSB 1 and is displayed in a normal, 1:1 zoom ratio. The Range Rings and Cardinal Directions are displayed, if enabled at OSB 17 on the HSD Control page.
- **EXP1.** The HSD is centered on the current position of the HSD cursor and switches to a 2:1 zoom ratio. The Range Rings and Cardinal Directions are removed from the HSD.
- **EXP2.** The HSD is centered on the current position of the HSD cursor and switches to a 4:1 zoom ratio. The Range Rings and Cardinal Directions are removed from the HSD.

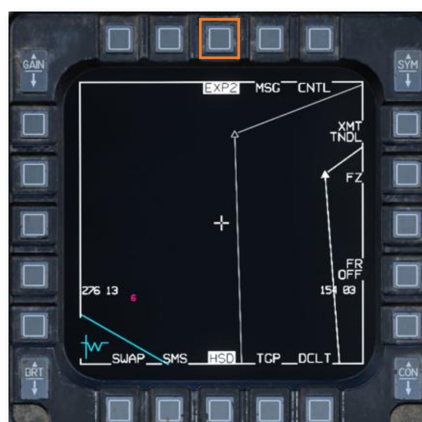
Additionally, the following options are removed from the HSD when EXP1 or EXP2 fields-of-view are entered:

- Centered/Depressed option at OSB 1.
- FCR Range Coupling option at O SB 2.
- Range Scale and Range Scale Increase/Decrease options at OSB 19 and OSB 20.

The Expand fields-of-view may be exited by pressing OSB 3 or the Expand/FOV button on the SSC to cycle back to NORM. The HSD will automatically return to NORM field-of-view if the SOI is assigned to another MFD format or the HUD.



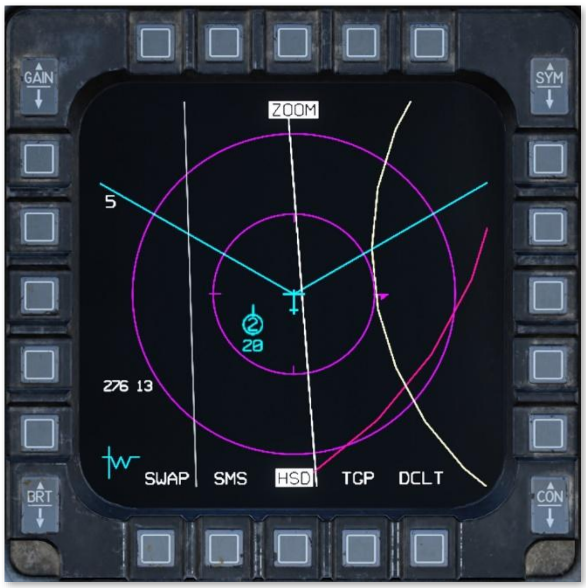




Zoom Mode

The HSD may be momentarily commanded to a range scale required to display all wingmen datalink symbols by pressing and holding the Expand/FOV button on the Side Stick Controller (SSC) for >0.5 seconds, regardless of the current Sensor-of-Interest (SOI). The HSD will automatically enter a Centered (CEN) format around the ownship and will be set to the minimum HSD scale that will encompass the datalink symbols of each Flight member (wingmen 1-4) and each Team member (wingmen 5-8).

Zoom mode provides a means of viewing the immediate surroundings around the ownship, particularly when in formation with other aircraft in which multiple symbols may be clustered around and/or superimposed on the ownship symbol at higher HSD range scales. The range scale limits of the HSD when in Zoom mode are between 5 and 160 NM.



The HSD field-of-view text below OSB 3 will be replaced with "ZOOM" to indicate the HSD is in Zoom mode. Additionally, the following OSB options are removed from the HSD:

- Centered/Depressed format option at OSB 1.
- FCR Range Coupling option at OSB 2.
- Free Text Message Page option at OSB 4.
- Control Page option at OSB 5.
- Datalink Transmit Selection option at OSB 6.
- Freeze Mode option at OSB 7.
- Friendly Declutter Option at OSB 9.
- Range Scale and Range Scale options at OSB 19 and OSB 20.

HSD Zoom mode will be exited upon release of the Expand/FOV button.

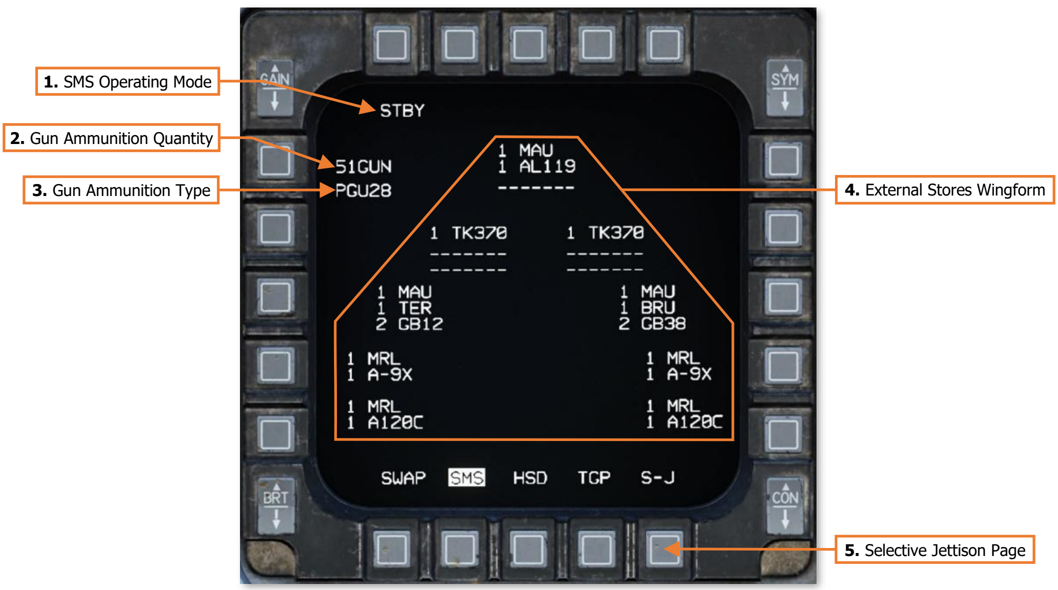
STORES MANAGEMENT SYSTEM (SMS)

The SMS MFD format is used for reviewing and configuring loaded munitions and external stores. SMS weapon profiles and settings are retained for each master mode. When the pilot switches to a different master mode, the SMS base page will be set to the SMS mode corresponding with the retained settings and/or weapon delivery sub-mode for the selected master mode.

See the Air-to-Air Employment and Air-to-Ground Employment chapters for more information regarding specific SMS functions during the employment of weapons.

SMS Inventory (INV) Page

An Inventory page is available that shows external stores loaded on each station. When the aircraft master mode is set to Navigation, Selective Jettison, or Emergency Jettison modes, the SMS Inventory page is displayed as the base page. When the aircraft master mode is set to Air-to-Air Missile, Air-to-Ground, Missile Override, or Dogfight modes, the INV page may be accessed from each respective base page by pressing the INV button (OSB 4).

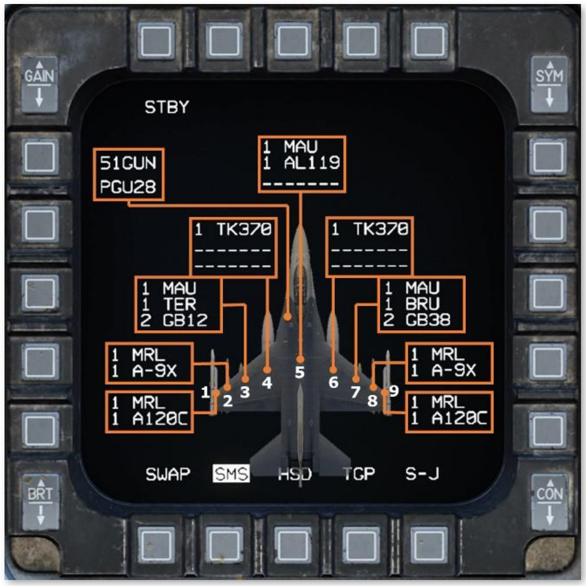


SMS Inventory Page – Navigation mode

1. **SMS Operating Mode.** Displays the operating mode of the of the Stores Management System.
2. **Gun Ammunition Quantity.** Displays the remaining ammunition quantity onboard for the M61 20mm rotary cannon, in 10 round increments (e.g. "51" indicates 510 rounds remaining).
3. **Gun Ammunition Type.** Displays the type of ammunition loaded into the internal ammunition drum. "M56" will be displayed for any M50-series ammunition. "PGU-28" will be displayed for any PGU-series ammunition.
4. **External Stores Wingform.** Displays external stores installed on underwing and center fuselage pylons, including with any associated missile launchers or bomb racks.
5. **Selective Jettison Page.** Selects Selective Jettison mode, overriding the current aircraft master mode.

In addition to the gun ammunition type displayed in the top left corner of the inventory page, the SMS will use a series of weapon and equipment codes to indicate specifically what external stores are loaded onto the underwing and centerline fuselage stations on the aircraft. A list of these codes is provided on the following page.

Stations 1, 2, 8, and 9 may only be equipped with LAU-129 air-to-air missile rails. These stations are displayed in a two-line format, with the LAU-129 Missile Rail Launcher on the first line and the corresponding air-to-air weapon on the second line.



SMS Inventory Page Layout

Stations 3, 4, 5, 6 and 7 may be equipped with a variety of external stores, including air-to-air or air-to-ground munitions, fuel tanks, and ECM or travel pods. These stations are displayed in a three-line format. Depending on the combination of external munitions or equipment that is installed on these stations, the station data may be composed of one, two or three lines of data.

In the example above, stations 3, 5, and 7 are installed with a MAU-12 Ejector Rack. However, the MAU-12 installed on station 3 is carrying a TER-9/A Triple Ejector Rack loaded with a pair of GBU-12 laser-guided bombs and station 7 is carrying a BRU-57/A Smart Multiple Carriage Rack loaded with a pair of GBU-38 inertially-aided bombs, whilst the MAU-12 on station 5 is simply carrying an ECM pod.

SMS Weapon/External Stores Codes

CODE	MUNITION/EQUIPMENT	CODE	MUNITION/EQUIPMENT
M56	M50-series 20mm ammunition	MAU	MAU-12 Ejector Rack
PGU28	PGU-series 20mm ammunition	TER	TER-9/A Triple Ejector Rack
		MRL	LAU-129A/A Missile Rail Launcher
TA9LM	CAP-9M Captive Air Training Missile	L03	LAU-3/A 19-tube Rocket Launcher
A-9J	AIM-9P IR-guided missile	L68	LAU-68D/A 7-tube Rocket Launcher
A-9NP	AIM-9P3 IR-guided missile	L131	LAU-131/A 7-tube Rocket Launcher
A-9LM	AIM-9P5, -9L, or -9M IR-guided missile	L88A	LAU-88/A Triple Rail Missile Launcher
A-9X	AIM-9X IR-guided missile	L117	LAU-117A(V)3/A Maverick Missile Launcher
A120B	AIM-120B active radar-guided missile	L118	LAU-118(V)2/A Guided Missile Launcher
A120C	AIM-120C active radar-guided missile	BRU	BRU-57/A Smart Multiple Carriage Rack
ACMI	AN/ASQ-T50 TCTS pod	TK300	300-gallon external centerline tank
AL131	AN/ALQ-131 ECM pod	TK370	370-gallon external wing tank
AL119	AN/ALQ-184 ECM pod		
		GB12	GBU-12 or BDU-50LGB laser-guided bomb
BD33T	BDU-33 practice bomb	GB10C	GBU-10C/B laser-guided bomb
B49	Mk-82 AIR or BDU-50HD with BSU-49	GB24A	GBU-24A/B laser-guided bomb
M82	Mk-82 or BDU-50LD bomb	GB31A	GBU-31(V)1/B INS/GPS-guided bomb
M82S	Mk-82 bomb with Mk15 Snakeye pedals	GB31B	GBU-31(V)3/B INS/GPS-guided bomb
M84	Mk-84 bomb	GB38	GBU-38 INS/GPS-guided bomb
B50	Mk-84 AIR bomb with BSU-50		
BD50	Mk-84 AIR practice bomb with BSU-50	CB103	CBU-103 INS/GPS-guided cluster bomb
		CB105	CBU-105 INS/GPS-guided cluster bomb
CB87B	CBU-87 with 202 BLU-97B submunitions		
CB97B	CBU-97 with 40 BLU-108 submunitions	AG65D	AGM-65D IR-guided missile 125lb warhead
		AG65G	AGM-65G IR-guided missile 300lb warhead
M151	M151 high explosive rockets	AG65H	AGM-65H TV-guided missile 125lb warhead
M156	M156 white phosphorus rockets	AG65K	AGM-65K TV-guided missile 300lb warhead
M5	Mk5 high explosive anti-tank rockets	AG88	AGM-88C anti-radar guided missile
M61	Mk61 or WTU-1/B training rockets	A154A	AGM-154A INS/GPS-guided glide bomb

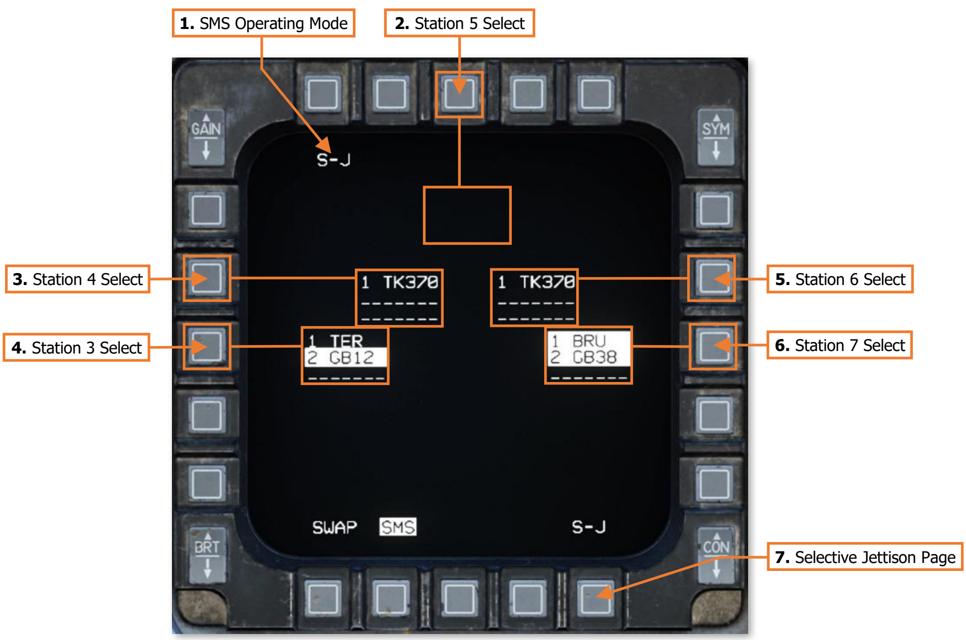
SMS Selective Jettison (S-J) Page

The Selective Jettison page facilitates jettison of individual weapons and/or weapon racks from the external stations. This allows the pilot to have greater control over what is physically jettisoned from the aircraft. Only external stores that are capable of being jettisoned will be displayed on the SMS Selective Jettison page. These include external fuel tanks, air-to-ground weapons, and air-to-ground weapon racks. Air-to-air missiles, air-to-air missile rails, and ECM/Travel pods cannot be jettisoned and will not be displayed.

When OSB 11 is pressed on the SMS MFD format, Selective Jettison master mode is entered, the SMS Selective Jettison page is displayed on the SMS MFD format, and "JETT" will be displayed in the HUD Master Mode Status. Pressing OSB 11 again while the SMS Selective Jettison page is already displayed will exit the Selective Jettison master mode and return to the previous master mode. Alternatively, if any other master mode is selected, Selective Jettison mode will be exited.

External stores are selected by pressing the corresponding OSB for that external wing or fuselage station. Any items that are highlighted in white are selected for jettison. If more than one item exists on a given station, the first press of the corresponding OSB will enable the lowest external store (shown below on Station 3), and the second press of the OSB will highlight the next highest external store (shown below on Station 7). An additional press will disable jettison for all items on that station and the stores will be de-highlighted.

If the Weapon Release button on the Side Stick Controller is pressed while the SMS Selective Jettison page is displayed, any highlighted external stores will be jettisoned in an unarmed state, regardless of whether the MASTER ARM switch is set to MASTER ARM, OFF, or SIMULATE.



SMS Selective Jettison page

1. **SMS Operating Mode.** The SMS is in Selective Jettison mode and will display any external stores that may be selected for jettison.

2. **Station 5 Select.** Selects the centerline fuselage pylon for jettison. This option will only be displayed when a 300-gallon external centerline tank is loaded.

3. **Station 4 Select.** Selects the left inboard underwing pylon for jettison. This option will only be displayed if a 370-gallon external wing tank is loaded or if an air-to-ground weapon and/or weapon rack is loaded.
4. **Station 3 Select.** Selects the left middle underwing pylon for jettison. This option will only be displayed when an air-to-ground weapon and/or weapon rack is loaded.
5. **Station 6 Select.** Selects the right inboard underwing pylon for jettison. This option will only be displayed if a 370-gallon external wing tank is loaded or if an air-to-ground weapon and/or weapon rack is loaded.
6. **Station 7 Select.** Selects the right middle underwing pylon for jettison. This option will only be displayed when an air-to-ground weapon and/or weapon rack is loaded.
7. **Selective Jettison Page.** Exits Selective Jettison mode, returning the aircraft to the previous master mode.

Selecting individual Stores or Stations for Jettison

To selectively jettison individual munitions, missile launchers, rocket launchers, bomb racks, or external fuel tanks, perform the following:

1. MFD format – Select **SMS**, as necessary.
2. SMS OSB 11 – Select **S-J** page.
3. SMS OSB 3 – Select to enable jettison of the centerline fuel tank from station 5, as desired.
4. SMS OSB 19/7 – Select once to enable jettison of the external wing tanks or the munitions loaded under stations 4 and 6, as desired.

   or

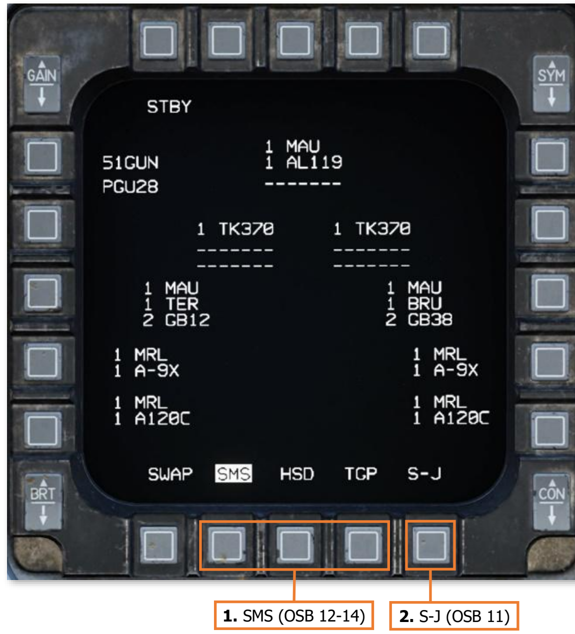
4. SMS OSB 19/7 – Select twice to enable jettison of the munitions and munition carriage racks loaded under stations 4 and 6, as desired.
5. SMS OSB 18/8 – Select once to enable jettison of the munitions loaded under stations 5 and 7, as desired.

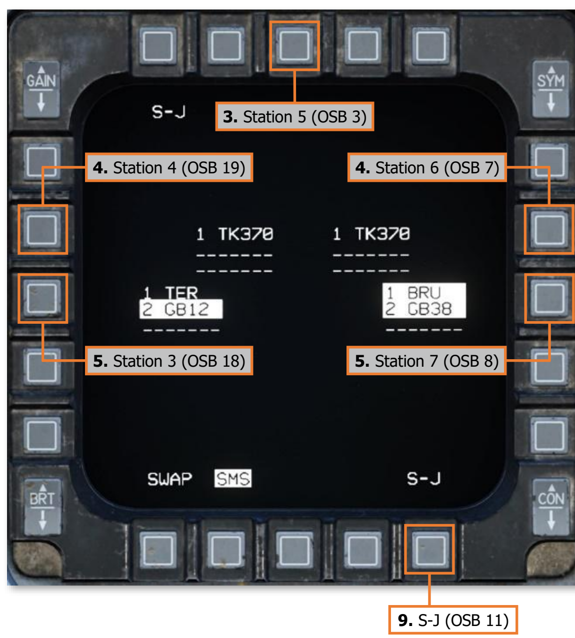
   or

5. SMS OSB 18/8 – Select twice to enable jettison of the munitions and munition carriage racks or launchers loaded under stations 5 and 7, as desired.
6. MASTER ARM switch – **MASTER ARM**.
7. **Weapon Release** Button – Press.

   or

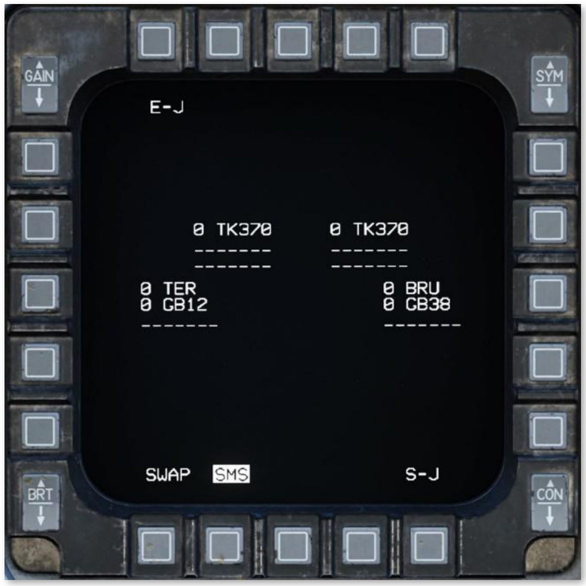
7. **ALT REL** Button – Press.
8. MASTER ARM Switch – **OFF**, or as desired.
9. SMS OSB 11 – De-select **S-J** page.





SMS Emergency Jettison (E-J) Page

When the Emergency Jettison button is pressed on the Left Auxiliary Console, the Emergency master mode is entered, overriding the existing master mode, and the SMS Emergency Jettison page is displayed on the SMS MFD format. "JETT" will be displayed in the HUD Master Mode Status. Releasing the Emergency Jettison button will exit Emergency Jettison mode and return to the previous master mode.



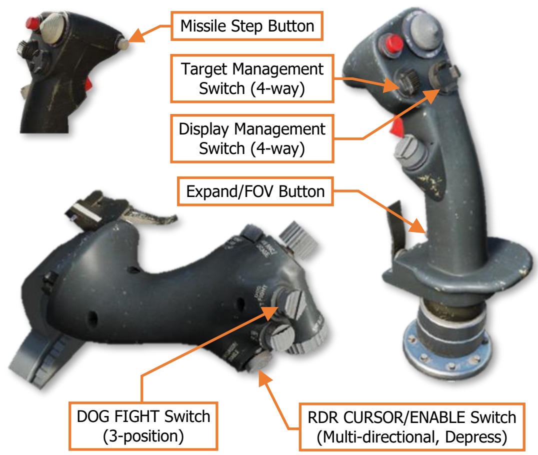
SMS Emergency Jettison page

Like the SMS Selective Jettison page, the Emergency Jettison page only displays external stores that can and have been jettisoned. These include external fuel tanks, air-to-ground weapons, and air-to-ground weapon racks. Air-to-air missiles, air-to-air missile rails, and ECM/Travel pods cannot be jettisoned and will not be displayed.

HANDS-ON CONTROLS

The Display Management Switch (DMS), Target Management Switch (TMS) and Expand/FOV button on the Side Stick Controller (SSC), along with the RDR CURSOR/ENABLE switch on the throttle grip, are the pilot's controls for selecting a Sensor-Of-Interest (SOI), changing MFD formats, designating targets seen visually by the pilot, or manually slewing existing designations or sighting points.

The Missile Step button on the SSC is the pilot's control for cycling between Air-to-Air or Air-to-Ground weapon delivery sub-modes. The DOG FIGHT switch on the throttle grip allows the pilot to rapidly transition to an air-to-air combat mode from an existing master mode when an imminent threat to the aircraft exists from hostile fighters.



Throttle Grip Commands. The RDR CURSOR/ENABLE switch is multi-directional, allowing the HUD TD Box or HSD cursor to be moved in any direction.

Side Stick Controller (SSC) Commands. The Target Management Switch (TMS), Missile Step button, and Expand/FOV button commands are contextual, based on the SOI, master mode, whether a HUD or HMCS designation exists; and in some cases the current weapon profile selected on the SMS MFD format.

DOG FIGHT
- Select Dogfight Mode
- Return to previous Mode
- Select Missile Override Mode

RDR CURSOR ENABLE
- C: **HSD** Slew HSD Cursor; **HUD** Slew VRP/VIP Cursor

- S: Short press (<0.5 sec)
- L: Long press (>0.5 sec)
- C: Continuous press

TMS
- Up, S: **HSD** Display threat ring (if hidden); **HSD** Designate selected steerpoint/PDLT; **HUD** Designate RP/IP
- Up, L: **HUD** Set SOI to HMCS
- Right, S: **HUD** Cycle Sighting Point [3]; **FCR** Cycle Sighting Point [3]
- Down, S: **HSD** Hide threat ring (if shown); **HSD** Drop PDLT designation; **HUD** DTOS/VIS Target Reject; **HMCS** Return SOI to HUD [4]

MSL STEP
- S: Missile Step; Cycle CCIP-DTOS-CCRP [1]
- L: Cycle A-A Missile Type [2]

DMS
- Up, S: Set SOI to HUD
- Left, S: Cycle Left MFD Format
- Right, S: Cycle Right MFD Format
- Down, S: **HUD** Set SOI to MFD; Swap SOI between MFDs
- Down, L: Toggle HDU On/Off

EXP/FOV
- S: **HSD** Cycle HSD EXP Modes
- C: Display HSD ZOOM Mode

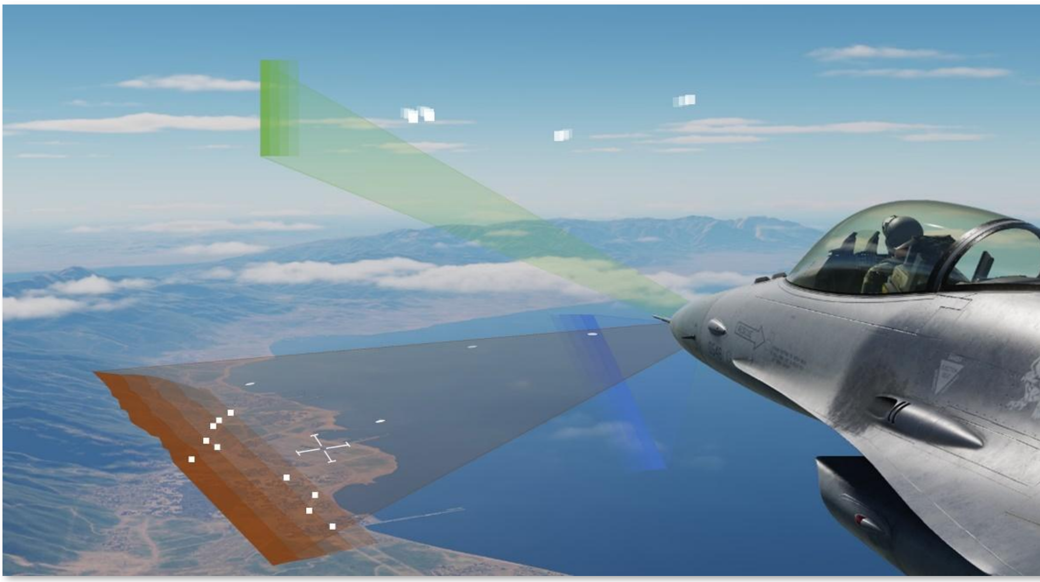
1. Master mode must be Air-to-Ground (A-G), and AGM-65 or AGM-88 not selected on the SMS MFD format.
2. Master mode must be Air-to-Air Missile (AAM), Missile Override (MSL), or Dogfight (DGFT).
3. Master mode must be Navigation (NAV), or Air-to-Ground (A-G) and set to a "Pre-planned" weapon delivery sub-mode.
4. An existing HMCS designation must be rejected before SOI can be returned to the HUD from the HMCS.

APG-68 FIRE CONTROL RADAR

USAF Photo
by A1C Jordyn Fetter

AN/APG-68 FIRE CONTROL RADAR

The Westinghouse AN/APG-68(V)5 is a digital pulse-Doppler radar that functions as the F-16C's Fire Control Radar (FCR). The APG-68 includes a variety of air-to-air and air-to-ground modes that enables the F-16C to simultaneously detect, track, and engage multiple aircraft within its scan volume, or perform all-weather strikes against large man-made structures or moving ground vehicles.



AN/APG-68 Detection, Targeting, and Ground Mapping

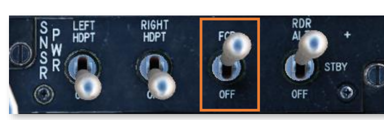
The APG-68 occupies the forward nose section of the F-16's fuselage and consists of a mechanically-steered planar array antenna, a dual mode transmitter, a modular low power radio frequency processor, and a programmable signal processor. The radar antenna itself is capable of scanning up to 60° in azimuth and elevation from the aircraft centerline and may employ multiple scan patterns to search a large volume of airspace; or may be directed against a singular target location to provide continuous tracking and ranging against an airborne or surface target.

The FCR interfaces seamlessly with the F-16C master modes and Hands-On Controls, allowing the pilot to switch between air-to-air and air-to-ground radar modes simply by selecting a corresponding master mode, and controlling the FCR scan volume and direction or designating targets using switches and buttons located on Side Stick Controller (SSC) and throttle grip.

Fire Control Radar Activation

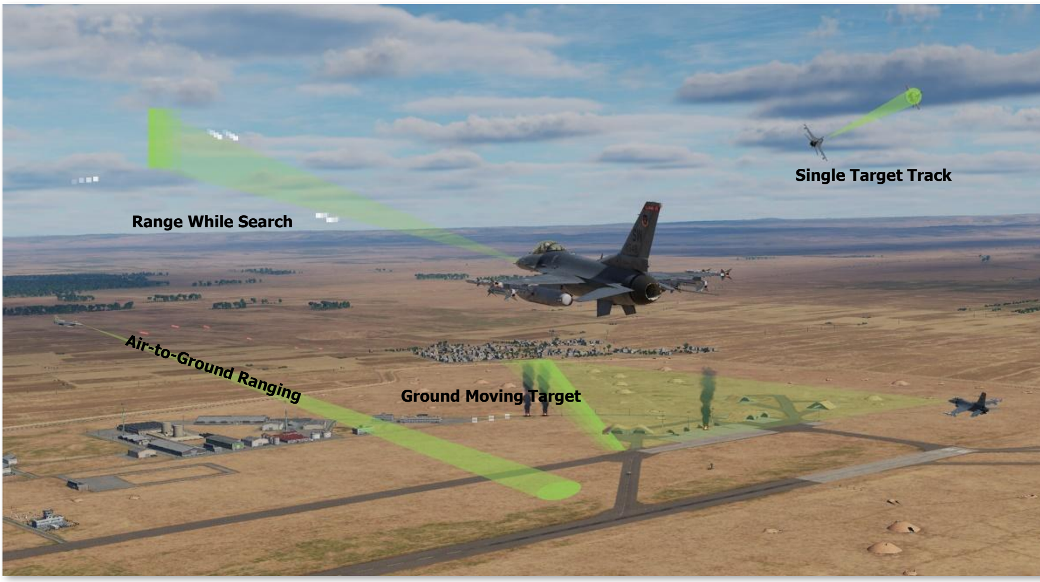
The FCR is powered by positioning the FCR switch to the forward position on the SNSR PWR control panel.

The FCR cannot function without the MMC or MFD avionics systems, or without an aligned INS.



Employment of the Fire Control Radar

The APG-68 FCR is the F-16C's primary sensor and provides the aircraft with an integrated fire control capability. The FCR includes a number of operational modes for providing line-of-sight, position, and target data to the Modular Mission Computer (MMC), navigation updates, sensor cueing to the targeting pod (if installed), and targeting for weapons employment across all air-to-air and air-to-ground missions the F-16C may perform.



AN/APG-68 Target Detection, Ranging, and Tracking

When employed in an air-to-air role, the FCR may be used for beyond visual range (BVR) engagement of hostile aircraft and is capable of supporting radar-guided missile engagements against multiple targets simultaneously. If engaging hostile aircraft within visual range (WVR), the FCR may be used to cue heat-seeking missiles to targets in the forward sector or perform aerial gunnery calculations against maneuvering targets.

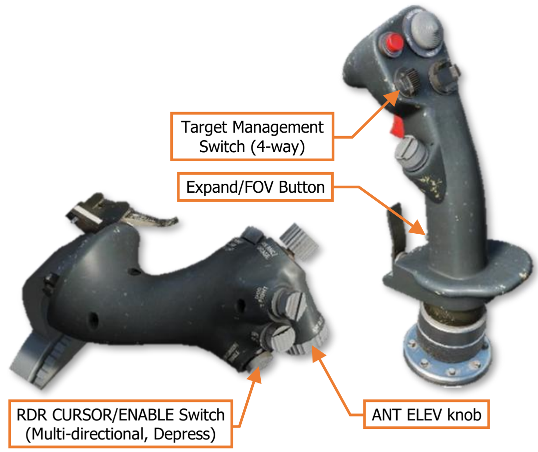
When employed in an air-to-ground role, the FCR may be used for ground mapping to refine targeting solutions against large radar-detectable ground objects, detecting and tracking moving ground vehicles amongst the terrain, detecting large surface vessels at sea, or performing ranging calculations for accurate delivery of ballistic munitions such as unguided bombs, rockets, or gun strafing.

When employed during navigation, the FCR may be used to perform a position fix relative to known, radar-detectable landmarks to update the INS navigation solution in flight, perform a radar-assisted rendezvous with other aircraft at night or inclement weather conditions, or may be used to assist in avoiding other aircraft in congested airspace.

When on the ground (weight-on-wheels), FCR transmissions are inhibited.

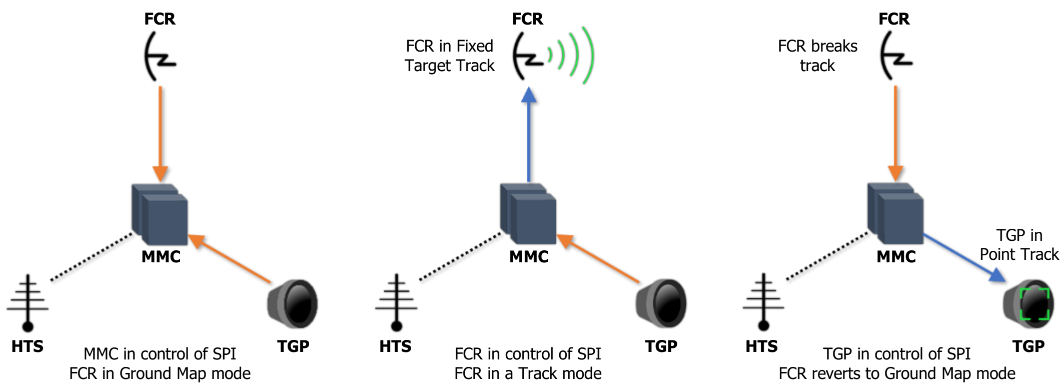
Slew and Tracking Controls

Operation of the APG-68 FCR is integrated with the cockpit Hands-On Controls. The FCR's functions are primarily controlled using the Target Management Switch (TMS) and the Expand/Field-Of-View button on the Side Stick Controller (SSC), the RDR CURSOR/ENABLE switch on the throttle grip to slew the Acquisition Cursor on the FCR MFD format, and the ANT ELEV knob on the throttle grip to adjust the FCR antenna elevation angle.



The FCR is also integrated into the F-16 avionics and cockpit interface as its primary sensor. When operating in their respective air-to-ground modes, each of the F-16's sensors are focused onto a single geographic location in the battlespace known as the System-Point-of-Interest (SPI). The SPI may be controlled by the Modular Mission Computer (MMC) or any of the aircraft sensors themselves.

When the MMC is in control of the SPI, each of the aircraft sensors will remain slaved to the SPI. If the FCR is in Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes, the FCR Acquisition Cursor coincides with the 3-dimensional location of the SPI. If the SPI moves, the Acquisition Cursor will slew with it; and if the Acquisition Cursor is slewed, the SPI will move with it.



F-16C Sensor Slave & Tracking Logic

If the FCR is in GM, GMT, or SEA mode and enters a tracking state (Fixed Target Track or Ground Moving Target Track), the FCR itself will determine the position of the SPI. If the TGP is in A-G mode and was tracking a surface target or location, the TGP will break track and the sensor turret's line-of-sight will slave to the FCR-controlled SPI. If an HTS-detected radar threat was designated on the HAD MFD format, the designation will be dropped.

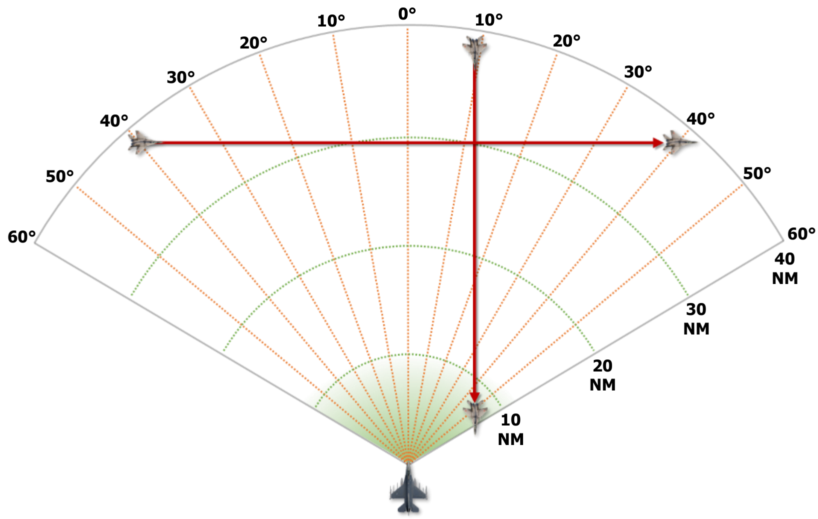
Accordingly, if the TGP is in A-G mode and enters a tracking state, or a radar threat is designated on the HAD MFD format, the FCR will break track and the Acquisition Cursor on the FCR MFD format will slave to the TGP- or HTS-controlled SPI.

It is worth noting that the singular SPI logic only applies when the F-16 sensors are operating in their respective air-to-ground modes. If the FCR and/or TGP are operating in air-to-air modes, they may be commanded to track an airborne target independently of the other sensors, to include simultaneously tracking two separate aircraft.

Radar Display

The FCR MFD format presents radar information in two display formats, depending on the selected FCR mode.

Plan Position Indicator (PPI). When the FCR is set to Ground Map, Ground Moving Target, or Sea modes, the MFD presents radar information in a radial format. (See FCR Air-to-Ground Modes for more information.)



Plan Position Indicator (PPI) Radar Display

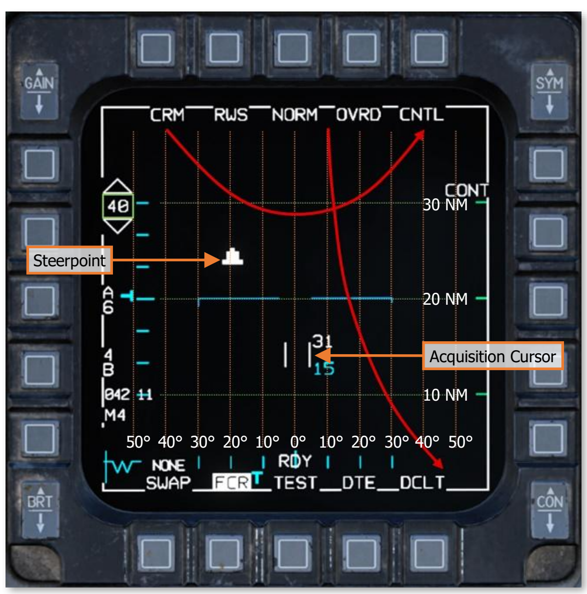
B-Scope. When the FCR is set to Combined Radar Mode or Air Combat Mode, the MFD presents radar information in a rectilinear format. Targets are displayed in the horizontal axis to represent the relative azimuth of the target from the nose, up to 60° to either side, and in the vertical axis to represent range, in nautical miles (NM)

As an example in the MFD image on the right, the steerpoint is 20° left of the nose at 24 NM and the Acquisition Cursor is placed directly ahead of the nose at approximately 14 NM.

If two targets are flying in a straight line like in the PPI image above, with one target flying perpendicular and the other flying parallel to the F-16, their movement across a B-scope would be as shown in the image on the right. For the purposes of the illustrations on this page, the trajectories are drawn as if the F-16 is stationary with no relative velocity, and the orange and green lines shown on the MFD are notionally depicted to illustrate the rectilinear presentation of the same information.

It is worth noting that the range values along the right side of the MFD correspond to quarter segments of the currently selected Range Scale (Green Box) between OSB 19 and 20, rather than fixed numerical values.

See FCR MFD Format for more information.



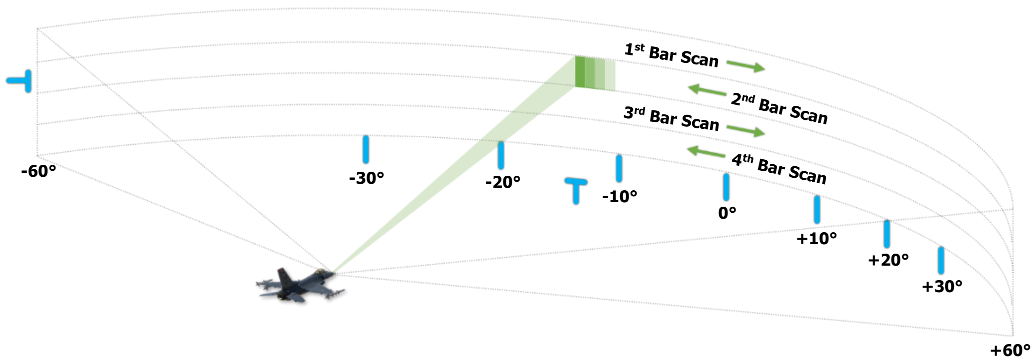
Scan Patterns

Like many radar systems, the FCR antenna is mechanically steered to direct the radar beam. As the radar beam is steered in azimuth and elevation, a given volume of 3-dimensional space may be systematically scanned by the radar beam within each scan pattern. This is known as the FCR search volume and may vary based on the selected FCR mode, the selected azimuth width and elevation bar settings within the cockpit, and the orientation of the search volume itself in relation to the aircraft fuselage, which can be steered using the Hands-On Controls.

The scan patterns within the FCR search volume will also vary based on whether the FCR is in an air-to-air or air-to-ground mode, as either a multiple-bar scan pattern or a single-bar scan pattern. In addition, separate Azimuth Scan Width and Elevation Bar Scan settings are retained for each CRM sub-mode and are automatically set when returning to the corresponding sub-mode. (See Azimuth, Range, and Elevation Control for more information.)

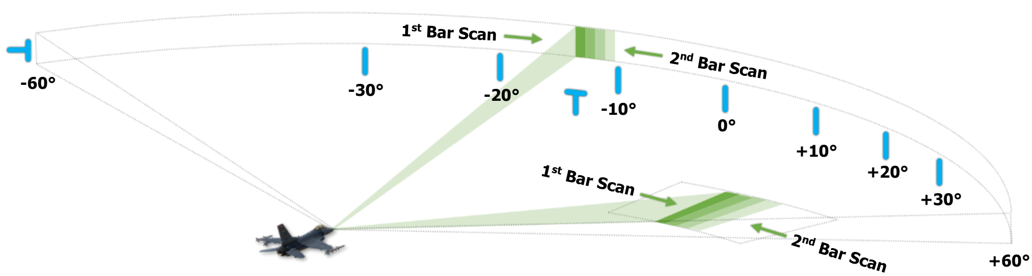
Bar Scan Patterns

When the FCR is set to Combined Radar Mode (CRM) or Air Combat Mode (ACM), the antenna will search a defined volume of airspace using multiple-bar scans, in which the antenna scans adjacent blocks of airspace within the larger search volume. This allows the FCR to search a 3-dimensional volume many times larger than would be captured within one sweep of the antenna's main radar beam. The number of bars within a given scan pattern and the length and direction of each bar scan will vary depending on the FCR sub-mode or settings chosen from within the cockpit.



Multiple-Bar Search Volume

When the FCR is set to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes, the antenna will search a defined surface area using a single-bar scan. The FCR antenna will simply scan left and right in a repeating pattern at a defined elevation and range, or while focused on a fixed geographical location for attaining higher resolution radar imagery of a small surface area.

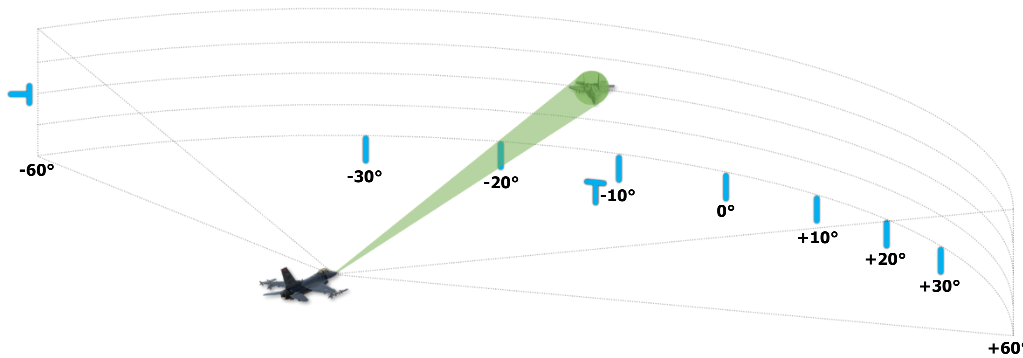


Single-Bar Search Volume

The pilot may also select a single-bar scan pattern in Combined Radar Mode (CRM) to focus the FCR scan pattern within a narrow block of airspace if necessary.

Target Tracking

When the FCR is in Single Target Track, Fixed Target Track, or Ground Moving Target Track, the antenna will be pointed directly toward the target so the radar beam can dwell on the target itself. This allows the FCR to generate reliable tracking data on the target, which may include position, altitude, course, and velocity. When the FCR is in Air-to-Ground Ranging, the antenna is directed at the calculated weapon impact point so the FCR can generate reliable range data to increase the delivery accuracy of ballistic munitions such as unguided bombs or gun strafing.

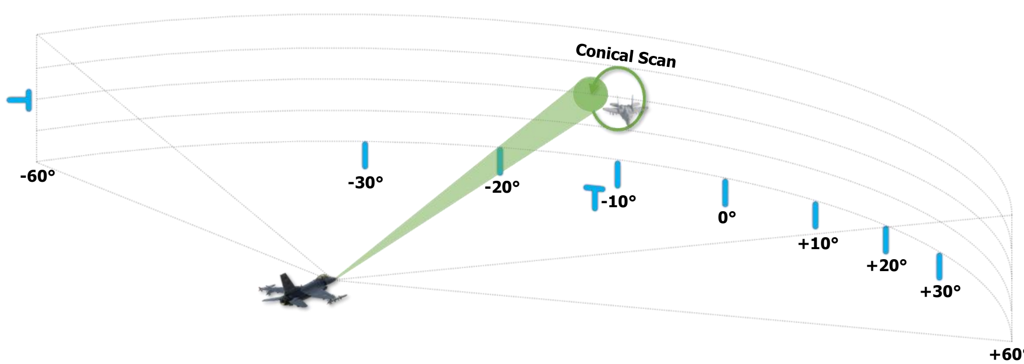


Target Tracking

When the FCR is in Dual Target Track, the antenna is alternately pointed at two close-range targets in a sequential manner, briefly dwelling on each target. When in Situation Awareness Mode, the antenna alternates between performing a multiple-bar or single-bar scan pattern to search for targets and periodically dwelling on one or two targets to generate reliable tracking data.

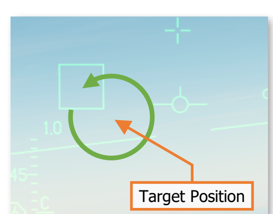
Mini-Search Conical Scan

If a target has been designated as the FCR Target-Of-Interest (FCR TOI) but the FCR loses track of the target, the FCR will attempt to re-acquire the target using a "Mini-Search" scan before dropping the track completely.



Mini-Search Scan

When a Mini-Search scan is performed, the antenna will be slewed in a conical scan pattern around the target's last known position. During the conical scan, the A-A Target Designator (TD) Box in the HUD/HMCS will spin in a counterclockwise direction. If the target cannot be re-acquired within two seconds, the Mini-Search will be terminated and the FCR TOI will be dropped.



A Mini-Search scan will only be performed in TWS, SAM, or DTT sub-modes when an FCR TOI has been designated. A Mini-Search scan may also occur in Single Target Track (STT) but is less likely due to higher track reliability.

Azimuth, Range, and Elevation Control

The radar antenna is mechanically steered in the horizontal and vertical axes by drive motors within the nose radome housing. The drive motors can steer the radar antenna up to 60° off-boresight from the nose for a total gimbal range of 120° in both azimuth and elevation, at a maximum gimbal rate of approximately 60° per second.

The radar antenna itself is not directly steered by the pilot in azimuth or elevation (except when using HMCS Cueing in ACM BORE sub-mode). Rather the entire FCR search volume may be slewed using the RDR CURSOR/ENABLE switch and/or the ANT ELEV knob on the throttle grip. (See Hands-On Controls for more information.)

- When the FCR is in Combined Radar Mode (CRM), Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA) modes, the RDR CURSOR/ENABLE switch may be used to slew the FCR search volume in azimuth and change the FCR Range Scale. The ANT ELEV knob may be used to slew the FCR search volume in elevation.
- When the FCR is in Air Combat Mode (ACM) and set to SLEW sub-mode the RDR CURSOR/ENABLE switch may be used to slew the FCR search volume in azimuth and elevation.
- When the FCR is in Air Combat Mode (ACM) and set to 30×20, 10×60, or BORE sub-modes, or is in Air-to-Ground Ranging (AGR), the FCR search volume is fixed and cannot be slewed in azimuth nor elevation.

In addition, the manner in which the FCR search volume is oriented or slewed in relation to the aircraft will vary depending on the antenna stabilization method for the current FCR mode and sub-mode.

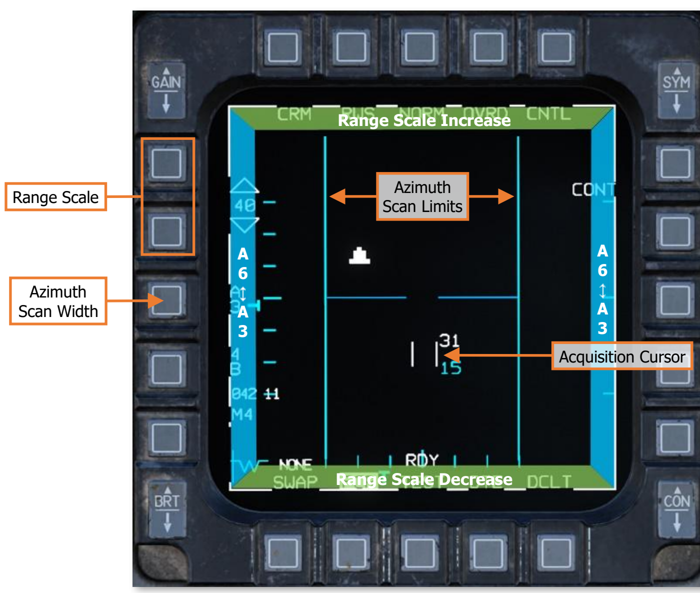
Azimuth and Range Control

If the Azimuth Scan Width setting is set to A6 (±60° to either side of the nose), the FCR search volume will be centered on the nose and cannot be slewed.

If the Azimuth Scan Width setting is set to A3, A2, or A1, the FCR search volume will be centered on the Acquisition Cursor, which may be slewed using the RDR CURSOR/ENABLE switch on the throttle grip. Two vertical Azimuth Scan Limit lines will be displayed to represent the scan width of the FCR search volume.

If the Acquisition Cursor is slewed to the left or right boundary (Shaded Area) of the MFD display area using the RDR CURSOR/ENABLE switch, the azimuth scan width will be "bumped" between A6 and A3 settings. Alternatively, OSB 18 may be pressed to cycle through the available Azimuth Scan Width settings for the current FCR mode and sub-mode.

If the Acquisition Cursor is slewed beyond the upper or lower limits (Shaded Area) of the current range scale using the RDR CURSOR/ENABLE switch, the range scale will be "bumped" to the next higher or lower setting in sequence. Alternatively, OSB 19 and 20 may be pressed to manually adjust the range scale.



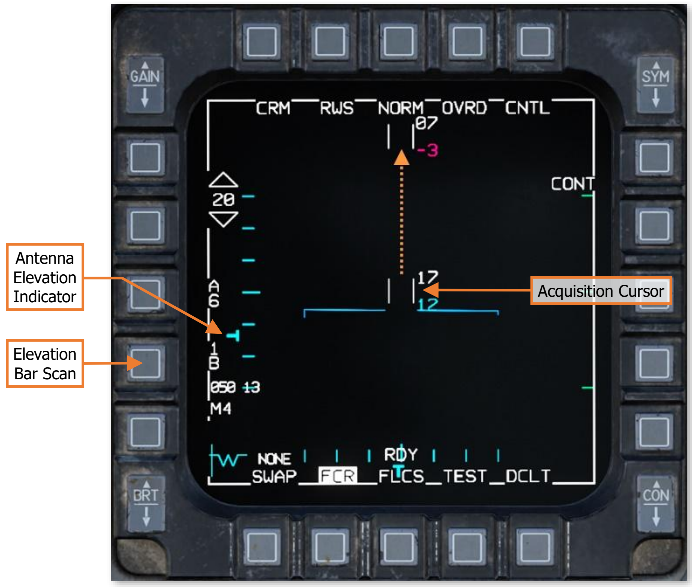
NOTE: The automatic range scale switching based on Acquisition Cursor movement may be disabled in GM, GMT, or SEA modes. (See FCR MFD Format for more information.)

Elevation Control

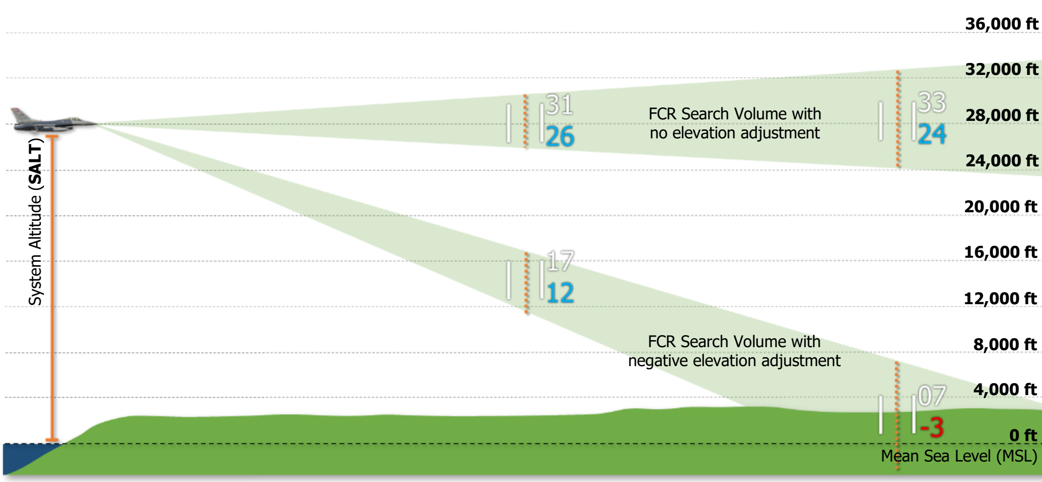
The vertical coverage of the FCR search volume is determined by the Elevation Bar Scan setting. Increasing the number of bars within the scan pattern increases the volume of airspace that is scanned by FCR, at the expense of increasing the time needed to perform a single scan of the FCR search volume. OSB 17 may be pressed to cycle through the available Elevation Bar Scan settings. (See Scan Patterns for more information.)

The entire FCR search volume itself may be adjusted in elevation using the ANT ELEV knob on the throttle. (See Hands-On Controls for more information.)

Adjusting the antenna elevation does not alter the volume of airspace that is scanned by the FCR. Rather it directs the entire FCR search volume upwards or downwards relative to the inertial horizon, as shown in the figure below. The vertical coverage of the FCR search volume is displayed to the right of the Acquisition Cursor on the FCR MFD format, corresponding with the upper and lower altitude limits (in thousands of feet above mean sea level, or MSL) at the position of the cursor itself, based on the ownship altitude, antenna elevation setting, and elevation bar scan setting.



If the Acquisition Cursor is slewed, the FCR antenna elevation is adjusted, a different Elevation Bar Scan setting is selected, or the aircraft ascends or descends in altitude, the cursor altitude values will update accordingly.

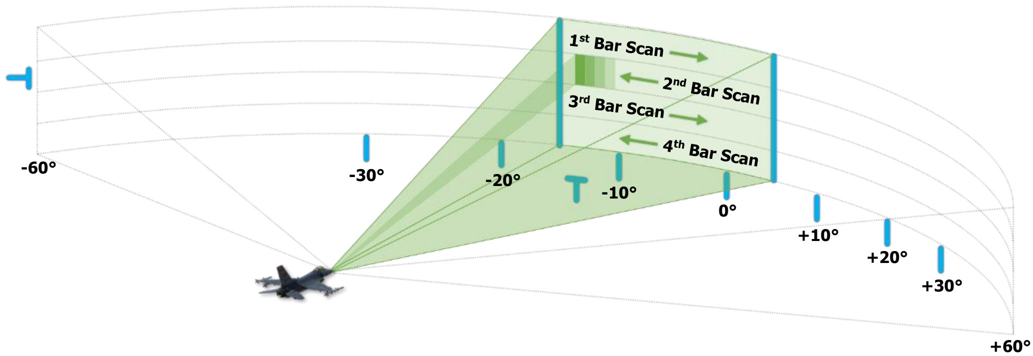


FCR Search Volume Altitude Limits (1-bar 20 NM Range Scale)

NOTE: When the FCR is set to the ACM sub-modes of 30×20, 10×60, or BORE, the FCR antenna is stabilized to the fuselage rather than the inertial horizon. (See Antenna Stabilization for more information.)

Spotlight Scan

If the FCR is set to Range While Search (RWS) or Track While Scan (TWS) sub-modes, and no target has been designated as the FCR Target-Of-Interest (FCR TOI), the pilot may utilize "Spotlight Scan" mode to focus the FCR search volume along a narrow sector of airspace to aid in detection and/or acquisition of airborne targets. This will reduce the search volume to approximately 17% of the maximum search volume, rapidly increasing the scan rate of the airspace within the Spotlight Scan and increasing the probability of detection, especially at longer ranges.



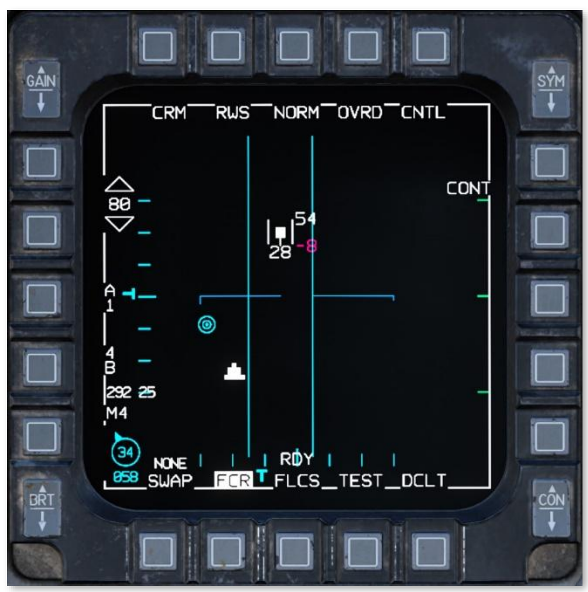
±10° 4-Bar Spotlight Scan (A1, 4B)

If TMS Forward is pressed and held, the current Azimuth Scan Width and Elevation Bar Scan settings will be temporarily overridden and the FCR will enter a ±10° 4-bar scan pattern, centered on the Acquisition Cursor, for the duration that TMS is held to the forward position.

When Spotlight Scan mode is enabled, the RDR CURSOR/ENABLE switch and ANT ELEV knob on the throttle grip may be used to adjust the FCR search volume in azimuth, range, and elevation. (See Azimuth, Range, and Elevation Control for more information.)

If TMS Forward is released while the Acquisition Cursor is over a target symbol, as shown in the image on the right, the target will be designated as the FCR TOI and the FCR will enter Single Target Track (STT) mode.

If TMS Forward is released while the Acquisition Cursor is not over a target symbol, the FCR will revert to the previous Azimuth Scan Width and Elevation Bar Scan settings.

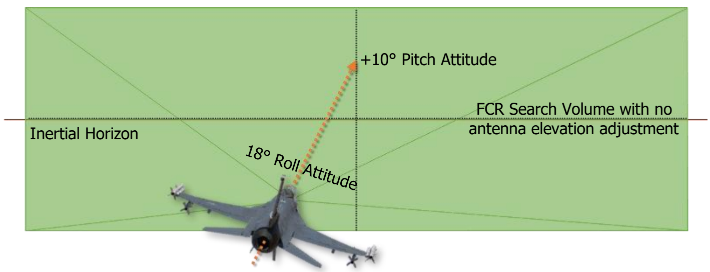


Antenna Stabilization

As described in the Azimuth, Range, and Elevation Control section on the previous pages, the FCR antenna itself is steered by the FCR electronics to perform the appropriate scan pattern within the FCR search volume. However, depending on the selected FCR mode and sub-mode, the FCR search volume as a whole may be oriented in relation to the inertial horizon, a geographic location on the surface, or the F-16 fuselage itself as the aircraft changes attitude.

Space Stabilization

If the FCR search volume is slewed and oriented in three-dimensional space independently of the orientation of the aircraft fuselage, the FCR antenna is using a "space stabilization" method.



Space Stabilization

The FCR search volume will be stabilized relative to the inertial horizon in roll and pitch but referenced to the aircraft heading when set to the following modes/sub-modes.

- Combined Radar Mode (CRM), all sub-modes.
- Air Combat Mode (ACM), SLEW sub-mode only.
- Ground Map (GM), when not in DBS1 or DBS2 formats.
- Ground Moving Target (GMT).
- Sea (SEA).
- Air-to-Ground Ranging (AGR).

The FCR search volume will be stabilized relative to a geographic location on the surface when set to the following modes/sub-modes.

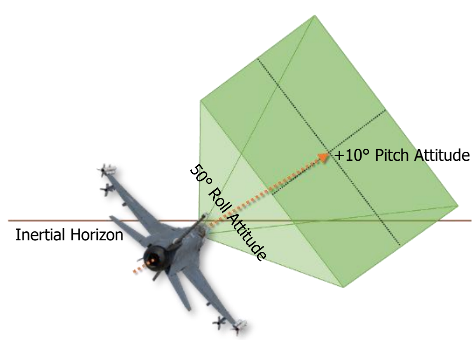
- Ground Map (GM), when in DBS1 or DBS2 format.
- Fixed Target Track (FTT).
- Ground Moving Target Track (GMTT).

Body Stabilization

If the FCR search volume is slewed and oriented in relation to the attitude of the aircraft fuselage, the FCR antenna is using a "body stabilization" method.

The FCR search volume will be stabilized relative to the aircraft fuselage in all axes when set to the following modes/sub-modes.

- Air Combat Mode (ACM), 30×20 sub-mode.
- Air Combat Mode (ACM), 10×60 sub-mode.
- Air Combat Mode (ACM), BORE sub-mode.



Body Stabilization

Radar Detection and Processing

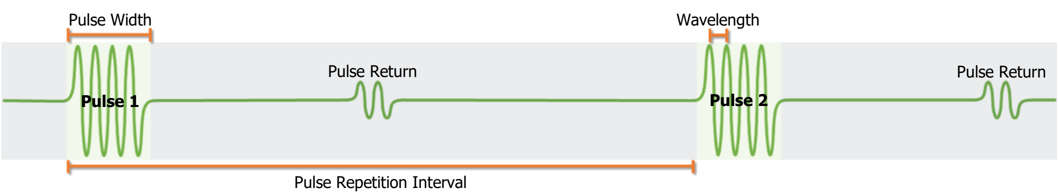
Radar is used to determine the distance, direction, and/or velocity of objects by transmitting narrowly focused radio waves, which are then reflected from other objects back to the source. As with all electromagnetic waves, radio waves travel at the speed of light in a vacuum, which allows a radar system to determine distance by measuring the time between the transmission of a radar pulse and the reception of the reflected radar pulse. This is the origination of the term "radar", meaning "Radio Detection And Ranging".

Although electromagnetic waves do not travel precisely at the speed of light in a non-vacuum such as the Earth's atmosphere, depending on their wavelength and frequency, the speed of light will be referenced below since such differences are negligible for the purposes of explanation.

Pulse Radar

The most common type of radar is "pulse radar", meaning the radar antenna itself functions as both a transmitter and a receiver, similar to transceivers of communication radios. Since the radar antenna cannot transmit and receive simultaneously, it must alternate between very short periods of transmission and longer periods of reception in which it is "listening" for any reflected radar waves. This creates a pulsing waveform of radar energy.

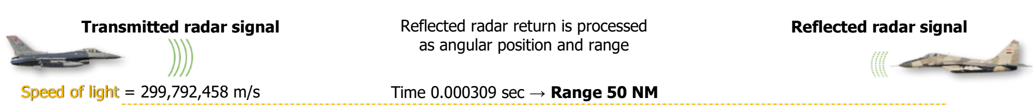
In the figure below, a radio-frequency (RF) signal is illustrated in the time domain. The radar antenna briefly transmits a pulse of radar energy (Green Shade), stops transmitting for a period of time (Gray Shade) to receive any radar returns, and then transmits another pulse of radar energy. This linear expression of a pulse radar signal in the time domain is referred to as a "pulse train".



Radar signal in time domain

- **Wavelength.** The physical distance between two consecutive crests or troughs of an oscillating wave. As the carrier frequency increases, the wavelength of the radar wave decreases, and vice versa.
- **Pulse Width.** The duration that the radar is transmitting for one pulse.
- **Pulse Repetition Interval (PRI).** The time between the initiation of each successive radar pulse.
- **Pulse Repetition Frequency (PRF).** The number of individual radar pulses that are transmitted within one second, in hertz (Hz).
- **Duty Cycle.** The ratio of time a radar is transmitting versus receiving within a single pulse repetition interval.
- **Pulse Train.** Signal characteristics of a pulse radar expressed within the time domain.

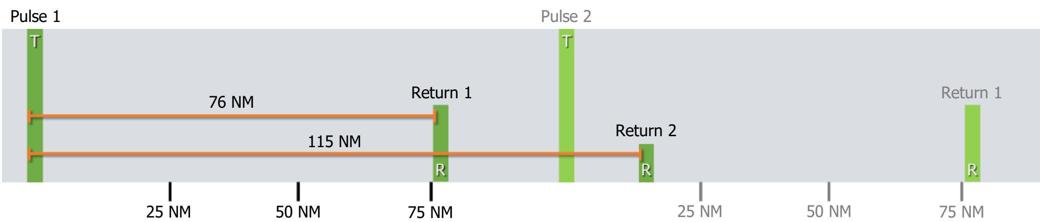
By calculating the amount of time it takes for a pulse to travel to a target and return to the antenna, the radar can determine the range to the target. In the figure shown below, the elapsed time between the transmission of a radar pulse and the reception of the reflected signal is 0.000618 seconds, or 618 μs (microseconds). By dividing this value in half, since it equates to the time needed to travel the distance between the radar and the target twice, and then multiplying the halved value by the speed of light (0.000309 sec × 299,792,458 m/s), the range to the target is calculated to be 92,636 meters, or 50 nautical miles.



Radar Ranging

Pulse Repetition Frequency (PRF) is the number of individual radar pulses within a pulse train that are transmitted within one second. The higher the PRF, the shorter the Pulse Repetition Interval (PRI) between pulses. It is important to note that a radar's PRF is distinct from the carrier frequency on which the radar signal is modulated. While the antenna characteristics and the carrier frequency of the radar determine the accuracy and angular resolution of the radar, PRF determines the range and velocity resolution of the radar.

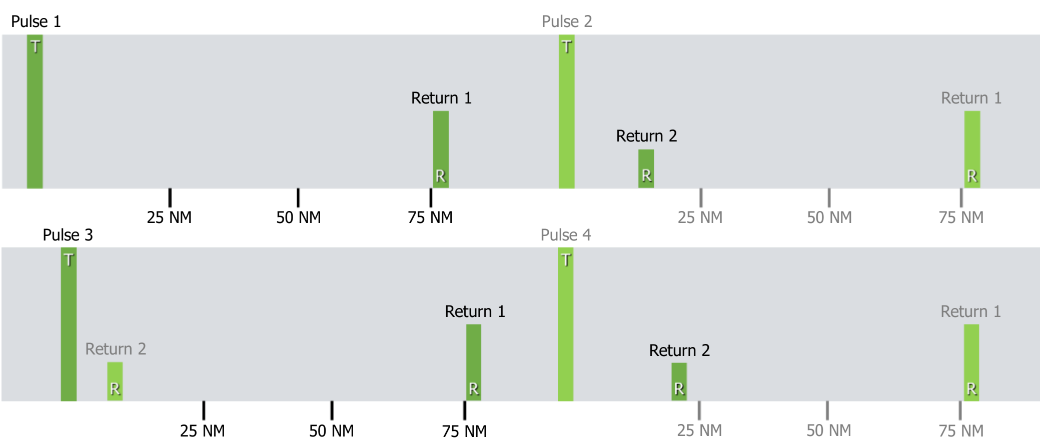
As mentioned on the previous page, pulse radars cannot simultaneously transmit and receive radar signals and must cease transmitting to receive the reflected radar returns. The further the radar signal must travel to a target and back, the longer the radar must remain silent to receive the reflected signal. If the radar signal is not reflected and returned to the radar before the next radar pulse is transmitted, the reflected signal will arrive after the subsequent pulse, creating an erroneous echo return at a much closer range than the target's true distance.



Radar Range Ambiguity

In the figure above, the radar is transmitting at a PRF with a maximum unambiguous range of 100 nautical miles (NM). Two radar returns are received by the radar, but the second return is being received after the subsequent pulse is transmitted. The second return is erroneously displayed much closer than the target's true distance, when it is in fact much further away than the first. This is known as range ambiguity, or "range aliasing".

Several methods may be employed by radar systems to mitigate erroneous returns from targets beyond the maximum unambiguous range, such as staggering the PRI of subsequent pulses. In the figure below, the radar staggers PRIs between alternating pulses, increasing the PRI between pulses 2 and 3, and decreasing the PRI between pulses 3 and 4. This results in inconsistent range measurements from the second return, allowing the radar to filter range-ambiguous returns and remove them from the radar display.



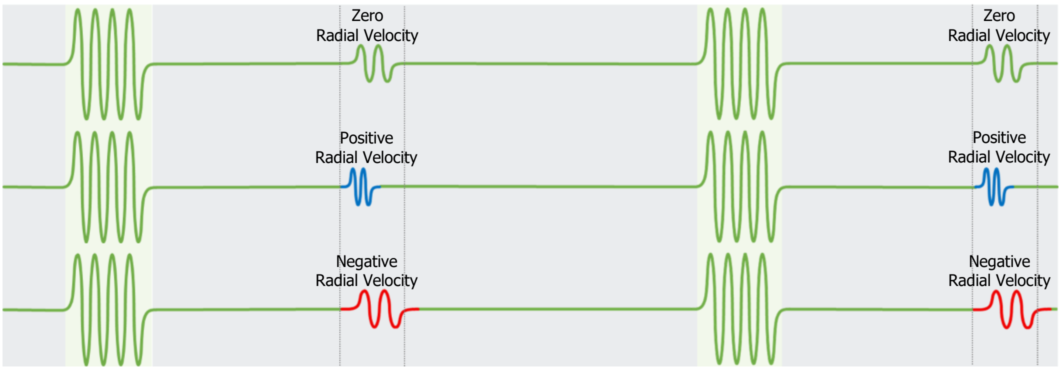
Staggered PRI to filter ambiguous returns

Decreasing the PRF will increase the radar's maximum unambiguous range and improve range resolution; however, increasing the PRF will result in more pulses and energy striking a target within a given time, improving probability of detection. As such, the design of any radar system must balance these advantages and disadvantages to achieve optimum radar performance.

Pulse-Doppler Radar

The APG-68 is a pulse-Doppler radar, meaning the radar antenna functions as both a transmitter and a receiver like a pulse radar, but it also measures the Doppler phase shift of radar returns to determine the radial velocity.

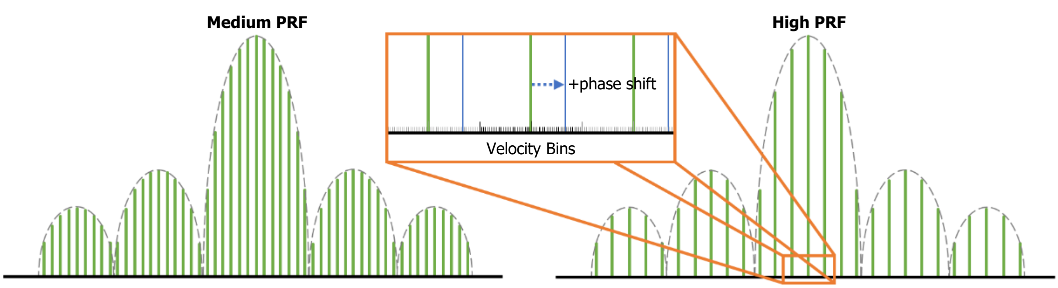
When a radar wave strikes an object that is moving toward or away from the transmitter, the Doppler effect will incur a phase shift in the radar wavelength. The practical example that is most commonly used to express the Doppler effect is the sound of a train as it approaches compared to the sound of the train after it has passed. In this situation, the Doppler effect is incurring a phase shift in the sound waves so that the positive radial velocity of the oncoming train sounds distinctly different than the negative radial velocity of the train after it passes.



Doppler Phase Shift

Similarly, the phase shift of a radar wave with positive or negative radial velocity can be measured by the radar processor. By measuring the phase shift of a radar return and combining this data with direction and range data, pulse-Doppler radars such as the APG-68 can determine the velocity of moving targets for calculating interception trajectories, generating ballistic solutions when engaging close-range targets during aerial gunnery, or filtering out ground clutter and atmospheric anomalies.

Just as PRF determines the maximum unambiguous range of a pulse radar, it also determines the maximum unambiguous velocity that can be measured by a pulse-Doppler radar. In the figure below, a radio-frequency (RF) signal is illustrated in the frequency domain. Increasing the PRF increases the Doppler bandwidth within which the phase shift of a radar return can be measured, providing better velocity resolution with more Doppler cells, also referred to as velocity bins. The maximum shift in a radar return's Doppler frequency that can be measured will always be half that of the pulse repetition frequency, otherwise the phase shift would occur within the next set of velocity bins. This is known as velocity ambiguity, or "velocity aliasing".



Radar signals in frequency domain

A higher PRF will provide better velocity resolution at the expense of reduced range resolution and overall range, and a lower PRF will permit longer range detections at the expense of lower velocity resolution. However, every PRF will have a "blind velocity" in which the measured phase shift is equal to the wavelength of the radar signal.

Radar Detection

When a radar antenna is transmitting, radar energy radiates outward and is focused along a narrow beam similar to the beam of a flashlight, along what is known as the main lobe. However, some of the radar energy is transmitted along smaller side lobes, or even back lobes, which can produce erroneous radar returns at closer ranges, particularly when flying a low altitudes near terrain. This is similar to how a flashlight can illuminate the environment outside of the main beam of light, just to a much lesser extent compared to the main beam.

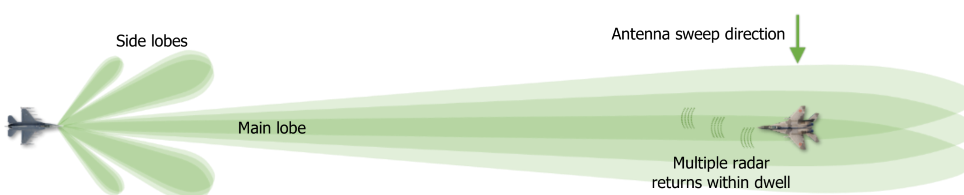
Antenna Radiation Pattern

NOTE: The illustration of a radar's main and side lobes in the figure above are only representative of the relative power output of the radar energy along each lobe, rather than the detection range of the radar in physical space.

As radar energy travels through the atmosphere, atmospheric particles attenuate the radar signal, reducing its amplitude, or signal power. Since the radar signal must travel the distance to a target and back, the radar signal must be powerful enough to travel the distance to the target and return to the radar antenna with sufficient energy to be detectable amongst the background radio "noise" from the environment and that caused by the radar electronics itself, otherwise known as signal-to-noise ratio (SNR). If a target is far enough away from the radar or small enough that the amplitude of the reflected radar signal is lost in the background noise, the target will be filtered out along with the rest of the background noise and not detected. In addition, radar signals will be subject to greater attenuation effects at lower altitudes due to the increased air density, further reducing SNR.

Similarly, the radar signal itself must have sufficient amplitude to be detectable by passive radar detection equipment (also known as radar warning receivers, or RWR) amongst the background noise. However, in this context, the radar signal must only travel one way toward the RWR-equipped aircraft, resulting in the radar signal being detectable at a much greater range than the source radar is capable of detecting targets. In other words, radar emissions can highlight the presence of the ownship to other aircraft equipped with radar warning receivers well beyond the operational range of the radar itself.

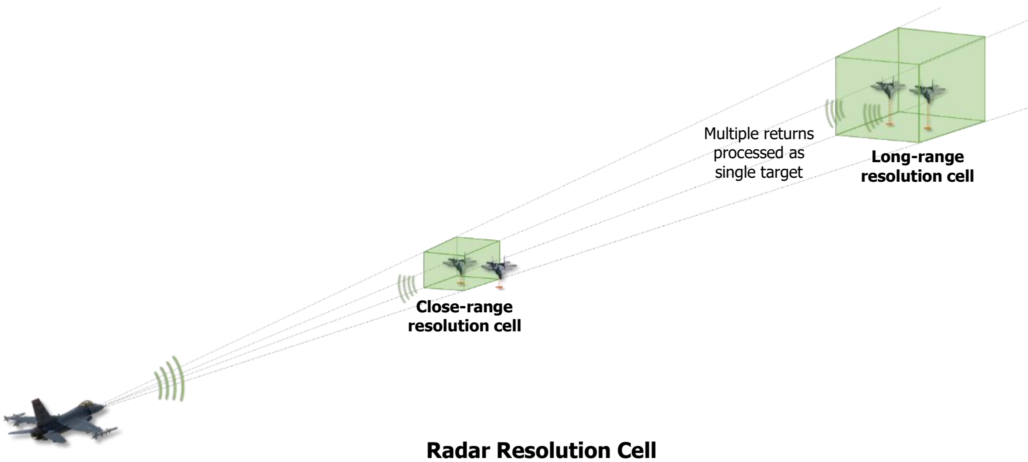
Another factor that affects whether a target is detected is the duration that the target is being "illuminated" by the radar within the radar's scan pattern, referred to as the radar dwell time. The longer a target is within the main lobe of a radar, the more radar pulses will strike the target, increasing the number of radar returns that may be received by the radar antenna. The size of the main lobe and the speed at which the radar antenna physically sweeps through its scan pattern will determine the dwell time.



Radar Dwell

PRF will also affect probability of detection, in that increasing the PRF will result in more pulses of radar energy being transmitted within a given dwell period, allowing more returns to be received from the same target before the main lobe of the radar sweeps beyond the target's position. Therefore, higher PRFs result in a greater amount of radar energy reflected back to the radar, increasing probability of detection at longer ranges.

In situations in which multiple targets are close together, such as several aircraft in tight formation, the targets may be collectively processed as a single target if they fall within the same radar resolution cell. The combination of range resolution and the antenna beamwidth of the radar, both horizontally and vertically, determine the size of the radar resolution cell at a given range. As the range from the radar antenna increases, the size of the resolution cells will accordingly increase.



Radar Resolution Cell

As described on the previous pages, the range and velocity resolution of a given PRF will be inversely related to the velocity and range ambiguities of any radar returns; in that increasing resolution of one will increase the ambiguity of the other. In addition, a radar return must be received with sufficient amplitude over a defined signal-to-noise ratio (SNR) threshold, which may be dynamically adjusted by the radar processor based on a constant false alarm rate (CFAR) algorithm.

Range resolution and noise rejection may be improved by integrating a series of coherent radar pulses into a Coherent Processing Interval (CPI). This processing method correlates radar returns in a way that true targets can be resolved in range while filtering out random background noise. In the example on the right, three pulses are integrated across a single CPI, allowing radar returns in each pulse that are above a defined SNR threshold to be processed as target detections.

Pulse Integration

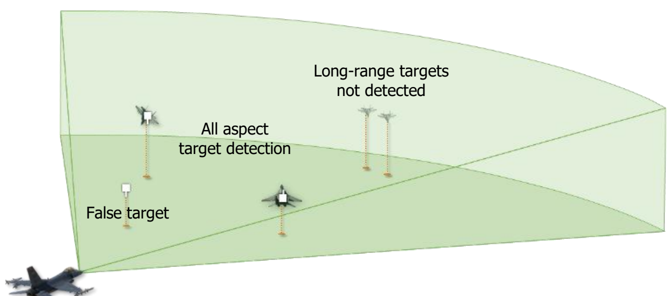
Velocity resolution may be improved by cycling through a different PRF waveform during each CPI within a single dwell period. Since each PRF has a different Doppler bandwidth and unique blind velocities in which a moving target will appear stationary, this allows the radar to more precisely determine the velocity of moving targets by correlating the phase shift in the frequency domain across each CPI.

In the figure at the top of the page, two formations of aircraft are at different ranges. Only the close-range aircraft are processed as separate targets as the beamwidth of the radar is narrower at the closer range. However, if the long-range aircraft are detected within the same CPIs and fall within the same range and velocity bins, the probability of long-range detection will increase as more returns are received from the same radar resolution cell and correlated across multiple CPIs within the dwell period, but the aircraft will be processed as a singular target rather than two separate targets.

Overall, the probability of detection is based on the combined factors of PRF, dwell time, range to the target, the altitude of the radar and the target, and the target's radar reflectivity (i.e., its "radar cross section", or RCS).

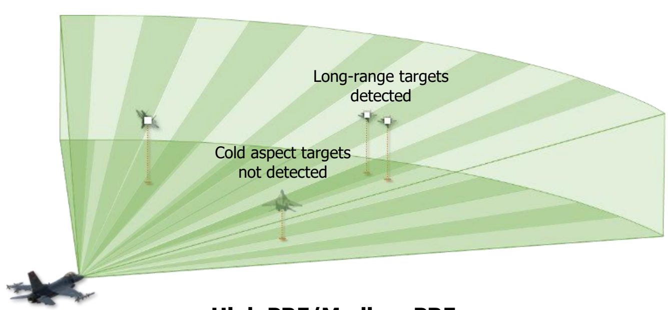
- Radar cross section, range, and altitude directly affect the amount of radar energy reflected back to the antenna. Smaller radar cross sections reflect less radar energy; and longer ranges and lower altitudes increase the amount of atmospheric attenuation to weaken the radar signal.
- PRF and dwell time affect how many radar pulses are reflected back to the antenna. Increasing the PRF produces more radar reflections within a given dwell period, increasing the total amount of radar energy reflected by a target, or targets, within a radar resolution cell.
- PRF directly affects range/velocity resolution and clutter rejection.
  - A high PRF (HPRF) avoids velocity ambiguity and permits more precise velocity measurements at the expense of range resolution, which leads to better clutter rejection and lower rates of false detections.
  - A medium PRF (MPRF) permits more precise range resolution at the expense of velocity resolution, which could lead to higher rates of false detections and intermittent detections of true targets that may be rejected as sidelobe clutter, particularly at low altitudes.
  - A low PRF (LPRF) avoids range ambiguity and permits longer range detection of targets at the expense of velocity resolution, resulting in poor clutter rejection.

Although most of these radar processes are automated in modern radar systems and transparent to the operator, the F-16 pilot does possess some control over these functions when deciding how to employ the onboard FCR. The APG-68 employs a dual mode transmitter (DMT) that can alternate between HPRF waveforms and MPRF waveforms. When using Range While Search (RWS) sub-mode, the APG-68 utilizes MPRF waveforms only, which is ideal for all-aspect target detection at the expense of reduced clutter rejection.



Medium PRF

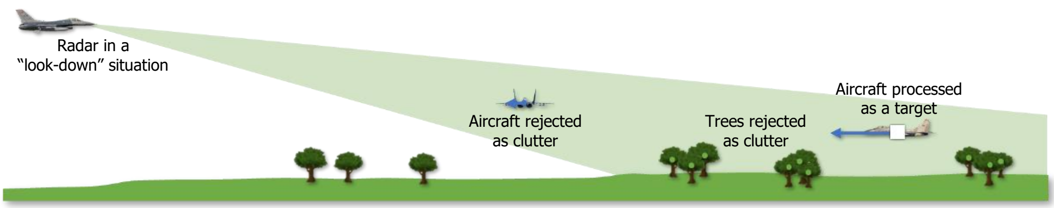
When using Velocity Search with Ranging (VSR) sub-mode, however, the radar alternates between HPRF waveforms for initial detection and MPRF waveforms for range confirmation, leveraging the advantages of both PRF waveforms for increased range and clutter rejection at the expense of only detecting hot-aspect targets.



High PRF/Medium PRF

The F-16 pilot can also adjust the Doppler filter threshold for rejecting ground clutter during "look-down" situations, which can be particularly important when using medium PRF waveforms. In the figure below, the APG-68 scan pattern is directed downward so that the surface and other terrain features are within its search volume. Despite many radar returns being received from terrain features, vegetation, or man-made objects, the radar uses Doppler filtering to distinguish airborne targets amongst the backdrop of the terrain, which is sometimes referred to as "look-down, shoot-down" capability.

As radar returns are received and the phase shift of each return is measured, the radar processor removes returns from the radar display with a radial velocity below the defined velocity rejection threshold. However, due to the lower velocity resolution of medium PRF waveforms and the fact the radar is onboard a moving aircraft, the radar is more susceptible to sidelobe clutter and higher rates of false detections. Further, depending on the velocity rejection threshold, slow-moving aircraft or aircraft flying perpendicular to the F-16 may also be rejected as ground clutter.



Pulse-Doppler Clutter Rejection

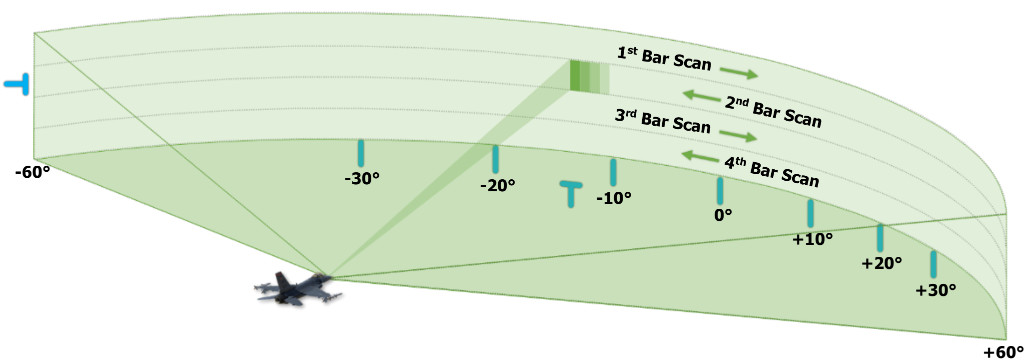
In the figure above, two targets are flying at 300 knots ground speed at low altitude, with the closest target flying perpendicular to the F-16's flight path and the furthest target flying directly toward the F-16, which is also flying at 300 knots ground speed. Since the closest target's *radial* velocity, or closure rate, relative to the F-16 is only 380 knots, its velocity is processed to be 80 knots ground speed (after subtracting the F-16's own velocity) and below the Moving Target Rejection (MTR) HI threshold of 110 knots as selected on the FCR CNTL page. The furthest target's radial velocity relative to the F-16 is 600 knots and processed to be 300 knots ground speed, and therefore is the only aircraft processed as a target. If desired, the pilot could select a lower MTR setting, which would allow the closest aircraft to be processed as a target since its radial velocity would be above the MTR LO threshold of 71 knots, but this may also increase the rate of false targets due to sidelobe clutter.

Radar Scan Frames

As the radar beam of the APG-68 is steered in azimuth and elevation, a given volume of 3-dimensional space may be systematically scanned by the radar beam within a single scan pattern. This 3-dimensional search volume is referred to as a "scan frame" and may be thought of as a radar-generated "photograph" of the airspace.

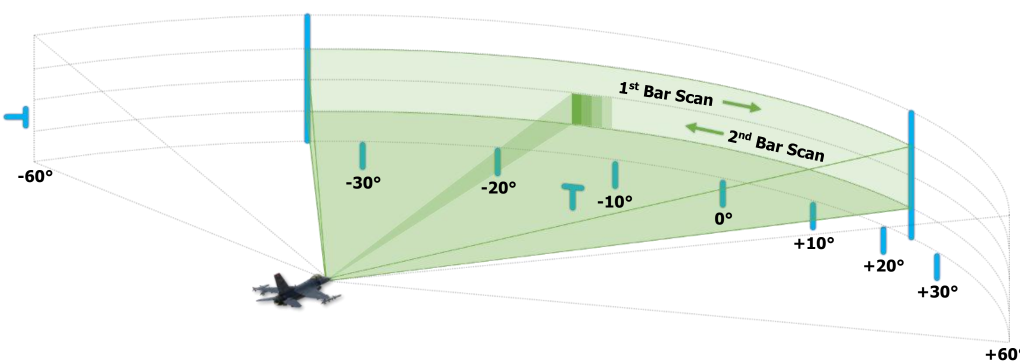
The search volume of the airspace within each scan frame may vary based on the FCR mode and is defined by the azimuth and elevation settings in the cockpit. The larger the scan frame, the greater the volume of airspace that is scanned by the radar. However, larger scan frames also require more time for the radar to perform the entire scan pattern to generate a new "photograph" of the airspace.

In the figure below, the pilot has selected the largest search volume, with the APG-68 scanning ±60° to either side of the nose and 4 bars in elevation. Such a large scan frame allows the pilot to monitor a huge volume of airspace, but the radar requires 8 seconds to generate a single scan frame, with the radar depiction of the airspace being refreshed at a slower rate.



±60° 4-Bar Scan Pattern (A6, 4B)

In the next figure below, the pilot has selected a smaller search volume, with the APG-68 scanning ±30° to either side of the nose and 2 bars in elevation. Although the pilot can only monitor 25% of the airspace compared to the previous figure, the radar only requires 2 seconds to generate a single scan frame, allowing the radar depiction of the airspace to be refreshed at a faster rate.

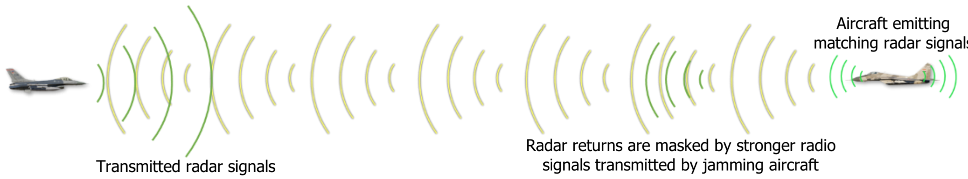


±30° 2-Bar Scan Pattern (A3, 2B)

When using the APG-68's Combined Radar Mode (CRM) to search for airborne targets, the pilot must weigh the factors of search volume versus refresh rate when selecting azimuth and elevation settings, based on the selected FCR sub-mode and the current tactical situation.

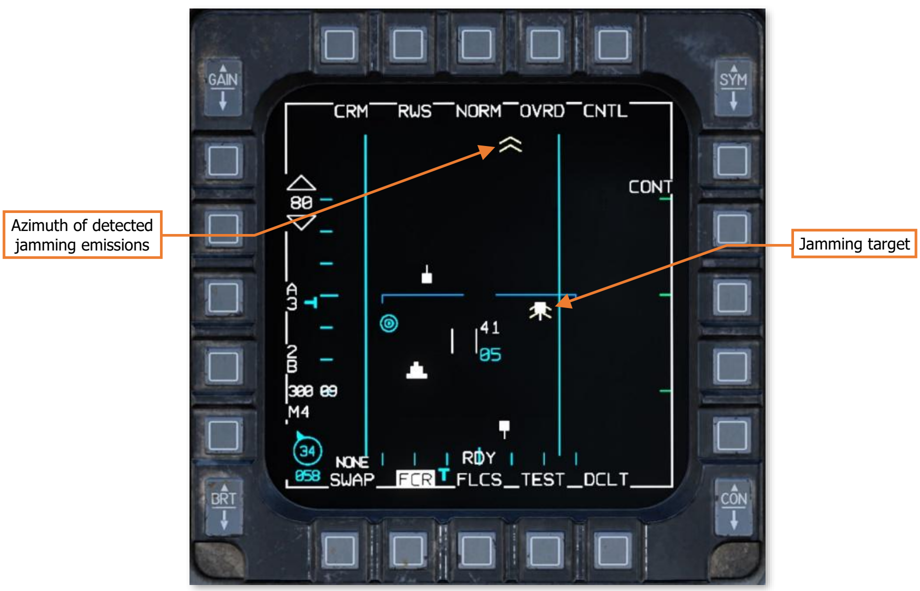
Jamming Interference

Radar jamming is a type of electronic countermeasure (ECM) that may be employed to deny, degrade, or delay detection by radar systems. Since a radar system relies on its ability to receive an accurately timed and measured reflected radar pulse from an object to determine its range and/or Doppler shift, radar jamming actively emits radio signals with the same waveform back to the radar to interfere with the radar's ability to resolve a target's range and/or velocity. However, by actively emitting radio signals, a radar jammer also highlights the presence of the emitting aircraft to radar systems, even if the aircraft had not yet been detected by the radar.



Radar Jamming

If radar jamming emissions are detected within the FCR frequency band being utilized by the APG-68, a pair of yellow chevrons will be displayed along the top of the MFD, corresponding with the azimuth from which the jamming signals are being received. In this situation, the jamming symbol is indicating the direction to a jamming-emitting target, but the range to the target is unknown.



The effectiveness of a radar jammer will vary based on the power of the jamming signals relative to the signals emitted from the victim radar. If the range between the radar and the jamming-emitting target is reduced, at some point the amplitude of the radar returns from the target will exceed the amplitude of the jamming signals, allowing the radar return to be resolved despite the interference from the jamming signals. This threshold in which the radar signal strength overcomes the strength of the jamming signals is known as "burnthrough".

If the jamming-emitting target is close enough that the FCR achieves "burnthrough" and the emissions are correlated to a target detected by the FCR, the yellow chevrons will be superimposed over the corresponding target symbol. (See Radar Jamming in the Defensive Systems chapter for more information.)

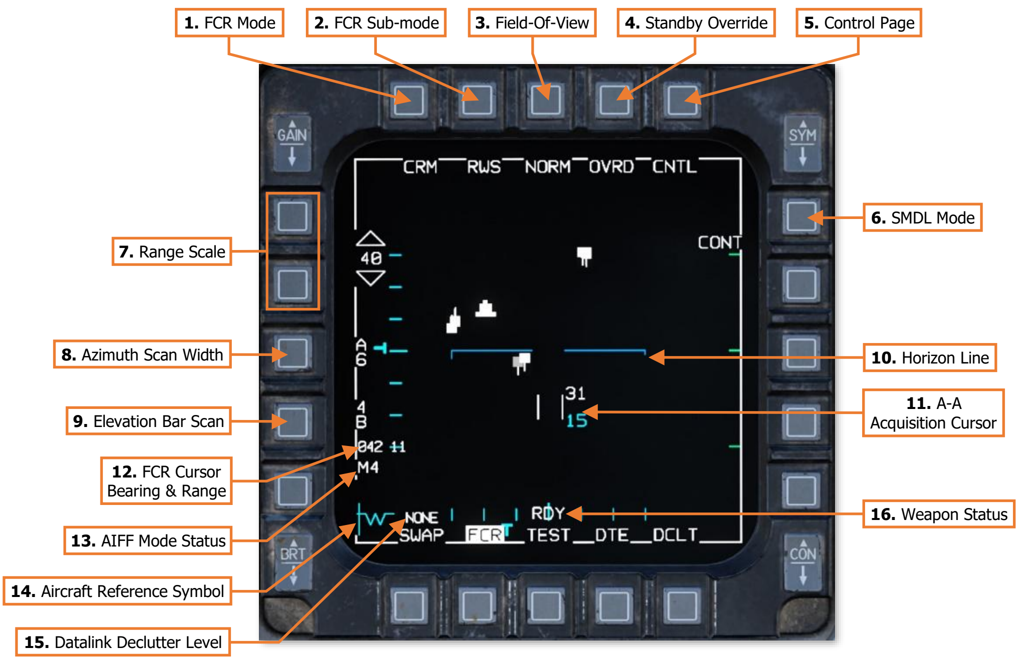
Fire Control Radar (FCR) MFD Format

The FCR MFD format is the primary interface with the fire control radar and presents radar targeting data and ground map imagery to the pilot in either an air-to-air format or an air-to-ground format. When the FCR air-to-air format is displayed, airborne targets detected by the ownship FCR are displayed along with airborne targets received via datalink from offboard sources. When the FCR air-to-ground format is displayed, radar-generated imagery of the surface and/or any moving ground targets are displayed.

See the Tactical Net Datalink chapter for more information regarding datalink target symbols displayed on the FCR MFD format.

FCR Air-to-Air Format

When displayed in air-to-air mode, the FCR displays radar returns of aircraft in a B-Scope format, in which the position of the ownship is centered along the bottom edge of the FCR display area. Radar targets are displayed laterally within the FCR display area based on azimuth in relation to the ownship nose, and vertically within the FCR display based on range or closure velocity.



1. **FCR Mode (Air-to-Air format).** Displays the FCR Mode Menu page. The current FCR mode is displayed below OSB 1.

2. **FCR Sub-mode.** Selects the air-to-air sub-mode when the FCR is not in a tracking sub-mode. The current air-to-air sub-mode is displayed below OSB 2.

   If the FCR mode is set to CRM when OSB 2 is pressed, the OSB selection will advance to the next sub-mode in a cyclic manner: RWS → VSR → TWS → RWS.

   - **RWS.** The FCR is set to Range While Scan sub-mode.
   - **VSR.** The FCR is set to Velocity Search with Ranging sub-mode.
   - **TWS.** The FCR is set to Track While Scan sub-mode.

If the FCR mode is set to ACM when OSB 2 is pressed, the OSB selection will advance to the next sub-mode in a cyclic manner: 20 → 60 → SLEW → BORE → 20.

- **20.** The FCR is set to 30×20 sub-mode.
- **60.** The FCR is set to 10×60 sub-mode.
- **SLEW.** The FCR is set to SLEW sub-mode.
- **BORE.** The FCR is set to BORE sub-mode.

3. **Field-Of-View.** Cycles the field-of-view of the FCR MFD format when the FCR is the Sensor-Of-Interest (SOI). The current field-of-view is displayed below OSB 3.

   If the FCR is set to CRM, GMT, or SEA when OSB 3 is pressed, the OSB selection will toggle between NORM and EXP. (See Expand Field-of-View in the FCR Air-to-Air Modes section for more information.)

   If the FCR is set to GM when OSB 3 is pressed, the OSB selection will advance to the next field-of-view in a cyclic manner: NORM → EXP → DBS1 → DBS2 → NORM. (See Expand Field-of-View in the FCR Air-to-Ground Modes section for more information.)

   - **NORM.** The FCR MFD format is set to the normal, unexpanded display area.
   - **EXP.** The FCR MFD format is expanded at a 4:1 display ratio.
   - **DBS1.** The FCR MFD format is expanded at a 4:1 display ratio. Doppler Beam Sharpening radar processing is enabled to increase radar image resolution. DBS1 is only available in GM mode.
   - **DBS2.** The FCR MFD format is expanded at a ratio dependent on the range to the radar cursor. Doppler Beam Sharpening radar processing is enabled to increase radar image resolution. DBS2 is only available in GM mode.

   The Expand/FOV button on the Side Stick Controller (SSC) may also be pressed to cycle the FCR field-of-view when the FCR is SOI.

4. **Standby Override (OVRD).** Sets the FCR to Standby mode. When Standby Override is enabled, the text below OSB 4 will be highlighted in white. When Standby Override is disabled, the FCR returns to the last FCR mode that it was set to within the current master mode prior to Standby Override being enabled.

5. **Control Page (CNTL).** Toggles the MFD between the FCR base page and the FCR Control page.

6. **SMDL Mode.** Not implemented.

7. **Range Scale.** Adjusts the scale of the FCR up or down, with the current range scale setting (in nautical miles) displayed between the arrow buttons. The maximum and minimum ranges that may be selected for each FCR mode are shown below:

FCR Mode	**CRM**	**ACM** (Bore)	**ACM** (20/60/Slew)	**GM/GMT/SEA**
Maximum Range	160 NM	40 NM	10 NM	80 NM
Minimum Range	5 NM	5 NM	10 NM	10 NM

   When the FCR is set to its highest or lowest range scales, the upper or lower range scale arrows are removed, respectively. If the Acquisition Cursor is slewed beyond the upper or lower limits of the current range scale using the RDR CURSOR/ENABLE switch when the FCR is not in a tracking sub-mode, the range scale will be "bumped" to the next higher or next lower range scale setting in sequence.

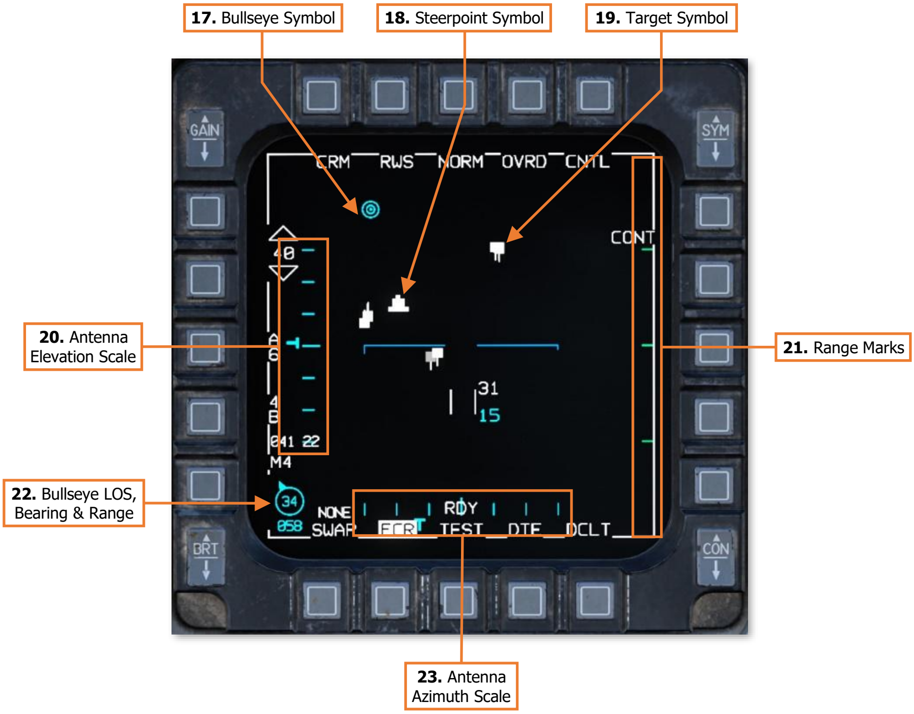
8. **Azimuth Scan Width.** Selects the horizontal radar scan size in azimuth when the FCR is in Combined Radar Mode (CRM) without a designated Bugged Target (FCR TOI), or Ground Map (GM) or Sea (SEA) modes. Separate Azimuth Scan Width settings are retained for each CRM sub-mode and are automatically set when returning to the corresponding sub-mode. The current setting is displayed to the right of OSB 18. Each press of OSB 18 will advance to the next azimuth scan width setting in a cyclic manner: A6 → A3 → A1 → A6.

- **A6.** The FCR is scanning ±60° to either side of the aircraft nose.
- **A3.** The FCR is scanning ±30° to either side of the Acquisition Cursor.
- **A2.** The FCR is scanning ±25° to either side of the Acquisition Cursor. This setting is only available when the FCR is set to TWS sub-mode with a designated Bugged Target or Cursor Target.
- **A1.** The FCR is scanning ±10° to either side of the Acquisition Cursor.

If the Acquisition Cursor is slewed to the left or right boundary of the MFD display area using the RDR CURSOR/ENABLE switch when the FCR is not in a tracking sub-mode, the azimuth scan width will be "bumped" between A6 and A3 settings.

9. **Elevation Bar Scan.** Selects the vertical radar scan size in elevation when the FCR is in Combined Radar Mode (CRM) without a designated Bugged Target (FCR TOI). Separate Elevation Bar Scan settings are retained for each CRM sub-mode and are automatically set when returning to the corresponding sub-mode. The current setting is displayed to the right of OSB 17. Each press of OSB 17 will advance to the next elevation bar scan setting in a cyclic manner: 4B → 2B → 1B → 4B.
   - **4B.** The FCR is scanning 4 bars in elevation.
   - **3B.** The FCR is scanning 3 bars in elevation. This setting is only available when the FCR is set to TWS sub-mode with a designated Bugged Target or Cursor Target.
   - **2B.** The FCR is scanning 2 bars in elevation.
   - **1B.** The FCR is scanning 1 bar in elevation.
10. **Horizon Line.** Indicates the aircraft attitude in pitch and roll to aid the pilot in maintaining spatial orientation when focused inside the cockpit. If the aircraft nose is on the horizon in level flight, the Horizon Line will be centered and parallel with the upper and lower edges of the MFD display area, with the two vertical tick marks on the outer edges of the Horizon Line indicating the direction toward the ground. If the nose is above the horizon, the Horizon Line will be displaced toward the bottom of the MFD but will remain at the bottom of the display at +60° pitch or beyond. If the nose is below the horizon, the Horizon Line will be displaced toward the top of the MFD but will remain at the top of the display at -60° pitch or beyond. If the aircraft banks left or right, the Horizon Line will rotate in opposite direction to remain level with the horizon.
11. **A-A Acquisition Cursor.** The A-A Acquisition Cursor is slewed using the RDR CURSOR/ENABLE switch and is used to designate target symbols or steer the FCR search volume left or right, or control the azimuth and range settings the FCR. Two numerical values are displayed to the right of the cursor, corresponding with the upper and lower altitude limits (in thousands of feet above mean sea level, or MSL) of the FCR search volume at the position of the cursor itself, based on the ownship altitude, antenna elevation setting, and elevation bar scan setting. The upper limit is displayed in blue to indicate a positive altitude and red to indicate a negative altitude. The lower limit is displayed in white to indicate a positive altitude and red to indicate a negative altitude.
12. **FCR Cursor Bearing & Range.** Displays the bearing (in degrees Magnetic) and range (in nautical miles) from the selected steerpoint to the FCR cursor or Bugged Target (FCR TOI). If Bullseye is enabled on the BULL DED page, this data field will display the bearing and range from the Bullseye steerpoint to the FCR cursor or the Bugged Target (FCR TOI). (See "Bullseye" Reference Point for more information.)
13. **AIFF Mode Status.** Displays the IFF modes that are selected for interrogation by the AIFF antenna array. (See Advanced Identification-Friend-or-Foe for more information.)
14. **Aircraft Reference Symbol.** Displays the relative alignment of the aircraft heading with the selected steerpoint, System Point-of-Interest (SPI), or weapon release solution. If the line is to the left or right of the watermark, the pilot must turn left or right respectively toward the vertical line to align the aircraft on course toward the selected steerpoint, SPI, or weapon release solution.
15. **Datalink Declutter Level.** Displays the current declutter level of Air Targets received via datalink from offboard sources. (See the Tactical Net Datalink chapter for more information.)

16. **Weapon Status.** Displays the status of the weapon type selected on the SMS MFD format. (See the Air-to-Air Weapons Employment or Air-to-Ground Weapons Employment chapters for more information.)



17. **Bullseye Symbol.** Depicts the location of the Bullseye steerpoint if enabled on the BULL DED page. Bullseye is normally set to steerpoint 25 but can be set to a different steerpoint on the BULL DED page.

18. **Steerpoint Symbol.** The location of the steerpoint selected for navigation is displayed as a white "wedding cake" symbol at the relative range and bearing within the FCR display area.

19. **Target Symbol.** Depicts the position of a target detected by the radar. Target symbols may be retained during subsequent radar scan frames, depending on the Target History setting on the FCR Control page. (See FCR Target Symbols for more information.)

20. **Antenna Elevation Scale.** Displays the FCR antenna elevation relative to the aircraft nose, indicated by a sideways "T" indicator. As the mechanical antenna moves up and down in elevation, the elevation indicator will move upwards and downwards along the scale. The elevation scale range is +60° at the top of the MFD -60° at the bottom of the MFD, with the major tick mark in the center of the scale corresponding to 0° and each minor tick mark above and below the center corresponding with 10° increments.

21. **Range Marks.** Depicts range from the ownship. The upper tick mark corresponds with ¾ of the range scale, the middle tick mark corresponds with ½ of the range scale, and the lower mark corresponds with ¼ of the range scale. The range mark distances for each FCR range scale are shown below:

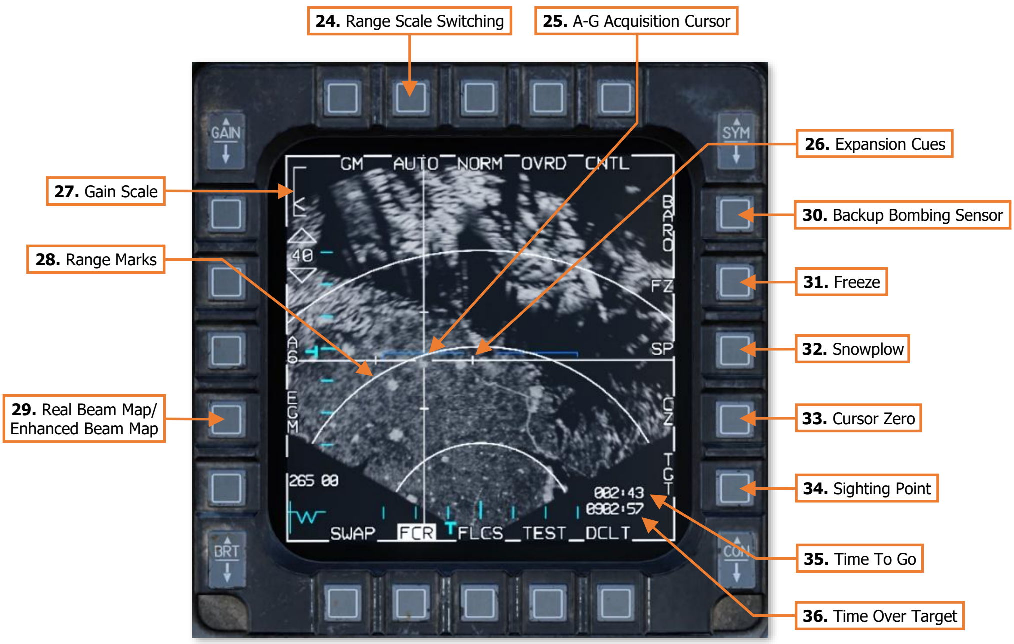
Range Scale	**5**	**10**	**20**	**40**	**80**	**160**
Upper Mark	1.25 NM	7.5 NM	15 NM	30 NM	60 NM	120 NM
Middle Mark	2.5 NM	5 NM	10 NM	20 NM	40 NM	80 NM
Lower Mark	3.75 NM	2.5 NM	5 NM	10 NM	20 NM	40 NM

22. **Bullseye LOS, Bearing & Range.** If Bullseye is enabled on the BULL DED page, a pointer symbol is displayed that indicates the relative direction (line-of-sight or LOS) to the Bullseye steerpoint from the nose of the ownship. The ownship range (in nautical miles) is displayed inside the pointer symbol and the ownship bearing (in degrees magnetic) from the Bullseye steerpoint is displayed below the pointer symbol.

23. **Antenna Azimuth Scale.** Displays the FCR antenna azimuth relative to the aircraft nose, indicated by a "T" indicator. As the mechanical antenna moves left and right in azimuth, the elevation indicator will move left and right along the scale. The azimuth scale range is ±60° at either edge of the MFD, with the major tick mark in the center of the scale corresponding to 0° and each minor tick mark left and right of center corresponding with 10° increments.

FCR Air-to-Ground Format

When displayed in air-to-ground format, the FCR depicts radar-generated imagery of the terrain in a Plan Position Indicator (PPI) format. If the FCR is operating in Ground Moving Target (GMT) mode, locations of moving ground vehicles are displayed as target symbols overlaid on the radar-generated imagery of the terrain.



24. **Range Scale Switching.** Toggles between automatic and manual range scale switching when the FCR mode is set to GM, GMT, or SEA.

- **AUTO.** Automatically increases or decreases the FCR range scale if the A-G Acquisition Cursor moves beyond the upper or lower limits of the current range scale, whether that be from the pilot-commanded slews of the cursor or if the cursor becomes displaced beyond the range scale limits due to aircraft movement. The A-G Acquisition cursor may only be slewed within the left or right boundaries of the FCR MFD display area at the current range scale, however it may become displaced beyond the left or right boundaries of the FCR MFD display area due to aircraft movement.
- **MAN.** The FCR range scale must be changed by the pilot and will not be affected by pilot-commanded slews of the A-G Acquisition Cursor. The A-G Acquisition cursor may only be slewed within the boundaries of the FCR MFD display area at the current range scale, however it may become displaced beyond the boundaries of the FCR MFD display area due to aircraft movement.

25. **A-G Acquisition Cursor.** Depicts the position of the selected sighting point based on the current navigation solution. If the pilot slews the cursor using the RDR CURSOR/ENABLE switch on the throttle, a cursor correction to the Navigation cursor is applied and the crosshairs will slew to the new position on the radar-generated image.

26. **Expansion Cues.** Indicates the area on the radar-generated image that will be displayed if the field-of-view is set to EXP. The expansion cues are only displayed on the A-G Acquisition Cursor if the field-of-view of the FCR MFD format is set to NORM. (See Expand Field-Of-View in the FCR Air-to-Ground Modes section for more information.)

27. **Gain Scale.** Displays the current radar gain setting, with the maximum gain corresponding with the top of the scale and the minimum gain corresponding with the bottom of the scale. If the FCR mode is set to GM or SEA, the scale displays the gain setting of the radar map image. If the FCR mode is set to GMT, the scale displays the gain setting of moving target indicator symbols.

28. **Range Marks.** Depicts range from the ownship. The outer ring corresponds with ¾ of the range scale, the middle ring corresponds with ½ of the range scale, and the inner ring corresponds with ¼ of the range scale. The range mark distances for each FCR range scale are shown below:

Range Scale	**10**	**20**	**40**	**80**
Outer Ring	7.5 NM	15 NM	30 NM	60 NM
Middle Ring	5 NM	10 NM	20 NM	40 NM
Inner Ring	2.5 NM	5 NM	10 NM	20 NM

29. **Real Beam Map/Enhanced Ground Map.** Enables/disables radar image sharpening.

- **RGM.** Selecting Real Beam Map displays raw radar images without EGM processing.
- **EGM.** Enhanced Ground Map processing sharpens raw radar images by a 4:1 ratio to increase radar image resolution in GM, GMT, and SEA modes.

NOTE: Changing between RGM and EGM processing is only applied at the completion of the current FCR scan cycle.

30. **Backup Bombing Sensor.** Not implemented.

31. **Freeze (FZ).** Freezes the radar image on the FCR MFD format and disables FCR emissions. When Freeze is enabled, the text adjacent to OSB 7 will be highlighted in white. (See Freeze Option for more information.)

32. **Snowplow (SP).** Enables/disables Snowplow sighting mode. When Snowplow is enabled, the text adjacent to OSB 8 will be highlighted in white. (See Snowplow Sighting Mode for more information.)

33. **Cursor Zero (CZ).** Zeroizes cursor slews. (See Cursor Zero for more information.)

34. **Sighting Point.** Cycles the selected sighting point. (See Sighting Points and Cursor Corrections for more information.)

35. **Time To Go.** When the master mode is set to Navigation (NAV), displays the time that is estimated to elapse before arriving at the selected steerpoint, based on the current ground speed. When the master mode is set to Air-to-Ground (A-G), displays the time remaining before pull-up or weapon release, based on the current ground speed. If a laser-guided bomb is released, displays the estimated time remaining until the bomb impacts the surface.

36. **Time Over Target.** When the master mode is set to Air-to-Ground (A-G) and the selected weapon type is a laser-guided bomb (GBU-10, GBU-12, or GBU-24), displays the estimated time (HHMM:SS format) at weapon release, based on the current ground speed, or the estimated time at weapon impact.

FCR Mode Menu Page

The FCR Mode Menu page is accessed by pressing OSB 1 on the FCR MFD format. The Mode Menu page allows the pilot to select a different FCR mode for the current master mode. The available FCR modes are dependent on the current master mode and, in the case of Air-to-Ground master mode, the weapon delivery sub-mode.

- When the master mode is set to Navigation (NAV), two air-to-air modes, four air-to-ground modes, and Standby mode are displayed for selection.
- When the master mode is set to Air-to-Air (A-A), Missile Override (MSL), Dogfight (DGFT), or Selective Jettison (JETT), two air-to-air modes and Standby mode are displayed for selection.
- When the master mode is set to Air-to-Ground (A-G), four air-to-ground FCR modes and Standby mode are displayed for selection when employing “Pre-planned” or Manual weapon delivery sub-modes. If employing “Visual” weapon delivery sub-modes, only Air-to-Ground Ranging and Standby modes may be selected.

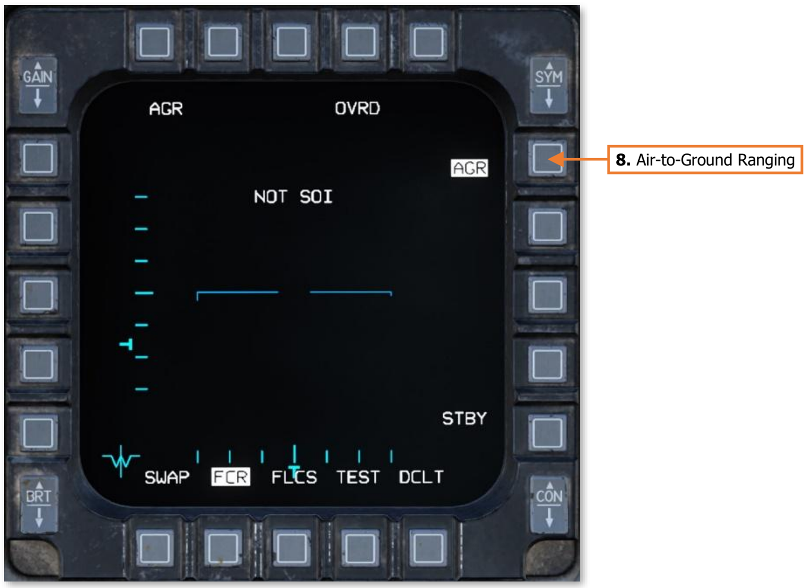
Pressing OSB 1 will exit the Mode Menu page without changing the FCR mode.

1. **Combined Radar Mode (CRM).** Sets the FCR mode to Combined Radar Mode and exits the FCR Mode Menu page. CRM is only displayed if the master mode is set to Navigation (NAV), Air-to-Air (A-A), Missile Override (MSL), Dogfight (DGFT), or Selective Jettison (JETT).
2. **Air Combat Mode (ACM).** Sets the FCR mode to Air Combat Mode and exits the FCR Mode Menu page. ACM is only displayed if the master mode is set to Navigation (NAV), Air-to-Air (A-A), Missile Override (MSL), Dogfight (DGFT), or Selective Jettison (JETT).
3. **Ground Map (GM).** Sets the FCR mode to Ground Map and exits the FCR Mode Menu page. GM is only displayed if the master mode is set to Navigation (NAV) or Air-to-Ground (A-G) when employing “Pre-planned” weapon delivery sub-modes (CCRP, LADD, EO-PRE, EO-BORE, PRE, HARM, HTS) or Manual (MAN).
4. **Ground Moving Target (GMT).** Sets the FCR mode to Ground Moving Target and exits the FCR Mode Menu page. GMT is only display if the master mode is set to Navigation (NAV) or Air-to-Ground (A-G) when employing “Pre-planned” weapon delivery sub-modes (CCRP, LADD, EO-PRE, EO-BORE, PRE, HARM, HTS) or Manual (MAN).

5. **Sea (SEA).** Sets the FCR mode to Sea and exits the FCR Mode Menu page. SEA is only displayed if the master mode is set to Navigation (NAV) or Air-to-Ground (A-G) when employing "Pre-planned" weapon delivery sub-modes (CCRP, LADD, EO-PRE, EO-BORE, PRE, HARM, HTS) or Manual (MAN).

6. **Beacon (BCN).** Sets the FCR mode to Beacon and exits the FCR Mode Menu page. BCN is only displayed if the master mode is set to Navigation (NAV) or Air-to-Ground (A-G) when employing "Pre-planned" weapon delivery sub-modes (CCRP, LADD, EO-PRE, EO-BORE, PRE, HARM, HTS) or Manual (MAN). (N/I)

7. **Standby (STBY).** Sets the FCR mode to Standby and exits the FCR Mode Menu page.



8. **Air-to-Ground Ranging (AGR).** Sets the FCR mode to Air-to-Ground Ranging and exits the FCR Mode Menu page. AGR is only displayed if the master mode is set to Air-to-Ground (A-G) when employing "Visual" weapon delivery sub-modes (CCIP, DTOS, STRF, EO-VIS, or VIS).

FCR Control (CNTL) Page

The FCR Control page is accessed by pressing OSB 5 on the base page of the FCR MFD format. The Control page is used to configure miscellaneous radar settings to suit the tactical situation or individual preferences of the pilot.

1. **Moving Target Rejection.** Toggles the MTR threshold setting between low and high. Radar returns that are detected with a velocity below the thresholds shown in the table below are rejected as clutter and are not displayed. Independent MTR settings are retained for air-to-air and air-to-ground FCR modes.

FCR MODE SUB-MODE	CRM RWS	CRM VSR	CRM TWS	ACM SLEW	ACM 20 / 60 / BORE	GMT GMTI
MTR HI	110 kt	110 kt	110 kt	110 kt	71 kt	16-75 kt
MTR LO	71 kt	59 kt	71 kt	71 kt	55 kt	8-55 kt

If the FCR mode is set to GMT, the MTR threshold will vary based on the ownship's ground speed and the position of the FCR antenna relative to the aircraft centerline. As the antenna rotates away from the aircraft centerline, the MTR threshold is automatically increased to improve rejection of stationary ground clutter.

2. **Altitude Tracker.** Toggles the altitude tracker function of the FCR on and off. (N/I)

3. **Target History.** Selects the number of radar scan frames within which a radar return will remain displayed on the FCR MFD format following detection.

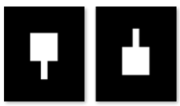
   - **1.** Radar returns are only displayed during the scan frame in which they are detected. Radar returns are removed if not detected during the subsequent scan frame.
   - **2.** Radar returns are displayed during the scan frame in which they are detected and one additional scan frame. Radar returns are removed if not detected within two subsequent scan frames.
   - **3.** Radar returns are displayed during the scan frame in which they are detected and two additional scan frames. Radar returns are removed if not detected within three subsequent scan frames.
   - **4.** Radar returns are displayed during the scan frame in which they are detected and three additional scan frames. Radar returns are removed if not detected within four subsequent scan frames.

4. **Radar Level.** Not implemented.
5. **Channel.** Selects the radar frequency channel employed by the FCR to avoid radar signal interference between multiple aircraft within a flight. (N/I)
6. **Range Mark Intensity.** Selects the brightness intensity of the concentric range marks overlaid on the radar image in GM, GMT, and SEA modes. (N/I)
7. **Frequency Agility Band.** Toggles the frequency agility band of the FCR between wide and narrow. (N/I)
8. **Beacon Delay.** Displays the Beacon Delay data entry page. The current beacon delay setting is displayed to the left of OSB 9. (N/I)
9. **Power Management.** Toggles the power management function of the FCR on and off. (N/I)

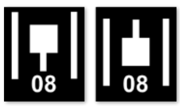
FCR Target Symbols

The following FCR target symbols will be displayed on the FCR MFD format. Each symbol represents a radar-reflective object that has been detected, or is being tracked, by the FCR. The size, shape, and appearance of the symbol indicates the priority of the target, the state of the tracking data, and the NCTR classification of the target as friendly, potentially hostile or suspect, hostile, or unknown.

NOTE: If the Datalink Declutter Level has been set to ALL, FTR+, or TGTS, permitting display of offboard system track files on the FCR MFD format, datalink information may alter the appearance of the symbols described below. See the Tactical Net Datalink chapter for more information regarding FCR and datalink correlation.



Search Target. Indicates a radar-reflective target has been detected at the displayed azimuth and range. A vertical "hot line" will be displayed above or below the target in RWS or TWS sub-modes to indicate the hemispherical aspect angle. If the tick mark is on the bottom of the symbol, the aircraft is "hot" and flying toward the ownship. If the tick mark is on the top of the symbol, the aircraft is "cold" and flying away from the ownship.



Search Altitude Display. If the Acquisition Cursor is placed over a Search Target, the estimated altitude of the target will be displayed below the target symbol in thousands of feet above mean sea level (e.g., 08 is 8,000 feet MSL).

NOTE: As the relative position of a Search Target is updated in subsequent radar scan frames, radar return histories may be displayed as reduced-intensity Search Target symbols, if enabled on the FCR CNTL page.

Track Target. Indicates a target with sufficient radar data to display the target's position and course. The symbol will rotate to represent the target's ground track in relation to the ownship, with a line extending in front of the symbol representing the nose of the aircraft, and the altitude will be displayed below the symbol in thousands of feet above mean sea level (e.g., 08 is 8,000 feet MSL).

System Track Target. Indicates a TWS Track Target that has been upgraded to one of the 10 FCR-derived track files maintained within the System Track File but is not the FCR Target-Of-Interest.

Bugged Target. Indicates the FCR Target-Of-Interest (TOI), which is the highest priority target in Track While Scan (TWS) sub-mode, or the Primary Target in Situation Awareness Mode (SAM) or Dual Target Track (DTT) sub-modes, designated by a circle. Track data and weapon symbology in the HUD and FCR MFD format are always referenced to the FCR TOI. In addition, the FCR TOI determines the position of the Collision Antenna Train Angle (CATA) symbol, the azimuth of an LOS IFF Interrogation, and the target to which the FCR will transition to Single Target Track (STT) mode.

AIM-120 Target. Indicates a System Track Target to which an onboard AIM-120 missile has been fired. The rectangular "tail" indicator will be displayed at the moment of launch and will begin flashing when the missile's onboard radar seeker becomes active.

When the missile is calculated to have impacted the target, an × symbol is superimposed over the target symbol for 13 seconds. After 8 seconds have elapsed since the calculated time of missile impact, the × symbol will flash for the remaining 5 seconds before being removed entirely.

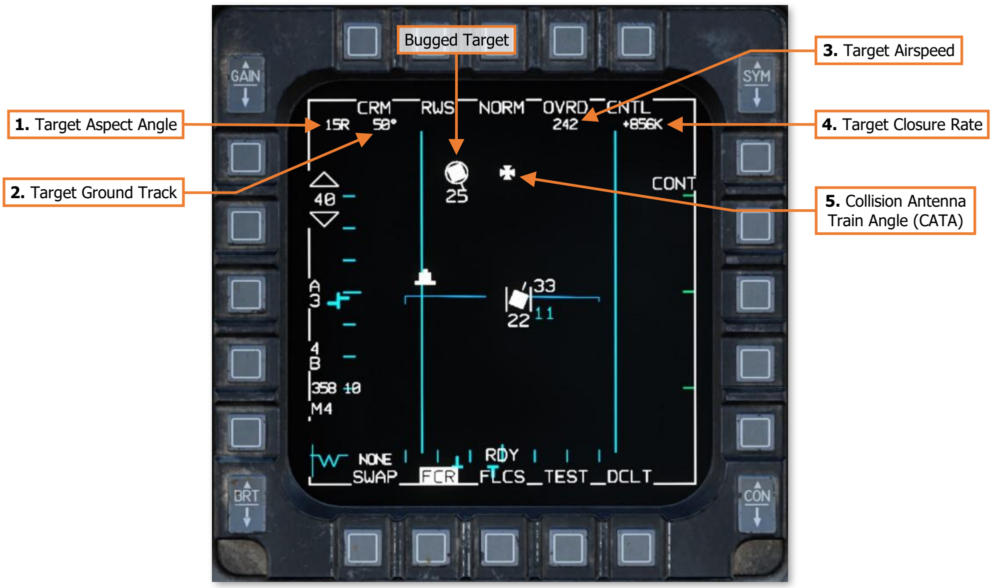
NOTE: The × symbol does not indicate whether the AIM-120 successfully hit a target nor what target was actually struck by the missile.

Non-Cooperative Target Recognition (NCTR). The shape and color of a System Track Target may be determined by the NCTR-derived classification of the target as unknown (white square), friendly (green circle), suspect (yellow square), or hostile (red triangle). See Non-Cooperative Target Recognition for more information.

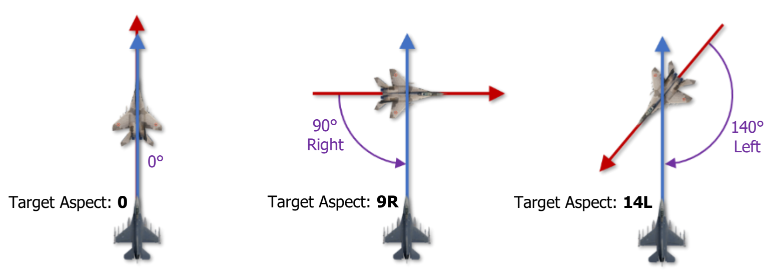
If datalink information is being received from wingmen, donors, or surveillance aircraft such as AWACS, onboard FCR tracks may be correlated with offboard track information, which may alter the appearance of target symbols displayed on the FCR MFD format.

FCR Target-Of-Interest (TOI)

If an airborne target is designated as the FCR Target-Of-Interest, referred to as the Bugged Target and indicated by a circle around the target symbol, additional tracking information will be displayed along the top of the FCR MFD format, additional symbology will be displayed in the HUD/HMCS and on the HSD MFD format as shown on the following page, and Non-Cooperative Target Recognition (NCTR) may be employed to classify the target type. In addition, the FCR range scale will automatically increment if the range to the FCR TOI exceeds 90% of the current range scale or decrement if the range to the FCR TOI is less than 40% of the current range scale.

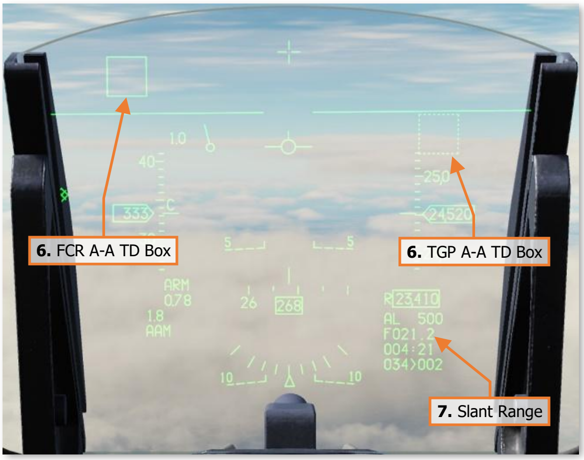


1. **Target Aspect Angle.** Indicates the aspect angle from the FCR TOI, in tens of degrees, left or right.

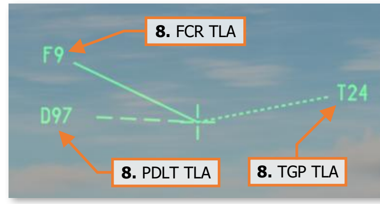


Target Aspect Angle

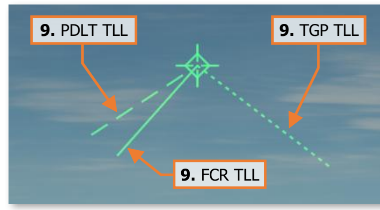
2. **Target Ground Track.** Indicates the magnetic ground track of the FCR TOI, in 10-degree increments.
3. **Target Airspeed.** Indicates the airspeed of the FCR TOI, in knots of calibrated airspeed.
4. **Target Closure Rate.** Indicates the closure rate with the FCR TOI, in knots of true airspeed. If the closure rate is positive, the range is decreasing. If the closure rate is negative, the range is increasing.
5. **Collision Antenna Train Angle (CATA).** Displayed at the same range as the FCR TOI and indicates horizontal steering for performing an interception. To intercept the target, the pilot must turn in the direction of the CATA symbol until the symbol itself is laterally centered on the MFD, as shown in the image above.



HUD/HMCS A-A Target Designator (TD) Boxes



HUD TLL and TLA Symbology



HMCS TLL Symbology

6. A-A Target Designator (TD) Box. Displays the position in azimuth and elevation of the aircraft designated as the FCR TOI (solid box) and/or the TGP-tracked aircraft (dotted box).

7. Slant Range. Indicates the distance from the aircraft to the FCR TOI, in nautical miles (NM). For range values greater than 1.0 NM, the range is displayed as a four-digit value to the nearest tenth of a nautical mile (e.g., 21.2 NM is displayed as "021.2"). For range values less than 1.0 NM, the range value is displayed as a three-digit value to the nearest hundred feet (e.g., 4500 feet is displayed as "045").

8. Target Locator Angle (TLA). Displays the relative offset angle (in degrees) from the nose to the FCR TOI, PDLT, and/or the TGP-tracked aircraft when the corresponding A-A TD Box or PDLT Octagon is outside the field-of-view of the HUD. TLA symbology is not displayed within the HMCS.

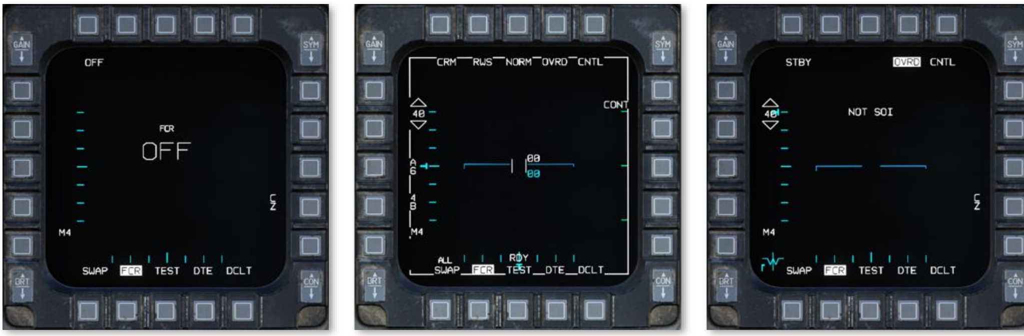
9. Target Locator Line (TLL). Displays the relative offset direction from the HUD Boresight Cross or HMCS Aiming Cross to the FCR TOI (solid line), PDLT (dashed line), and/or the TGP-tracked aircraft (dotted line) when the corresponding A-A TD Box or PDLT Octagon is outside the field-of-view of the HUD or HMCS.

FCR target symbols are displayed on the HSD MFD format any time the FCR establishes a track file, as shown in the image on the right. For more information regarding radar track files, see Track While Scan (TWS) sub-mode.

If an airborne target is designated as the FCR Target-Of-Interest (TOI) while the MMC master mode is set to A-A, MSL, or DGFT, and a valid air-to-air weapon is selected on the SMS MFD format, weapon engagement symbology for the selected weapon is displayed on the FCR MFD format and in the HUD/HMCS. (See Air-to-Air Weapons Employment for more information.)

FCR STANDBY (STBY) MODE

After power is applied to the FCR, the FCR will enter the default FCR mode for the currently selected MMC master mode. During start-up on the ground when the master mode is normally set to NAV, the default FCR mode will be Combined Radar Mode (CRM), unless configured differently via DTC upload.



FCR Off (Left), Initialization (Center), and STBY Mode (Right)

If the aircraft on the ground with weight-on-wheels, the FCR transmissions will be inhibited regardless of the selected FCR mode. However, if the pilot wishes to inhibit FCR transmissions while the aircraft is airborne, the FCR may be set to Standby mode on the FCR Mode Menu page or by pressing OSB 4 on the FCR MFD format. Alternatively, the RF switch on the MISC panel may be used to inhibit FCR transmissions.

Standby Override (OVRD)

Standby Override (OVRD) allows the pilot to immediately set the FCR to STBY independently of the selected master mode, and stows the FCR antenna to 60° left in azimuth and +30° in elevation. OVRD may be selected from any page of the FCR MFD format by pressing OSB 4. When OVRD is enabled, the FCR mode will be set to STBY and will remain in STBY throughout any changes to the MMC master mode until OVRD is disabled with a subsequent press of OSB 4.

- If OVRD is disabled while set to the same master mode in which OVRD was enabled, the FCR will return to its previous mode prior to selecting OVRD.
- If OVRD is disabled while set to a different master mode than that in which OVRD was enabled, the FCR will be set to the mode that was last selected in the corresponding master mode.

RF Switch

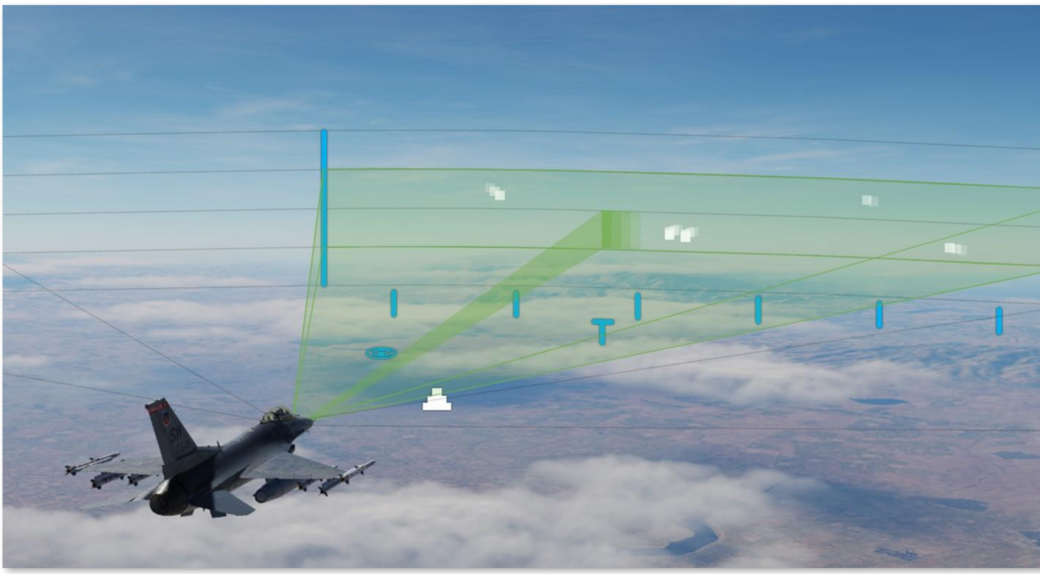
The pilot may prevent the FCR from emitting without setting the FCR to STBY mode by setting the Radio Frequency (RF) switch on the MISC panel to QUIET or SILENT.

If the RF switch is set to the QUIET or SILENT positions, FCR emissions will be inhibited and the FCR antenna will remain stationary throughout any changes to the MMC master mode or FCR mode.

Once the RF switch is returned to the NORM position, FCR emissions will be permitted and the FCR antenna will resume the appropriate scan cycle within the current FCR mode.

FCR AIR-TO-AIR MODES

The APG-68 Fire Control Radar (FCR) is capable of scanning a large volume of airspace in front of the aircraft while simultaneously processing up to ten potential targets for airborne missile engagement from beyond visual range. When tracking an airborne target, the FCR may employ Non-Cooperative Target Recognition (NCTR) analysis to identify the targeted aircraft type. In addition, the AN/APX-113 Advanced Identification-Friend-or-Foe (AIFF) interrogator may be employed to identify friendly aircraft in order to prevent fratricide (also referred to as "friendly fire"), which may also be used independently of the FCR if necessary.



AN/APG-68 Air-to-Air Search and Tracking Modes

The two primary modes used during air-to-air operations are Combined Radar Mode (CRM) and Air Combat Mode (ACM). Each of these modes include several pilot-selectable sub-modes which are optimized for a variety of target engagement scenarios, depending on the current tactical situation.

CRM Combined Radar Mode
Air-to-air search and tracking sub-modes optimized for long-range engagements.

- **RWS** Range While Search
- **VSR** Velocity Search with Ranging
- **TWS** Track While Scan
- **SAM** Situation Awareness Mode
- **DTT** Dual Target Track
- **STT** Single Target Track

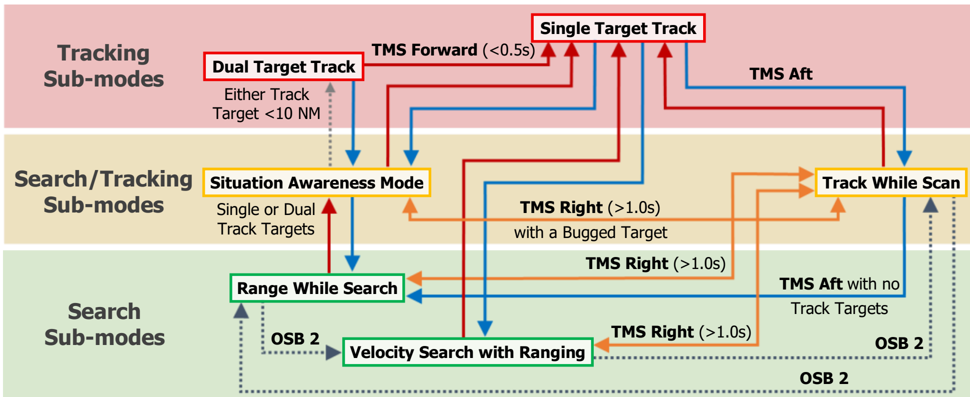
ACM Air Combat Mode
Automatic acquisition and tracking sub-modes optimized for short-range, maneuvering engagements.

- **30×20** HUD Scan
- **10×60** Vertical Scan
- **SLEW** Slewable Scan
- **BORE** Boresight Scan
- **STT** Single Target Track

Upon initial power-up in Navigation (NAV) master mode, the FCR will default to CRM but may be changed to ACM. When entering Air-to-Air (A-A) or Missile Override (MSL) master modes, the FCR will automatically enter CRM but may be changed to ACM if desired. When entering Dogfight (DGFT) master mode, the FCR will automatically enter ACM but may be changed to CRM if desired.

Combined Radar Mode (CRM)

CRM is optimized for detection, tracking, and engagement of airborne targets in beyond visual range (BVR) situations. As the name suggests, CRM combines several radar sub-modes into a single interface that enables the pilot to smoothly transition between different search and tracking sub-modes as dictated by the tactical situation.



CRM Search and Tracking Sub-modes

Search sub-modes present radar returns within the FCR search volume but cannot support missile engagements.

- **Range While Search (RWS).** The FCR performs the selected scan pattern using an MPRF scan cycle and displays potential targets in azimuth and range. RWS is suitable for detecting hot or cold aspect targets at moderate range at the expense of reduced clutter rejection.
- **Velocity Search with Ranging (VSR).** The FCR performs the selected scan pattern using interleaved MPRF and HPRF scan cycles and displays potential targets in azimuth and range. VSR is suitable for detecting hot aspect targets with increased range and clutter rejection at the expense of cold aspect target detection.

Search/Tracking sub-modes present radar returns within the FCR search volume and allow the pilot to select multiple targets for focused tracking and/or missile engagements while maintaining a limited FCR search volume.

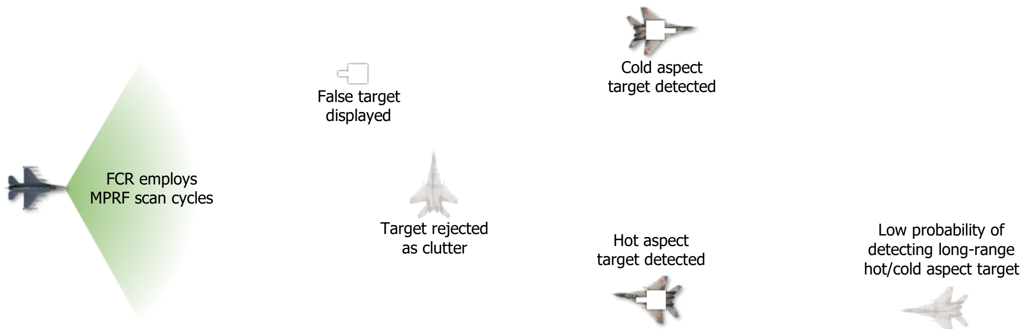
- **Track While Scan (TWS).** The FCR performs the selected scan pattern using an MPRF scan cycle and displays potential targets in azimuth and range. Repetitive detections are used to build track information for up to 10 targets at the expense of reduced track reliability and increased pilot workload compared to SAM.
- **Situation Awareness Mode (SAM).** The FCR alternates between an RWS scan pattern and focused tracking of a primary target, known as the FCR Target-Of-Interest (FCR TOI). If a secondary target is designated, the FCR will alternate between an RWS scan pattern and focused tracking of each target, also referred to as Dual Target SAM (DT SAM). SAM provides increased track reliability and reduced pilot workload compared to TWS, at the expense of being limited to only two targets for which track information is available.

Tracking sub-modes provide precise tracking on single or dual targets for interception or missile engagements but cannot maintain an FCR search volume, which limits the pilot's awareness of other airborne targets.

- **Dual Target Track (DTT).** If two targets are being tracked in DT SAM and the range to either target decreases below 10 nautical miles (NM), the FCR will automatically switch to DTT. The FCR suspends its RWS scan pattern and rapidly alternates between tracking of the primary and secondary targets. DTT provides increased track reliability at close ranges compared to DT SAM or TWS at the expense of overall awareness of the airspace.
- **Single Target Track (STT).** The FCR tracks a single, primary target. STT provides the highest track reliability compared to all other CRM sub-modes at the expense of overall awareness of the airspace.

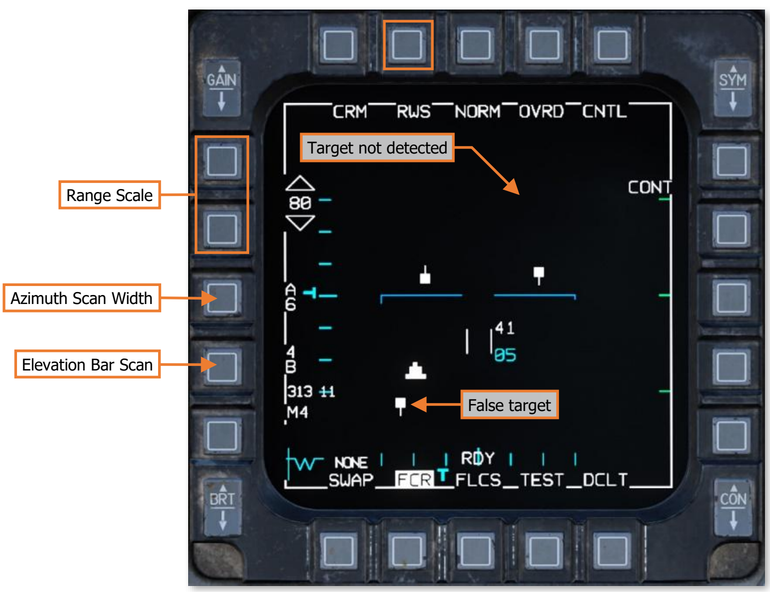
Range While Search (RWS) Sub-mode

Broadly speaking, RWS is the best all-around sub-mode for initial detection and acquisition of targets in beyond visual range (BVR) situations. RWS uses a Medium Pulse Repetition Frequency (MPRF) scan cycle which provides a good balance between simultaneous detection of hot and cold aspect targets and moderate clutter rejection. However, some false targets may still be presented on the FCR MFD format and the detection range of hot aspect targets will be less than VSR sub-mode. RWS is the default sub-mode when CRM is entered.



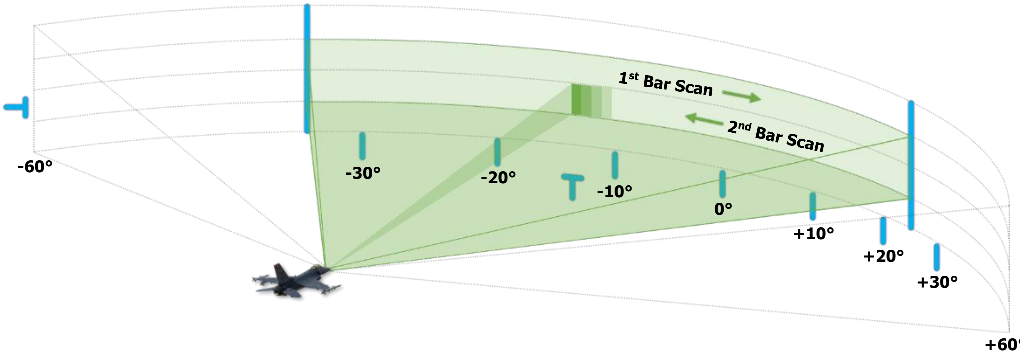
Range While Search (RWS) Sub-mode

When RWS sub-mode is selected, the FCR MFD format will display "RWS" below OSB 2. Pressing OSB 2 will cycle the CRM sub-mode to Velocity Search with Ranging (VSR). Alternatively, pressing TMS Right on the Side Stick Controller (SSC) for 1 full second will toggle between RWS and Track While Scan (TWS) sub-modes.



The FCR search volume may be set to a full horizontal azimuth scan width of ±60° (A6) or a reduced scan width of ±30° (A3) or ±10° (A1) by pressing OSB 18; and may be set to scan 4 bars (4B), 2 bars (2B), or 1 bar (1B) in elevation by pressing OSB 17. The RWS range scale may be set to 5, 10, 20, 40, 80, or 160 nautical miles (NM) by pressing OSB 19 to reduce the range scale or OSB 20 to increase the range scale.

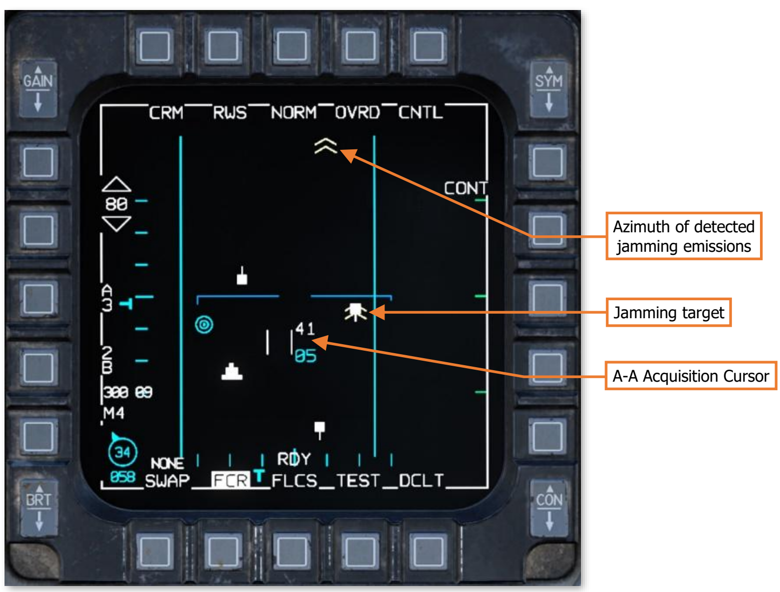
Reducing the search volume provides a faster scan rate at the expense of scanning less airspace. However, if the approximate location and/or altitude of a target's position is known, reducing and directing the search volume toward a target's known position will typically accelerate its detection and subsequent acquisition. The figure below illustrates a reduced RWS search volume as configured on the corresponding MFD image below.



±30° 2-Bar Scan Pattern (A3, 2B)

If TMS Forward is pressed and held, the FCR will temporarily switch to a ±10° 4-bar Spotlight Scan pattern until TMS Forward is released, at which point it will revert to the previous scan settings.

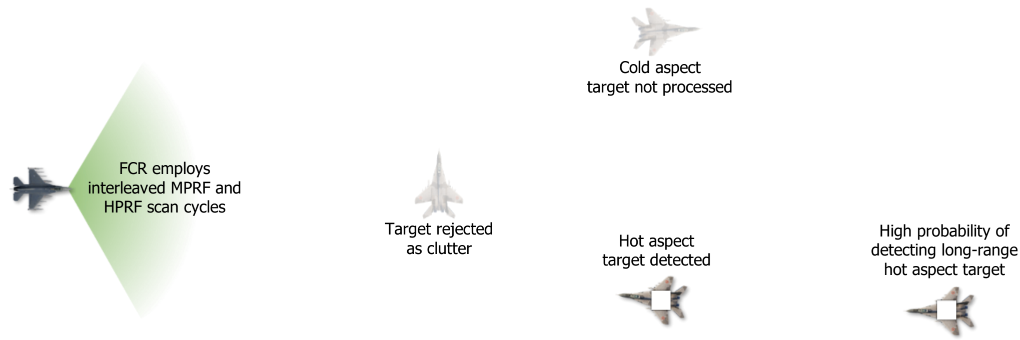
If TMS Forward is pressed and released while the Acquisition Cursor is over a Search Target, the FCR will enter Situation Awareness Mode (SAM).



If radar jamming emissions are detected within the FCR frequency band, a pair of yellow chevrons will be displayed along the top of the MFD, corresponding with the azimuth from which the jamming signals are being received. If the jamming signal-emitting aircraft is close enough that the FCR achieves "burnthrough" and the emissions are correlated to a target detected by the FCR, the yellow chevrons will be superimposed over the corresponding Search Target. (See Jamming Interference for more information.)

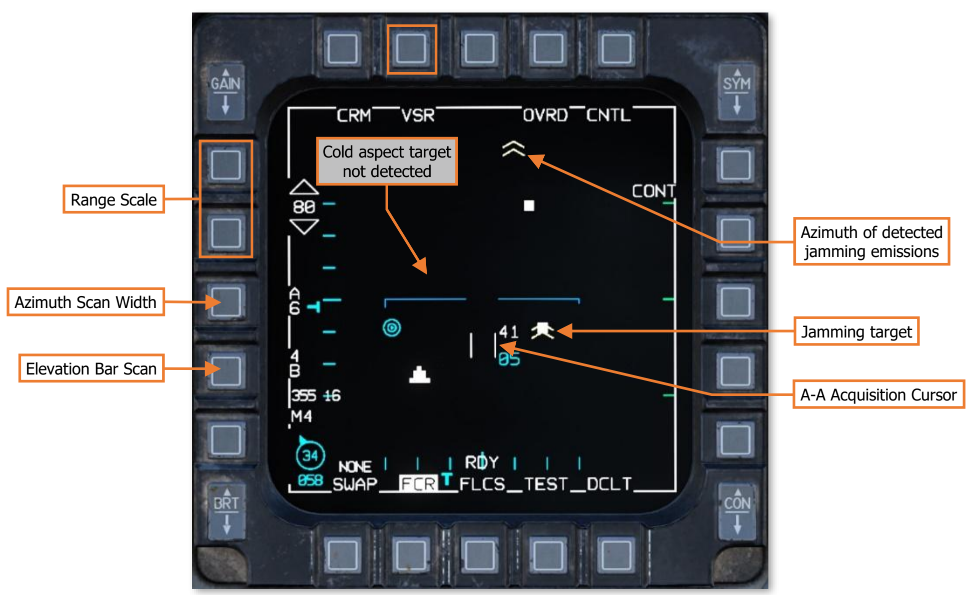
Velocity Search with Ranging (VSR) Sub-mode

VSR is the ideal sub-mode for long-range detection and acquisition of hot aspect targets in in beyond visual range (BVR) situations or to reduce the potential for false targets. VSR interleaves Medium Pulse Repetition Frequency (MPRF) together with High Pulse Repetition Frequency (HPRF) scan cycles which provides an increase in detection range of hot aspect targets and improved clutter rejection. However, as VSR is intended for detection of hot aspect targets, it will not process cold aspect targets and hot lines will not be displayed on Search Target symbols.



Velocity Search with Ranging (VSR) Sub-mode

When VSR sub-mode is selected, the FCR MFD format will display "VSR" below OSB 2. Pressing OSB 2 will cycle the CRM sub-mode to Track While Scan (TWS). Alternatively, pressing TMS Right on the Side Stick Controller (SSC) for 1 full second will toggle between VSR and TWS sub-modes.

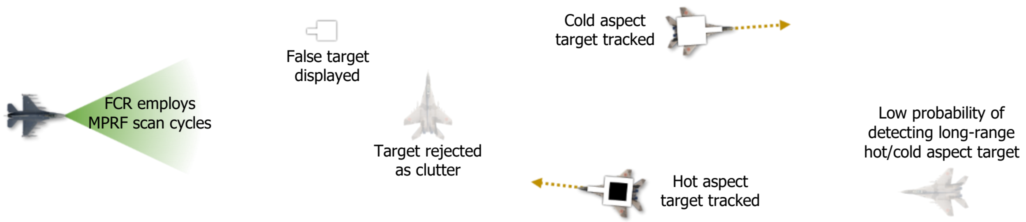


The azimuth, range, and elevation controls of the FCR search volume remain the same as Range While Search (RWS), with the exception that a Spotlight Scan cannot be commanded by pressing and holding TMS Forward.

If TMS Forward is pressed and released while the Acquisition Cursor is over a Search Target, the FCR will enter Single Target Track (STT). Situation Awareness Mode (SAM) cannot be entered from VSR sub-mode.

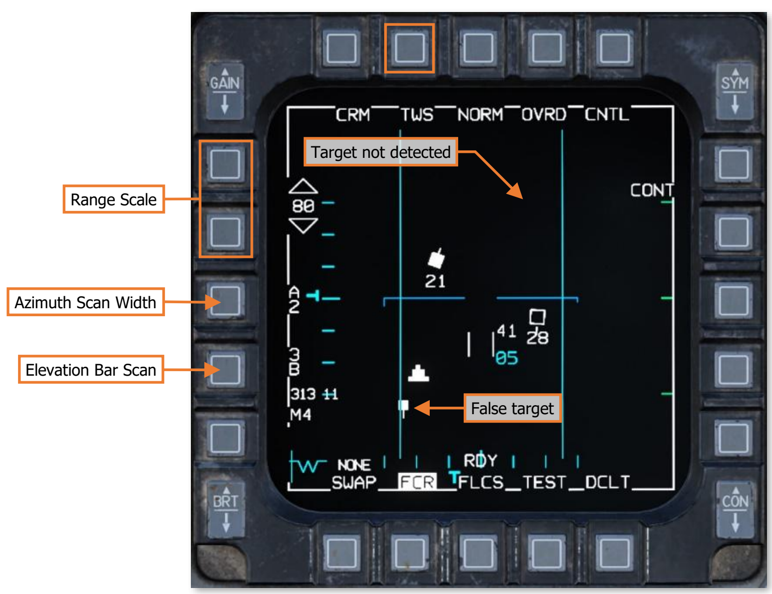
Track While Scan (TWS) Sub-mode

TWS combines the search functions of Range While Search (RWS) sub-mode with multi-target tracking and engagement functions. As such, TWS is capable of simultaneous detection of hot and cold aspect targets but is subject to the same range and clutter rejection limitations as RWS. However, unlike RWS sub-mode, multiple radar returns from an airborne target are combined into a single target track, which may be used to discriminate actual targets from intermittent false targets or employ weapons against a tracked airborne target.



Track While Scan (TWS) Sub-mode

When TWS sub-mode is selected, the FCR MFD format will display "TWS" below OSB 2. Pressing OSB 2 will cycle the CRM sub-mode to Range While Search (RWS). Alternatively, pressing TMS Right on the Side Stick Controller (SSC) for 1 full second will toggle between TWS and RWS or VSR, whichever was last selected in this manner.

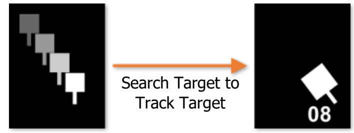


The FCR search volume may be set to a full horizontal azimuth scan width of ±60° (A6) or a reduced scan width of ±30° (A3) or ±10° (A1) by pressing OSB 18; and may be set to scan 4 bars (4B), 3 bars (3B), 2 bars (2B), or 1 bar (1B) in elevation by pressing OSB 17. The TWS range scale may be set to 5, 10, 20, 40, 80, or 160 nautical miles (NM) by pressing OSB 19 to reduce the range scale or OSB 20 to increase the range scale.

If TMS Forward is pressed and held, the FCR will temporarily switch to a ±10° 4-bar Spotlight Scan pattern until TMS Forward is released, at which point it will revert to the previous scan settings.

If the Acquisition Cursor is used to establish a Cursor Target or designate a Bugged Target, the FCR search volume will automatically be set to a ±25° 3-bar scan pattern (A2, 3B), centered on the Cursor or Bugged Target.

Track Targets



Track File Established

When a target is initially detected in TWS, Search Target symbols will be displayed in the same manner as RWS. When enough radar returns from the same target are detected within subsequent radar scan frames, the FCR will compare the returns to extrapolate the target's course, velocity, and altitude. The Search Target symbol is then replaced with a Track Target symbol, also referred to as a "Tank Target". The FCR can maintain a maximum of 10 track files in TWS sub-mode, each of which may be generated automatically by the FCR itself without pilot interaction.

Track Target Movement

Unlike Search Targets, which indicate positions of actual radar returns, Track Targets indicate the extrapolated position of the target in real-time based on the most recent track data. If the target changes flight direction or velocity, and the target's actual position diverges from the position at which the FCR predicts the target will be when the next FCR scan updates the track data, the symbol may "jump" to reflect the new data.

The ability for the FCR to maintain sufficiently accurate track data for any given target is hindered by large FCR search volumes, which decreases the refresh rate of the track data for any given target. If a target's course, velocity, and/or altitude significantly changes between radar scan frames, the FCR may not be able to accurately extrapolate the target's trajectory and may drop the track file after 13 seconds of stale track data. If a track file is dropped, the Track Target will be removed from the FCR MFD format until the track file can be re-established.

System Track Targets

Any of the 10 Track Targets may be upgraded to a System Track Target. System Track Targets are upgraded track files for the purposes of target sorting or engagement but are not processed by the FCR any differently than Track Targets. Specifically, only System Track Targets may be a Cursor Target or Bugged Target (FCR TOI), which allows the pilot to isolate these targets for the purposes of elevated scan priority, viewing additional target data, employing NCTR, or engaging with weapons.

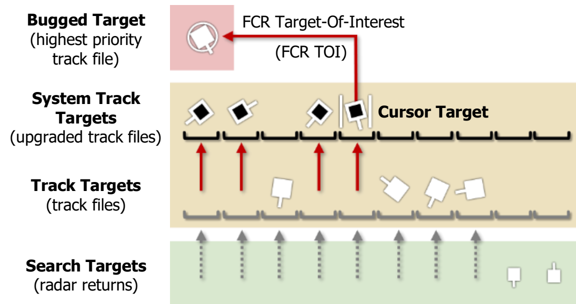
Track Targets may be individually upgraded to System Track Targets by slewing the Acquisition Cursor to the desired target symbol using the RDR CURSOR/ENABLE switch and then pressing TMS Forward. However, if no Track Targets have been upgraded to System Track Targets, all 10 Track Targets may be collectively upgraded to System Track Targets by pressing TMS Right.

Cursor Target

Placing the Acquisition Cursor over a System Track Target will elevate the scan priority of that target to prevent a loss of track. The Acquisition Cursor will snap to that symbol, the current Azimuth Scan Width and Elevation Bar Scan settings will be temporarily overridden, and the FCR will enter a ±25° 3-bar scan pattern centered on the Cursor Target, as shown in the image above. If the cursor is slewed away from the System Track Target, the FCR will revert to the previous Azimuth Scan Width and Elevation Bar Scan settings. A Cursor Target cannot be established on any System Track Target if a Bugged Target (FCR TOI) has already been designated.

Bugged Target

Placing the Acquisition Cursor over a System Track Target and pressing TMS Forward will designate it as the FCR Target-Of-Interest (TOI), referred to as the Bugged Target, and will elevate the scan priority of the target to prevent a loss of track. If a Bugged Target is not present, pressing TMS Right will automatically designate the closest System Track Target as the Bugged Target. The current Azimuth Scan Width and Elevation Bar Scan settings will be temporarily overridden and the FCR will enter a ±25° 3-bar scan pattern centered on the Bugged Target until the "bug" is rejected.

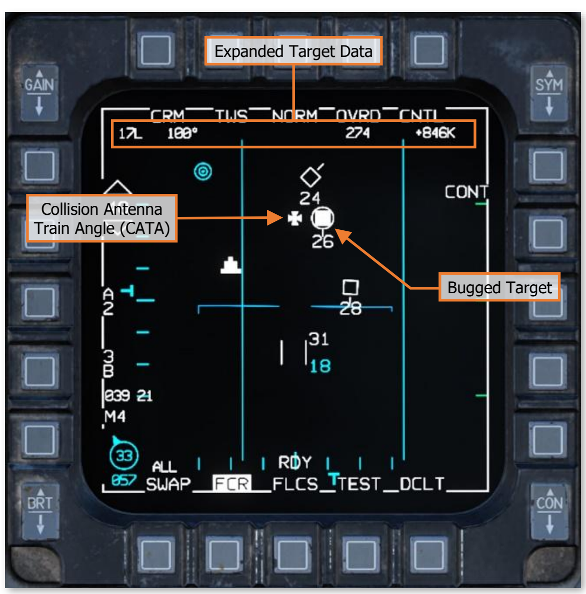


TWS Track File Management

Designating a Bugged Target (FCR TOI) will also result in the following.

- Expanded target data and a Collision Antenna Train Angle (CATA) interception steering cue are displayed on the FCR MFD format. (See FCR Target-Of-Interest for more information.)
- An A-A Target Designator Box is displayed in the HUD/HMCS over the position of the FCR TOI.
- If the MMC master mode is set to A-A, MSL, or DGFT, and a valid air-to-air weapon is selected on the SMS MFD format, weapon engagement symbology for the selected weapon is displayed on the FCR MFD format and in the HUD/HMCS. (See Air-to-Air Weapons Employment for more information.)
- The range scale will automatically increment if the range to the FCR TOI exceeds 90% of the current range scale or decrement if the range to the FCR TOI is less than 40% of the current Range Scale.

The scan priority of a Cursor Target or the Bugged Target is elevated over other targets to increase the refresh rate of the track file data, even at the expense of dropping other track files. However, only a Bugged Target (FCR TOI) may be engaged using onboard weapons such as the AIM-120 missile or classified by type using NCTR.



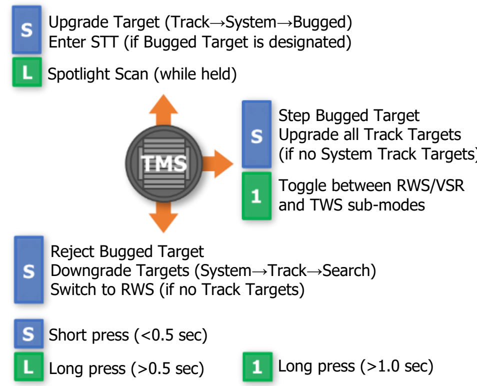
Target Management Switch in TWS sub-mode

The Target Management Switch (TMS) on the Side Stick Controller (SSC), is used to designate, upgrade, downgrade, or purge track files in TWS sub-mode; or transition to a different Combined Radar Mode sub-mode.

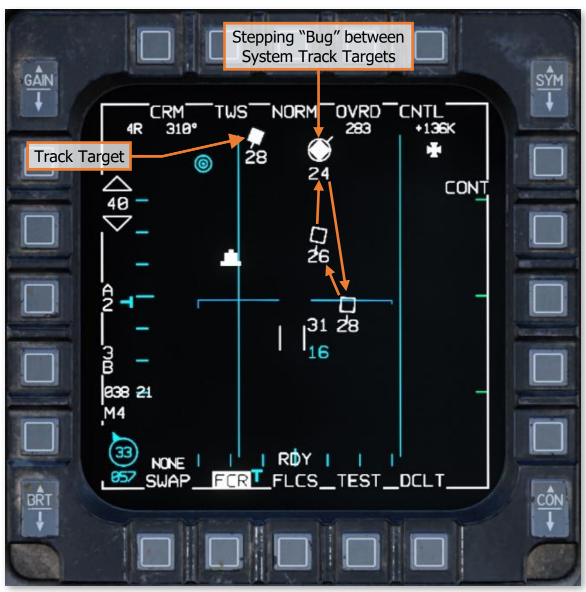
If any System Track Targets are present, pressing TMS Right will automatically designate the closest System Track Target as the Bugged Target. Subsequent presses of TMS Right will step the "bug" to each System Track Target in a cyclic manner, from closest to furthest.

By using TMS Right to step the "bug" to another System Track Target between each sequential launch of AIM-120 missiles, multiple targets may be engaged simultaneously using TWS sub-mode. (See AIM-120 Engagement for more information.)

If TMS Right is pressed for 1 full second while a Bugged Target is designated in TWS, the FCR will switch to Situation Awareness Mode (SAM) with the Bugged Target as the SAM Primary Target.



If TMS Forward is pressed while the Acquisition Cursor is over the Bugged Target, the FCR will enter Single Target Track (STT) and solely track the Bugged Target.

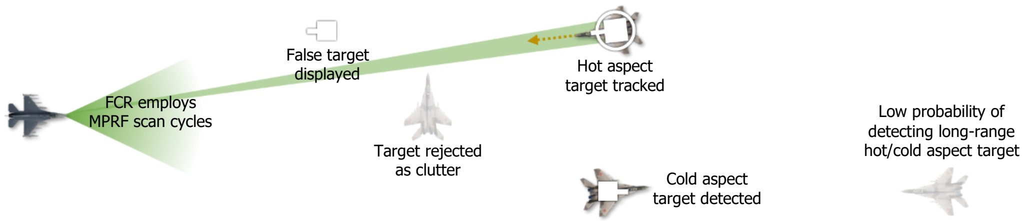


If TMS Aft is pressed, the following will occur in sequence, as it applies to the current tracking state of the FCR.

- The Bugged Target (FCR TOI) will be rejected and the FCR will revert to the previous Azimuth Scan Width and Elevation Bar Scan settings.
- If no Bugged Target is designated, all System Track Targets will be downgraded to Track Targets.
- If no System Track Targets are present, all track files will be purged and Track Targets removed.
- If no Track Targets are present, the FCR will switch to Range While Search (RWS) sub-mode.

Situation Awareness Mode (SAM)

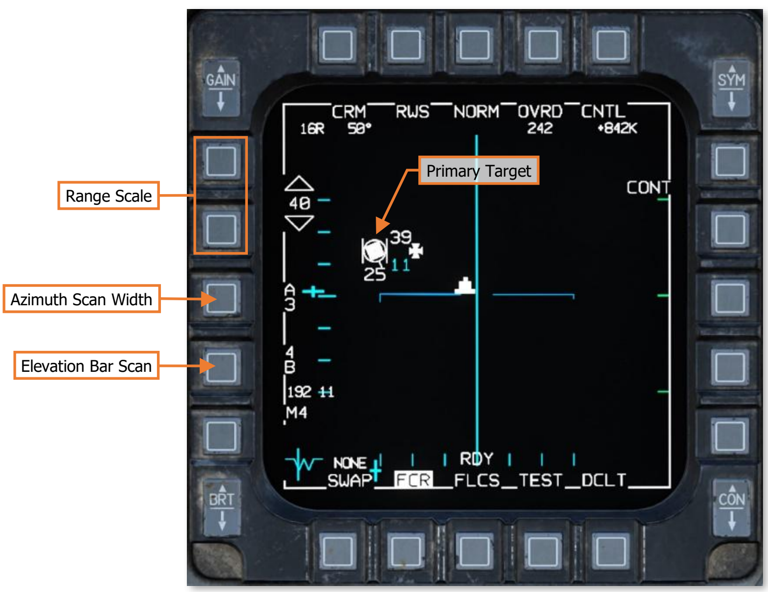
SAM combines the search functions of Range While Search (RWS) sub-mode with target tracking and engagement functions, similar to Track While Scan (TWS). However, unlike TWS, which extrapolates track files from subsequent radar returns within a scan pattern, SAM alternates between an RWS scan pattern and focused tracking of designated targets. As such, SAM provides increased track reliability and reduced pilot workload compared to TWS, at the expense of being limited to only two targets for which track information is available.



Situation Awareness Mode (SAM)

SAM may be entered from RWS sub-mode by placing the Acquisition Cursor over a Search Target and pressing TMS Forward, which will designate it as the SAM Primary Target, or FCR Target-Of-Interest (FCR TOI).

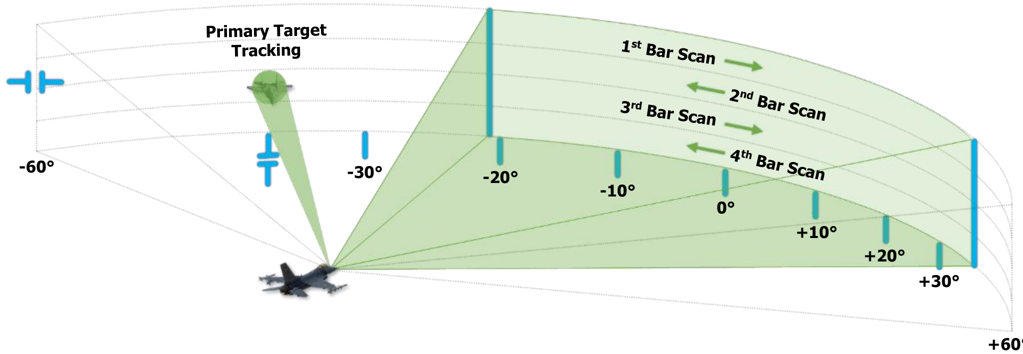
SAM may be entered from TWS sub-mode by designating a Bugged Target and then pressing TMS Right for 1 full second. TWS will switch to SAM sub-mode with the Bugged Target as the SAM Primary Target.



When SAM sub-mode is entered, the FCR search volume will automatically be set to a reduced scan width of ±30° (A3) and the Acquisition Cursor will snap to the Primary Target to facilitate an efficient transition to Single Target Track (STT) sub-mode. The range scale will automatically increment if the range to the Primary Target exceeds 90% of the current range scale or decrement if the range is less than 40% of the current range scale.

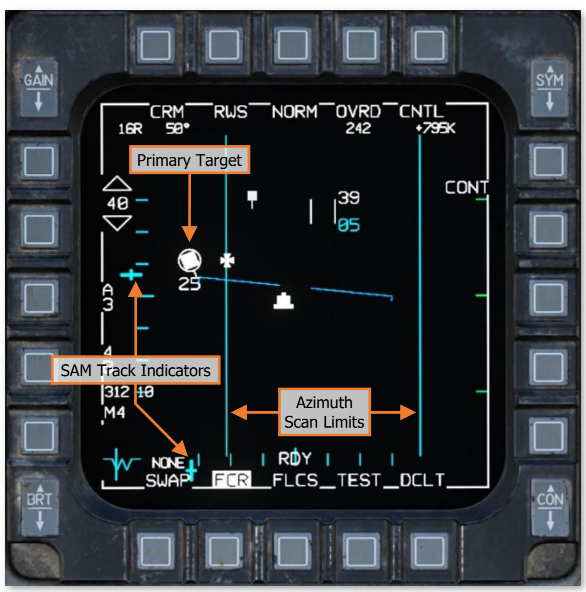
However, if desired, the Acquisition Cursor may be slewed away from the Primary Target after designation and the search volume may be subsequently set to an azimuth scan width of ±60° (A6), ±30° (A3) or ±10° (A1) by pressing OSB 18; and may be set to scan 4 bars (4B), 2 bars (2B), or 1 bar (1B) in elevation by pressing OSB 17.

Unlike TWS, in which the FCR search volume must be manually maintained over a target's position to refresh the track file data during the scan pattern, the FCR will dwell on the SAM Primary Target for a brief moment to refresh the track data every few seconds before returning to the selected scan pattern. This not only decreases the pilot workload and increases the track reliability, but the likelihood that radar warning sensors onboard the target aircraft will recognize the intermittent and brief FCR dwell periods as a threat will be reduced. This allows the target aircraft to be engaged with onboard weapons without alerting the target of an impending attack.



SAM Tracking and Search Pattern

A pair of SAM Track Indicators will be displayed along the Azimuth and Elevation Antenna Scales on the FCR MFD format, corresponding with the position of the SAM Primary Target in azimuth and elevation, respectively.



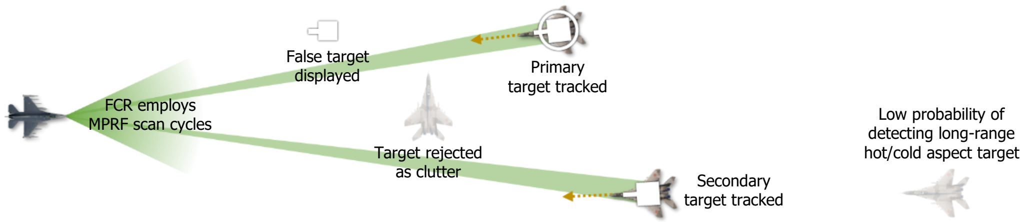
If TMS Right is pressed for 1 full second, the FCR will switch to Track While Scan (TWS) with the SAM Primary Target automatically set as the Bugged Target.

If TMS Forward is pressed while the Acquisition Cursor is over the Primary Target, or if the range to the Primary Target decreases below 3 NM, the FCR will enter Single Target Track (STT) and terminate the scan pattern.

If TMS Aft is pressed, the Primary Target will be rejected and the FCR will return to Range While Search (RWS).

Dual Target Situation Awareness Mode (DT SAM)

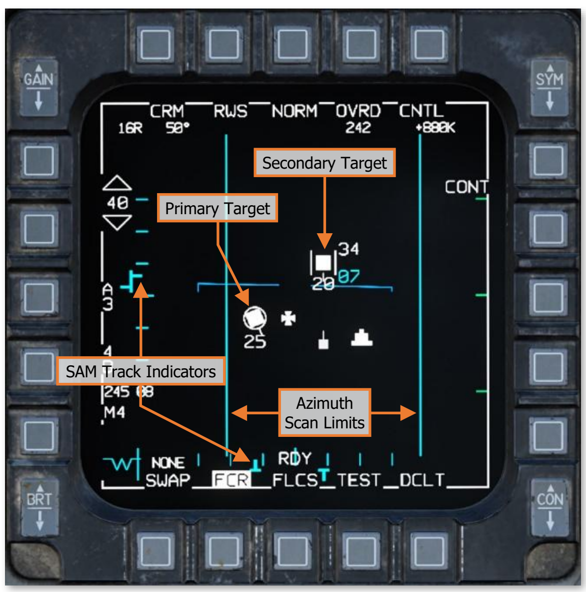
If the FCR is in SAM sub-mode and TMS Forward is pressed while the Acquisition Cursor is over a separate Search Target, the target will be designated as the SAM Secondary Target and the FCR will enter DT SAM sub-mode. DT SAM is identical to SAM in that the FCR alternates between search and tracking, except the FCR will dwell on the SAM Primary Target followed by the SAM Secondary Target before returning to the selected scan pattern.



Dual Target Situation Awareness Mode (DT SAM)

When DT SAM is entered, the Acquisition Cursor will initially snap to the Secondary Target but may be slewed away from the Secondary Target after designation. The automatic decrement of the range scale will be suspended if the Secondary Target would be forced beyond the subsequent range scale setting.

If TMS Right is pressed for less than 1 full second, the Secondary Target will become the Primary Target. By using TMS Right to step the "bug" to the Secondary Target between launches of AIM-120 missiles, both targets may be engaged simultaneously. (See AIM-120 Engagement for more information.)

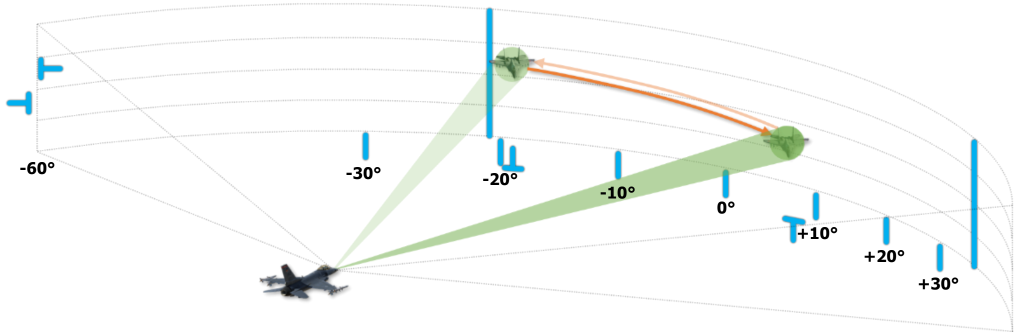


If TMS Right is pressed for 1 full second, the FCR will switch to Track While Scan (TWS) with the SAM Primary Target automatically set as the Bugged Target. The SAM Secondary Target may be retained as a Track Target if sufficiently accurate track data is present.

If TMS Forward is pressed while the Acquisition Cursor is over either SAM target, the FCR will enter Single Target Track (STT) and solely track the selected SAM target. If the range to either SAM target decreases below 10 NM, the FCR will enter Dual Target Track (DTT).

Dual Target Track (DTT)

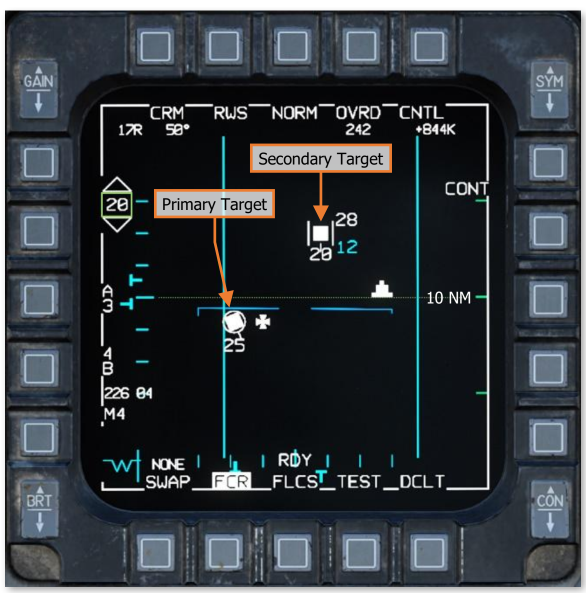
DTT is a tracking-only sub-mode for close-range tracking and engagement of two designated targets. Unlike Dual Target Situation Awareness Mode (DT SAM), in which the FCR alternates between an RWS scan pattern and focused tracking of designated targets, DTT solely tracks two targets without performing a scan pattern. This ensures the FCR can maintain track reliability at close range at the expense of overall awareness of the airspace.



Dual Target Track (DTT)

If the FCR is tracking two targets in DT SAM and the range to either SAM target decreases below 10 NM, the RWS scan pattern is suspended, and the radar will alternate between tracking the Primary and Secondary Target.

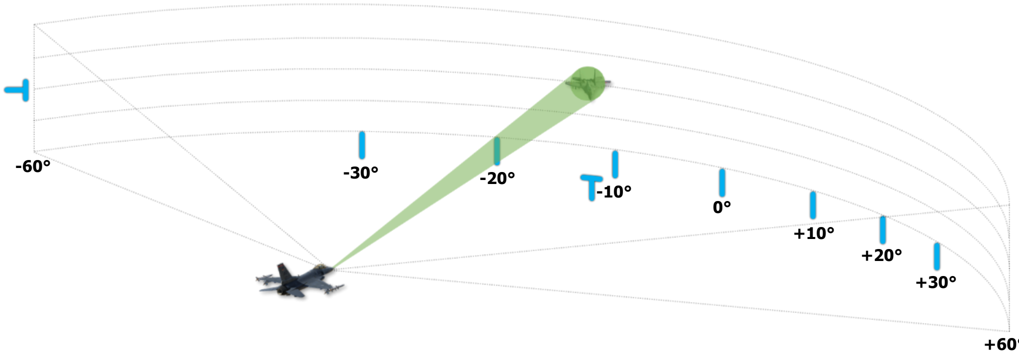
If TMS Right is pressed for less than 1 full second, the Secondary Target will become the Primary Target. By using TMS Right to step the "bug" to the Secondary Target between launches of AIM-120 missiles, both targets may be engaged simultaneously. (See AIM-120 Engagement using DT SAM or DTT for more information.)



If TMS Forward is pressed while the Acquisition Cursor is over either target, the FCR will enter Single Target Track (STT) and solely track the selected target. If the range to either target decreases below 3 NM, the FCR will enter Single Target Track (STT) and solely track the closest target.

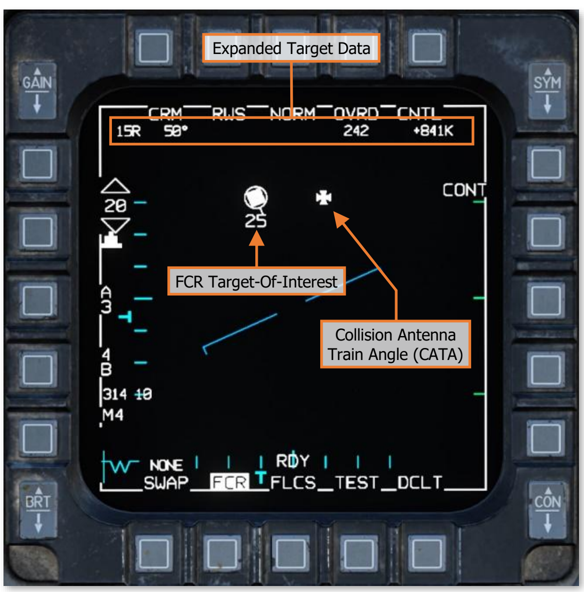
Single Target Track (STT)

STT is a tracking-only sub-mode for tracking and engagement of a single designated target, or FCR Target-Of-Interest (FCR TOI), and may be manually entered by designating a target in Combined Radar Mode when set to VSR, TWS, SAM, or DTT sub-modes, or automatically upon first detection of a target in Air Combat Mode. STT provides the highest track reliability of any FCR sub-mode at the expense of overall awareness of the airspace. In addition, radar warning sensors onboard the target aircraft will likely recognize the continuous radar dwell from STT as a radar lock, and the target will be alerted to an impending attack.



Single Target Track (STT)

When STT sub-mode is entered, the Acquisition Cursor is removed from the FCR MFD format. The range scale will automatically increment if the range to the FCR TOI exceeds 90% of the current range scale or decrement if the range to the FCR TOI is less than 40% of the current range scale. For more information regarding the expanded target data and the Collision Antenna Train Angle (CATA) symbol, see FCR Target-Of-Interest.



If TMS Aft is pressed, the FCR will return to Situation Awareness Mode (SAM), Velocity Search with Ranging (VSR), or Track While Scan (TWS), whichever was the previous FCR sub-mode.

Expand (EXP) Field-Of-View

If multiple airborne targets are in close proximity, making it difficult to determine the number of targets or designate a specific target amongst the group, such as the flight leader, a portion of the FCR display may be enlarged to assist the pilot with target sorting. If the FCR is the Sensor-Of-Interest (SOI), FCR Expand field-of-view may be entered by pressing OSB 3 on the base page of the FCR MFD format or by pressing the Expand/FOV button on the Side Stick Controller (SSC).

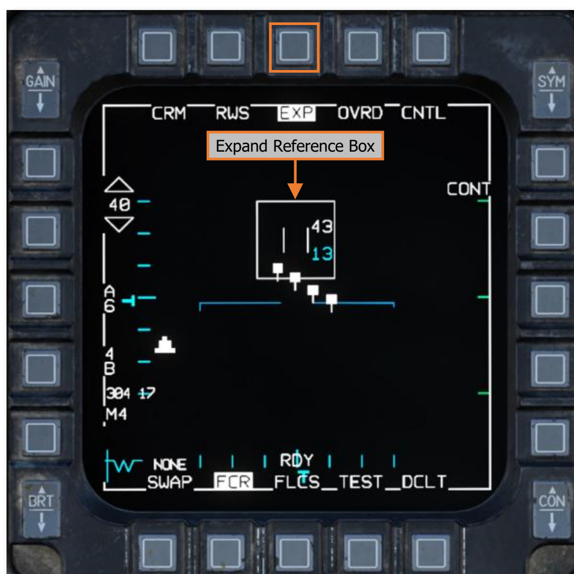
When OSB 3 or the Expand/FOV button is pressed, an 8×8 nautical mile (NM) area around the Acquisition Cursor will be enlarged to encompass the entire MFD display area. An Expand Reference Box is displayed around the Acquisition Cursor that represents the expanded area of the MFD within the current range scale. This box will scale in size if the range scale is incremented or decremented while EXP is selected, or removed entirely at the 160 NM range scale.

All FCR functions remain the same regardless of whether the field-of-view is set to NORM or EXP. However, EXP may only be entered in RWS, TWS, SAM, and DTT sub-modes.

If an FCR Target-Of-Interest (FCR TOI) is designated as the Bugged Target in TWS sub-mode or as the Primary Target in SAM or DTT sub-modes, the expanded area will be centered on the FCR TOI, regardless of whether the TOI was designated before or after EXP field-of-view was selected.

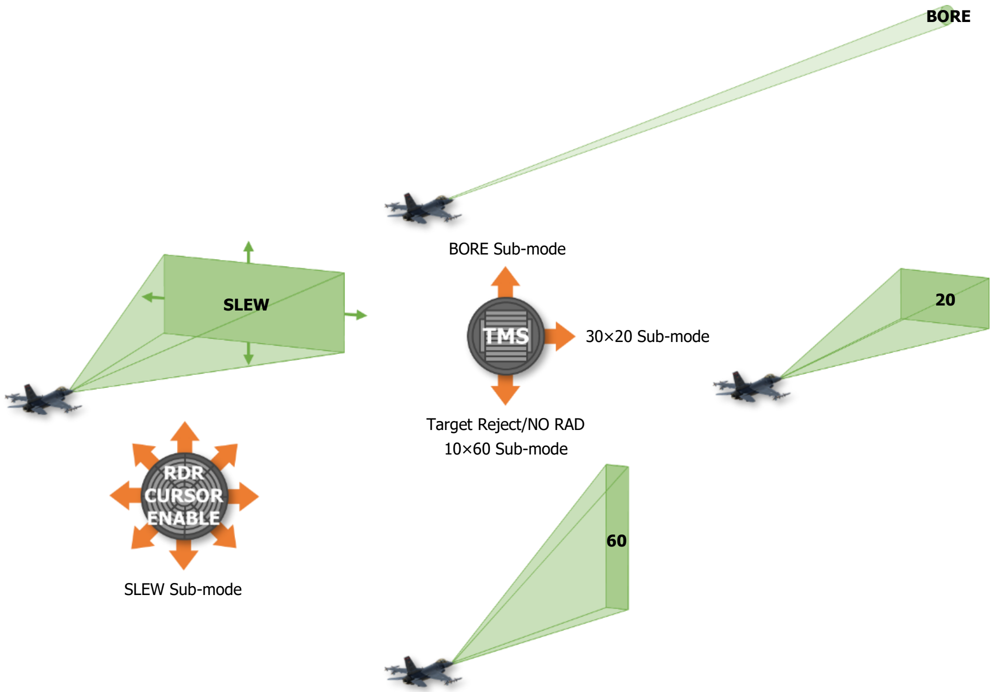
If an FCR TOI has not been designated, the Acquisition Cursor may be slewed just as in NORM field-of-view, with the enlarged portion of the FCR display slewing with it, represented by the Expand Reference Box.

A subsequent press of OSB 3 or the Expand/FOV button will return the FCR MFD format to NORM field-of-view.



Air Combat Mode (ACM)

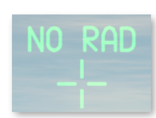
ACM is optimized for tracking and engagement of aircraft within visual range (WVR). ACM includes several radar sub-modes that are designed for rapid acquisition and automatic tracking of airborne targets at close range. The scan patterns utilized by the FCR in each ACM sub-mode are designed for different tactical scenarios, requiring the pilot to select the ACM sub-mode best suited for the positional and attack geometry between the F-16 and the intended target aircraft.



ACM Acquisition Sub-modes

ACM may be entered via the FCR Mode Menu page or by setting the DOG FIGHT switch on the throttle grip to the outboard position to enter DGFT master mode.

When the FCR enters ACM mode, 30×20 sub-mode is automatically selected in a non-radiating state, indicated by "NO RAD" above the HUD Boresight Cross, unless the FCR is already in Single Target Track (STT) sub-mode. Pressing TMS Forward, Right, or Aft, or pressing the RDR CURSOR/ENABLE switch in any direction, will command the FCR to begin transmitting in the corresponding ACM sub-mode.

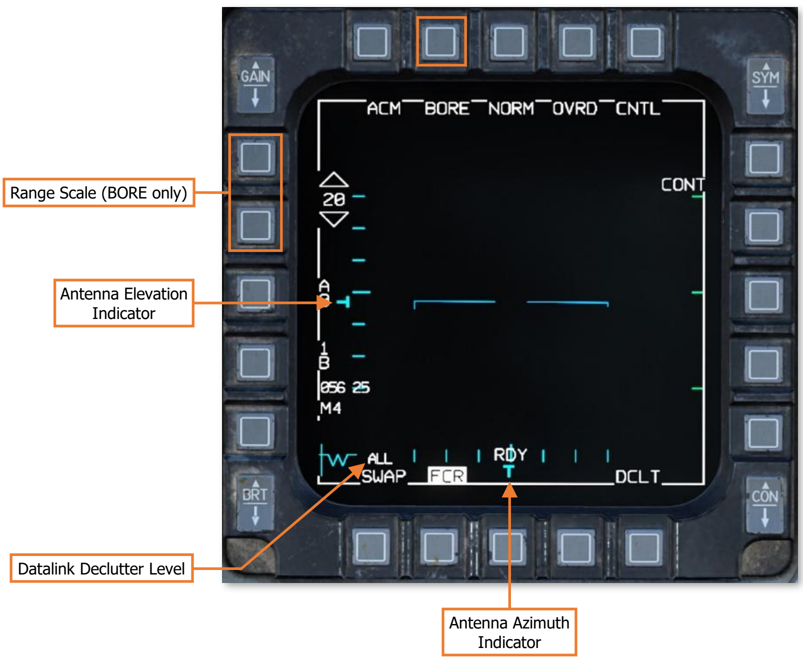


- **30×20 Sub-mode.** If TMS Right is pressed, the FCR will search an area approximately encompassing the HUD (±15° azimuth, +4° to -16° in elevation) and scan to a range of 10 NM.
- **10×60 Sub-mode.** If TMS Aft is pressed while the FCR is in a NO RAD state, the FCR will search a narrow area in front of and above the nose (±5° azimuth, +53° to -7° elevation) and scan to a range of 10 NM.
- **BORE Sub-mode.** If TMS Forward is pressed, the FCR antenna will be fixed to the aircraft boresight position (0° azimuth, -3° elevation) or the HMCS Aiming Cross and scan to a selectable range of 5 to 40 NM.
- **SLEW Sub-mode.** If the RDR CURSOR/ENABLE switch is depressed in any direction, the FCR will enter a 4-bar, ±30° azimuth scan pattern and scan to a range of 10 NM, which may be slewed in any direction.

The ACM sub-mode may be selected using the Target Management Switch (TMS) on the Side Stick Controller (SSC) as described on the previous page or by pressing OSB 2 on the FCR MFD format, which will advance to the next sub-mode in a cyclic manner: 20 → 60 → SLEW → BORE → 20. Pressing OSB 2 to advance to the next ACM sub-mode will also command the FCR to begin transmitting in the corresponding ACM sub-mode.

When the radar begins transmitting in 30×20, 10×60, or SLEW sub-modes, the Antenna Elevation Indicator and Antenna Azimuth Indicator will move within the Antenna Elevation Scale and Antenna Azimuth Scale, respectively, to indicate the FCR antenna's position within the corresponding ACM scan pattern. The FCR will be limited to a maximum range of 10 NM and the range scale arrows are removed from the MFD.

When the radar begins transmitting in BORE sub-mode, the Antenna Elevation Indicator and Antenna Azimuth Indicator will only move from the aircraft boresight position (±0° azimuth, -3° elevation) if the FCR antenna is cued to the HMCS line-of-sight. The range scale will default to 20 NM but may be set to 40, 20, 10, or 5 NM to limit the FCR's maximum range of acquisition to the value selected on the range scale.



Upon detection of a target within the FCR search volume, the FCR will immediately transition to Single Target Track (STT) sub-mode, accompanied by a "Lock" voice message. If the FCR is scanning in any ACM sub-mode or is tracking a target in STT, pressing TMS Aft while the FCR is the Sensor-Of-Interest (SOI) will command the FCR to reject an STT target and return to a non-radiating state (NO RAD).

FCR target symbols are not displayed on the FCR MFD format while scanning in any ACM sub-mode since the FCR will immediately enter STT sub-mode upon the first detection of a target within the search volume.

NOTE: Datalink tracks received from offboard sources are not displayed on the FCR MFD format in ACM, to include friendly aircraft, regardless of the Datalink Declutter Level setting. Prudence must be exercised when employing weapons in close-range aerial combat to ensure friendly aircraft are not inadvertently targeted, such as performing an IFF interrogation of the target aircraft after an STT lock has been established.

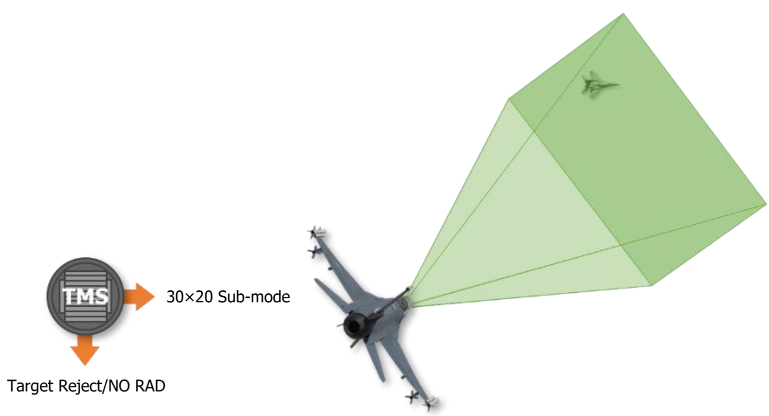
30×20 (20) Sub-mode

The 30×20 sub-mode scans ±15° in azimuth and +4° to -16° in elevation, which coincides with a search area that is slightly larger than the field-of-view of the HUD. The search volume is body-stabilized and extends to 10 nautical miles (NM). 30×20 is ideal for acquiring an STT lock on a close-range target directly in front of the aircraft that may be maneuvering within a different plane of turn than the ownship.

When 30×20 sub-mode is selected, the FCR MFD format will display "20" below OSB 2. However, unlike the other three ACM sub-modes, 30×20 does not present any unique symbology within the HUD to identify the selection of this mode. 30×20 is the default sub-mode when ACM is entered.

Pressing TMS Right while the FCR is Sensor-Of-Interest (SOI) will command the FCR to begin transmitting in 30×20 sub-mode. The FCR will lock onto the first target detected within the search volume and transition to Single Target Track (STT) sub-mode.

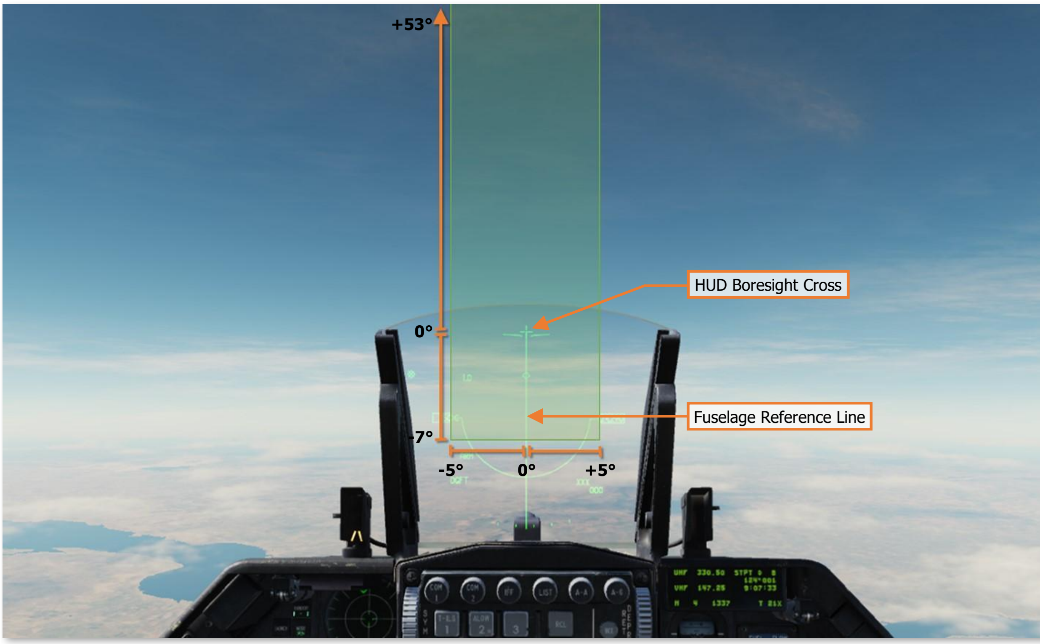
Pressing TMS Aft while the FCR is SOI and transmitting will command the FCR to return to a non-radiating state (NO RAD) and reject an STT target.



30×20 Sub-mode

10×60 (60) Sub-mode

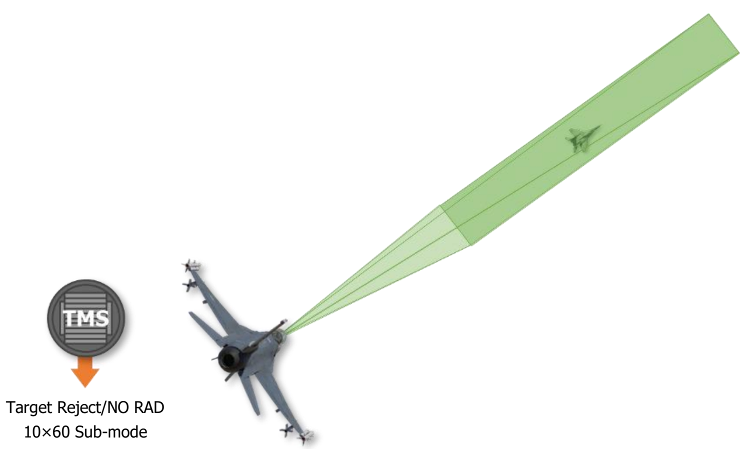
The 10×60 sub-mode scans ±5° in azimuth and +53° to -7° in elevation, which coincides with a narrow search area in front of and above the nose. The search volume is body-stabilized and extends to 10 nautical miles (NM). 10×60 is ideal for acquiring an STT lock on a close-range target directly in front of the aircraft that is maneuvering within the same plane of turn as the ownship, especially if the ownship is in a lag pursuit behind the target.



When 10×60 sub-mode is selected, the FCR MFD format will display "60" below OSB 2 and the Fuselage Reference Line is displayed in the HUD, extending from the Boresight Cross through the bottom of the HUD itself. The Fuselage Reference Line may be used as an aiming device to align the search volume with the intended target.

Pressing TMS Aft while the FCR is Sensor-Of-Interest (SOI) and in a non-radiating state (NO RAD) will command the FCR to begin transmitting in 10×60 sub-mode. The FCR will lock onto the first target detected within the search volume and transition to Single Target Track (STT) sub-mode.

Pressing TMS Aft while the FCR is SOI and transmitting will command the FCR to return to a non-radiating state (NO RAD) and reject an STT target.



10×60 Sub-mode

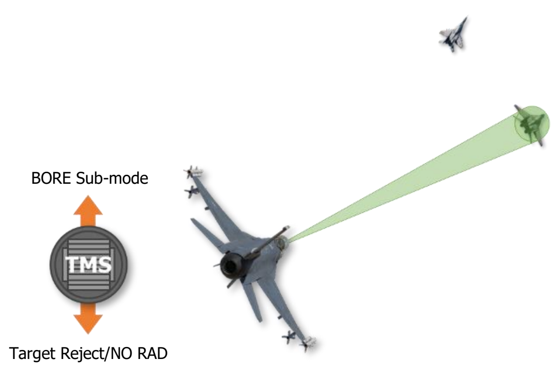
Boresight (BORE) Sub-mode

The BORE sub-mode scans at 0° in azimuth and -3° in elevation while utilizing a fixed radar antenna position, the beamwidth of which coincides with the approximate dimensions of the Radar Bore Cross displayed within the HUD. The search volume is body-stabilized and extends to 20 nautical miles (NM) by default, but may be set to 40, 20, 10, or 5 NM. BORE is ideal for acquiring an STT lock on a specific close-range target directly in front of the aircraft at the exclusion of other aircraft that may be within proximity to the intended target. The fixed antenna position allows the pilot to use the Radar Bore Cross within the HUD to precisely aim the FCR antenna beamwidth at the intended target.

When BORE sub-mode is selected, the FCR MFD format will display "BORE" below OSB 2 and a large Radar Bore Cross is displayed just below the HUD Boresight Cross.

Pressing TMS Forward while the FCR is Sensor-Of-Interest (SOI) will command the FCR to begin transmitting in BORE sub-mode. The FCR will lock onto the first target detected within the search volume and transition to Single Target Track (STT) sub-mode.

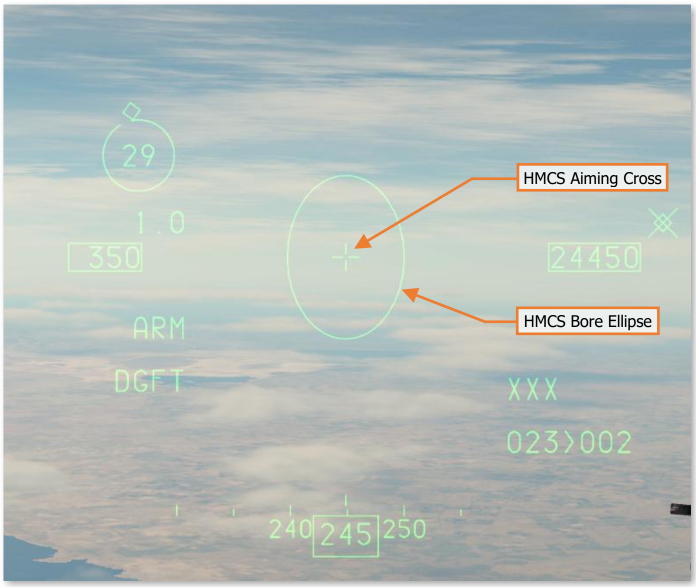
Pressing TMS Aft while the FCR is SOI and transmitting will command the FCR to return to a non-radiating state (NO RAD) and reject an STT target.



BORE Sub-mode

BORE Sub-mode with HMCS Cueing

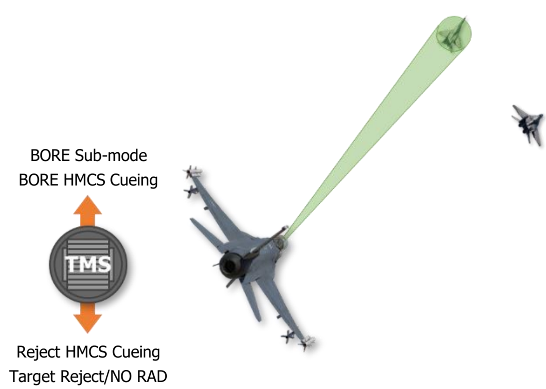
When HMCS cueing is enabled, the FCR scans along the line-of-sight of the HMCS Aiming Cross while utilizing a fixed radar antenna position, the beamwidth of which coincides with the approximate dimensions of the HMCS Bore Ellipse. The search volume is body-stabilized and extends to 20 nautical miles (NM) by default, but may be set to 40, 20, 10, or 5 NM. HMCS cueing is ideal for acquiring an STT lock on a specific close-range target outside the HUD field-of-view. This allows the pilot to precisely aim the FCR antenna beamwidth at the intended target if it is not feasible to align the HUD Radar Bore Cross with the target, particularly if intending to engage the target with a missile while it remains outside the HUD field-of-view.



The HMCS may be used to cue the FCR antenna position to acquire an off-boresight target if BORE sub-mode is selected and the HMCS symbology is displayed. When HMCS Cueing is enabled, a HMCS Bore Ellipse is displayed around the HMCS Aiming Cross.

Pressing TMS Forward while the FCR is Sensor-Of-Interest (SOI) will command the FCR to begin transmitting in BORE sub-mode. A second press of TMS Forward while the HMCS symbology is displayed will cue the FCR antenna to align with the HMCS Aiming Cross and display the HMCS Bore Ellipse. The FCR will lock onto the first target detected within the search volume and transition to Single Target Track (STT) sub-mode.

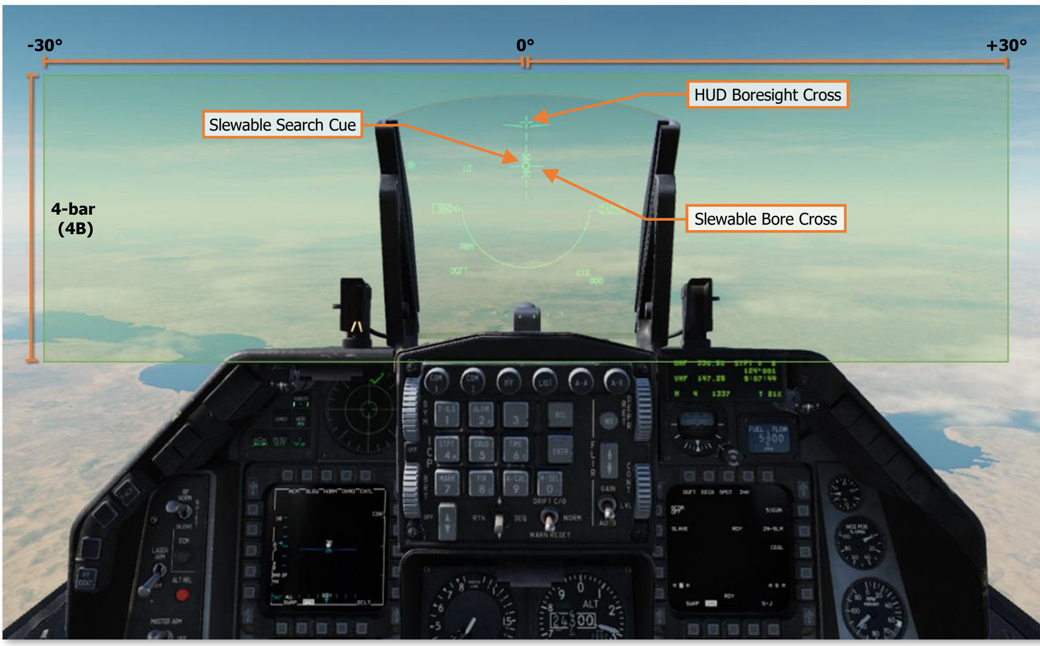
Pressing TMS Aft while the FCR is SOI after cueing the FCR antenna to the HMCS Aiming Cross will reject HMCS Cueing in BORE sub-mode, command the FCR antenna to re-align to the HUD Radar Bore Cross, and remove the HMCS Bore Ellipse from the HMCS symbology. Pressing TMS Aft will also reject an STT target and command the FCR to return to a non-radiating state (NO RAD).



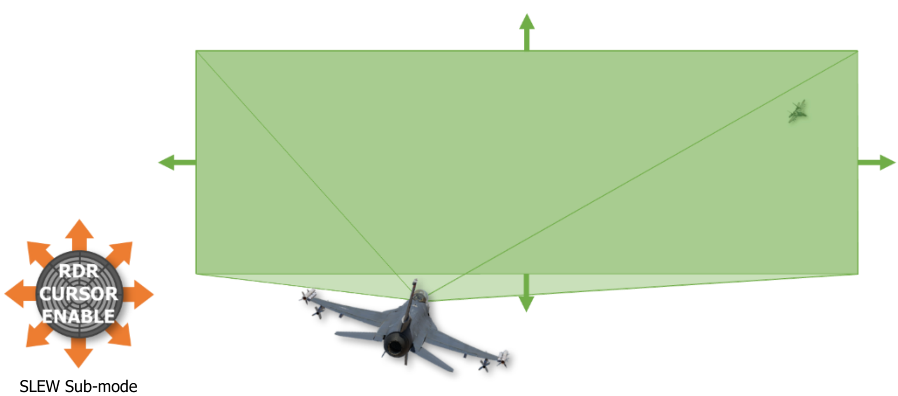
BORE Sub-mode (HMCS Cueing)

Slew (SLEW) Sub-mode

The SLEW sub-mode uses a 4-bar, ±30° azimuth scan pattern that is initially centered on the nose along the inertial horizon, but may be slewed in azimuth and elevation within the mechanical FCR antenna gimbal limits using the RDR CURSOR/ENABLE switch on the throttle grip. The search volume is space-stabilized and extends to 10 nautical miles (NM). SLEW is ideal for acquiring an STT lock on a close-range target that has not yet been visually acquired, particularly when transitioning into within visual range combat during which Combined Radar Mode (CRM) is no longer ideal but the intended target is still far enough away that visual acquisition is difficult.

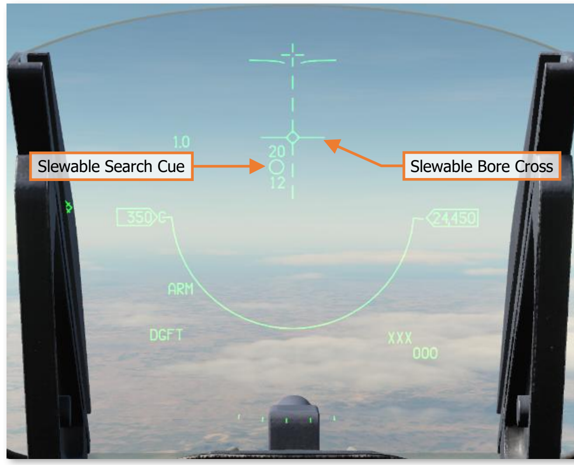


When SLEW sub-mode is selected, the FCR MFD format will display "SLEW" below OSB 2, the Antenna Pointing Cross symbol, and Maximum and Minimum Search Altitudes. The HUD will display the dashed Slewable Bore Cross, Slewable Search Cue, and Maximum and Minimum Search Altitudes just below the HUD Boresight Cross.



SLEW Sub-mode

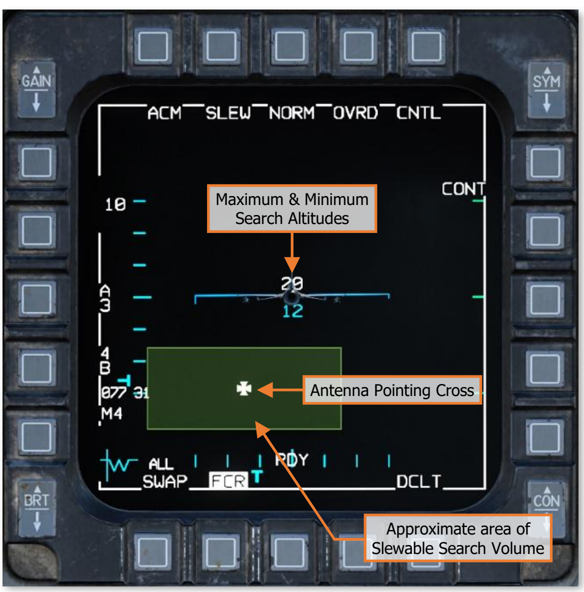
Pressing the RDR CURSOR/ENABLE switch in any direction while the FCR is Sensor-Of-Interest (SOI) will simultaneously command the FCR to begin transmitting in SLEW sub-mode and slew the FCR search volume in the corresponding cursor direction. The FCR will lock onto the first target detected within the search volume and transition to Single Target Track (STT) sub-mode.



Pressing TMS Aft while the FCR is SOI and transmitting will command the FCR to return to a non-radiating state (NO RAD) and reject an STT target.

Two numerical values will be displayed above and below the Slewable Search Cue, which indicate the Maximum and Minimum Search Altitudes, respectively, above mean sea level (MSL) at a range of 10 NM.

When SLEW sub-mode is entered, the Maximum and Minimum Search Altitudes will also be displayed in the center of the FCR MFD format, along with an Antenna Pointing Cross symbol. The Antenna Pointing Cross on the MFD and the Slewable Search Cue in the HUD indicate the center position of the FCR Slewable Search Volume in relation to the aircraft heading and inertial horizon. Both symbols are positioned based on a forward-looking perspective in relation to the aircraft fuselage, as depicted by the notional F-16 superimposed in the center of the MFD below.

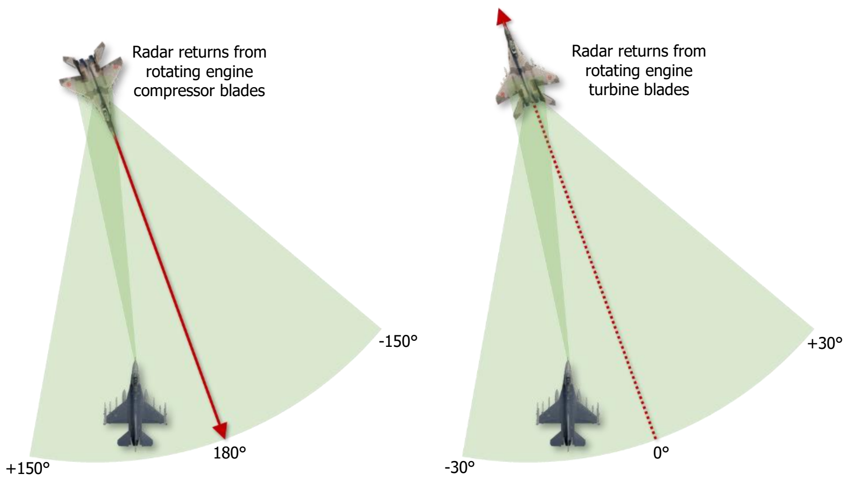


In the example images of the HUD and FCR MFD format on this page, the FCR search volume has been slewed left and downward, with the maximum search altitude corresponding with 20,000 feet MSL at 10 NM and the minimum search altitude corresponding with 12,000 feet MSL at 10 NM.

The approximate area of the Slewable Search Volume is notionally depicted on the MFD on the left (Shaded Area) in relation to the Antenna Elevation Scale along the left side of the MFD and the Antenna Azimuth Scale along the bottom of the MFD.

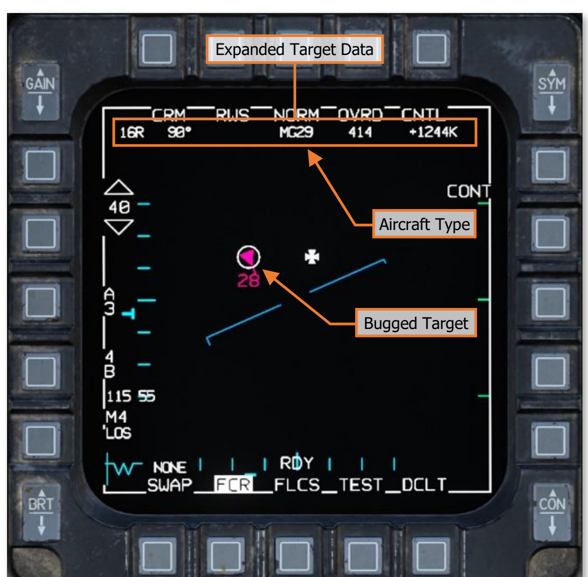
Non-Cooperative Target Recognition (NCTR)

The FCR is equipped with a Non-Cooperative Target Recognition (NCTR) capability that uses radar processing algorithms to compare a target's radar signature to a data set pre-loaded within the onboard memory in an attempt to identify the type of aircraft that is being targeted. NCTR analyzes radar returns from the rotating components of an aircraft's engine(s) to determine the aircraft type, which requires NCTR be employed in a head-on or tail-on aspect angle only.



NCTR Radar Signature Analysis

If TMS Left is pressed for >0.5 seconds while an FCR Target-Of-Interest (TOI) is designated, a NCTR classification of the FCR TOI and an AIFF LOS Interrogation along the azimuth of the Acquisition Cursor will be performed simultaneously.



A NCTR classification can only be performed within 25 nautical miles (NM) of the FCR TOI and from an aspect angle between 0°-30° or 150°-180°, which can be referenced within the Expanded Target Data on the FCR MFD format as "3L" to "3R" or "15L" to "15R".

If the NCTR classification is successful, the NCTR identification code of the aircraft type will be displayed in the Expanded Target Data and the FCR TOI target symbol will be updated in shape and color based on the coalition affiliation of that aircraft type. See the following page for more information.

If the NCTR classification is unsuccessful due to the radar signature not matching a pre-loaded aircraft type, the NCTR classification will be displayed as "UKN", or unknown.

If the NCTR classification is unsuccessful due to the target being outside the range or aspect angle constraints, the NCTR classification will be displayed as "INVL", or invalid.

NCTR-classified Target Symbols

The shape and color of NCTR-classified FCR target symbols are based on the coalition affiliation of that aircraft type, as shown on the left.

NOTE: Offboard track information received from wingmen, donors, or surveillance aircraft via the datalink may affect the shape/color of symbols. (See the Tactical Net Datalink chapter for more information.)

NCTR Identification Codes

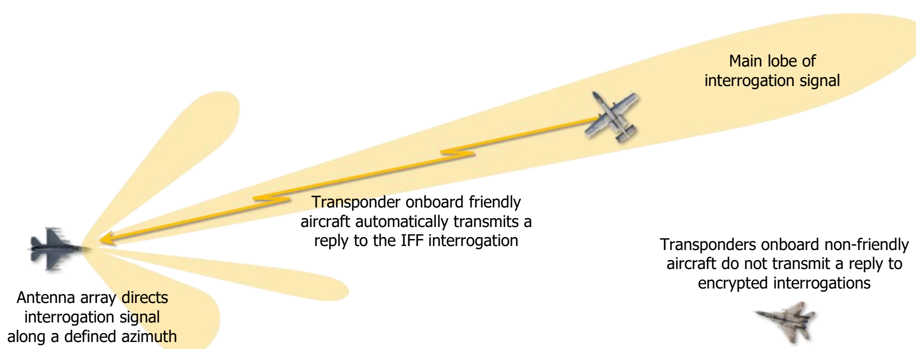
The following table displays the pre-loaded NCTR codes for the corresponding aircraft types.

CODE	AIRCRAFT TYPE	CODE	AIRCRAFT TYPE
MG19	MiG-19	F4	F-4
MG21	MiG-21	F5	F-5
MG23	MiG-23	F14	F-14
MG25	MiG-25	F15	F-15
MG27	MiG-27	F16	F-16
MG29	MiG-29	FA18	F/A-18
MG31	MiG-31	AV8B	AV-8B (front aspect only)
SU17	Su-17	A6	A-6
SU24	Su-24	A10	A-10
SU25	Su-25	B1	B-1
SU27	Su-27, J-11	B52	B-52
SU30	Su-30	C17	C-17
SU33	Su-33	C130	C-130
SU34	Su-34	E2	E-2
TU22	Tu-22M	E3	E-3
TU95	Tu-95	KC135	KC-135
TU142	Tu-142	S3	S-3
TU160	Tu-160	AJS37	AJS 37
AN26	An-26	MF1	Mirage F1
AN30	An-30	M2000	Mirage 2000
IL76	Il-76, A-50	GR1	Tornado IDS
IL78	Il-78	GR4	Tornado GR4
JF17	JF-17	L39	L-39
TU16	H-6		
KJ2000	KJ-2000		
YK40	Yak-40		

Advanced Identification-Friend-or-Foe (AIFF)

The Advanced Identification-Friend-or-Foe (AIFF) system allows the F-16 to transmit radio signals to "interrogate" other aircraft to determine if they are friendly. The AIFF system on the F-16 utilizes an array of four antennas mounted on the nose of the aircraft to transmit encrypted signals to which transponder systems onboard friendly aircraft will recognize and transmit an encrypted code as a reply. When the correct reply code is received, the interrogated aircraft is recognized as friendly. If an interrogated aircraft does not transmit a reply or transmits an incorrect reply, it may not be a friendly aircraft.

The AIFF uses a signal processing method known as "beamforming" to electronically focus and direct an interrogation signal along a specific azimuth by altering the amplitude and phase of the transmissions from multiple antennas. This allows the AIFF to sweep the main lobe of the interrogation signal across a wide area of airspace and then process any reply signals that are received along the corresponding azimuths to correlate the replies with radar targets displayed on the FCR MFD format.



Encrypted IFF Interrogation

The F-16C is capable of transmitting Mode 1, Mode 2, Mode 3, or Mode 4 interrogations via its nose-mounted interrogator array, or a combination of these modes sequentially during the same interrogation. However, only Mode 4 interrogations may be performed in DCS: F-16C Viper.

The APX-113(V) provides AIFF functions, which consists of both interrogator and transponder components, and is primarily controlled via the IFF control panel and the Upfront Controls (UFC). The MASTER knob on the IFF control panel enables power to the AIFF system.

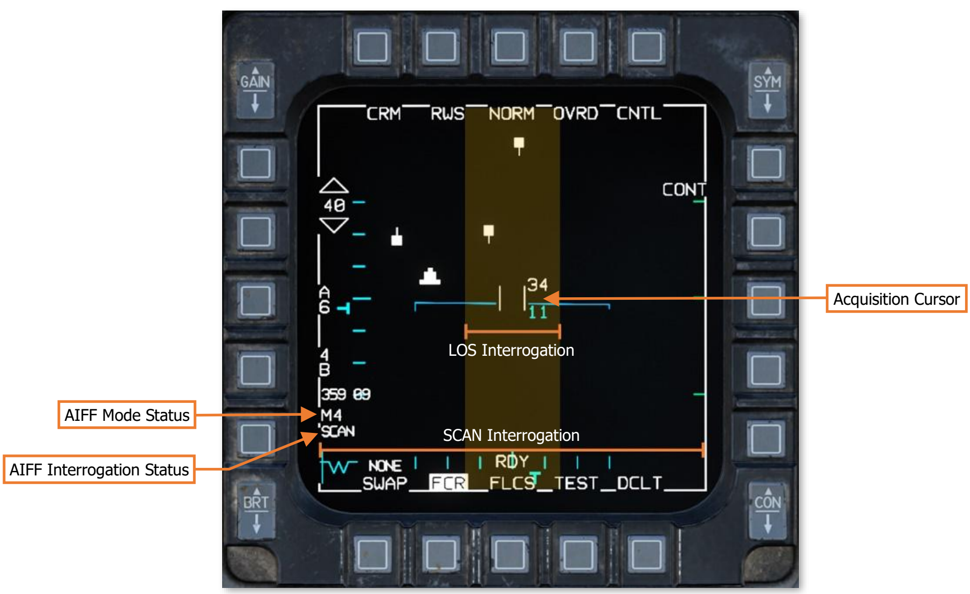
- **OFF.** Transponder and interrogation functions are disabled. The AIFF Mode Status data field on the FCR MFD format will display "OFF".
- **STBY.** Transponder functions are powered but inhibited. Interrogation functions are enabled. The AIFF Mode Status data field on the FCR MFD format will display "M4".
- **LOW/NORM/EMER.** Transponder and interrogation functions are enabled. The AIFF Mode Status data field on the FCR MFD format will display "M4".

If the FCR is the Sensor-Of-Interest (SOI), an IFF interrogation may be performed by pressing TMS Left on the Side Stick Controller (SSC). The duration of the press will determine which type of interrogation is performed.

SCAN Interrogation. If TMS Left is pressed for <0.5 seconds, the AIFF antenna array will scan a volume of airspace consisting of ±60° in azimuth, centered on the aircraft nose, and ±60° in elevation.

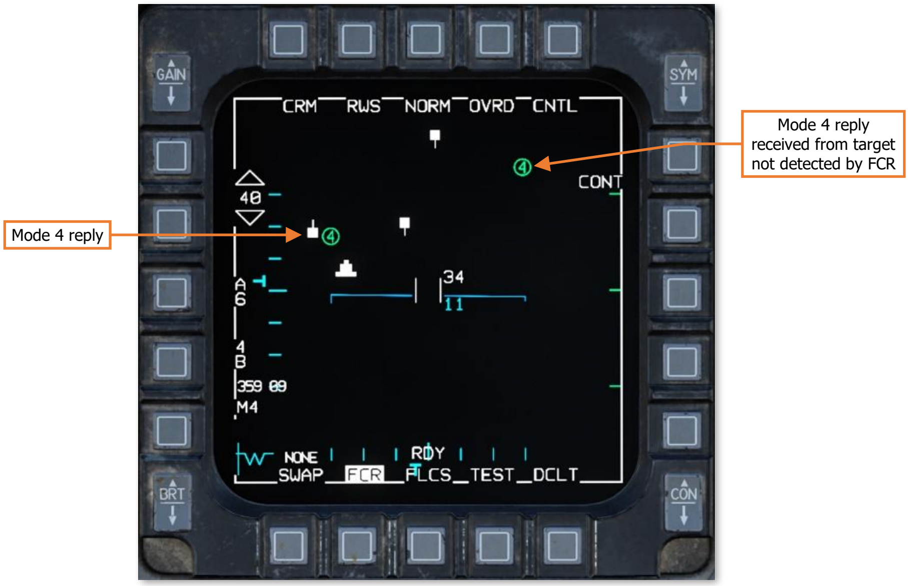
Line-Of-Sight (LOS) Interrogation. If TMS Left is pressed for >0.5 seconds, the AIFF antenna array will scan a volume of airspace consisting of ±15° in azimuth, centered on the Acquisition Cursor, and ±60° in elevation.

When the AIFF antenna array is transmitting an interrogation signal, the AIFF Interrogation Status data field FCR on the FCR MFD format will display "SCAN" or "LOS", depending on the type of interrogation being performed.



If a reply to an interrogation is received, the timing and direction of the reply will be processed in a similar manner to a radar return, and an IFF symbol will be displayed on the FCR MFD format in azimuth and range. However, it is important to note that IFF interrogations do not have the same precision as the FCR, so IFF symbols may be offset from their true position compared to a corresponding radar target from which the reply was received.

Each IFF interrogation is only performed momentarily and the corresponding IFF reply symbols are displayed on the FCR MFD format for two seconds as brief "photographs" of the airspace. Correct replies to an interrogation are displayed as a green circle, with the type of reply displayed in the center of the symbol itself (e.g., a Mode 4 reply symbol will display a "4" in the center).



IFF interrogations are limited to a maximum range of 115 nautical miles (NM), regardless of the selected range scale on the FCR MFD format. However, IFF interrogations may be performed independently of the FCR if the RF switch on the MISC panel is set to QUIET or SILENT.

It is important to understand that a valid reply to a Mode 4 interrogation confirms that the target is friendly, but the lack of a valid reply does not necessarily confirm the target is hostile, as it may be an aircraft from a neutral country or a civilian aircraft. Rather, the lack of a valid Mode 4 reply should be considered as one factor amongst others that may be used to assess whether the target is in fact a hostile military aircraft. Rules Of Engagement (ROE) and proper judgement by the pilot should determine whether a target should be engaged with onboard weapons. Other factors that may be considered, depending on the tactical situation, are as follows.

- The type of aircraft that the target is assessed to be, compared to the types of aircraft that each coalition is known to possess within their operational inventory (referred to as the Order Of Battle). Non-Cooperative Target Recognition (NCTR) may be used to determine this factor.
- Target information or identification verbally relayed from other friendly platforms via radio communications, such as the E-3 AWACS command and control aircraft.
- Target information or identification digitally relayed from other friendly platforms via datalink systems, which may include aircraft type, coalition affiliation, offboard IFF interrogation status, and speed and/or altitude.
- Speed and altitude profile of the aircraft. If the aircraft is capable of high-speeds, high rates of climb to high altitudes, aggressive maneuvers, or a combination of these capabilities, the aircraft is likely military in nature.
- Point of origin or area of operation. If the aircraft is climbing away from a location coinciding with an airbase that is controlled by a specific coalition, the aircraft could be departing from that airbase or egressing following an attack on it. Similarly, if an aircraft is operating over an area of the battlefield under control of a specific coalition, the aircraft could be patrolling over friendly territory or actively searching for and/or engaging hostile ground forces. Situational awareness must be used to assess the most likely scenario.

FCR AIR-TO-GROUND MODES

The APG-68 Fire Control Radar (FCR) is capable of generating radar imagery of the surface in front of the aircraft, which may be used to locate significant terrain features and landmarks for navigation or distinctive man-made objects and structures for orientation prior to an attack run against a known target location. The FCR may also employ Ground Moving Target processing to detect and highlight positions of mobile ground vehicles. When performing visual attacks using Continuously Computed Impact Point (CCIP) bombing or gun strafing (STRF), the FCR may be used for ranging calculations for accurate delivery of ballistic munitions.

AN/APG-68 Air-to-Ground Search, Tracking, and Ranging Modes

When in Navigation (NAV) master mode or Air-to-Ground (A-G) master mode with a "Pre-planned" weapon delivery sub-mode selected, several pilot-selectable modes are available for targeting or performing an update to the navigation system. When in A-G master mode with a "Visual" weapon delivery sub-mode selected, the FCR is used for ranging only.

NAV/A-G "Pre-planned" Weapon Delivery Sub-modes

Target location is designated by a steerpoint.

- **GM** Ground Map
- **GMT** Ground Moving Target
- **SEA** Sea
- **BCN** Beacon (Not implemented)
- **FTT** Fixed Target Track
- **GMTT** Ground Moving Target Track

A-G "Visual" Weapon Delivery Sub-modes

Target is visually acquired by the pilot.

- **AGR** Air-to-Ground Ranging

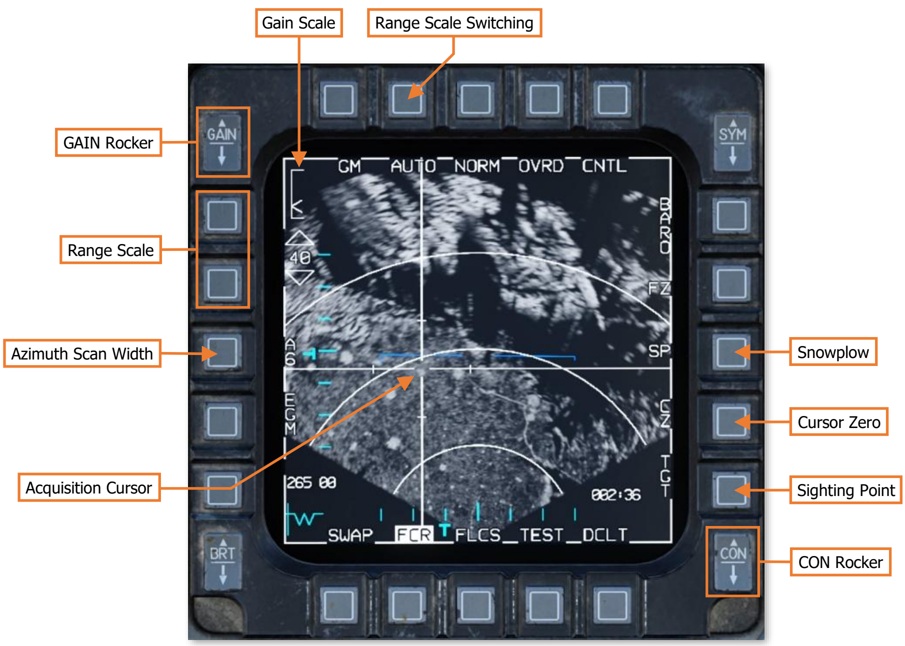
When entering A-G master mode with CCRP, LADD, EO-PRE, EO-BORE, PRE, or MAN selected as the weapon delivery sub-mode, the FCR will automatically default to GM, but may be changed to GMT or SEA if desired. When entering A-G master mode with CCIP, DTOS, EO-VIS, VIS, or STRF selected as the weapon delivery sub-mode, the FCR will automatically enter AGR and cannot be changed to any other sub-mode.

Ground Map (GM) Mode

GM mode produces a radar-generated image of the terrain in front of the aircraft, displayed in a Plan Position Indicator (PPI) format, and is used for navigation and targeting of large, fixed structures or offset aimpoints. As the FCR scans the terrain ahead of the aircraft, a radar map is displayed on the MFD based on the strength or reflectivity of the raw radar returns, allowing the pilot to distinguish terrain features that cannot be visually seen due to distance, low-visibility, or hours of darkness. Terrain features with generally low radar reflectivity include rivers, lakes, or open plains with minimal terrain relief; and those with generally high radar reflectivity include man-made structures, urban areas, mountains, and rolling hills.

The gain of the radar map underlay may be adjusted independently of the MFD symbology using the GAIN rocker on the top left corner of the MFD itself, with the current gain setting displayed on the adjacent Gain Scale. In addition, the contrast of the radar map may be adjusted using the CON rocker on the bottom right corner of the MFD.

GM is the default FCR mode when the MMC master mode is set to Air-to-Ground (A-G) with a "Pre-planned" weapon delivery sub-mode selected. GM mode may also be selected from the FCR Mode Menu page by pressing OSB 1 when the MMC master mode is set to Navigation (NAV). When GM mode is selected, the FCR MFD format will display "GM" below OSB 1.

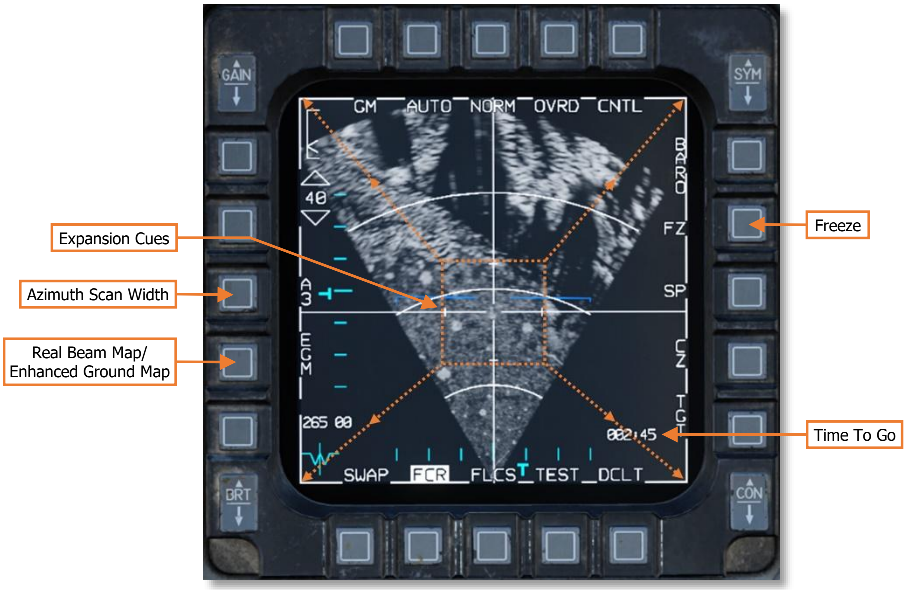


The GM footprint may be set to a full horizontal azimuth scan width of ±60° (A6) or a reduced scan width of ±30° (A3) or ±10° (A1) by pressing OSB 18. The GM range scale may be set to 10, 20, 40, or 80 nautical miles (NM) by pressing OSB 19 to reduce the range scale or OSB 20 to increase the range scale.

The Acquisition Cursor coincides with the 3-dimensional location of the System-Point-of-Interest (SPI), which may be assigned to a different sighting point by pressing OSB 10 or TMS Right on the Side Stick Controller (SSC), or to the Snowplow cursor by pressing OSB 8. The Acquisition Cursor may be slewed using the RDR CURSOR/ENABLE switch on the throttle grip, which coincides with a slew of the Navigation cursor, or zeroized by pressing OSB 9.

The Acquisition Cursor will automatically increase or decrease the FCR range scale setting if slewed beyond the upper or lower limits of the current range scale while the Range Scale Switching option at OSB 2 is set to AUTO.

As the Acquisition Cursor is slewed in Navigation master mode, the Time To Go data field in the bottom right corner will update to reflect the estimated time remaining before arriving at the selected steerpoint. If in Air-to-Ground master mode, the Time To Go data field will display the time remaining before pull-up or weapon release, or the time remaining until the bomb impacts the surface if a laser guided bomb is released.



Reducing the azimuth scan width increases the refresh rate of the radar map; or switching the radar processing to Real Beam Map (RGM) by pressing OSB 17 provides a faster refresh rate of the radar map at the expense of displaying raw radar imagery of the terrain with less detail. Inversely, Enhanced Ground Map (EGM) processing sharpens the radar imagery with a 4:1 increase in resolution of the radar map but slows down the refresh rate to accommodate the increased radar processing.

NOTE: Changing between RGM and EGM processing is only applied at the completion of the current FCR scan cycle.

Alternatively, a more detailed and expanded image of the terrain around the Acquisition Cursor may be viewed by pressing OSB 3 on the base page of the FCR MFD format or the Expand/FOV button on the Side Stick Controller (SSC). Four expansion cues are displayed around the Acquisition Cursor that indicate the area on the radar-generated image that will be displayed on the MFD if the field-of-view is set to EXP. (See Expand Field-Of-View for more information.)

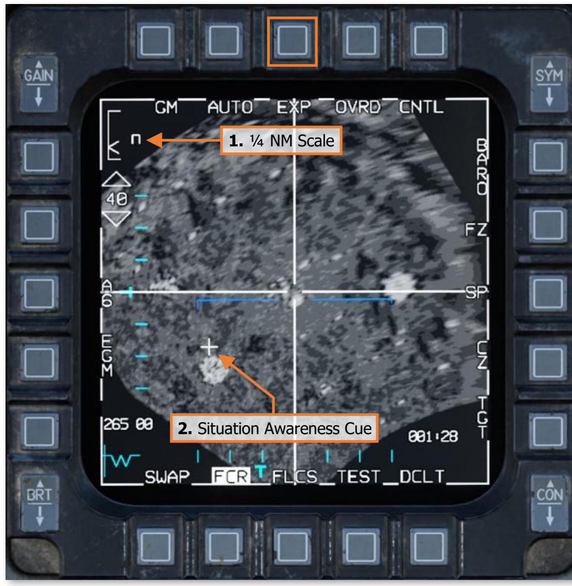
If desired, the pilot may enable the Freeze (FZ) option by pressing OSB 7, which will disable the FCR emissions while retaining the most recent radar image of the terrain on the MFD. (See Freeze Option for more information.)

If TMS Forward is pressed and released, the terrain location under the Acquisition Cursor will be designated and the most recent radar image of the terrain will be frozen on the MFD in a similar manner to enabling Freeze, but the FCR will continue to emit in Fixed Target Track (FTT) mode.

Expand (EXP) Field-Of-View

When viewing the radar-generated image of the terrain on the FCR MFD format, it may be difficult to distinguish details, particularly at long distances. The Expand field-of-view may be entered by pressing OSB 3 on the base page of the FCR MFD format or by pressing the Expand/FOV button on the Side Stick Controller (SSC), which provides a 4:1 increase in resolution and more precision when slewing the Acquisition Cursor within a small area of the terrain, ensuring it is placed over the intended target or offset aimpoint.

When the FCR field-of-view is cycled to EXP, the area outlined by the Expansion Cues is enlarged to encompass the entire MFD display area, the Acquisition Cursor is positioned within the large crosshairs fixed to the center of the MFD, and a Situation Awareness Cue and ¼ NM Scale are displayed. If the Acquisition Cursor is slewed, the expanded radar map, or "patch", is slewed relative to the crosshairs and subsequently refreshed during the next FCR scan.



1. **¼ NM Scale.** Indicates the distance on the expanded radar map which corresponds to 0.25 nautical miles (NM).
2. **Situation Awareness Cue**. Indicates the position of the Acquisition Cursor relative to the current range scale, independent of the expanded radar map.

In the image on the right, with a range scale of 40 NM, the Situation Awareness Cue indicates the radar map "patch" displayed on the MFD is approximately 15 NM away and to the left of the aircraft's flight path.

The resolution of the radar-generated ground map will be at its lowest directly in front of the aircraft's flight path. Flying at an off-axis angle relative to the expanded radar map will typically increase the resolution of the terrain features. The pilot may further increase the resolution of the terrain using a radar processing method known as Doppler beam sharpening, as described on the following pages, by pressing OSB 3 or the Expand/FOV button when already in EXP field-of-view to cycle the FCR MFD format to DBS1 or DBS2 fields-of-view.

The patch sizes in the EXP, DBS1, and DBS2 fields-of-view are dependent on the current range scale:

Range Scale	**10**	**20**	**40**	**80**
EXP Patch Size	2.5 NM	5 NM	10 NM	20 NM
DBS1 Patch Size	2.5 NM	5 NM	10 NM	20 NM
DBS2 Patch Size	Variable with range	Variable with range	Variable with range	Variable with range

A different patch size may be manually selected by pressing OSB 19 to reduce the range scale or OSB 20 to increase the range scale, even if the cursor position is beyond the corresponding range scale. However, this will revert the field-of-view to NORM and set the Range Scale Switching option at OSB 2 to MAN, requiring the pilot re-select EXP, DBS1, or DBS2 field-of-view, as desired.

All FCR functions remain the same regardless of whether the field-of-view is set to NORM, EXP, DBS1, or DBS2; however, DBS processing may only be entered while in GM mode. If the FCR is set to GMT or SEA, pressing OSB 3 or the Expand/FOV button will only toggle the FCR MFD format between NORM and EXP fields-of-view.

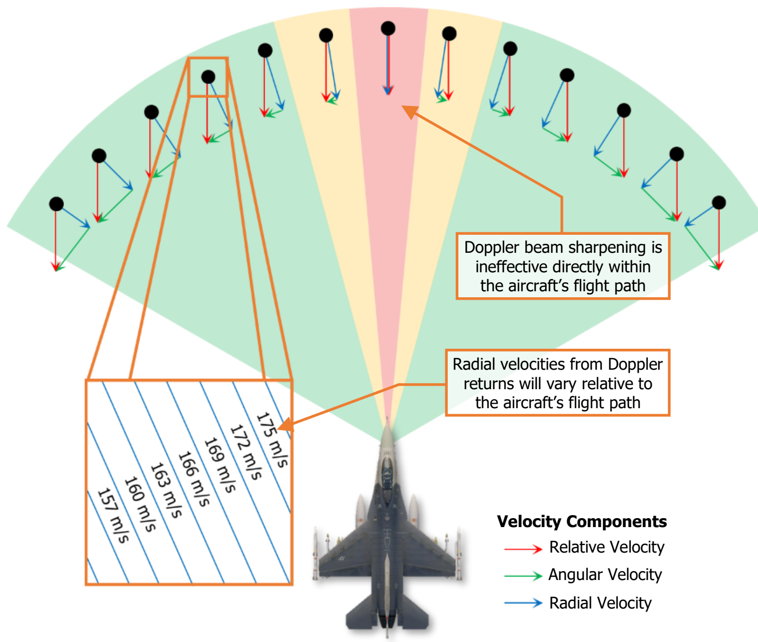
NOTE: If the aircraft is maneuvered abruptly or aggressively while the FCR is scanning in EXP, DBS1, or DBS2 fields-of-view, the radar processing may fail and the FCR will start a new scan to regenerate the radar map.

Doppler Beam Sharpening (DBS1/DBS2)

If the FCR mode is set to Ground Map (GM), the Doppler Beam Sharpening fields-of-view (DBS1 and DBS2) may be entered from the EXP field-of-view by pressing OSB 3 on the base page of the FCR MFD format or by pressing the Expand/FOV button on the Side Stick Controller (SSC). The DBS1 and DBS2 fields-of-view are not available if the FCR mode is set to GMT or SEA.

Doppler beam sharpening is a method of processing received radar returns to produce a higher resolution radar map and is used in many applications in the world today, even outside of military aviation. Typical real-beam radar mapping is limited in resolution, whereas Doppler beam sharpening uses differences in radial velocity to achieve a more detailed radar image. However, Doppler beam sharpening is limited by the relative aspect angle of the radar returns in relation to the movement of the transmitting radar antenna across the surface.

As the radar antenna moves across the surface, radar returns are received from terrain and objects such as vegetation, structures, or vehicles. Even if all detected objects are stationary, the velocity of the aircraft itself generates a measurable shift in the frequency of the electromagnetic radar energy reflected back toward the radar antenna; a Doppler effect. However, radar reflections that are received from either side of the aircraft's track across the surface will generate a lower Doppler shift due to their lower radial velocity compared to those directly in front of the aircraft. The greater the angular offset from the aircraft's flight path, the lower the measured radial velocity.



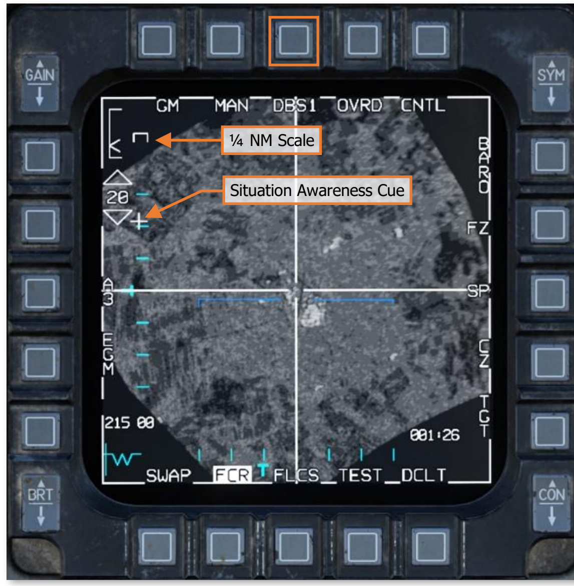
Doppler Beam Sharpening Processing Method

As the radar returns are processed for these small differences in Doppler shift, the returns from any location within the radar image can be calculated and further separated into distinct points to account for the deviations in radial velocity. This results in a more refined and higher resolution radar image.

Since Doppler beam sharpening relies on a sufficient difference in Doppler frequency within a measurable area, such calculations cannot be performed when the radar is scanning an area directly in front of the aircraft's flight path (nor directly abeam). As a result, Doppler beam sharpening is rendered ineffective unless the scanned area is sufficiently offset to either side of the aircraft's flight path, with the maximum resolution achieved at 45° to either side of the aircraft's flight path and gradually degrading the closer it is to the nose.

DBS1 Field-Of-View

DBS1 field-of-view provides the same patch size as EXP field-of-view but with an 8:1 increase in resolution over EXP at the expense of a slower refresh rate. As Doppler beam sharpening cannot be employed directly in front of the aircraft's flight path, any portion of the radar map that is within ±5° of the aircraft's flight path will suffer from decreased resolution.



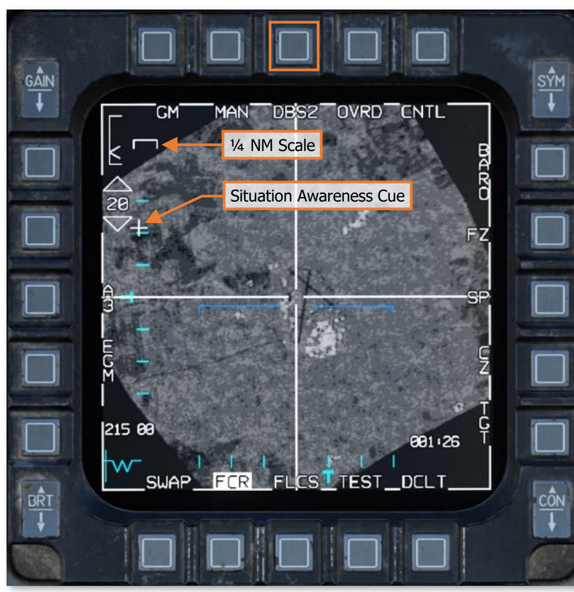
If the Acquisition Cursor is slewed, the radar map itself is slewed relative to the crosshairs and subsequently refreshed during the next FCR scan, just as in EXP field-of-view.

The Situation Awareness Cue and ¼ NM Scale are displayed in the same manner as EXP field-of-view. In the image on the right, at a range scale of 20 NM, the Situation Awareness Cue indicates the terrain map displayed on the MFD is approximately 15 NM away and to the left of the aircraft's flight path.

A subsequent press of OSB 3 or the Expand/FOV button will cycle the FCR MFD format to DBS2 field-of-view.

DBS2 Field-Of-View

DBS2 field-of-view provides a patch size that is anywhere from 50% to 25% the size of DBS1 field-of-view but with a 64:1 increase in resolution over EXP at the expense of an even slower refresh rate compared to DBS1. Doppler beam sharpening processing is more restrictive in DBS2 field-of-view, and any portion of the radar map that is within ±15° of the aircraft's flight path will suffer from decreased resolution.



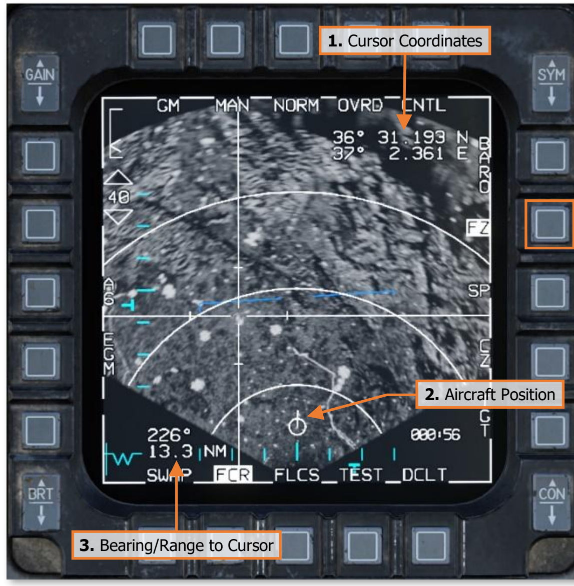
The Situation Awareness Cue and ¼ NM Scale are displayed in the same manner as EXP and DBS1 fields-of-view.

A subsequent press of OSB 3 or the Expand/FOV button will cycle the FCR MFD format back to NORM field-of-view.

Freeze (FZ) Option

If the pilot wishes to cease FCR emissions but retain the most recent radar-generated image of the terrain on the FCR MFD format, or if line-of-sight to an expanded radar map "patch" in EXP, DBS1, or DBS2 fields-of-view cannot be maintained due to maneuvers or terrain obstructions, the radar image on the MFD may be frozen by pressing OSB 7 on the base page of the FCR MFD format.

When the Freeze option is enabled, indicated by the highlighted "FZ" text adjacent to OSB 7, FCR emissions are temporarily inhibited and the radar map is frozen in its current state on the MFD. An aircraft position symbol is displayed that indicates the position of the ownship over the displayed radar map.



1. **Cursor Coordinates.** Displays the 2-dimensional position of the System Point-of-Interest (SPI) within the center of the Acquisition Cursor crosshairs, as latitude and longitude, in Degrees-Minutes-Decimal format (DDD° MM.MMM').

   Pressing and holding TMS Aft on the Side Stick Controller (SSC) will remove the coordinates for the duration of the press.

2. **Aircraft Position.** Indicates the current position of the ownship in relation to the radar map. If the ownship is beyond the MFD boundaries, the symbol will be pinned along the edge of the radar map.

3. **Bearing/Range to Cursor.** Displays the bearing (in degrees magnetic) and slant range (in nautical miles) from the ownship to the position of the SPI.

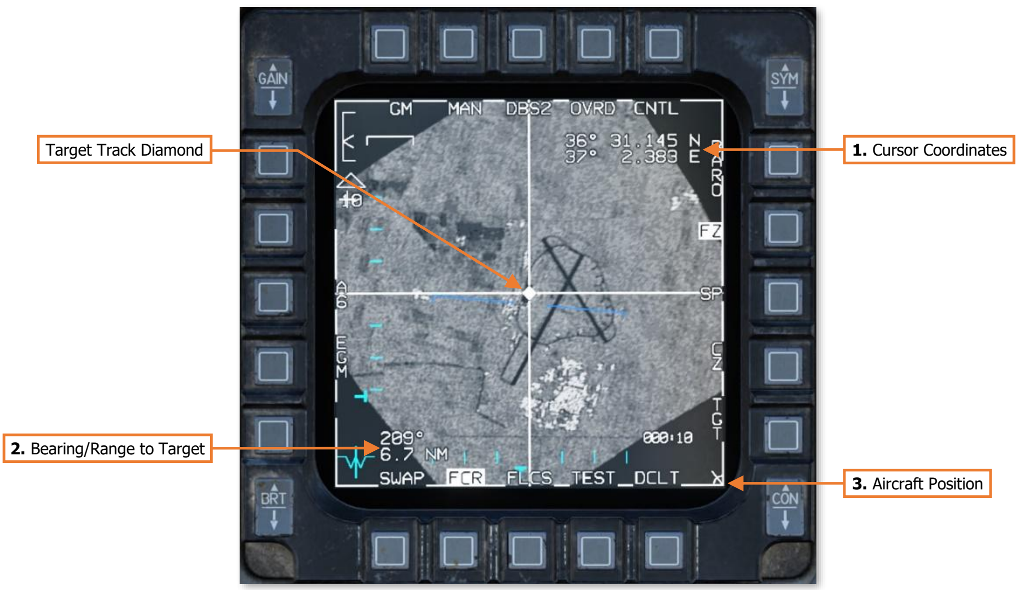
The Acquisition Cursor may still be slewed while the radar map is frozen, allowing the pilot to adjust the position of the SPI over the intended target or offset aimpoint based on the last FCR scan of the terrain. However, automatic range scale switching is inhibited when FZ is enabled and the Acquisition Cursor may only be slewed within the boundaries of the MFD at the current range scale.

FZ will automatically be de-selected if the FCR mode is changed or a different range scale or field-of-view is selected.

Fixed Target Track (FTT) Mode

FTT mode allows the pilot to track a defined terrain feature, man-made object, or slow-moving naval vessel in order to generate precise coordinates prior to an engagement in Air-to-Ground (A-G) master mode or when performing a position fix or altitude calibration in Navigation (NAV) master mode. FTT is manually entered by designating a stationary or slow-moving target while the FCR is in GM, GMT, or SEA modes. If a ground vehicle with sufficient velocity is designated while the FCR is in GMT mode, the FCR will enter Ground Moving Target Track (GMTT) mode.

A target is designated by slewing the Acquisition Cursor over the intended location or object using the RDR CURSOR/ENABLE switch on the throttle grip, followed by pressing and releasing TMS Forward. When FTT mode is entered, the radar map is frozen in its current state, "FZ" is highlighted adjacent to OSB 7, and additional information and symbology is displayed on the FCR MFD format, similar to enabling the Freeze option described on the previous page. However, the FCR will continue to emit and track the designated target, which is indicated by a solid diamond symbol within the center of the Acquisition Cursor.



1. **Cursor Coordinates.** Displays the 2-dimensional position of the System Point-of-Interest (SPI) within the center of the Acquisition Cursor crosshairs, as latitude and longitude, in Degrees-Minutes-Decimal format (DDD° MM.MMM').

   Pressing and holding TMS Aft on the Side Stick Controller (SSC) will remove the coordinates for the duration of the press.

2. **Bearing/Range to Target.** Displays the bearing (in degrees magnetic) and slant range (in nautical miles) from the ownship to the position of the designated target.

3. **Aircraft Position.** Indicates the current position of the ownship in relation to the radar map. If the ownship is beyond the MFD boundaries, the symbol will be pinned along the edge of the radar map.

If TMS Forward is pressed when already in FTT mode, the Cursor Coordinates, Bearing/Range to Target, and the radar map will be blanked from the FCR MFD format and cannot be restored unless FTT mode is exited.

If TMS Aft is pressed, the FCR will return to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA), whichever was the previous FCR mode.

If the target track cannot be maintained, whether it be due to terrain or a man-made structure obstructing the line-of-sight between the ownship FCR and target or the pilot maneuvering the aircraft in such a way that the FCR antenna encounters a mechanical gimbal limit, the target location will be extrapolated, or "coast", for up to 5 seconds using INS data. Any time the FCR transitions to an FTT "coast" state, FCR emissions are temporarily inhibited, the FCR antenna returns to the mechanical boresight position of 0° in azimuth and elevation, and the diamond symbol in the center of the Acquisition Cursor crosshairs is replaced with a hollow square.

If the target location returns to within the mechanical gimbal limits of the FCR, the antenna will be directed back toward the target to attempt re-acquisition of the target itself and the hollow square. If re-acquisition is successful, the hollow square symbol in the center of the Acquisition Cursor crosshairs will be replaced with the solid diamond symbol.

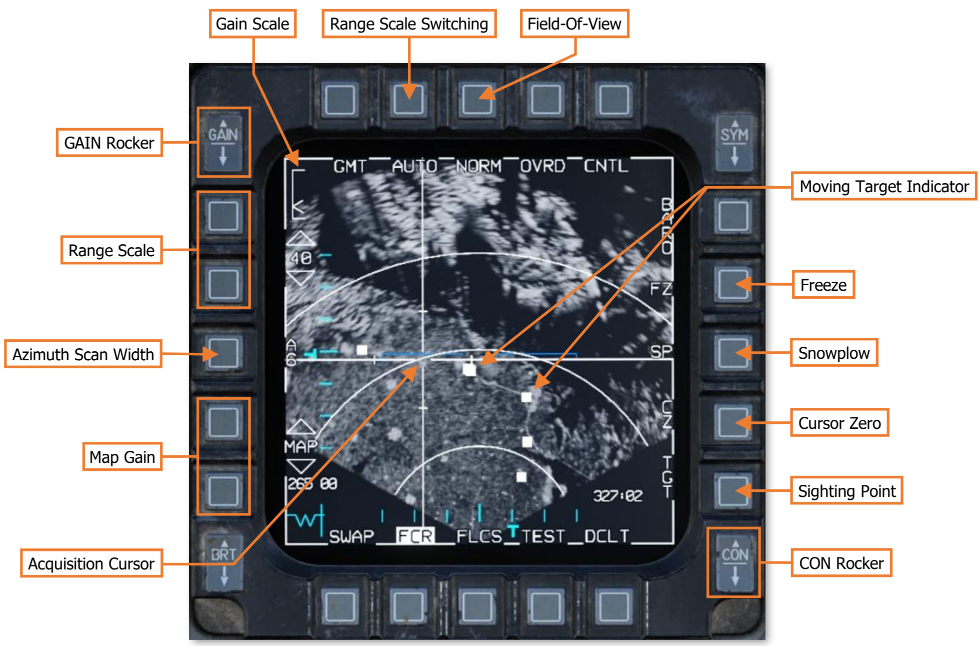
If the FCR cannot re-acquire the target after exiting an FTT "coast" state, or if 5 seconds have elapsed since the FCR transitioned to an FTT "coast" state, FTT mode will automatically be exited and the FCR will return to to Ground Map (GM), Ground Moving Target (GMT), or Sea (SEA), whichever was the previous FCR mode.

Ground Moving Target (GMT) Mode

GMT mode is used to detect mobile ground vehicles, the positions of which are highlighted on a radar-generated image of the terrain in front of the aircraft and displayed in a Plan Position Indicator (PPI) format. As the FCR scans the terrain ahead of the aircraft, an initial scan produces a radar map on the MFD based on the strength or reflectivity of the raw radar returns, the same as Ground Map (GM) mode. A subsequent Ground Moving Target Indicator (GMTI) scan analyzes the Doppler shift of radar returns amongst the terrain clutter and highlights any returns that exceed a specific velocity threshold to be processed as a moving ground vehicle. These positions are then displayed on the FCR MFD format as solid white squares overlaid on the radar map, allowing the pilot to acquire moving ground vehicles on the battlefield at long-range, at night, and/or during low-visibility conditions.

Unlike GM mode, the GAIN rocker on the top left corner of the MFD itself adjusts the gain of the Moving Target Indicators independently of the radar map underlay or the remaining MFD symbology. The gain of the radar map underlay may be increased or decreased by pressing OSB 17 and 16, respectively, with the current gain setting of the radar map displayed on the Gain Scale in the top left corner of the MFD display area. In addition, the contrast of the radar map may be adjusted using the CON rocker on the bottom right corner of the MFD.

GMT may be selected from the FCR Mode Menu page by pressing OSB 1 when the MMC master mode is set to Air-to-Ground (A-G) with a "Pre-planned" weapon delivery sub-mode selected, or if the master mode is set to Navigation (NAV). When GMT mode is selected, the FCR MFD format will display "GMT" below OSB 1.



The GMT footprint may be set to a full horizontal azimuth scan width of ±60° (A6) or a reduced scan width of ±30° (A3) or ±10° (A1) by pressing OSB 18. The GMT range scale may be set to 10, 20, 40, or 80 nautical miles (NM) by pressing OSB 19 to reduce the range scale or OSB 20 to increase the range scale.

All FCR functions in GMT mode remain the same as GM mode, with the exception that DBS1 and DBS2 fields-of-view are not available in GMT mode. Pressing OSB 3 or the Expand/FOV button on the Side Stick Controller (SSC) will only toggle the FCR MFD format between NORM and EXP fields-of-view, which may be used to increase separation between multiple Moving Target Indicators located in close proximity, as shown on the following page. This can be particularly useful when engaging a vehicle convoy or a large formation of armor units moving across open terrain. (See Expand Field-Of-View for more information.)

The pilot may adjust the target history (TGT HIS) setting on the FCR Control (CNTL) page, which may also aid in discerning individual moving vehicles. The TGT HIS setting determines the number of radar scan frames within which a radar return will remain displayed on the FCR MFD format following detection. However, setting the TGT HIS to the minimum value of 1 may result in intermittent display of Moving Target Indicator symbols between subsequent Ground Moving Target Indicator (GMTI) scans.

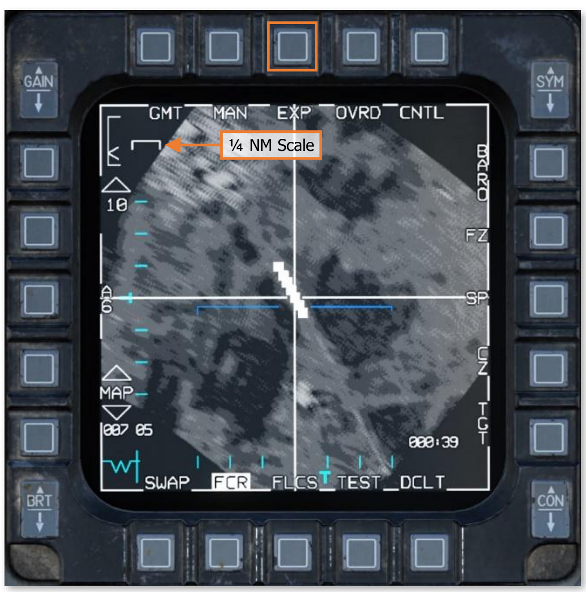
Each GMTI scan utilizes a variable target rejection velocity based on the ownship's ground speed and the position of the FCR antenna relative to the aircraft centerline. As the antenna rotates away from the aircraft centerline, the MTR threshold is automatically increased to improve rejection of stationary ground clutter. As such, slow-moving targets will generally be detected more reliably directly in front of the aircraft's flight path.

The pilot may adjust the Moving Target Rejection (MTR) thresholds from the FCR Control (CNTL) page. Although setting the MTR to LO will allow moving ground vehicles to be detected across a wider range of velocities, setting the MTR to HI may be used to isolate GMTI detections of ground vehicles moving at higher speeds. In the table below, the MTR threshold velocities are shown, converted between several speed measurements.

MTR Setting	**Nautical miles per hour** (kt)	**Statute miles per hour** (mph)	**Kilometers per hour** (km/h)
MTR HI	16 – 75 kt	19 – 87 mph	30 – 139 km/h
MTR LO	8 – 55 kt	10 – 64 mph	15 – 102 km/h

NOTE: Independent TGT HIS and MTR settings are retained for air-to-air and air-to-ground FCR modes.

In image below, a convoy of five vehicles is detected moving along a highway. By accessing the Expand (EXP) field-of-view and manually selecting the smallest range scale setting to minimize the patch size, the pilot can reliably select a target at the front, middle, or rear of the convoy. Visually acquiring individual vehicles prior to any engagement, whether it be through a targeting pod, an AGM-65 missile seeker, or using the naked eye, will still be prudent to ensure the correct target is being targeted.



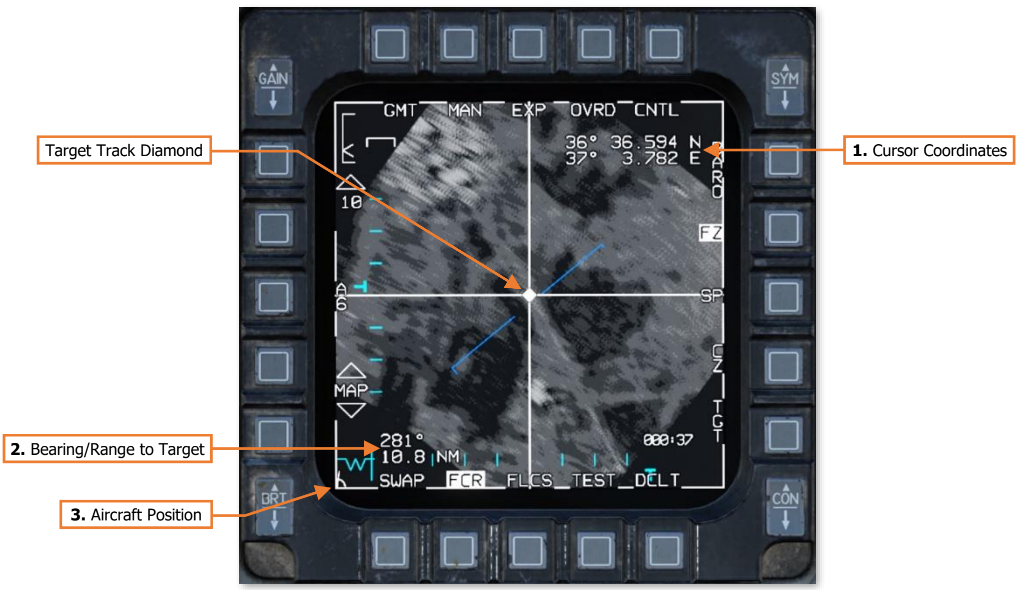
If TMS Forward is pressed while the Acquisition Cursor is over a Moving Target Indicator symbol, the FCR will enter Ground Moving Target Track (GMTT) and terminate the radar map and GMTI scans. The most recent radar image of the terrain will be frozen on the MFD in a similar manner to enabling Freeze (FZ).

Ground Moving Target Track (GMTT) Mode

GMTT mode allows the pilot to track a moving ground vehicle prior to an engagement in Air-to-Ground (A-G) master mode, or for reconnaissance or general observation of battlefield targets using an onboard targeting pod when in Navigation (NAV) master mode. GMTT is manually entered by designating a moving ground target while the FCR is in Ground Moving Target (GMT) mode. If a stationary target or terrain feature is designated while the FCR is in GMT mode, the FCR will enter Fixed Target Track (FTT) mode.

A target is designated by slewing the Acquisition Cursor over the intended Moving Target Indicator symbol using the RDR CURSOR/ENABLE switch on the throttle grip, followed by pressing and releasing TMS Forward. When GMTT mode is entered, the radar map is frozen in its current state, "FZ" is highlighted adjacent to OSB 7, and additional information and symbology is displayed on the FCR MFD format, similar to enabling the Freeze (FZ) option by pressing OSB 7. However, the FCR will continue to emit and track the designated target, which is indicated by a solid diamond symbol within the center of the Acquisition Cursor.

NOTE: When the FCR transitions from GMT mode to GMTT, all Moving Target Indicator symbols are removed.



1. **Cursor Coordinates.** Displays the 2-dimensional position of the System Point-of-Interest (SPI) within the center of the Acquisition Cursor crosshairs, as latitude and longitude, in Degrees-Minutes-Decimal format (DDD° MM.MMM').

   Pressing and holding TMS Aft on the Side Stick Controller (SSC) will remove the coordinates for the duration of the press.

2. **Bearing/Range to Target.** Displays the bearing (in degrees magnetic) and slant range (in nautical miles) from the ownship to the position of the designated target.

3. **Aircraft Position.** Indicates the current position of the ownship in relation to the radar map. If the ownship is beyond the MFD boundaries, the symbol will be pinned along the edge of the radar map.

If TMS Forward is pressed when already in GMTT mode, the Cursor Coordinates, Bearing/Range to Target, and the radar map will be blanked from the FCR MFD format and cannot be restored unless GMTT mode is exited.

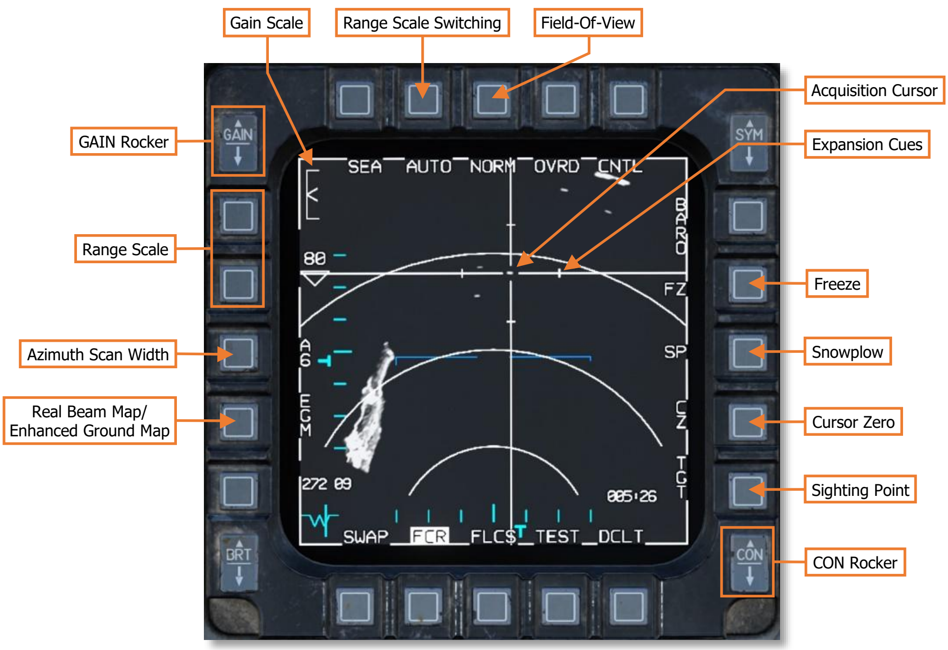
If TMS Aft is pressed, the FCR will return to Ground Moving Target (GMT) mode.

Sea (SEA) Mode

SEA mode produces a radar-generated image of the surface in front of the aircraft, displayed in a Plan Position Indicator (PPI) format, and is used for detection and targeting of slow-moving or stationary naval vessels. As the FCR scans the surface ahead of the aircraft, a radar map is displayed on the MFD based on the strength or reflectivity of the raw radar returns, allowing the pilot to distinguish naval vessels that cannot be visually seen due to distance, low-visibility, or hours of darkness. SEA functions similarly to Ground Map (GM) mode and will display terrain features such as coastlines, islands, and man-made structures such as harbors and docks, but is specifically optimized for a maritime environment and rejection of clutter in low to medium sea states.

The brightness of the radar map underlay may be adjusted independently of the MFD symbology using the GAIN rocker on the top left corner of the MFD itself, with the current gain setting displayed on the adjacent Gain Scale. In addition, the contrast of the radar map may be adjusted using the CON rocker on the bottom right corner of the MFD.

SEA may be selected from the FCR Mode Menu page by pressing OSB 1 when the MMC master mode is set to Air-to-Ground (A-G) with a "Pre-planned" weapon delivery sub-mode selected, or if the master mode is set to Navigation (NAV). When SEA mode is selected, the FCR MFD format will display "SEA" below OSB 1.



The SEA footprint may be set to a full horizontal azimuth scan width of ±60° (A6) or a reduced scan width of ±30° (A3) or ±10° (A1) by pressing OSB 18. The SEA range scale may be set to 10, 20, 40, or 80 nautical miles (NM) by pressing OSB 19 to reduce the range scale or OSB 20 to increase the range scale.

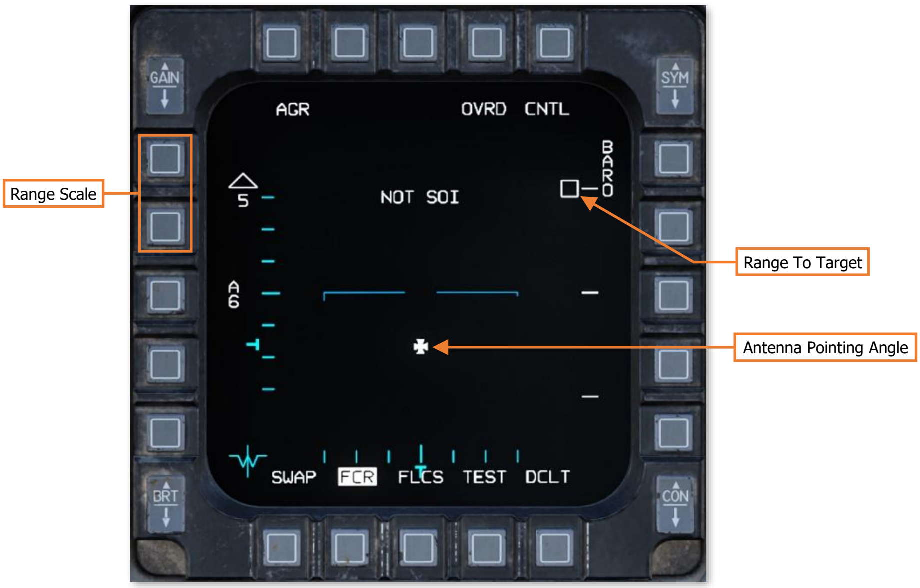
All FCR functions in SEA mode remain the same as GM mode, with the exception that DBS1 and DBS2 fields-of-view are not available in SEA mode. Pressing OSB 3 or the Expand/FOV button on the Side Stick Controller (SSC) will only toggle the FCR MFD format between NORM and EXP fields-of-view. (See Expand Field-Of-View for more information.)

If TMS Forward is pressed and released, the surface location under the Acquisition Cursor will be designated and the most recent radar image of the surface will be frozen on the MFD in a similar manner as enabling Freeze, but the FCR will continue to emit in Fixed Target Track (FTT) mode.

Air-to-Ground Ranging (AGR) Mode

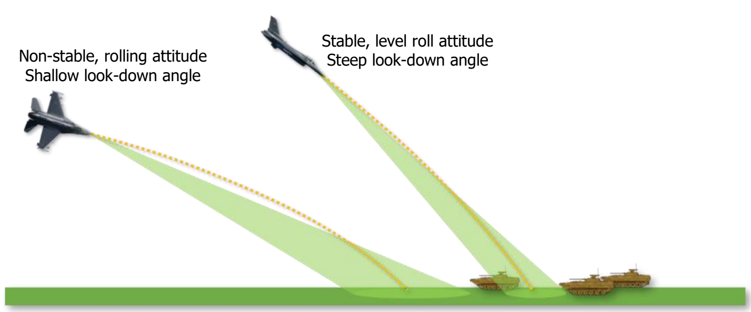
AGR mode is used to perform ranging calculations for accurate delivery of ballistic munitions such as unguided bombs, rockets, or gun strafing; or when performing a position fix, altitude calibration, or storing a markpoint while using HUD as the selected sensor option. AGR is also used for ranging calculations when designating a surface location in DTOS, EO-VIS, or VIS weapon delivery sub-modes.

The FCR automatically enters AGR mode any time a "Visual" weapon delivery sub-mode is selected in Air-to-Ground (A-G) master mode or when "HUD" is selected as the sensor option on the FIX, A-CAL, or MARK DED pages. If the FCR Mode Menu page is displayed by pressing OSB 1 when the FCR is in AGR mode, the only two FCR mode options that will be available for selection will be AGR and STBY.



The FCR antenna angle is automatically steered to maintain alignment with the ballistic trajectory of the selected munition up to the mechanical gimbal limits of ±60° in azimuth and elevation. Accordingly, the azimuth scan width setting is automatically set to A6 and cannot be changed. The AGR range scale may be set to 5 or 10 nautical miles (NM) by pressing OSB 19 to reduce the range scale or OSB 20 to increase the range scale. However, this only changes the scale of the Range Marks along the right side of the FCR MFD format and the AGR ranging calculations are not limited by the current range scale.

FCR ranging calculations will be more accurate when the aircraft is in a stable and level attitude. In addition, when delivering munitions such as unguided bombs or rockets, or employing the M61 cannon, the ballistic accuracy will increase at closer ranges and steeper look-down angles.

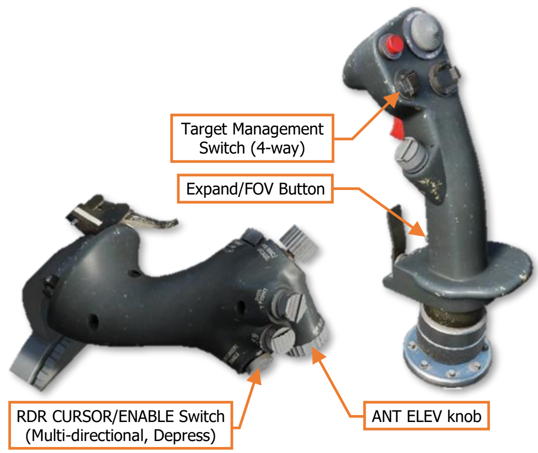


FCR Air-to-Ground Ranging (AGR)

HANDS-ON CONTROLS

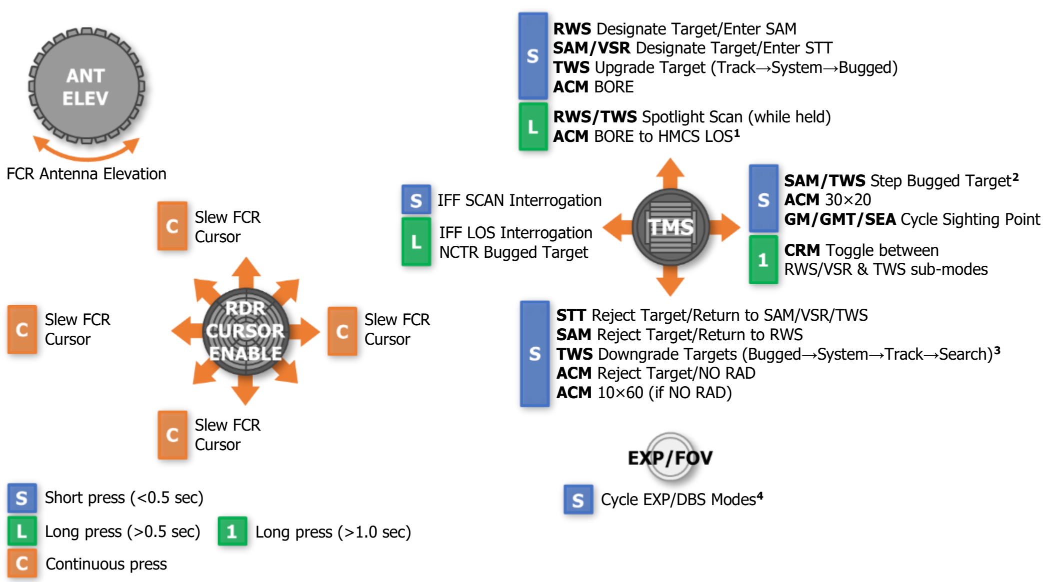
The Target Management Switch (TMS) and Expand/FOV button on the Side Stick Controller (SSC), along with the RDR CURSOR/ENABLE switch and ANT ELEV knob on the throttle grip, are the pilot's controls for adjusting the azimuth, range, and elevation settings of the FCR search volume, slewing the Acquisition Cursor, or transitioning between the search and tracking sub-modes.

If AGM-65 is the selected weapon type, the TMS Forward command on the SSC will automatically transition the Sensor-Of-Interest (SOI) from FCR to WPN when TMS Forward is released if the WPN MFD format is displayed. (See AGM-65 Maverick in the Air-to-Ground Weapons Employment chapter for more information.)



Throttle Grip Commands. The RDR CURSOR/ENABLE switch is multi-directional, allowing the Acquisition Cursor to be slewed in in any direction. The ANT ELEV knob controls the elevation of the FCR antenna.

Side Stick Controller (SSC) Commands. The Target Management Switch (TMS) and Expand/FOV button commands are contextual, based on the FCR sub-mode, whether a valid target is within the Acquisition Cursor, and the state of the target itself within the Acquisition Cursor.



1. HMCS cueing in ACM BORE sub-mode will not be available if the HMCS symbology is not displayed.
2. If no targets are bugged, the 10 highest priority Track Targets will be upgraded to System Track Targets.
3. If all TWS Track Targets are purged, pressing TMS Aft will switch the CRM sub-mode from TWS to RWS.
4. DBS1 and DBS2 sub-modes are only available in Ground Map (GM) mode.

TACTICAL NET DATALINK

USAF Photo
by A1C Matthew Seefeldt

TACTICAL NET DATALINK (TNDL)

The F-16C utilizes a Multifunction Information Distribution System Low Volume Terminal (MIDS LVT) that allows the transmission and reception of tactical information over the Tactical Net Datalink (TNDL). This datalink network allows multiple platforms to exchange data with other friendly forces to collectively maintain a common tactical picture of the battlespace.

The MIDS LVT also provides the F-16C with TACAN functions for radio-based navigation. As such, the MIDS LVT must be operational to utilize ground-based TACAN navigational beacons or employ air-to-air distance measuring functions. (See Tactical Air Navigation in the Navigation chapter for more information.)

TNDL allows various air and surface platforms to cooperatively build situational awareness and facilitate command and control. The datalink system utilizes secure radio signals across numerous frequencies, which provides resistance to jamming and permits multiple network channels to function simultaneously within the same geographic region.

TNDL data may be received from Flight/Team members, Donors, C2 platforms, and other TNDL participants.

Flight/Team Member. Flight/Team member data permits efficient coordination of flight maneuvers, sensor data, and weapons and engagement deconfliction. A maximum of 8 aircraft may be present within the F-16 Flight/Team member list, to include the ownship; which communicate on the Fighter channel.

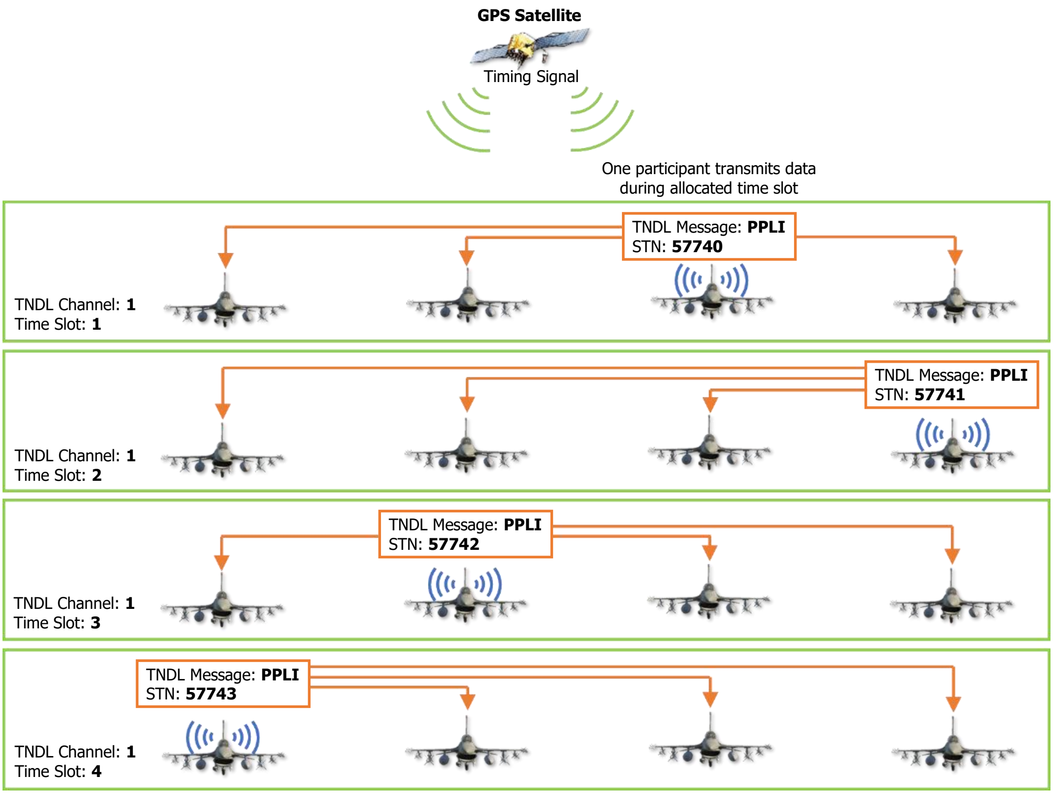
Donor. Similar data may be received from participants that are not part of the ownship's flight but may be operating within the same "mission package". These participants are known as Donors, of which a maximum of 4 may be present within the F-16 Donor list; which normally communicate on the Fighter channel.

C2 Platform. Data received from C2 (Command and Control) platforms provide broader situational awareness by transmitting position and identification of TNDL participants on other network channels, position and identification of friendly platforms that are not TNDL participants, or position and identification data of hostile air or surface units. C2 platforms communicate with non-C2 participants using a dedicated Mission channel.

Participant. Position and identification data is received from TNDL participants that are on the same channel but are not designated as a Flight/Team member, a Donor, or a C2 platform.

Tactical Net Datalink Network

Each participant on a TNDL network periodically transmits identification, position, and/or targeting data over the assigned network channel(s). Since each participant cannot transmit and receive data at the same time, nor can multiple participants transmit data simultaneously without potentially interfering with the other, TNDL participants transmit their data within pre-allocated and synchronized intervals. This method of network management is known as Time Division Multiple Access (TDMA) and designates a time slot for each participant in which they may transmit data. As such, the TDMA and anti-jam nature of TNDL requires all network participants that are on the same channel to maintain synchronization through a common timing signal, which may be provided by GPS.



Time Division Multiple Access (TDMA) Datalink Transmissions

Multiple types of messages may be transmitted by TNDL network participants, which may simply identify the participant's position, or it may include information that is intended for a specific recipient on the network. These messages are processed within the avionics in various ways, depending on the type of message, the source of the message, and the channel over which the message was received.

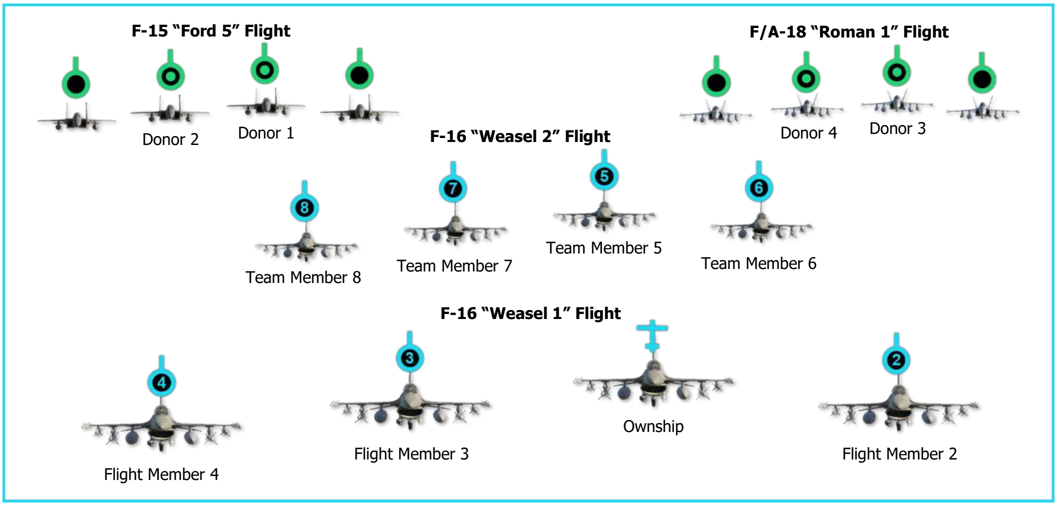
Each participant within a TNDL network is assigned a Source Track Number (STN) consisting of five octal numbers, where each digit may be 0 through 7. When a TNDL message is received, the STN embedded within the message is used by the Modular Mission Computer (MMC) to identify the source of the message. The MMC compares the STN to those that have been programmed as the ownship's Flight/Team members or Donors. If the STN matches that of a Flight/Team member or a Donor, the data within the message is presented to the pilot accordingly on the relevant MFD formats. If the STN does not match that of a Flight/Team member or a Donor, and the message type is not a PPLI or a C2 message (such as Air Surveillance tracks), the data within the message is discarded.

TNDL Channels

The MIDS LVT can monitor three TNDL channels simultaneously, the Fighter channel, Mission channel, and Special channel, each with a unique tactical function. Each TNDL channel functions as a separate datalink network and may be tuned independently of the others. The Special channel (SC) is not implemented in DCS: F-16C Viper.

Fighter Channel (FC)

The Fighter channel is intended for Fighter-to-Fighter data messaging, which facilitates cooperative targeting and engagement amongst Flight/Team members and Donors. A maximum of four Flight members (including the ownship), four Team members, and four Donors may be configured within each F-16C.



TNDL Fighter Channel

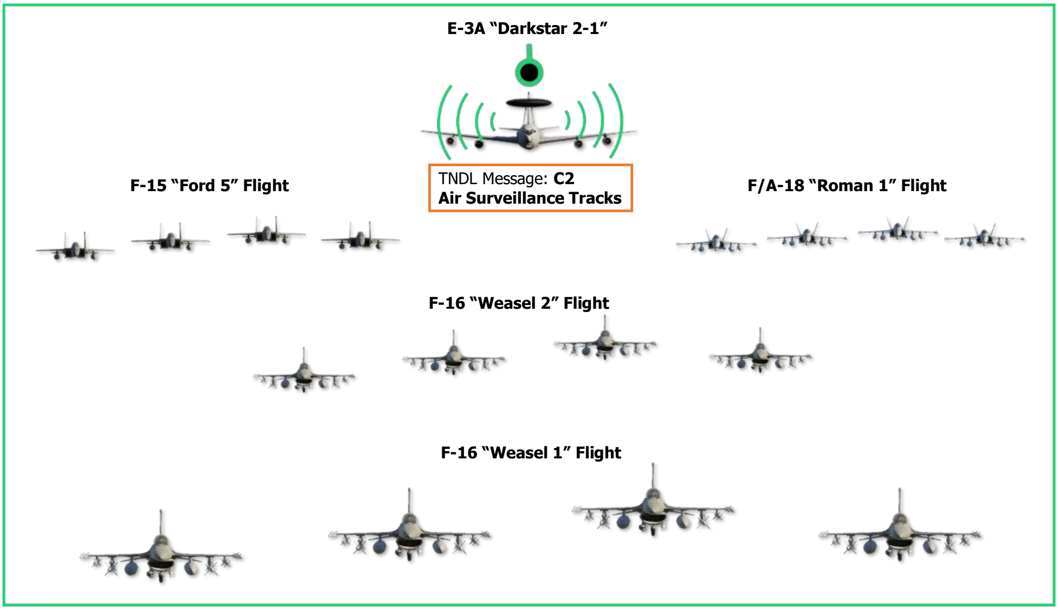
All network participants will periodically transmit data messages that include identification, position, sensor tracks, target sorting, and/or weapon engagement data. However, depending on whether a participant's STN has been programmed within the ownship as a Flight/Team member, a Donor, or neither, this data will either be retained/updated within the avionics and presented to the pilot, or rejected and purged without pilot interaction.

- **Flight Member (1-4).** Message types received from Flight members include present position (PPLI), Air Target tracks (including lock lines and shot lines), markpoints, SEAD targets, and TDOA messages.
- **Team Member (5-8).** Message types received from Team members include present position (PPLI), Air Target tracks (lock lines and shot lines are not displayed), markpoints, SEAD targets, and TDOA messages.
- **Donor.** Message types received from Donors include present position (PPLI), Air Target tracks (lock lines and shot lines are not displayed), and markpoints.
- **Participant.** Message types received from participants that are neither Flight/Team members nor Donors are limited to present position (PPLI).

In the example above, all of the F-15 and F/A-18 aircraft are transmitting Air Target track data across the same Fighter channel. However, the ownship in "Weasel 1" Flight will only retain Air Target tracks received from two of the four F-15s of "Ford 5" Flight and two of the four F/A-18s of "Roman 1" Flight, since the STNs of those participants have been programmed as Donors within the ownship. Air Target track data received from the remaining F-15s and F/A-18s are still received by the ownship, but this data is purged since the STNs of those participants are not programmed as Donors, and only their PPLI data is retained and updated.

Mission Channel (MC)

The Mission channel is intended for Surveillance data messaging, which facilitates situation awareness from C2 Platform participants, such as E-3A or E-2D AWACS aircraft.



TNDL Mission Channel

The C2 platforms will transmit position data of all aircraft detected within the volume of airspace it is capable of monitoring and will update these positions periodically. As the AWACS radar scans the battlespace, the AWACS crew will concurrently perform interrogations of each detected aircraft's Mode 4 IFF transponder to assess each aircraft's coalition affiliation. This allows the AWACS crew to monitor the positions of friendly aircraft that are not transmitting PPLI messages across the TNDL Mission channel, or to detect and classify potentially hostile aircraft.

C2 Platform. Message types received from C2 platforms include present position (PPLI) of the C2 aircraft itself and Air Surveillance tracks.

All non-C2 network participants will periodically transmit data messages that include identification and position. However, even if a participant's PPLI is not directly received by other participants due to terrain obstructing line-of-sight (LOS), the positions of friendly aircraft may still be received by the C2 Platform and relayed across the Mission channel to other friendly aircraft that would otherwise not receive the PPLI across either TNDL channel.

The C2 Platform may also transmit mission assignments or targeting data across the Mission channel to specific flights of participating aircraft, which facilitates efficient command and control of the battlespace. Although the mission assignment and targeting data is transmitted to all members within a flight, only the participants that have been designated as a Flight Lead will have the ability to accept or reject a mission assignment.

(See TNDL DED page for more information.)

TNDL Messages

Depending on the type of message being transmitted, TNDL messages may be transmitted over the corresponding TNDL channels automatically without pilot interaction, or they may be transmitted on command by the pilot. Automatic messages may be transmitted periodically at pre-determined intervals, such as PPLI; or they may be automatically transmitted when specific criteria have been met, such as fighter Air Target tracks.

Fighter-to-Fighter Messages

Situational awareness, targeting, coordination.

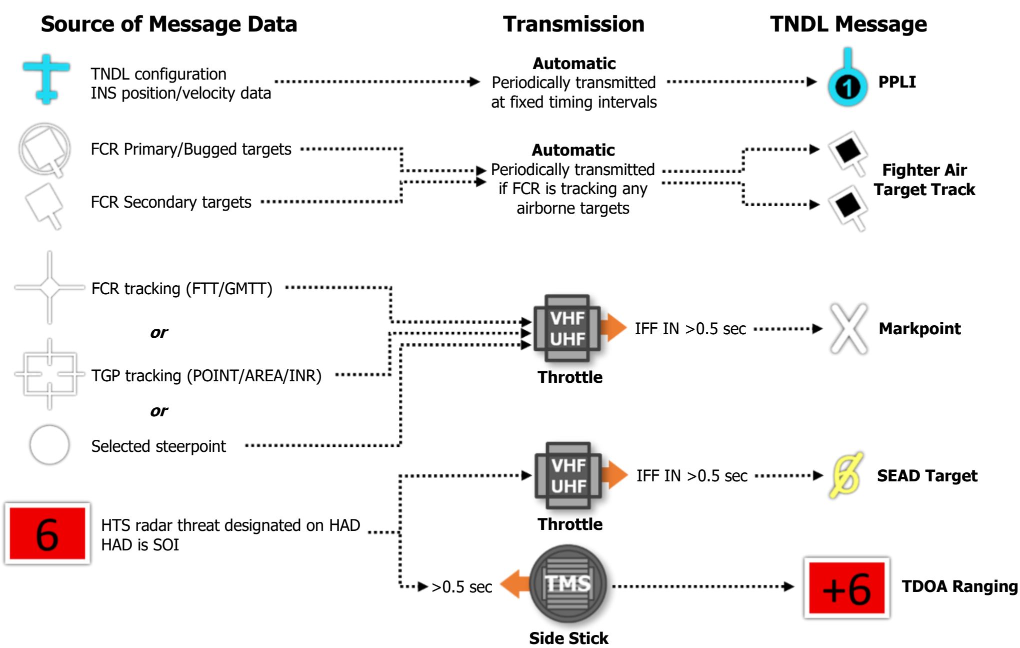
- **PPLI** Location/identification of TNDL participant
- **Fighter Air Target Track** Position of aircraft detected by friendly, radar-equipped fighter
- **Markpoint** Tactical reference point
- **SEAD Target** Location of air defense threat
- **TDOA Ranging** Air defense radar timing/position data by HTS-equipped fighter

Surveillance and C2 Messages

Situational awareness, command and control.

- **PPLI** Location/identification of TNDL participant
- **Surveillance Air Track** Position of aircraft detected/relayed by AWACS platform

The figure below illustrates the source of each TNDL message type and when it is transmitted from the F-16C.



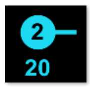
Transmission of TNDL Messages

(See the ASQ-213 HARM Targeting System chapter for more information regarding TDOA ranging.)

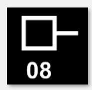
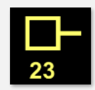
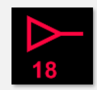
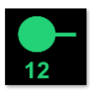
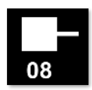
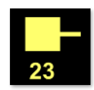
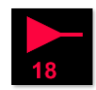
When a TNDL message is received that includes position data of either a network participant or a target detected by the sensors of a network participant, a "track" is generated and maintained within the ownship's System Track File for a short period of time. When new position data for the same track is received, which may also include velocity data such as course and speed, the "track" is updated accordingly, similar to a radar-generated track.

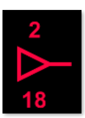
TNDL Symbols

Precise Participant Location Identification (PPLI). PPLI tracks are received from other TNDL participants on the Fighter channel or Mission channel and identified as Flight/Team members or Donors based on the received Source Track Numbers (STN) within the PPLI message.

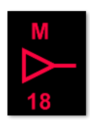
	FLIGHT/TEAM	DONOR	PARTICIPANT
PPLI			
PPLI CORRELATED WITH OWNSHIP FCR			

Air Target/Surveillance Tracks. Air Target tracks are received from Flight/Team members and Donors on the Fighter channel. Air Surveillance tracks are received from C2 platforms, such as AWACS, on the Mission channel.

	FRIENDLY	UNKNOWN	SUSPECT	HOSTILE
AIR TARGET / SURVEILLANCE TRACK				
AIR TARGET / SURVEILLANCE TRACK CORRELATED WITH OWNSHIP FCR				

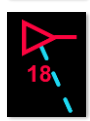


Air Target tracks displayed on the FCR format will include a number above the symbol if the target is bugged by the corresponding Fight/Team member.



Air Target tracks displayed on the FCR format will include an "M" above the symbol if the target is bugged by multiple Flight/Team members and/or Donors.

Air Target tracks displayed on the FCR format will include a four-character callsign above the symbol if the target is bugged by the corresponding Donor.

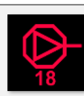
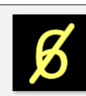


Air Target tracks displayed on the HSD format will include a lock line leading to the symbol if the target is bugged by a Flight member (1-4 only).

Primary Datalink Track. PPLI, Air Target, or Air Surveillance track designated as the PDLT on the HSD format.

Markpoints. Markpoints correspond with steerpoints or SPI locations that are received from Flight/Team members or Donors on the Fighter channel. Markpoints are displayed on the HSD format only.

SEAD Targets. SEAD targets correspond with designated air defense threats that are received from Flight/Team members or Donors on the Fighter channel. SEAD targets are displayed on the HSD and HAD MFD formats.

	PDLT	MARKPOINT	SEAD TARGET
OTHER SYMBOLS			

Markpoints will include a lock line leading to the symbol if transmitted by a Flight member (1-4 only) with a sensor in a tracking state.

SEAD targets will include a lock line leading to the symbol if designated by a transmitting Flight member (1-4 only).

Tactical Net Datalink Configuration

The F-16C requires four elements to participate within the TNDL network itself and transmit/receive data from wingmen, other aircraft that are part of the same "mission package", or AWACS aircraft.

TNDL Network Synchronization. Due to the Time Division Multiple Access (TDMA) nature of the TNDL network, the chronometer within the ownship's MIDS LVT must be synchronized with the network time reference.

TNDL Channel Selection. All Flight/Team members and Donors must be set to the same Fighter channel to transmit and receive Fighter-to-Fighter messages. The ownship must be set to the same Mission channel as the designated C2 platform (AWACS) to receive Surveillance and C2 messages.

Ownship Identification. The Voice Callsign and Source Track Number (STN) transmitted by the ownship over the TNDL network should correspond with the ownship's pre-planned flight callsign.

Configuration of Source Track Number(s). The STNs assigned to Flight members and/or Team members on the TNDL STN DED page must match the STNs that are transmitted by each Flight/Team member over the TNDL network. Donor STNs must be configured prior to the mission and cannot be configured from within the cockpit.

Prior to powering the MIDS LVT, the following criteria must be met.

- The INS alignment must be complete and in NAV mode.
- If intending to use GPS signals as the timing reference for network synchronization, the GPS receiver must be powered on the AVIONICS POWER control panel and fully initialized before the MIDS LVT knob is set to the ON position. This can be verified by ensuring "GPS SYSTEM" is displayed on the TIME DED page.

  NOTE: GPS will only be available if the DCS mission date is 28 March 1994 or later. In addition, GPS precision will be degraded unless USA is one of the countries assigned to the player's coalition within the DCS mission. However, these limitations may be overridden if both of the following conditions are true:

  - **Unrestricted SATNAV** is enabled in the player's GAMEPLAY options or is enforced as enabled in the Mission Options for the mission being played.
  - **Unrestricted SATNAV** is not enforced as disabled in the Mission Options for the mission being played.
- The Network Time Reference (NTR) should be disabled on the NET STATUS DED page unless the ownship is acting as the NTR-transmitting unit for all other TNDL participants on the network.

MIDS LVT Initialization

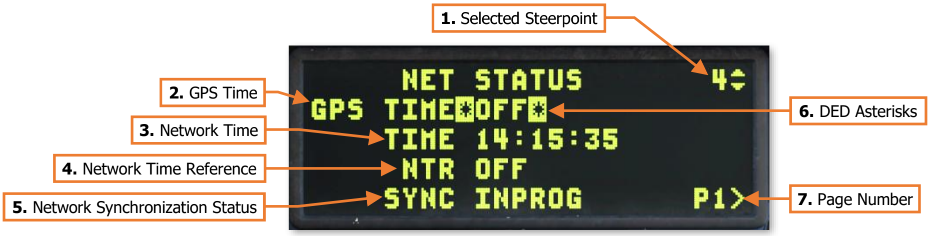
The MIDS LVT knob powers Multifunctional Information Distribution System.

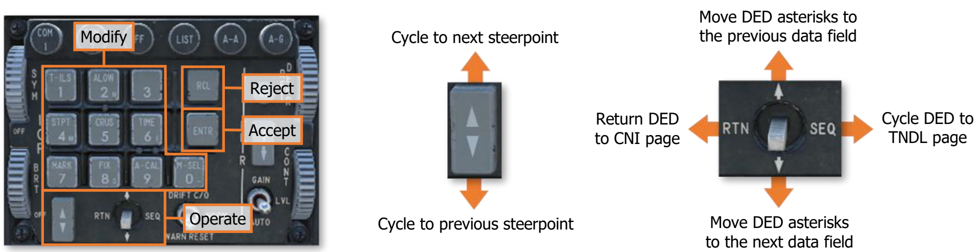
- **ZERO.** Zeroizes sensitive data within MIDS LVT internal memory.
- **OFF.** Disables power to the MIDS LVT.
- **ON.** Enables power to the MIDS LVT.

Once the MIDS LVT is powered, the pilot may access the DLNK DED pages to confirm or modify the TNDL settings, if necessary, as described on the following pages.

NET STATUS DED Page

The Net Status DED page is accessed by pressing **ENTR** on the ICP keypad when the LIST DED page is displayed. This page is used to configure the MIDS LVT timing reference and view the network synchronization status.

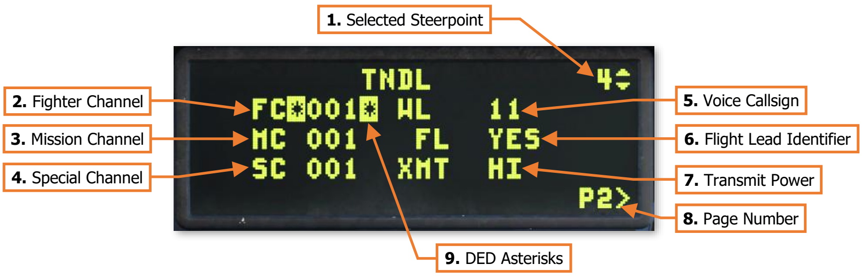


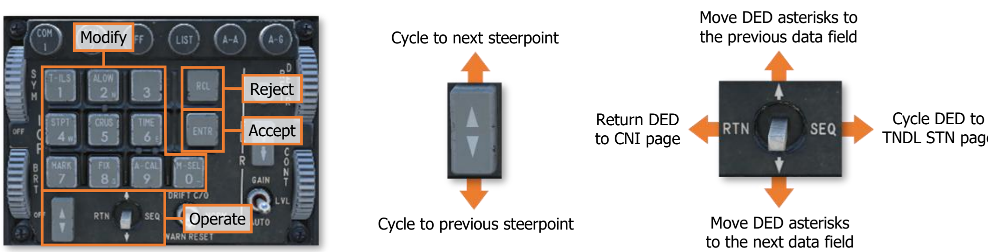


1. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
2. **GPS Time.** Enables/disables GPS time as the source of the ownship's timing signal. May be toggled between ON and OFF by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field.
3. **Network Time.** Displays the TNDL network time in a 24-hour time format based on Zulu time (UTC). When GPS is being used as the timing source, this data field is blanked. May be modified by placing the DED asterisks over the data field, entering a time in HHMMSS format using the ICP keypad, and pressing ENTR.
4. **Network Time Reference (NTR).** Enables/disables the transmission of the NTR from the ownship to other TNDL participants. May be toggled between ON and OFF by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field.
5. **Network Synchronization Status.** Displays the ownship's synchronization quality with the TNDL network.
   - **(Blank).** The MIDS LVT is unable to synchronize with the TNDL network. TNDL messages cannot be received nor transmitted.
   - **INPROG.** The MIDS LVT is attempting to synchronize with the TNDL network. TNDL messages cannot be received nor transmitted.
   - **COARSE.** The MIDS LVT has achieved a coarse synchronization with the TNDL network. TNDL messages may be received but not transmitted.
   - **FINE.** The MIDS LVT has achieved a fine synchronization with the TNDL network. TNDL messages may be received and transmitted.
6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.
7. **Page Number.** Displays the DED page number and indicates that additional pages may be viewed.

TNDL DED Page

The Tactical Net Datalink page is accessed by pressing **ENTR** on the ICP when the LIST DED page is displayed, and then momentarily setting the ICP DCS to the SEQ position. This page is used to configure TNDL channels, the ownship Callsign and Flight Lead setting, and the transmission power setting of the MIDS LVT.

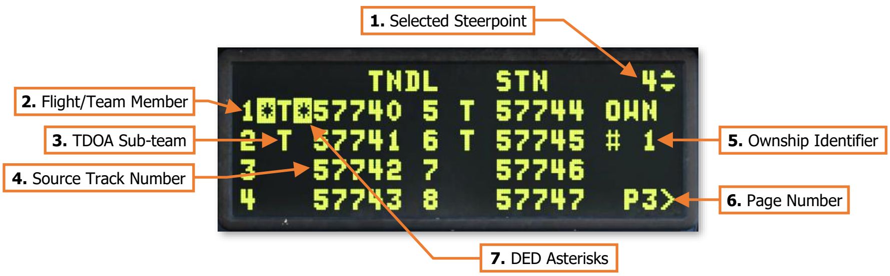


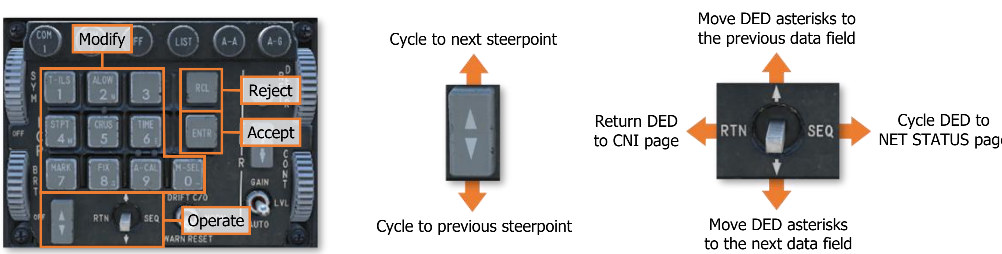


1. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
2. **Fighter Channel (FC).** Displays the TNDL channel over which the MIDS will transmit/receive Fighter-to-Fighter data from Flight/Team members and Donors. May be modified by placing the DED asterisks over the data field, entering a channel between 1 and 126 using the ICP keypad, and pressing ENTR. (N/I)
3. **Mission Channel (MC).** Displays the TNDL channel over which the MIDS will receive Surveillance data from C2 platforms, such as AWACS. May be modified by placing the DED asterisks over the data field, entering a channel between 1 and 126 using the ICP keypad, and pressing ENTR. (N/I)
4. **Special Channel (SC).** Not implemented.
5. **Voice Callsign.** Displays the ownship's identification transmitted to other TNDL participants. The letters may be modified by placing the DED asterisks over the data field, using the ICP Increment/Decrement rocker to select a different letter, and then pressing ENTR. The numbers may be modified by placing the DED asterisks over the data field, inputting different values using the ICP keypad, and pressing ENTR.
6. **Flight Lead (FL) Identifier.** When set to YES, the ownship is designated as the Flight Leader within the Flight/Team member list. May be toggled between YES and NO by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field. Only one aircraft within the flight should enable this option. (N/I)
7. **Transmit Power (XMT).** Selects the MIDS power setting for outgoing transmissions. May be cycled between HI, MED, LO, and NONE by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field. When set to NONE, MIDS transmissions are inhibited.
8. **Page Number.** Displays the DED page number and indicates that additional pages may be viewed.
9. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted.

TNDL STN DED Page

The Tactical Net Datalink Source Track Number page is accessed by pressing **ENTR** on the ICP when the LIST DED page is displayed, and then momentarily setting the ICP DCS to the SEQ position as necessary. This page is used to configure the STN for each Flight/Team member, designate the TDOA sub-team if necessary, and designate the ownship's position within the flight.





1. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
2. **Flight/Team Member.** Identifies the Source Track Number for each Flight member (1-4) and each Team member (5-8).
3. **TDOA Sub-team (T).** A "T" symbol in this data field indicates that the corresponding Flight/Team members are designated as the TDOA sub-team within the flight. May be toggled by pressing any ICP keypad button 1-9 while the DED asterisks are around the data field between the Flight/Team member number and the member's STN. (See the ASQ-213 HARM Targeting System chapter for more information regarding TDOA sub-teams.)
4. **Source Track Number.** The Source Track Number (STN) will determine how outgoing messages are recognized by other participants, and how incoming messages intended for the ownship are recognized. May be modified by placing the DED asterisks over the data field, entering a 5-digit number using the ICP keypad, and pressing ENTR. Each digit of the STN may be 0 through 7; for a total of 32,768 unique STN numbers.
5. **Ownship Identifier (OWN).** Displays the ownship's position within the flight. This data field determines the STN that the ownship will utilize when transmitting TNDL messages, or when receiving TNDL messages intended for a specific recipient. May be modified by placing the DED asterisks over the data field, entering a number within the range of 1 through 8 using the ICP keypad, and pressing ENTR.
6. **Page Number.** Displays the DED page number and indicates that additional pages may be viewed.
7. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted.

Manually Synchronizing with TNDL Network

The MIDS LVT automatically attempts to synchronize with the TNDL network time reference when the MIDS LVT knob on the AVIONICS POWER control panel is rotated to the ON position. However, if the onboard INS is not aligned or the GPS receiver is not initialized before the MIDS LVT is powered, the MIDS LVT cannot perform an automatic synchronization with the TNDL network.

A manual synchronization with the TNDL network may be performed from the DLNK DED pages, which are accessed by pressing the **ENTR** button on the ICP keypad when the LIST DED page is displayed.

To manually synchronize with the TNDL network, perform the following:

1. **(Recommended)** ICP Keypad – Press any button **1-9** to set GPS TIME to ON if intending to use GPS as the ownship's timing signal. Proceed to step 5.

or

1. **(Optional)** ICP Keypad – Press any button **1-9** to set GPS TIME to OFF if intending to use a manual time entry for network synchronization.

2. ICP DCS Switch – **Down** to move DED asterisks around TIME data field to input a manual time.

3. ICP **Keypad** – Input the desired manual time in HHMMSS format.

4. ICP Keypad – Press **ENTR** to accept the manual time or **RCL** to reject it.

NOTE: The MIDS LVT chronometer will be manually updated to the manual time value when the ENTR button is pressed on the ICP to accept the TIME data field. When manually synchronizing to another TNDL participant that is transmitting the network time reference, the ENTR button must be pressed at the moment *their* onboard system time corresponds with the manual time on *your* DED.

Repeat steps 3 and 4 if the MIDS LVT is unable to manually synchronize with the TNDL network.

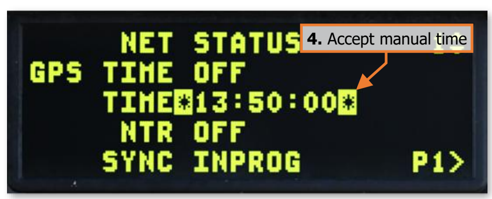
5. ICP DCS Switch – **Down** to move DED asterisks around NTR data field.

6. **(Recommended)** ICP Keypad – Press any button **1-9** to set NTR to OFF, if necessary.

or

7. **(Optional)** ICP Keypad – Press any button **1-9** to set NTR to ON if intending to provide the network timing reference for the TNDL network.

NOTE: Coordination must be performed with all other TNDL participants if your aircraft is intended to be the network timing reference.



Editing Ownship Datalink Settings

The settings used by the MIDS LVT when sending and receiving data across the TNDL network may be configured from the DLNK DED pages, which are accessed by pressing the **ENTR** button on the ICP keypad when the LIST DED page is displayed.

To edit the MIDS LVT datalink settings, perform the following:

1. ICP DCS Switch – **SEQ** to cycle to the TNDL DED page (P2>).

Fighter Channel (FC)

Not implemented.

Mission Channel (MC)

Not implemented.

Special Channel (SC)

Not implemented.

Voice Callsign

2. ICP DCS Switch – **Down** to move DED asterisks around first Voice Callsign data field.

3. ICP **Keypad** – Input the 2-digit Voice Callsign number for the ownship within the flight.

4. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

5. ICP **Increment/Decrement** rocker – Select the first letter of the Voice Callsign as necessary.

6. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

7. ICP **Increment/Decrement** rocker – Select the second letter of the Voice Callsign as necessary.

8. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

Flight Lead (FL)

9. ICP DCS Switch – **Down** to move DED asterisks around the FL data field, if necessary.

10. ICP Keypad – Press any button **1-9** as necessary to set FL to YES if the ownship is the Flight Lead, or NO if the ownship is not the Flight Lead.

Transmit Power (XMT)

11. ICP DCS Switch – **Down** to move DED asterisks around the XMT data field.

12. ICP Keypad – Press any button **1-9** as necessary to cycle XMT to HI, MED, LO, or NONE.

NOTE: If XMT is set to NONE, the MIDS LVT will operate in a receive-only mode and transmissions will be inhibited.

Editing Flight/Team STN Network

The Source Track Number (STN) for each Flight/Team member may be configured from the DLNK DED pages, which are accessed by pressing the **ENTR** button on the ICP keypad when the LIST DED page is displayed.

To edit the Source Track Number (STN) network of Flight members (1-4) and/or Team members (5-8), perform the following:

1. ICP DCS Switch – **SEQ** to cycle to the TNDL STN DED page (P3>).

Flight Members (1-4)

2. ICP DCS Switch – **Down** to move DED asterisks around the STN data field of Flight member 1.

3. ICP **Keypad** – Input the 5-digit STN of Flight member 1, or enter 00000 to zeroize the STN.

4. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

5. ICP DCS Switch – **Down** to move DED asterisks around the STN data field of the next Flight member and repeat steps 3 and 4.

Team Members (5-8)

6. ICP DCS Switch – **Down** to move DED asterisks around the STN data field of Team member 5.

7. ICP **Keypad** – Input the 5-digit STN of Team member 5, or enter 00000 to zeroize the STN.

8. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

9. ICP DCS Switch – **Down** to move DED asterisks around the STN data field of the next Team member and repeat steps 7 and 8.

Ownship Identifier (OWN #)

10. ICP DCS Switch – **Down** to move DED asterisks around the OWN # data field.

11. ICP **Keypad** – Input the number corresponding with the ownship position within the flight (1-8).

NOTE: This data field determines the STN from within the Flight/Team network that the ownship will utilize when transmitting TNDL messages, or when receiving TNDL messages intended for a specific recipient.

12. ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

(See the ASQ-213 HARM Targeting System chapter for more information regarding TDOA sub-teams.)

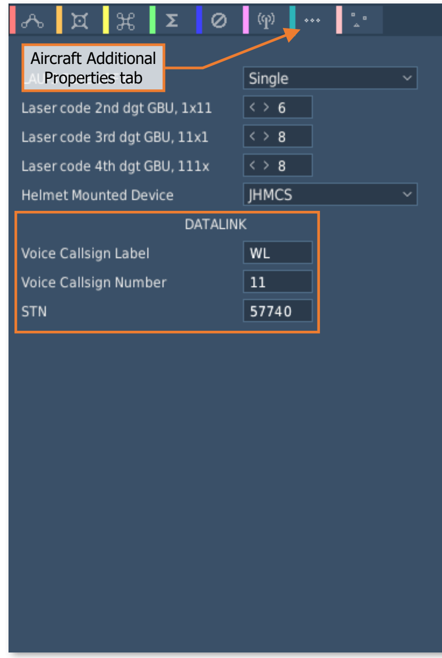
Datalink Mission Editor Options

Mission creators may configure the datalink settings for each aircraft within the Mission Editor. These settings are located on the Aircraft Additional Properties and Datalinks tabs.

Aircraft Additional Properties. Allows the mission creator to configure any remaining properties that are unique to the aircraft type.

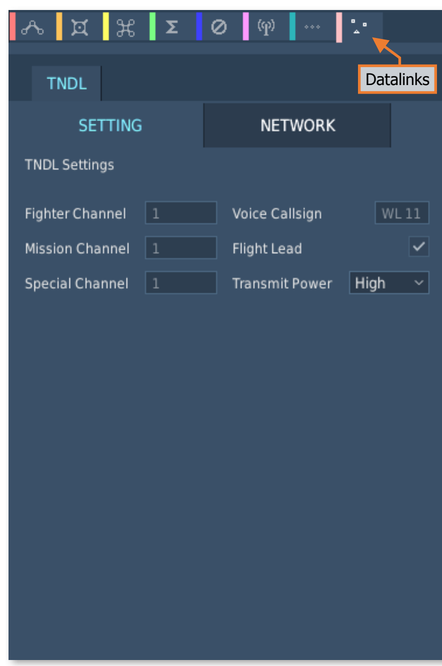
- **Voice Callsign Label.** This data field will determine the first two characters of the participant's identification within the cockpit of other TNDL participants on the network. Any combination of two letters may be entered.
- **Voice Callsign Number.** This data field will determine the final two characters of the participant's identification within the cockpit of other TNDL participants on the network. Any combination of two numbers may be entered.
- **Source Track Number.** The Source Track Number will determine how outgoing messages are recognized by other participants, and how incoming messages intended for the ownship are recognized. The STN consists of 5 numeric digits, with each digit limited to a range of 0-7; for a total of 32,768 unique STN numbers.

  NOTE: Each participant, to include the ownship, must have a unique STN. If two or more participants on the same datalink network are assigned the same source track number, erroneous behavior may be observed when using the datalink, or when using functions within the cockpit that are associated with the datalink.

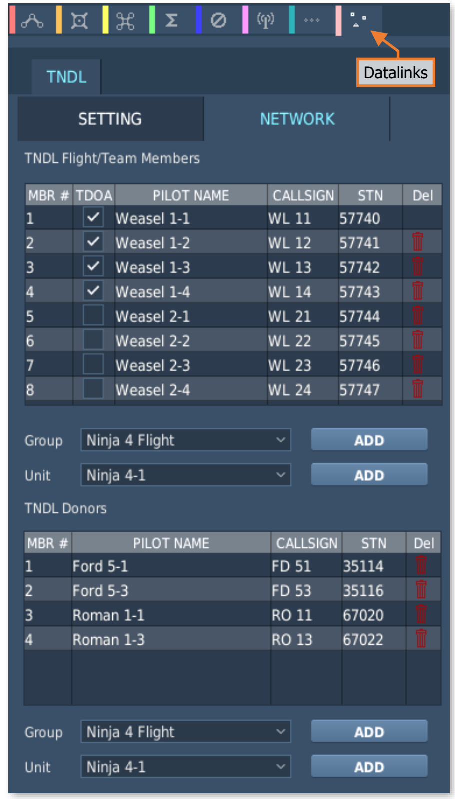


Datalinks – SETTING tab. Allows the mission creator to configure the details on the second DLNK DED page.

- **Fighter Channel.** This data field configures the TNDL channel to be used for Fight-to-Fighter data messages. (N/I)
- **Mission Channel.** This data field configures the TNDL channel to be used for Surveillance data messages. (N/I)
- **Special Channel.** Not implemented.
- **Voice Callsign.** This data field repeats the Voice Callsign from the Aircraft Additional Properties tab.
- **Flight Lead.** This checkbox designates the selected aircraft as the Flight Lead for incoming TNDL messages. (N/I)
- **Transmit Power.** This setting determines the ownship's transmission power for outgoing messages.



(See TNDL DED page for more information.)



Datalinks – NETWORK tab. Allows the mission creator to configure the Flight/Team member and Donor lists for the current F-16 selected within the Mission Editor.

- **MBR #.** Displays the STN index of each network participant within the corresponding list. A maximum of 8 participants may be present on the list of Flight/Team members. A maximum of 4 participants may be present on the list of Donors.

  NOTE: Only the Flight/Team members may be edited from within the cockpit via the TNDL STN DED page. Donors cannot be edited from within the cockpit.

- **TDOA.** This checkbox determines which Flight/Team members are enabled for cooperative TDOA ranging using the HARM Targeting System (HTS) pod.
- (See the ASQ-213 HARM Targeting System chapter for more information regarding TDOA sub-teams.)
- **PILOT NAME.** Displays the name of each network participant.
- **CALLSIGN.** Displays the Voice Callsign of the network participant.
- **STN.** Displays the source track number of each network participant.
- **Del.** When the red "trash can" icon within this column is selected, the network participant will be removed from the corresponding list. The ownship cannot be deleted from the Flight/Team member list, and will not display a red "trash can" icon within the list.
- **Groups Selection/ADD Button.** Displays options for selecting other Airplane Groups within the mission. Only TNDL-capable Airplane Groups that are of the same coalition and not already present within the corresponding list will be available for selection.

  When the ADD button is pressed, all aircraft within the selected Airplane Group will be added to the corresponding list.

- **Units Selection/ADD Button.** Displays options for selecting individual aircraft within the mission. Only TNDL-capable aircraft that are of the same coalition not already present within the corresponding list will be available for selection.

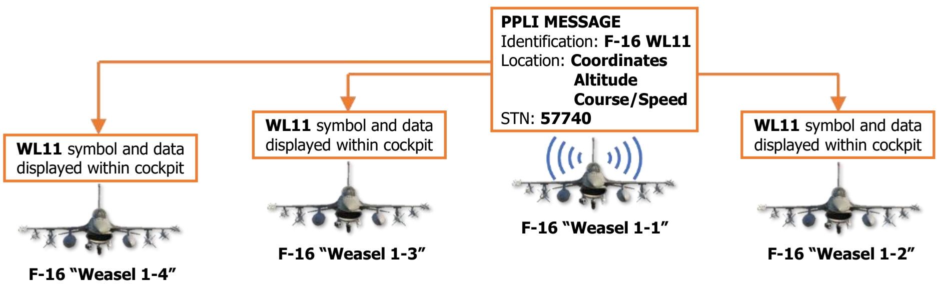
  When the ADD button is pressed, the selected aircraft will be added to the corresponding list.

PRECISE PARTICIPANT LOCATION IDENTIFICATION (PPLI)

PPLI messages are automatically transmitted to other TNDL participants across the network and identify the transmitting participant's platform type, callsign, 3-dimensional location, course and speed, and source track number (STN). PPLI messages are transmitted at fixed intervals and provide situational awareness of other friendly aircraft and units within the battlespace.

When a PPLI message is received from another network participant, the STN is compared to an STN list uploaded into the avionics to determine if the participant is a Flight/Team member or a Donor. The nature of this track is then displayed on the FCR, HSD, and HAD formats of either MFD, which will reflect the location of the participant and how the PPLI is affiliated to the ownship's flight.

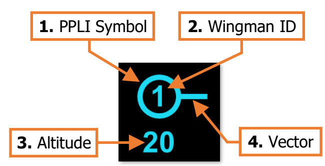
PPLIs are extrapolated for 13 seconds and then purged from the System Track File if no update is received.



PPLI Message

1. **PPLI Symbol.** Indicates the participant's affiliation to the ownship. Since any aircraft transmitting PPLI messages on the TNDL network are friendly, all airborne PPLI symbols are displayed as a circle.
   - Flight/Team members are colored blue.
   - All other friendly aircraft are colored green.
2. **Wingman ID.** Indentifies the PPLI as a Flight/Team member or Donor.
   - Flight members are identified as 1-4.
   - Team members are identified as 5-8.
   - Donors are identified by a dot within the symbol.
   - Participants that are neither Flight/Team members nor Donors are displayed with a blank symbol.

   (See TNDL Symbols for more information.)

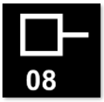


PPLI Track Symbol

3. **Altitude.** Indicates the participant's altitude above mean sea level (MSL), in increments of 1,000 feet. In this example, the participant is at an altitude of approximately 20,000 feet MSL.
4. **Vector.** Indicates the relative course line of the participant.

PPLI tracks are correlated with other TNDL data to avoid duplicate tracks. When a PPLI message is received, the STN embedded within the message is compared to existing TNDL tracks. If any existing tracks are referenced to the same STN, whether the tracks are generated from PPLI messages or from Air Surveillance tracks, the most recent data is used and the old data is purged. For example, if two aircraft were transmitting PPLI messages with identical STN data, the PPLI symbol on the MFD would alternate, or "mipple", between the positions of each aircraft as each aircraft's PPLI was received and cyclically updated during the TNDL transmit interval.

AIR TARGET/AIR SURVEILLANCE TRACKS



Air Target tracks are automatically transmitted to other TNDL participants across the network and are received from Flight/Team members or Donors on the Fighter channel. Air Target tracks allow multiple fighter aircraft to exchange radar track data to build a composite radar picture of the airspace, enhance the collective situational awareness of the flight, and sort targets amongst wingmen when engaging multiple hostile aircraft simultaneously.

Air Surveillance tracks are transmitted by C2 platforms, such as AWACS, across the network on the Mission channel to augment the situational awareness of all TNDL-participant aircraft within the area. Air Surveillance tracks may include positions of hostile aircraft, allowing friendly fighters to minimize radar emissions, if necessary; or friendly non-TNDL participant aircraft, which helps deconflict congested airspace and avoid fratricide (i.e., "friendly fire").

System Track File (STF)

All air tracks, whether received from other TNDL participants across the network or generated by the F-16C's onboard Fire Control Radar (FCR), are stored within the MMC System Track File (STF). The STF consists of a series of track file "slots" across two partitions, with the first 10 slots allocated to onboard system tracks generated by the FCR and the remaining slots allocated to offboard system tracks received through the MIDS LVT.

System Track File (STF)

Each system track consists of several data attributes regarding the nature of the track itself.

- **Track Number (TN).** The track's numerical reference across the TNDL network, used for sensor correlation and target sorting.
- **Position/Altitude**. The 3-dimensional location of the aircraft.
- **Velocity/Course.** The velocity and course of the aircraft, which is used to extrapolate the position and altitude of the track between track updates.
- **Aircraft Type.** The type of aircraft (i.e., "F-16" or "MiG-29"), if known.
- **Sovereignty.** The coalition affiliation of the aircraft (i.e., "Friendly", "Unknown", "Suspect", or "Hostile").
- **Mode 4 Status.** The IFF interrogation status of the aircraft. This includes whether a Mode 4 interrogation has been performed against the aircraft's transponder and the outcome of the interrogation.

As subsequent updates to the Air Target or Air Surveillance tracks are received through the MIDS LVT, the Track Number (TN) of each air track received in these messages are compared to those already present within the STF. If the TN matches an existing air track within the STF, the MMC updates the track file information with the most recent data that has been received. If the TN does not match an existing air track within the STF, the MMC generates a new track within the STF from the received data.

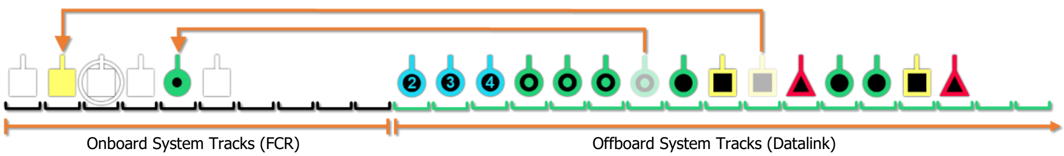
If multiple air tracks are received from different sources across the TNDL network, with different TNs but identical attributes of position, altitude, velocity, and course, the MMC will correlate these tracks and combine their attributes within a single track file slot. The MMC will also correlate air tracks with PPLI tracks received across the TNDL network as well as onboard FCR tracks. (See the following page for more information regarding track correlation.)

Track Correlation

The MMC continuously compares offboard track data received through the MIDS LVT with existing track data that is stored within the System Track File (STF) to resolve duplication of system tracks. If the MMC determines multiple system tracks contain the same track data, a correlation of those tracks are performed to combine the track data into a singular system track. The MMC performs track correlation using three methods:

Onboard-Offboard Track Correlation

If an offboard system track is correlated with an onboard FCR track, the FCR track will inherit the track data from the offboard system track and the offboard system track will be deleted. As an example, if an FCR target was being tracked in position and velocity and was subsequently correlated with an Air Surveillance track with identical position and velocity attributes that also included a negative Mode 4 IFF Status after interrogation by the AWACS, the FCR track inherits the negative Mode 4 IFF Status following the correlation, which may also affect its Sovereignty attribute as shown in the image below.



Onboard-Offboard System Track Correlation

As another example, if an FCR target was being tracked in position and velocity and was subsequently correlated with a PPLI track received from a TNDL Donor with identical position and velocity attributes, the FCR track inherits the Aircraft Type and Sovereignty attributes of the PPLI track, as shown in the image above.

NOTE: If the FCR is in Track While Scan (TWS) sub-mode and an FCR Track Target is correlated with an offboard System Track, the FCR Track Target is automatically elevated to an FCR System Track Target to complete the correlation process within the STF.

FCR System Track Targets will retain any attributes inherited from offboard sources as long as the FCR maintains a track on the aircraft, even if the MIDS LVT is no longer receiving offboard track updates across the TNDL network for the corresponding track. However, if the FCR cannot maintain a track on the aircraft and the FCR System Track Target is deleted, the track attributes will be deleted as well. If the FCR loses track on the aircraft but the MIDS LVT is still receiving offboard track updates across the TNDL network for the corresponding track, the track is decorrelated and re-inserted back into the STF as an offboard system track.

Offboard-Offboard Track Correlation

If an offboard system track is correlated with another offboard system track with identical position and velocity attributes, the MMC will combine the data into a single system track based on the most recent or most reliable track attributes. This typically occurs when the ownship receives Air Target tracks from multiple wingmen that have bugged the same target aircraft, or if an Air Target track received from a wingman is correlated with an Air Surveillance track received from a C2 platform.

Track Number (TN) Correlation

If an offboard system track is correlated with another offboard system track with an identical Track Number (TN), the MMC will combine the data into a single system track based on the most recent or most reliable track attributes. This typically occurs when the ownship receives a PPLI track directly from another TNDL participant that is correlated with an Air Surveillance track received from a C2 platform that was re-broadcasting the PPLI track to other network participants.

NOTE: If an offboard system track is correlated between multiple sources across the TNDL network, that track will only be hidden from the FCR or HSD MFD formats if all of the relevant show options affecting the sources of offboard tracks are disabled. For example, if a PPLI track is correlated to a friendly Air Surveillance track, the Friendly Declutter option (OSB 9) on the HSD base page must be set to FR OFF and the A SURV option (OSB 6) on the HSD CNTL page must be de-selected. If either of these options are enabled, the track symbol will still appear on the HSD as the data is being received from two different sources across the TNDL network.

Air Target Data Table (ATDT)

Air tracks within the System Track File are displayed using a combination of shape and color to express the track's sovereignty attribute (i.e., "Friendly", "Unknown", "Suspect", or "Hostile"). An air track's sovereignty may be supplied directly from offboard platforms via the TNDL network, such as an AWACS declaring an air track to be friendly or hostile; or the F-16's onboard Modular Mission Computer (MMC) may derive an air track's sovereignty from other attributes of the track itself, based on an Air Target Data Table (ATDT) uploaded from the DTC into the aircraft memory prior to the mission.

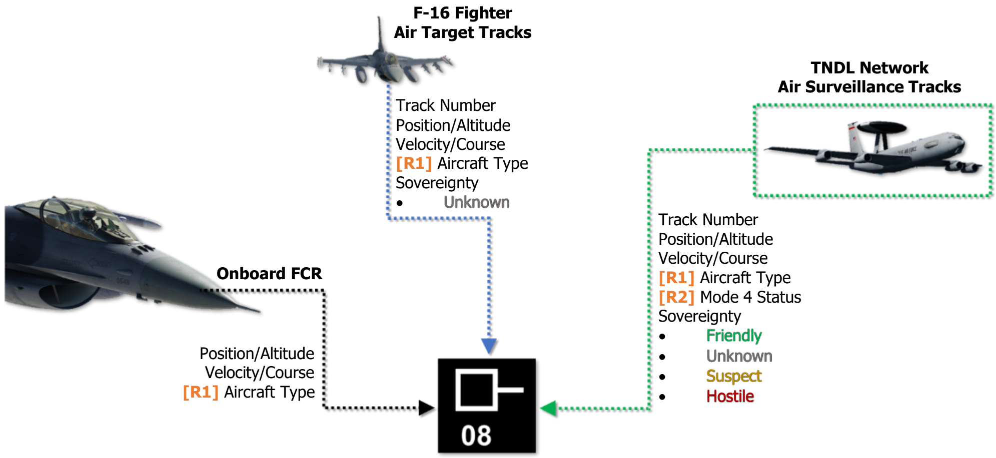
The ATDT is intended to aid the pilot in determining whether rules-of-engagement (ROE) criteria have been met prior to employing weapons against an airborne target. Two ATDT criteria may be configured within the DTC ROE settings to determine a track's sovereignty, or the ATDT may be disabled altogether.

ROE Factor 1 [R1] – Aircraft Type. The type of aircraft is categorized with a friendly, hostile, or unknown coalition affiliation within the ATDT. The aircraft type attribute may be sourced from either of the following:

- Onboard FCR via Non-Cooperative Target Recognition (NCTR).
- Offboard datalink information via TNDL.

ROE Factor 2 [R2] – Mode 4 Status. If the aircraft transponder has been interrogated using a Mode 4 code, and whether the aircraft returned the correct reply code (friendly) or not (hostile). Since the F-16C's onboard AIFF interrogation system is not integrated with the System Track File (STF), the Mode 4 status attribute may only be sourced from the following:

- Offboard datalink information via TNDL.



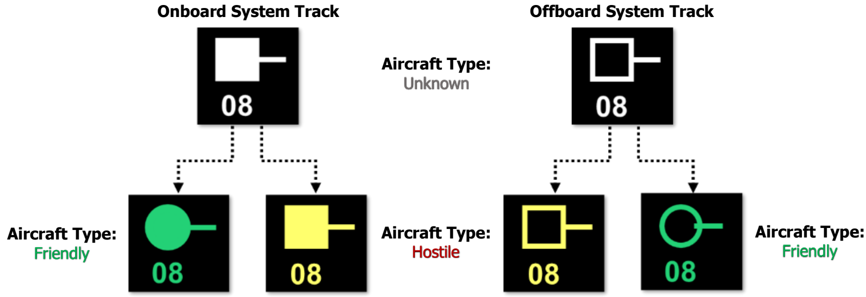
Sources of Air Track Attributes

If **both** of the ATDT factors are **disabled** within the DTC ROE settings, the MMC will assign sovereignty to an air track based on the sovereignty attribute supplied by the TNDL network.

If **either** of the ATDT factors are **enabled** within the DTC ROE settings, the MMC will assign sovereignty to an air track based on a combination of the aircraft type and Mode 4 status attributes.

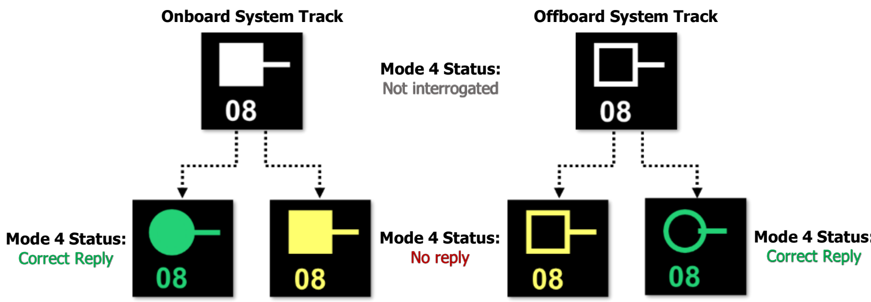
NOTE: When an FCR target is "bugged" as the FCR Target-Of-Interest (TOI) and transmitted across the Fighter channel, the F-16C will always transmit Air Target tracks with a sovereignty attribute of "Unknown", regardless of the sovereignty attribute the MMC has assigned to the track within the STF, or whether the ATDT ROE factors are enabled/disabled.

If **Aircraft Type** is enabled within the DTC ROE settings, sovereignty will be assigned using the following logic, regardless of whether the aircraft type is obtained from NCTR or the TNDL network.



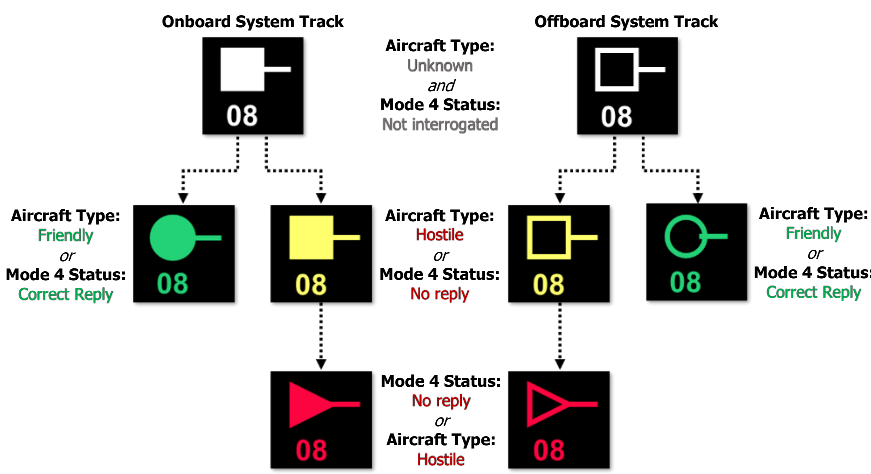
ATDT ID-Tree (Aircraft Type enabled)

If **Mode 4 Status** is enabled within the DTC ROE settings, sovereignty will be assigned using the following logic.



ATDT ID-Tree (Mode 4 Status enabled)

If **Aircraft Type** and **Mode 4 Status** are enabled within the DTC ROE settings, sovereignty will be assigned using the following logic, regardless of whether the aircraft type is obtained from NCTR or the TNDL network.



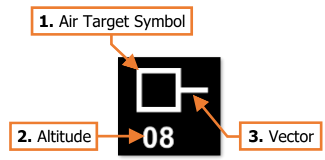
ATDT ID-Tree (2 ROE factors enabled)

Fighter Air Target Tracks

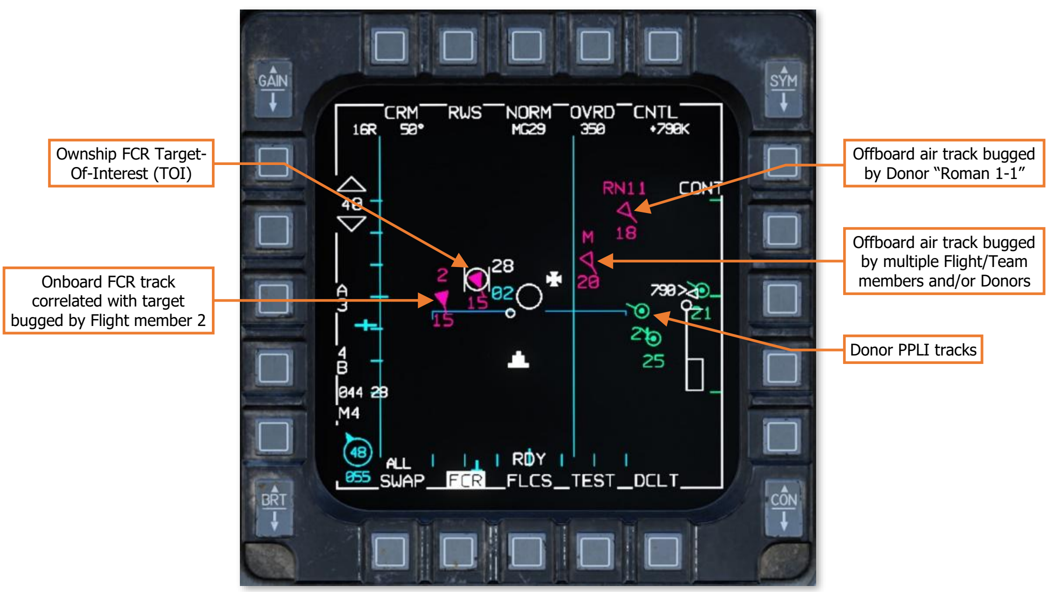
Air Target tracks allow multiple fighter aircraft to exchange radar track data to build a composite radar picture of the airspace, enhance the collective situational awareness of the flight, and sort targets amongst wingmen when engaging multiple hostile aircraft simultaneously. Air Target tracks are automatically transmitted from the F-16C across the Fighter channel any time an FCR target is "bugged" as the FCR Target-Of-Interest (TOI), or the FCR is tracking a secondary target in SAM or DTT sub-modes.

Air Target tracks received from Flight/Team members or Donors are correlated with onboard and offboard track data as necessary and displayed on the FCR and HSD MFD formats. Offboard track data is extrapolated for 13 seconds following the most recent track update and then purged from the System Track File if no further updates are received from the contributing TNDL participant.

1. **Air Target Symbol.** Indicates the aircraft's sovereignty, based on shape and color. (See TNDL Symbols for more information.)
2. **Altitude.** Indicates the aircraft's altitude above mean sea level (MSL), in increments of 1,000 feet. In this example, the aircraft is at an altitude of approximately 8,000 feet MSL.
3. **Vector.** Indicates the relative course line of the aircraft.

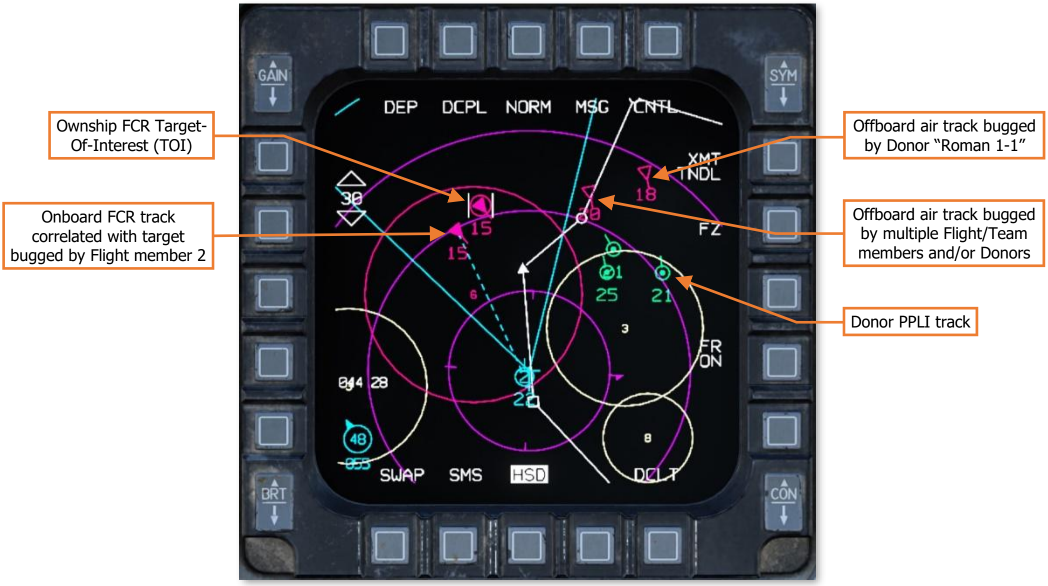


Air Target Symbol



If an Air Target track is bugged as the FCR Target-Of-Interest by any Flight/Team members or Donors, additional characters will be displayed above the target symbols themselves on the FCR MFD format to identify which fighter is tracking the target. These characters aid in target sorting prior to engaging enemy aircraft.

- If the Air Target track is bugged by Flight members 1-4 or Team members 5-8, a number (i.e., "2" for Flight member 2) will be displayed over the target symbol corresponding with the Flight/Team member.
- If the Air Target track is bugged by Donor, a four-character callsign (i.e., "RN11" for "Roman 1-1") will be displayed over the target symbol corresponding with the voice callsign of the Donor.
- If the Air Target track is bugged by multiple Flight/Team members and/or Donors, an "M" will be displayed over the target symbol to indicate multiple fighters are tracking the target.



Air Target track symbols displayed on the HSD MFD format do not include additional characters to identify which fighter is tracking the target. However, if an Air Target track is received from a Flight member (1-4), a dashed lock line or shot line may be displayed on the HSD between the target and the corresponding Flight member.

- If the Air Target track is a Flight member's primary target (Target-Of-Interest), a solid lock line will be displayed between the target and the corresponding Flight member.
- If the Air Target track has been engaged by a Flight member with an AIM-120 AMRAAM missile, a flashing shot line will be displayed between the target and the corresponding Flight member until the time-until-impact timer for that missile reaches zero.

  NOTE: Only two shot lines may be displayed for each Flight member, corresponding with the two most recently fired AIM-120 missiles from that Flight member.
- If the Air Target track is a Flight member's secondary target, a lock line will **not** be displayed.

Lock lines and shot lines are not displayed for Team members (5-8) or Donors.

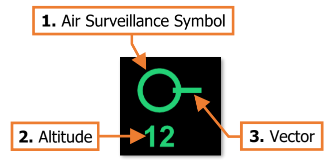
Fighter Air Target tracks may be decluttered from the FCR MFD format using the FCR Datalink Declutter setting, or decluttered from the HSD MFD format by accessing the HSD Control page.

Air Surveillance Tracks

Air Surveillance tracks are received from C2 aircraft, such as AWACS, across the Mission channel and provide enhanced situational awareness of the battlespace. This allows TNDL-participant aircraft to extend their situational awareness beyond the sensors within their own flight, minimize their own radar emissions if necessary, receive re-broadcasted PPLI tracks from TNDL participants that may be separated by range or terrain obstructions, and receive positions of friendly units such as A-10 attack aircraft, AH-64D attack helicopters, or other coalition aircraft that are not TNDL-compatible.

Air Surveillance tracks are correlated with onboard and offboard track data as necessary and displayed on the FCR and HSD MFD formats. Air Surveillance tracks are extrapolated for 20 seconds following the most recent track update and then purged from the System Track File if no further updates are received.

1. **Air Surveillance Symbol.** Indicates the aircraft's sovereignty, based on shape and color. (See TNDL Symbols for more information.)
2. **Altitude.** Indicates the aircraft's altitude above mean sea level (MSL), in increments of 1,000 feet. In this example, the aircraft is at an altitude of approximately 12,000 feet MSL.
3. **Vector.** Indicates the relative course line of the aircraft.



Air Surveillance Symbol

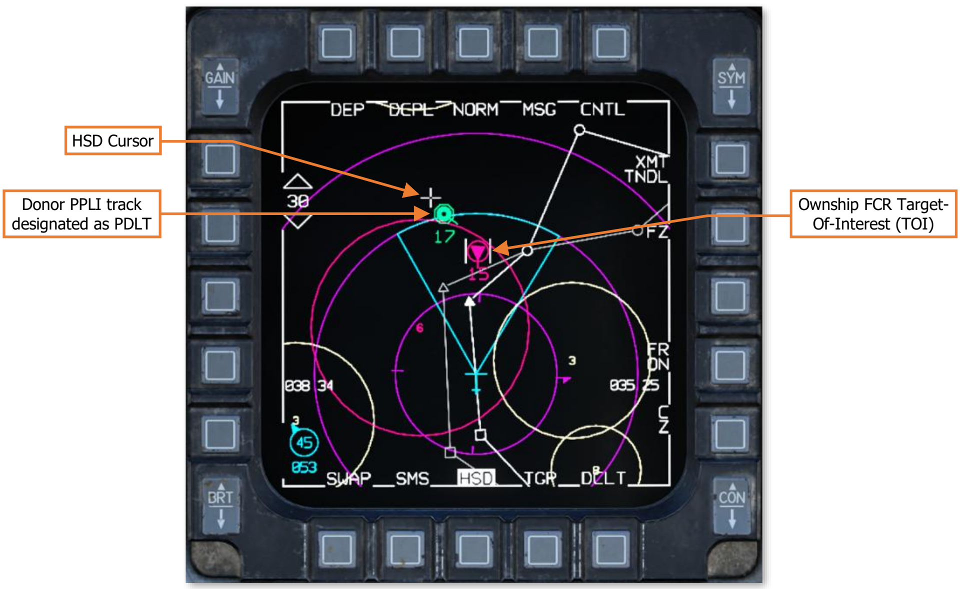
Air Surveillance tracks may be decluttered from the FCR MFD format using the FCR Datalink Declutter setting, or decluttered from the HSD MFD format by accessing the HSD Control page.

Primary Datalink Track (PDLT)

The pilot may designate any air PPLI track, Air Target track, or Air Surveillance track as the PDLT. When an offboard TNDL track is designated as the PDLT, an octagon is placed around the symbol on the FCR and HSD MFD formats, with the color of the octagon matching the color of the TNDL track to which it is coupled. An octagon symbol is also displayed over the track's position as seen "out-the-window" through the HUD and HMCS.

Designating an air track as PDLT may be used for a variety of purposes, allowing the pilot to maintain awareness of a specific target's position within the battlespace independently of the FCR, such as when a target is beyond the range or gimbal limits of the FCR or when trying to minimize FCR emissions to avoid detection. Alternatively, designating a friendly aircraft as PDLT may be used to differentiate a friendly aircraft from a hostile aircraft that are in close proximity to one another, or aid in performing a rendezvous with other friendly aircraft.

If the HSD is the Sensor-Of-Interest (SOI), an air track may be designated as PDLT by placing the HSD cursor over an air PPLI track, Air Target track, or Air Surveillance track and pressing TMS Forward.



If the HSD cursor is positioned over a pre-planned threat steerpoint with a hidden threat ring, or over any other position on the HSD, pressing TMS Aft will drop the PDLT designation.

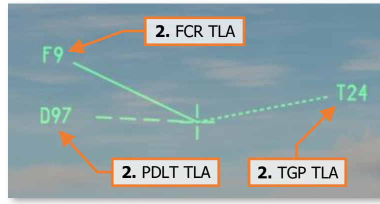
If the HSD cursor is positioned over a pre-planned threat steerpoint with a displayed threat ring, pressing TMS Aft will hide the threat ring, and a subsequent press of TMS Aft will drop the PDLT designation.

The PDLT designation will be automatically dropped under the following conditions:

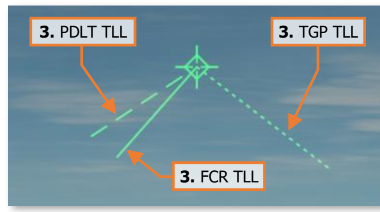
- If an offboard TNDL track has been designated as the PDLT and the offboard track is no longer being received, the PDLT will be dropped.
- If an onboard FCR target is correlated with an offboard TNDL track that has been designated as the PDLT and the offboard track is no longer being received, the PDLT will be dropped.
- If an onboard FCR target is correlated with an offboard TNDL track that has been designated as the PDLT, and the FCR target is subsequently bugged as the FCR Target-Of-Interest (TOI), the PDLT will be dropped.

If a PDLT has been designated on the HSD, additional symbology will be displayed within the HUD and HMCS to display the position of the PDLT.

HUD/HMCS Primary Datalink Target (PDLT) Octagon



HUD TLL and TLA Symbology



HMCS TLL Symbology

1. **Primary Datalink Target (PDLT) Octagon.** Displays the position in azimuth, elevation, and altitude above mean sea level (MSL) of the air PPLI, Air Target, or Air Surveillance track designated as the PDLT.
2. **Target Locator Angle (TLA).** Displays the relative offset angle (in degrees) from the nose to the FCR TOI, PDLT, and/or the TGP-tracked aircraft when the corresponding A-A TD Box or PDLT Octagon is outside the field-of-view of the HUD. TLA symbology is not displayed within the HMCS.
3. **Target Locator Line (TLL).** Displays the relative offset direction from the HUD Boresight Cross or HMCS Aiming Cross to the FCR TOI (solid line), PDLT (dashed line), and/or the TGP-tracked aircraft (dotted line) when the corresponding A-A TD Box or PDLT Octagon is outside the field-of-view of the HUD or HMCS.

FCR Datalink Declutter

PPLI tracks received from other TNDL-participant aircraft, Air Target tracks received from Flight/Team members or Donors, and Air Surveillance tracks received from AWACS may be selectively decluttered from the FCR MFD format by cycling the datalink declutter setting using the UHF/VHF Transmit switch on the throttle grip. The hands-on datalink declutter only affects offboard datalink tracks displayed on the FCR format and does not affect those displayed on the HSD or HAD formats.

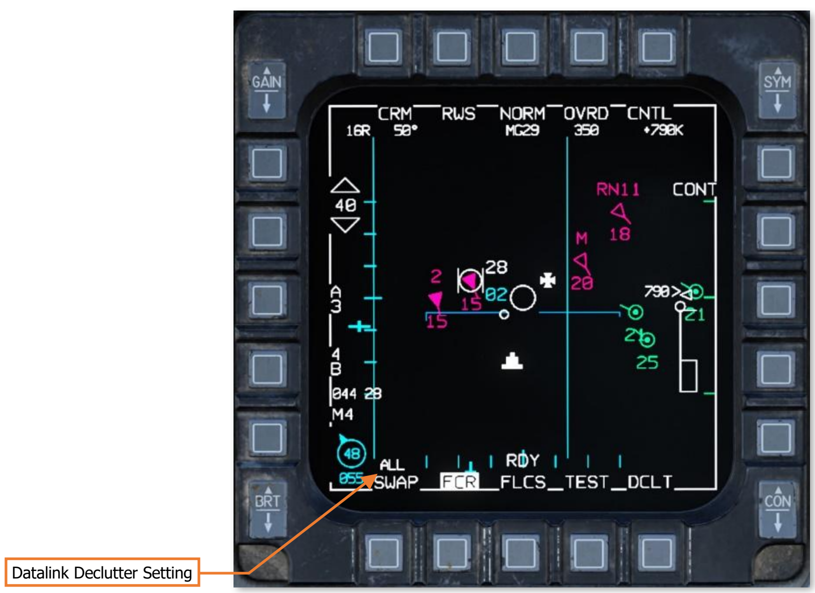
Pressing the UHF VHF Transmit switch to the inboard IFF IN position on the throttle for <0.5 second will cycle the declutter setting in a cyclic manner: ALL → FTR+ → TGTS → ALL.

Pressing the UHF VHF Transmit switch to the outboard IFF OUT position on the throttle for <0.5 second will toggle the declutter setting between the current setting (ALL, FTR+, TGTS) and NONE.

The selected declutter setting is displayed at the bottom left of the FCR MFD format.

- **ALL.** All offboard datalink tracks are displayed.
- **FTR+.** Air Target tracks and PPLI tracks are displayed. Air Surveillance tracks are removed.
- **TGTS.** Air Target tracks are displayed. Air Surveillance tracks and PPLI tracks are removed.
- **NONE.** All offboard datalink tracks are removed.

Declutter Setting	PPLI Tracks	Air Target Tracks	Air Surveillance Tracks
All datalink tracks (**ALL**)	Displayed	Displayed	Displayed
Fighter Targets + PPLI (**FTR+**)	Displayed	Displayed	Not displayed
Fighter Targets only (**TGTS**)	Not displayed	Displayed	Not displayed
No datalink tracks (**NONE**)	Not displayed	Not displayed	Not displayed



MARKPOINTS

Markpoints may be transmitted to other TNDL participants across the network and received from Flight/Team members or Donors on the Fighter channel. Markpoints are used to reference geographic locations to enhance the situational awareness of other aircrews or streamline tactical coordination, which facilitates a more efficient use of the radios for voice communications.

Markpoint messages may be generated based on the following sources of data, in descending order of priority:

- **System Point-Of-Interest (SPI).** The location of the SPI when the FCR or the TGP are in an air-to-ground track mode. The Markpoint message is transmitted with a "lock-on" status.
- **Selected Steerpoint.** The location of the steerpoint currently selected for navigation.

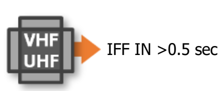
If neither the FCR nor TGP are in an air-to-ground tracking mode and no radar threat is designated on the HAD MFD format, the selected steerpoint will be transmitted as a markpoint. Once the FCR or TGP are in an air-to-ground track mode, or a radar threat has been designated on the HAD MFD format with the HAD as SOI, the SPI of the tracking sensor will be prioritized for transmission as a markpoint or a SEAD target, respectively, in lieu of the selected steerpoint.

If a Markpoint message is received from a Flight member (1-4) with an associated "lock-on" status, a lock line will be displayed between the markpoint and the transmitting Flight member for 30 seconds.

Transmitting Selected Steerpoint as a Markpoint

To transmit a steerpoint as a Markpoint, perform the following:

1. MFD format – Select **HSD**.
2. XMT (OSB 6) – Select **TNDL**, if SMDL is displayed.
3. Select the steerpoint intended for transmission as a markpoint.
4. **(If a radar is designated on HAD)** DMS Forward/Aft – Press as necessary to ensure HAD is not the Sensor-Of-Interest (SOI).
5. Verify FCR and TGP are not in an air-to-ground track mode.
6. IFF IN-Long – Press. (Throttle)



Transmitting FCR or TGP SPI as a Markpoint

To transmit the FCR or TGP SPI location as a markpoint, perform the following:

1. MFD format – Select **HSD**.

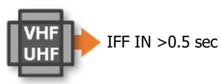
2. XMT (OSB 6) – Select **TNDL**, if SMDL is displayed.

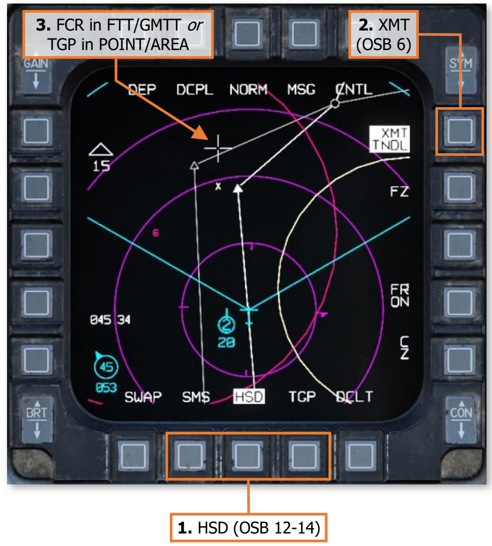
3. Enter FCR Fixed Target Track or Ground Moving Target Track mode.

or

3. Enter TGP Point Track or Area Track mode.

4. IFF IN-Long – Press. (Throttle)





Receiving a Markpoint

When a Markpoint message is received and stored, a "Data" voice message will be heard and a "MKPT ## DATA" notification will be displayed in the HUD, with ## corresponding with the steerpoint number within which the markpoint has been stored.

The MKPT notification may be acknowledged by momentarily setting the DRIFT C/O & WARN RESET switch on the Integrated Control Panel to the WARN RESET position.

To set the markpoint as your selected steerpoint using the Upfront Controls, perform the following:

1. ICP **Increment/Decrement** Rocker – Select the steerpoint number corresponding with the received markpoint.

   or

1. ICP Keypad – Press **4/STPT** to display the STPT DED page.
2. ICP **Keypad** – Input the steerpoint number corresponding with the received markpoint.
3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

To set the markpoint as your selected steerpoint using the Hands-On Controls, perform the following:

1. MFD format – Select **HSD**.
2. DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HSD MFD format.
3. RDR CURSOR/ENABLE Switch – Slew the HSD cursor to the symbol of the received markpoint.
4. TMS Up-Short – Press to select the markpoint symbol.

SEAD TARGETS

SEAD targets may be transmitted to other TNDL participants across the network and received from Flight/Team members or Donors on the Fighter channel. SEAD targets are used to distribute and reference geographic locations of air defenses to coordinate the efforts of multiple F-16s when performing Suppression of Enemy Air Defense (SEAD) missions, which facilitates a more efficient use of the radios for voice communications.

SEAD Target messages are similar to Markpoint messages, except that they are generated by designating radar locations on the HARM Attack Display (HAD) MFD format and the HAD must be the Sensor-Of-Interest (SOI) when the datalink transmission is commanded. If the SOI is not assigned to the HAD MFD format when the datalink transmission is commanded, a Markpoint message will be transmitted instead of a SEAD Target message. (See the ASQ-213 HARM Targeting System chapter for more information regarding SEAD target designation.)

SEAD target symbols are composed of a slash drawn across alphanumeric characters corresponding with the type of radar designated on the HAD MFD format. If a SEAD Target message is received from a Flight member (1-4), a lock line will be displayed between the SEAD target and the transmitting Flight member for 30 seconds.

Transmitting a SEAD Target

To transmit an HTS-detected radar as a SEAD target, perform the following:

1. MFD format – Select **HSD**.
2. XMT (OSB 6) – Select **TNDL**.
3. MFD format – Select **HAD**.
4. DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HAD MFD format.
5. RDR CURSOR/ENABLE Switch – Slew the HAD cursor to the symbol of the HTS-detected radar intended for transmission as a SEAD target.
6. TMS Up-Short – Press to designate the radar symbol.
7. IFF IN-Long – Press. (Throttle)

Receiving a SEAD Target

SEAD Target messages are automatically received from Flight/Team members and Donors and stored in steerpoints 107-127. If all 21 of these steerpoints are occupied with data, the oldest data will be automatically overwritten as required when new data is received.

If a SEAD Target message is received from a Flight/Team member or Donor, a "Data" voice message will be heard and a "MKPT ### DATA" notification will be displayed in the HUD, with ### corresponding with the steerpoint number within which the SEAD target has been stored.

The MKPT notification may be acknowledged by momentarily setting the DRIFT C/O & WARN RESET switch on the Integrated Control Panel to the WARN RESET position.

To set the SEAD target as your selected steerpoint using the Upfront Controls, perform the following:

1. ICP **Increment/Decrement** Rocker – Select the steerpoint number corresponding with the received SEAD target.

   or

1. ICP Keypad – Press **4/STPT** to display the STPT DED page.
2. ICP **Keypad** – Input the steerpoint number corresponding with the received SEAD target.
3. ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

To set the SEAD target as your selected steerpoint using the Hands-On Controls, perform the following:

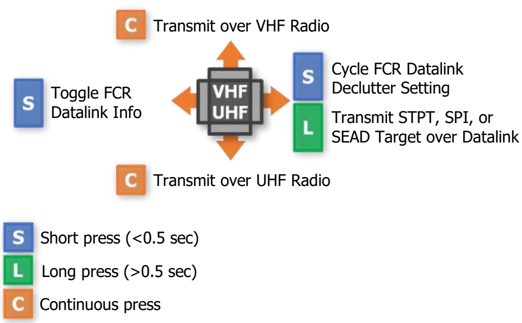
1. MFD format – Select **HSD**.
2. DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HSD MFD format.
3. RDR CURSOR/ENABLE Switch – Slew the HSD cursor to the symbol of the received SEAD target.
4. TMS Up-Short – Press to select the SEAD target symbol.

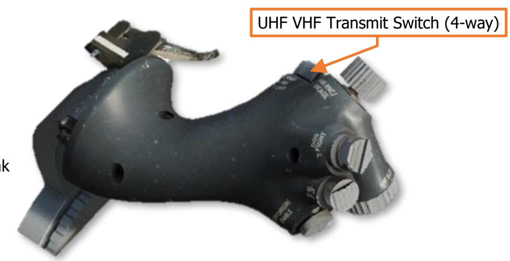
HANDS-ON CONTROLS

The UHF VHF Transmit switch on the Throttle controls the datalink information that is displayed on the FCR MFD format and transmits datalink messages across the datalink selected on the HSD MFD format adjacent to OSB 6.

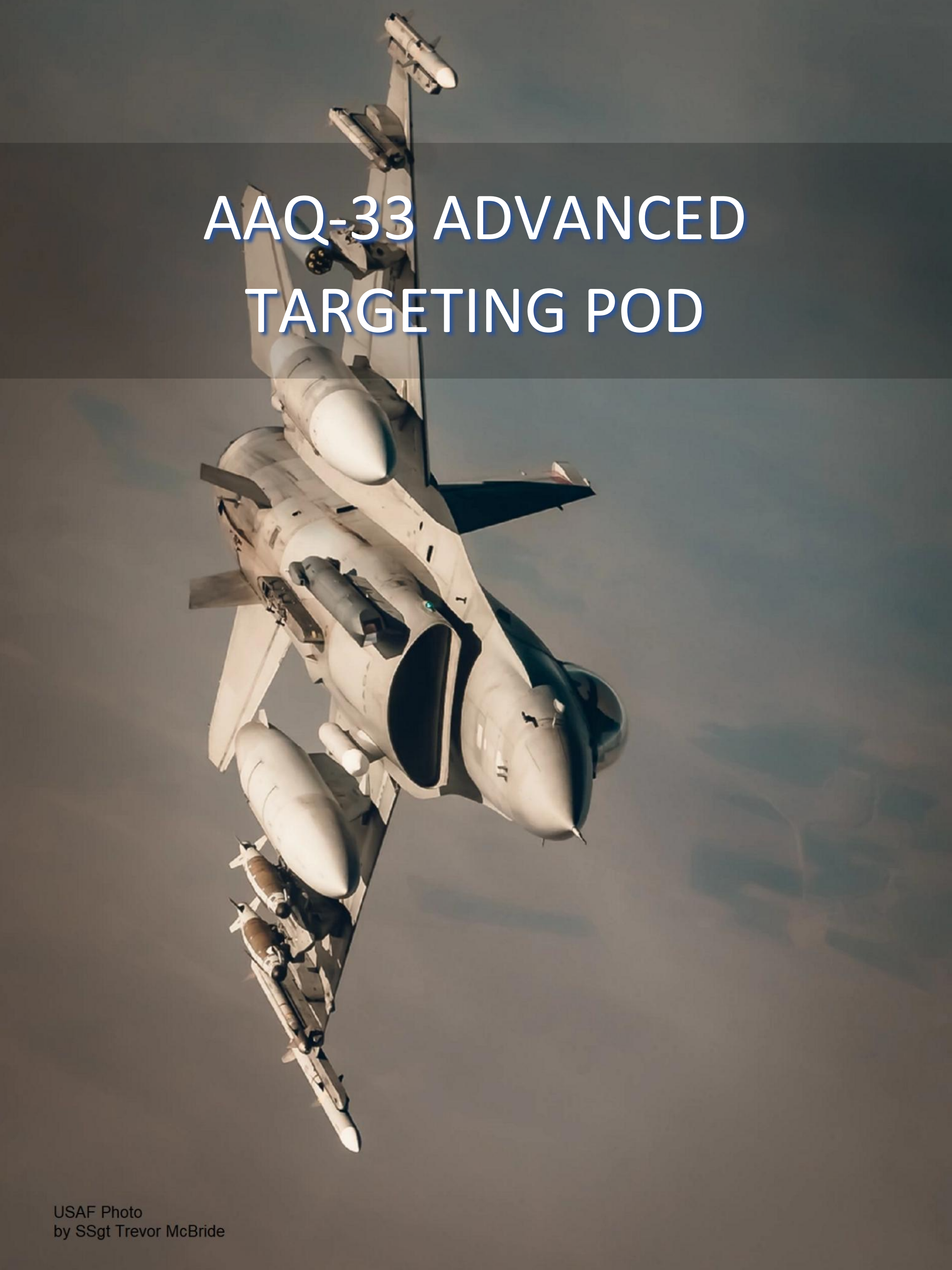
NOTE: TNDL is the only datalink type simulated in DCS: F-16C Viper.

- Pressing the switch to the left/outboard IFF OUT position on the throttle for <0.5 seconds will toggle the Datalink Declutter Setting on the FCR MFD format between the current selection and NONE.
- Pressing the switch to the right/inboard IFF IN position on the throttle for <0.5 seconds will cycle the Datalink Declutter Setting on the FCR MFD format in a cyclic manner: ALL → FTR+ → TGTS → ALL.
- Pressing the switch to the right/inboard IFF IN position on the throttle for >0.5 seconds will transmit a Markpoint or SEAD Target message over the selected datalink.





AAQ-33 ADVANCED TARGETING POD



USAF Photo
by SSgt Trevor McBride

AN/AAQ-33 ADVANCED TARGETING POD

The AN/AAQ-33 Advanced Targeting Pod (ATP), designed by Lockheed Martin, enables the F-16C to electro-optically search, acquire, track, and designate targets on the ground or in the air from longer ranges than previous generations of targeting pods. The ATP can be used to perform reconnaissance from high altitudes, laser designate ground targets for engagement using precision-guided munitions, or optically track and identify aircraft at long range.

AN/AAQ-33 Reconnaissance, Targeting, and Designation

The AAQ-33 pod includes four sensors within a steerable turret located on the forward face of the pod itself: a charge-coupled device (CCD) TV camera, a forward looking infrared (FLIR) thermographic camera, a dual-mode laser designator/ranger for designating targets or ground locations, and a laser spot tracker for detecting offboard laser designations. The AAQ-33 also includes an infrared (IR) pointer for visually highlighting targets or locations on the battlefield for anybody wearing night vision goggles (NVGs) and a video datalink (VDL) antenna for transmitting sensor video to ground forces (VDL is not implemented).

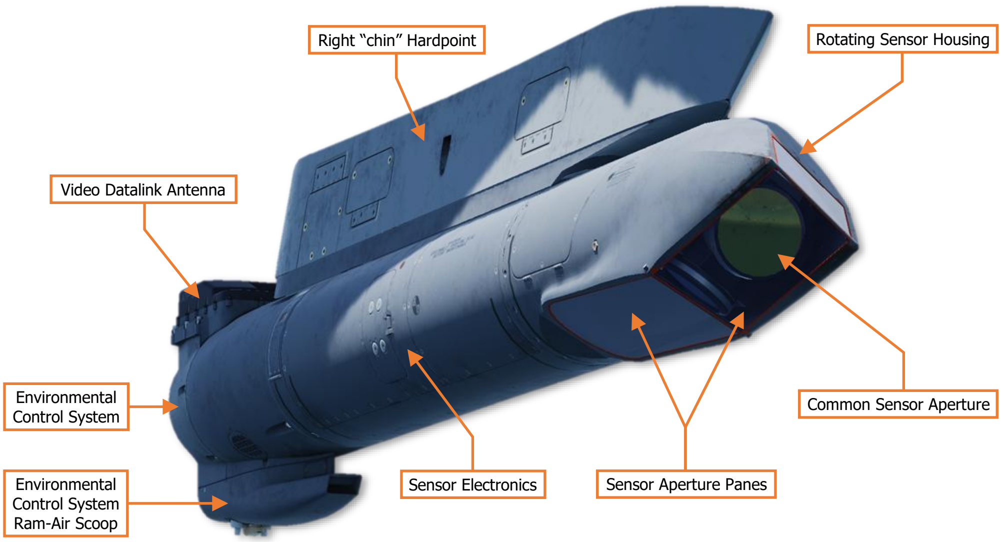
Advanced Targeting Pod Activation

The ATP (if equipped) is powered through the right "chin" hardpoint. This is accomplished by positioning the RIGHT HDPT switch to the forward position on the SNSR PWR control panel on the right console.

NOTE: The ATP cannot function without powering the MMC, ST STA, UFC, and MFD avionics systems, or without an aligned INS.

The ATP will require approximately 12 minutes to initialize, perform self-tests, and cool down the FLIR sensor. During initialization, the TGP MFD format will continue to display TGP OFF for approximately 90 seconds before the MFD displays the NOT TIMED OUT message and the ATP begins its Initiated Built-In-Test (IBIT) sequence. The IBIT requires approximately 10 minutes to complete, after which the ATP will enter Standby (STBY) mode.

Advanced Targeting Pod Overview



AAQ-33 Advanced Targeting Pod

Forward-Looking Infrared (FLIR) Sensor

The FLIR sensor is a thermographic camera that enables the F-16C to detect and identify targets in any lighting conditions. Although primarily used during night operations, the FLIR is equally capable during daylight hours. The FLIR sensor includes two optical fields-of-view, Wide and Narrow.

Television (TV) Sensor

The TV sensor is a charge-coupled device (CCD) television camera that enables the F-16C to identify targets at long-range during daylight hours only. Although the TV sensor only includes one optical field-of-view and is less versatile than the FLIR, the magnification of the TV sensor facilitates target identification at further distances than is possible with the FLIR sensor.

Picture-In-Picture (PIP)

The TV sensor's greater magnification over the FLIR sensor provides improved image quality and clarity but restricts the field-of-view to a much narrower area. When utilizing the TV sensor, the pilot may view a picture-in-picture presentation of TV video overlaid on the wider FLIR field-of-view to improve situational awareness of the area beyond the TV sensor field-of-view.

Variable Zoom

The sensor video from the FLIR and TV cameras may be enlarged using a variable zoom function. The variable zoom allows the sensor video to be digitally enlarged between 1x to 4x the original size. The zoom does not provide increased resolution of the sensor video but can facilitate better aiming precision of the laser or IR pointer at longer ranges, or to increase separation between multiple targets detected or tracked within a small area.

Extended Range (XR) Zoom

An Extended Range (XR) zoom function provides a 3x digital zoom of the FLIR and TV cameras. Unlike the variable zoom, which simply enlarges the sensor video, the XR zoom uses video processing algorithms to enhance the enlarged video for increased resolution and clarity. However, the XR function is fixed to a 3x zoom setting, requires the ATP sensors to be tracking a fixed location to provide stabilized video for processing, and the processing itself takes several moments after image stabilization before the enhancement can be seen.

Multi-Target (MT) Tracking

The MT tracking mode facilitates the tracking of multiple targets within the selected sensor's optical field-of-view, to include stationary ground vehicles, moving ground vehicles, and aircraft. MT uses digital tracking of objects defined within the sensor video and is capable of maintaining an optical track of 10 separate ground targets or 50 separate airborne targets, but only if the targets remain within the optical field-of-view of the sensor.

Targets may be manually added to, or deleted from, the target list by the pilot, which are maintained as long as they remain within the sensor's optical field-of-view without obstruction. Any target may be selected by the pilot, after which the ATP sensor line-of-sight may be commanded to automatically slew to the selected target location.

(See Air-to-Ground (A-G) Mode and Air-to-Air (A-A) Mode for more information regarding Multi-Target tracking.)

Dual-mode Laser Designator/Ranger

The laser uses focused light energy to precisely measure range to target locations and employs pilot-selectable pulsed repetition frequencies (PRF) to designate targets for laser-guided munitions, such as the Paveway-series guided bombs. In addition to providing terminal guidance for laser-guided munitions, the laser also provides ranging data for ballistic computations of unguided munitions or refining the target location prior to releasing inertially-aided munitions such as Joint Direct Attack Munition (JDAM), Joint Stand-Off Weapon (JSOW), or Wind-Corrected Munitions Dispenser (WCMD).

When employed in A-G mode, the laser may be switched between Combat mode for weapon designation and ranging, or an "eye-safe" Training mode for ranging only. In A-A mode, the laser is limited to the Training mode.

(See the LASR DED page for more information regarding setting the laser designator/ranger code.)

NOTE: Laser returns from vehicles, structures, or terrain are limited to a maximum range of 8.0 NM (14.8 km) in DCS: F-16C Viper.

Laser Spot Tracker (LST)

The LST may be employed to detect other laser designations within a tactical environment when using known PRF codes. Like the laser designator/ranger, the specific PRF code for which the LST will scan is pilot-selectable from the cockpit at any time during the mission, and may be used as an efficient method for handing over target locations to the F-16C from ground-based designators or other aircraft, such as the Joint Terminal Attack Controllers (JTACs), Forward Air Controllers (FACs), or Forward Air Controller-Airborne (FAC-A) aircrews.

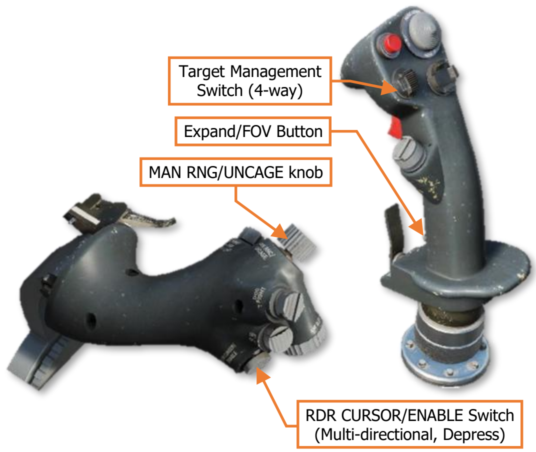
(See Laser Spot Track and LASR DED page for more information regarding setting the LST code.)

IR Pointer (PTR)

The infrared (IR) pointer uses a tightly focused beam of light that continuously emits in the near-infrared spectrum to aid in visual recognition of targets for any aircrews or ground personnel that are wearing night vision goggles. The IR pointer is coincident with the laser along the sensor turret's line-of-sight, allowing the pilot to rapidly switch between designating a target with the laser or visually marking the target with the IR pointer.

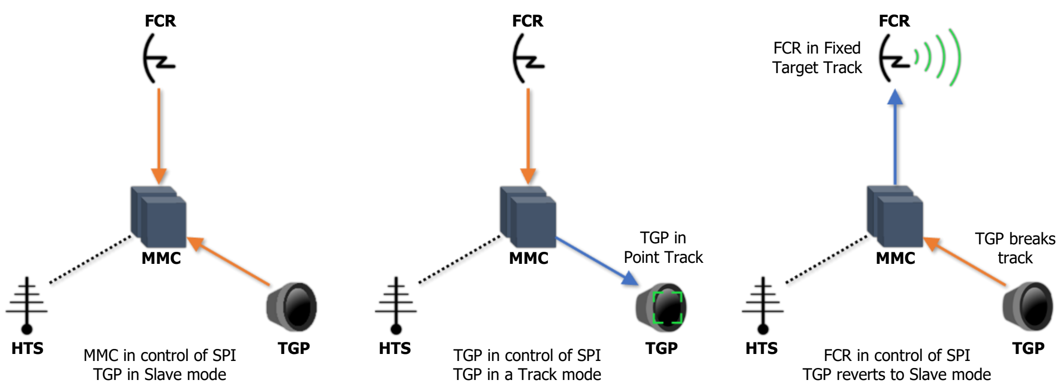
Slave, Slew, and Tracking Controls

The AAQ-33 Advanced Targeting Pod, otherwise referred to as simply the TGP in the F-16C avionics lexicon when installed, is integrated with the cockpit Hands-On Controls. The pod's functions are primarily controlled using the Target Management Switch (TMS) and the Expand/Field-Of-View button on the Side Stick Controller (SSC), and the pod's sensor turret is steered using the RDR CURSOR/ENABLE switch on the throttle grip.



When installed, the TGP is integrated into the F-16 avionics and cockpit interface as an additional sensor. When operating in their respective air-to-ground modes, each of the F-16's sensors are focused onto a single geographic location in the battlespace known as the System-Point-of-Interest (SPI). The SPI may be controlled by the Modular Mission Computer (MMC) or any of the aircraft sensors themselves.

When the MMC is in control of the SPI, each of the aircraft sensors will remain slaved to the SPI. If the TGP is in Slave mode, which is signified by the large Line-Of-Sight Crosshairs on the TGP MFD format, the TGP sensor line-of-sight is slaved to the 3-dimensional location of the SPI. If the SPI moves, the TGP line-of-sight will automatically slew to remain aligned with the SPI. The exception to this logic is if the TGP's Laser Spot Track (LST) mode is enabled, in which the TGP is "decoupled" from the SPI while searching for an offboard laser designation.



F-16C Sensor Slave & Tracking Logic

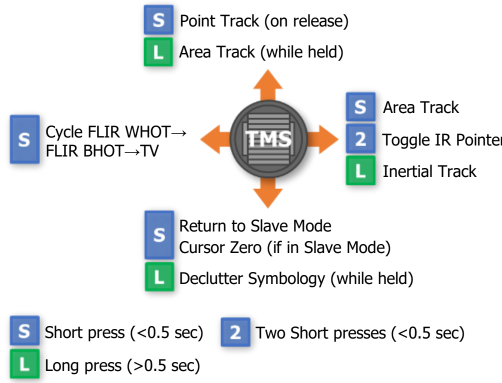
If the TGP is in Air-to-Ground (A-G) mode and enters a tracking state, the TGP itself will determine the position of the SPI. If the FCR is in GM, GMT, or SEA mode and was tracking a surface target or location, the FCR will break track and the A-G Acquisition Cursor on the FCR MFD format will slave to the TGP-controlled SPI. If an HTS-detected radar threat was designated on the HAD MFD format, the designation will be dropped.

Accordingly, if the FCR is in GM, GMT, or SEA mode and enters a tracking state, or a radar threat is designated on the HAD MFD format, the TGP will break track and will slave to the FCR- or HTS-controlled SPI.

It is worth noting that the singular SPI logic only applies when the F-16 sensors are operating in their respective air-to-ground modes. If the FCR and/or TGP are operating in air-to-air modes, they may commanded to track an airborne target independently of the other sensors, to include simultaneously tracking two separate aircraft.

Track Modes

The AAQ-33 may be commanded into one of three track modes using the Target Management Switch (TMS) while the TGP is set as Sensor-Of-Interest (SOI): Area track, Point track, or Inertial track. The current track mode is displayed on the TGP MFD format, which will be accompanied by the small Line-Of-Sight Crosshairs.



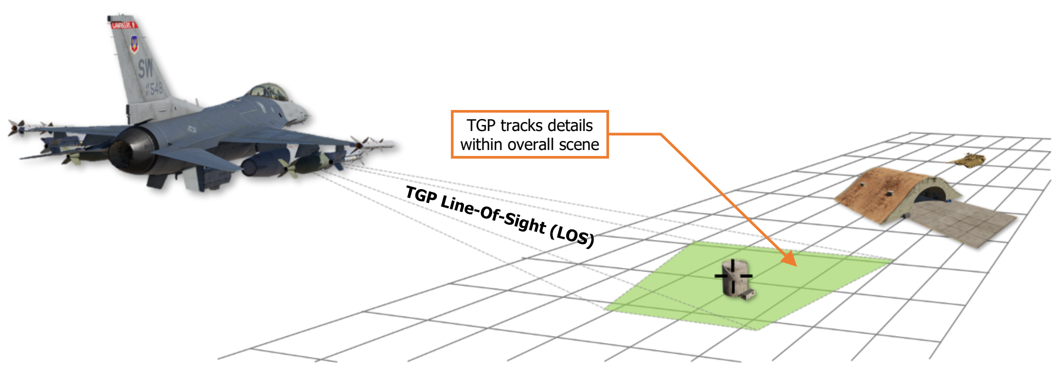
When the TGP enters one of these track modes, the optical and/or inertial sensors within the AAQ-33 itself sends discrete slew commands to the sensor turret to maintain the TGP line-of-sight on the intended target. The pilot may still apply inputs to the RDR CURSOR/ENABLE switch to slew the TGP line-of-sight, which will override the tracking commands. When the pilot releases pressure on the RDR CURSOR/ENABLE switch, the TGP will attempt to re-establish a track on the target within the Line-Of-Sight Crosshairs.

The TGP may be manually commanded back into Slave mode, which will return SPI control to the MMC, by pressing TMS Aft for less than 0.5 seconds while the TGP is SOI. If TMS Aft is pressed and the TGP is already in Slave mode, the MMC will be commanded to zeroize the cursor slews. (See Cursor Zero for more information.)

Area Track

Pressing TMS Right for less than 0.5 seconds will command the TGP into Area track. In Area track mode, the TGP performs image correlation to track details within the overall scene captured in the tracking sensor's video. Area track mode is effective at tracking large structures and stationary targets; or maintaining the TGP sensor at a fixed location on the surface with minimal sensor drift.

If the TGP is in Area track and the pilot applies an input to the RDR CURSOR/ENABLE switch, the TGP line-of-sight will cease tracking the video scene details and slew as commanded, but will remain in Area track mode. When the slewing ceases, the TGP will begin tracking the scene details captured in the selected sensor's video.



Area Track Mode

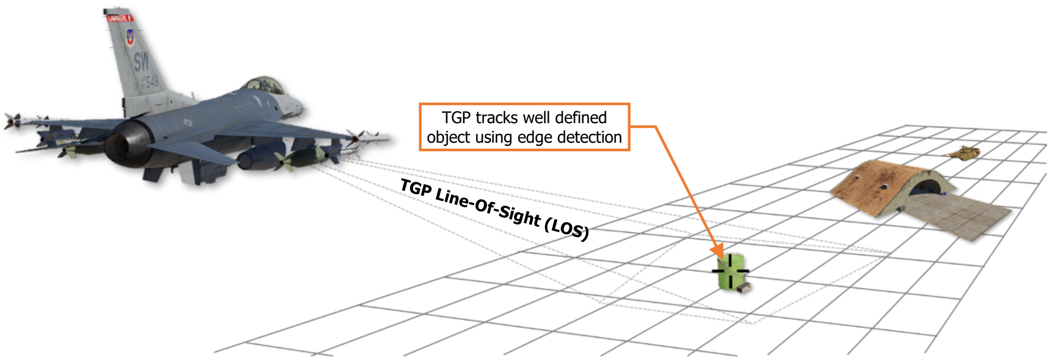
If Multi-Target (MT) track mode is enabled at OSB 18, Area track is entered by pressing TMS Right for *greater* than 0.5 seconds. Area track is not available if the TGP is in A-A mode.

NOTE: When MT track mode is disabled and a single, short press of TMS Right is used to command the TGP into Area track mode, there will be a slight delay before the TGP actually enters Area track. Since the IR pointer is enabled using two short presses of TMS Right within 0.5 seconds, the MMC will wait for a second press of TMS Right before it actually commands the TGP into Area track.

Point Track

Pressing TMS Forward and then releasing will command the TGP into Point track. In Point track mode, the TGP attempts to track a well-defined object within the center of the sensor video using edge detection algorithms. Point track mode is effective at tracking stationary or moving vehicles, well-defined surface objects, or aircraft in flight when the TGP is in A-A mode.

If MT track mode is disabled, the TGP is in Point track, and the pilot applies an input to the RDR CURSOR/ENABLE switch, the TGP will cease tracking the current target and slew as commanded, but will remain in Point track mode. When the slewing ceases, the TGP will attempt to enter Point track if a well-defined object is within the center of the sensor video. If Point track cannot be established, the TGP will switch to Area track.

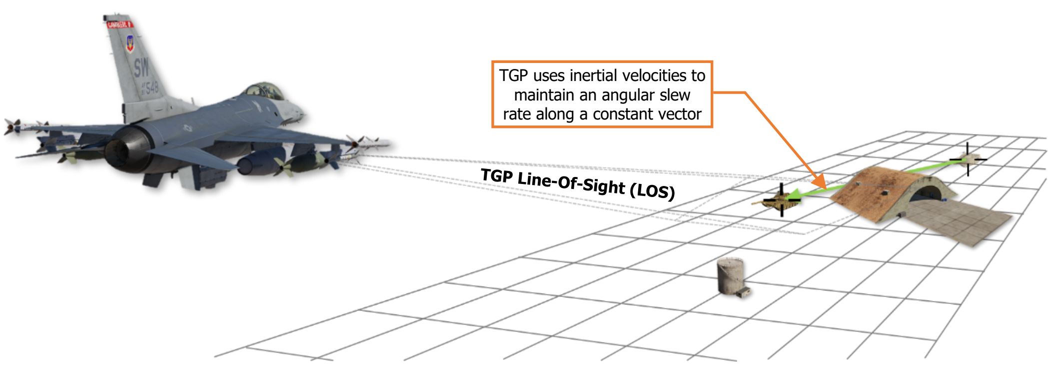


Point Track Mode

If the pilot presses and holds TMS in Forward position, the TGP will enter and remain in Area track. When TMS Forward is released, the TGP will attempt to enter Point track. If Point track cannot be established on any well-defined objects within the Line-Of-Sight Crosshairs, the TGP will remain in Area track.

Inertial Track

Pressing TMS Right for greater than 0.5 seconds will command the TGP into Inertial track. In Inertial track mode, the TGP will maintain the current angular slew rate along a constant vector, independent of the aircraft velocity or any visual details captured within the sensor video. Switching from Point or Area track to Inertial track allows the pilot to maintain the TGP sensor on a target if a direct line-of-sight to that target is obscured in any way, due to terrain, structures, or if the aircraft is maneuvered in a manner that masks the TGP.



Inertial Track Mode

Inertial track is not available if Multi-Target (MT) Track mode is enabled at OSB 18 or if the TGP is in A-A mode.

Sensor Management

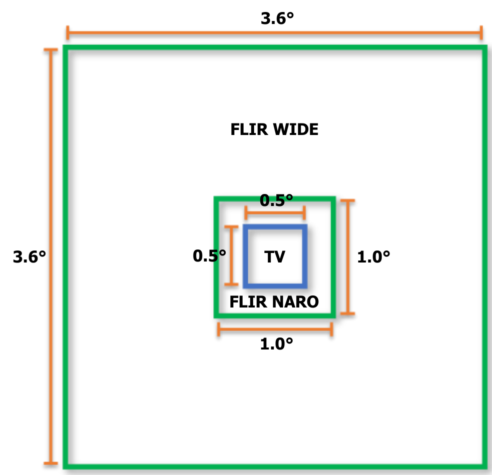
The optical cameras of the AAQ-33 allow the pilot to detect and identify targets from long distances using a combination of optical magnification and electronic enhancements. The FLIR camera provides two optical fields-of-view for target detection and tracking in either White-Hot or Black-Hot polarity. The TV camera provides a single, highly-magnified field-of-view for long-range tracking and identification.

The pilot may select a different optical camera by setting the TGP as the Sensor-Of-Interest (SOI) using the Display Management Switch (DMS) and then pressing the Target Management Switch (TMS) Left on the Side Stick Controller (SSC), which will cycle the video displayed on the TGP MFD format between FLIR White-Hot, FLIR Black-Hot, and TV. If desired, the pilot may disable the TV camera on the TGP Control page to configure the AAQ-33 for FLIR-only operation during hours of darkness, which will transition the TMS Left command into a FLIR polarity toggle between White-Hot and Black-Hot.

If FLIR is selected in either White-Hot (WHOT) or Black-Hot (BHOT), the field-of-view may be toggled between Wide and Narrow FOV by pressing the Expand/FOV button on the SSC while the TGP is SOI.

If TV is selected, the field-of-view may be cycled in the same manner, which will cycle between FLIR in Wide FOV, FLIR in Narrow FOV with a TV Picture-In-Picture overlay, and the TV FOV in a full-screen format.

When the TV PIP field-of-view is selected as shown in the image below, the TV video is overlaid onto the FLIR video within the center 50% of the display area to improve the pilot's situational awareness of the surroundings beyond the TV sensor's highly magnified but very narrow field-of-view. By cycling from FLIR Wide FOV to the TV PIP and finally to the TV in full-screen, the pilot may use the FLIR for wide area detection of targets and then incrementally transition down to the more magnified TV camera video for viewing targets in greater detail.



AAQ-33 FLIR/TV Optical Fields-Of-View

Decluttered TV Picture-In-Picture (PIP)

To view a target in its entirety without obstructions, the MFD symbology in the center area of the TGP video may be momentarily decluttered, as shown on the left, by pressing and holding TMS Aft while the TGP is SOI.

If necessary, the sensor video on the MFD may be enlarged up to 4x times the original size by rotating the MAN RNG-UNCAGE knob on the throttle grip. This variable zoom function does not increase the resolution of the video but may be used to facilitate better aiming precision of the laser or IR pointer at longer ranges, or to increase separation between multiple targets that are detected or tracked within a small area.

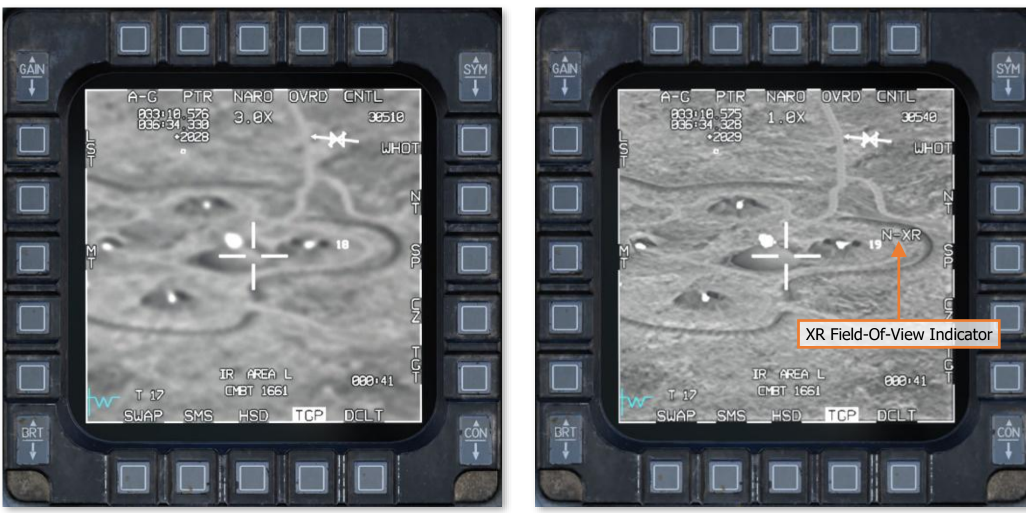
If the sensors are stabilized and tracking a fixed object or location, the pilot may enable Extended Range (XR) processing to digitally enhance the sensor video by rapidly pressing the Expand/FOV button twice within 0.5 seconds while the TGP is SOI. The XR zoom uses video processing algorithms to enhance the video for increased resolution and clarity, but is limited to a fixed 3x zoom setting, and cannot be used with the variable zoom.

Extended Range (XR) Processing

The XR zoom function of the AAQ-33 allows the pilot to observe and identify targets at greater ranges and altitudes than previous generations of targeting pods. The XR video processing algorithms digitally enhance the resolution of the video displayed on the TGP MFD format but require a stabilized video scene to function properly.

When XR zoom is enabled, the sensor video will be digitally enlarged three times greater than normal and the XR Field-Of-View Indicator will be displayed along the right side of the MFD. However, if the TGP is not in Area, Point, or Inertial track modes, XR processing will not actually occur. Once stabilized in a track mode, several seconds are required for the XR processing to finish before the enhanced video is displayed on the MFD. During this time, the XR Field-Of-View indicator will flash to indicate XR processing is occurring but has not finished. Once the XR processing has finished, the XR Field-Of-View indicator will stop flashing and the Line-Of-Sight Crosshairs, Point Track Box, and Meterstick Length are removed unless the ATP laser designator/ranger is firing.

If the pilot uses the RDR CURSOR/ENABLE switch to slew the TGP line-of-sight, the XR processing will be disabled until the slewing stops and the sensor is re-established in a track mode. Once the video scene is stabilized, the XR Field-Of-View indicator will flash while the XR processing resumes.



3.0x Variable Zoom (Left) & XR Zoom (Right)

The XR zoom function may be enabled using OSB 3 on the TGP MFD format or the Expand/FOV button on the Side Stick Controller (SSC).

- If OSB 3 is pressed on the TGP MFD format to change the field-of-view (FOV) of the selected sensor, **XR** zoom will be included as an additional FOV setting as the selected sensor is advanced through each FOV.
  - FLIR sensor: WIDE → **W-XR** → NARO → **N-XR** → WIDE.
  - TV sensor: TV Wide → TV PIP → TV → **TVXR** → TV Wide.
- If the Expand/FOV button is pressed and released once within 0.5 seconds while the TGP is SOI, the optical field-of-view of the selected sensor will be cycled independently of the XR zoom.
- If the Expand/FOV button is rapidly pressed twice within 0.5 seconds while the TGP is SOI, XR zoom will be toggled while retaining the current FLIR optical field-of-view; or will toggle between the current TV field-of-view (TV Wide, TV PIP, or full-screen TV) and full-screen TV with XR zoom enabled (TVXR).

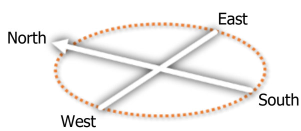
NOTE: Variable zoom using the MANRNG/UNCAGE knob is disabled while XR zoom is enabled. If XR zoom is enabled while a variable zoom setting was applied, the variable zoom will be set to 1.0x until XR zoom is disabled.

Sensor Orientation

When viewing the AAQ-33 sensor video on the TGP MFD format, the video signal received from the optical sensors is automatically roll-stabilized so that it appears level with the inertial horizon. In addition, the North Pointing Cue and Situational Awareness Indicator symbology assist the pilot in understanding the sensor turret's orientation in relation to the aircraft fuselage and the camera's geographic perspective in relation to the battlespace.

Both symbology elements can be considered as overlaid onto a geometric plane, with the plane of the North Pointing Cue aligned with the surface of the Earth and the plane of the Situational Awareness Indicator aligned with the fuselage of the aircraft.

As the camera orientation moves in relation to the surface, the camera's perspective in relation to the cardinal directions is represented by the North Pointing Cue.



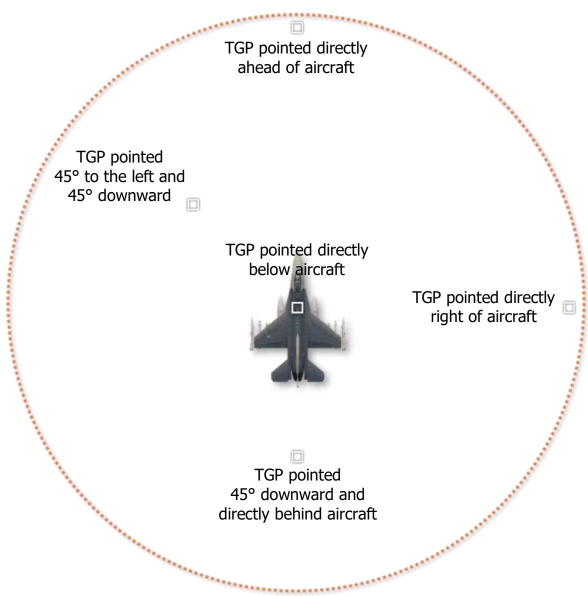
North Pointing Cue

The plane of the North Pointing Cue is akin to a compass laid flat across the Earth's surface and will appear to flatten as the camera's elevation is slewed toward the horizon.

As the sensor turret moves in relation to the aircraft fuselage, the turret's position in azimuth and elevation is represented by the Situational Awareness Indicator as it moves about the Line-Of-Sight Crosshairs as viewed from a top-down orientation, with the aircraft in the center of the crosshairs themselves.

If the indicator is at the top of the MFD, the turret is pointed in front of the aircraft; and if it is at the bottom, the turret is pointed behind the aircraft. If the indicator is along the edge of the MFD, the turret is pointed directly in front, behind, or to either side of the aircraft, in the same horizontal plane as the aircraft fuselage. If the indicator is in the center, the turret is pointed at a 90° angle directly away from the underside of the aircraft fuselage.

Note that the Situational Awareness Indicator does not display whether the sensor turret is pointed above or below the horizontal plane of the aircraft fuselage. In some situations in which the turret is pointed upward, the indicator may seem to indicate the sensor is pointed below the plane of the fuselage.



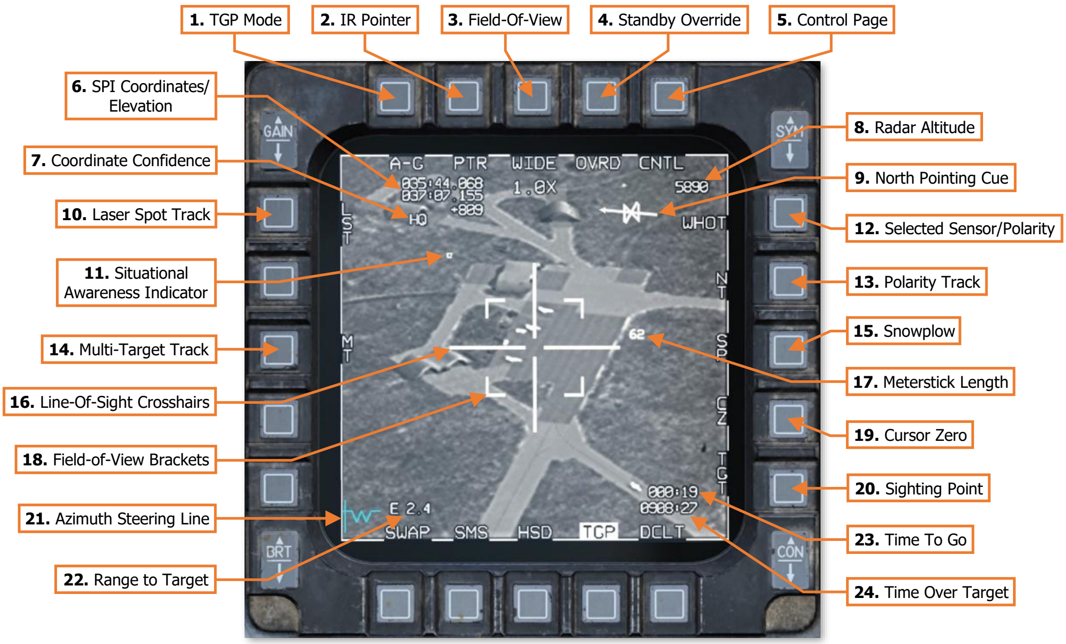
Situational Awareness Indicator

Targeting Pod (TGP) MFD Format

The TGP MFD format is the primary interface with the targeting pod and presents targeting symbology and magnified video from the sensor aperture's optical cameras.

When employing the targeting pod in Air-to-Ground (A-G) mode, the TGP MFD format will display coordinate data of the System Point-of-Interest (SPI), a north-pointing arrow to assist with orientation of battlefield, and options for employing the pod's IR pointer or laser spot tracker.

When employing the targeting pod in Air-to-Air (A-A) mode, the TGP MFD format may be used for passively detecting and tracking other aircraft, or performing visual identification of unknown aircraft at distances beyond the range of normal eyesight. However, the laser spot tracker and IR pointer are disabled in A-A mode, and the laser designator/ranger is limited to TRNG mode only and cannot be switched to CMBT mode. (See LASR DED page for more information.)



1. **TGP Mode.** Displays the TGP Mode Menu page. The current TGP mode is displayed below OSB 1.

2. **IR Pointer (PTR).** Enables/disables the IR pointer. When the IR pointer is enabled, the text below OSB 2 will be highlighted in white. (See IR Pointer for more information.)

3. **Field-Of-View.** Cycles the optical and/or Extended Range (XR) fields-of-view of the selected sensor. The current field-of-view is displayed below OSB 3. (See Extended Range Processing for more information.)

   When OSB 3 is pressed and FLIR is the selected sensor, the OSB selection will advance to the next optical or XR field-of-view in a cyclic manner: WIDE → W-XR → NARO → N-XR → WIDE.

   - **WIDE.** Wide field-of-view of the FLIR camera is displayed.
     - If XR processing is enabled, "W-XR" will be displayed on the right side of the MFD.
   - **NARO.** Narrow field-of-view of the FLIR camera is displayed.
     - If XR processing is enabled, "N-XR" will be displayed on the right side of the MFD.

When OSB 3 is pressed and TV is the selected sensor, the OSB selection will advance to the next optical or XR field-of-view in a cyclic manner: TV Wide → TV PIP → TV → TVXR → TV Wide.

- **TV.** The singular field-of-view of the TV camera is displayed.
  - When set to "TV Wide", the FLIR camera in Wide field-of-view is displayed.
  - When set to "TV PIP", the FLIR camera in Narrow field-of-view is displayed with the TV camera video overlaid on top of the FLIR video as a Picture-In-Picture (PIP) format.
  - When set to "TV", the full-screen TV camera video is displayed.
  - If XR processing is enabled, the full-screen TV camera video is displayed with "TVXR" displayed on the right side of the MFD.

The Expand/FOV button on the Side Stick Controller (SSC) may also be pressed to cycle the TGP optical field-of-view or toggle the Extended Range (XR) field-of-view when the TGP is SOI.

NOTE: If the TV sensor has been disabled on the TGP Control page, the TV fields-of-view will not be available for selection using OSB 3 or the Expand/FOV button on the SSC.

4. **Standby Override (OVRD).** Sets the TGP to Standby mode. When Standby Override is enabled, the text below OSB 4 will be highlighted in white. When Standby Override is disabled, the TGP returns to the last TGP mode that it was set to within the current MMC master mode prior to Standby Override being enabled.

5. **Control Page (CNTL).** Toggles the MFD between the TGP base page and the TGP Control page.

6. **SPI Coordinates/Elevation.** Displays the 3-dimensional position of the System Point-of-Interest (SPI) within the center of the crosshairs. The first and second rows of data are the latitude and longitude coordinates, respectively, in Degrees-Minutes-Decimal format (DDD° MM.MMM'). The third row of data is the elevation above mean sea level (MSL) in feet.

   The SPI coordinates and elevation displayed on the TGP MFD format are normally generated by the ownship Modular Mission Computer (MMC). However, if the selected weapon type is an inertially-aided munition such as JDAM, JSOW, or WCMD, the displayed coordinates and elevation are generated by the AAQ-33 itself.

   The SPI coordinates/elevation may be removed from the TGP MFD format on the TGP Control page.

7. **Coordinate Confidence.** Displays the estimated Target Location Error (TLE) of the SPI coordinates and elevation displayed on the TGP MFD format.

   - **HQ.** The confidence of the SPI coordinates/elevation is high quality. The estimated circular error probability is ≤9 meters.
   - **MQ.** The confidence of the SPI coordinates/elevation is medium quality. The estimated circular error probability is >9 meters but ≤15 meters.
   - **LQ.** The confidence of the SPI coordinates/elevation is low quality. The estimated circular error probability is >15 meters but <30 meters.
   - **(Blank).** The confidence of the SPI coordinates/elevation is poor quality. The estimated circular error probability is ≥30 meters.

   The coordinate confidence may be removed from the TGP MFD format on the TGP Control page.

8. **Radar Altitude.** Displays the ownship's altitude above ground level (AGL) as indicated by the Combined Altitude Radar Altimeter (CARA).

9. **North Pointing Cue.** Indicates the position of the TGP sensor aperture in relation to the cardinal directions (north, east, south, west), with the arrow of the symbology corresponding to north.

   The north pointing cue may be removed from the TGP MFD format on the TGP Control page.

10. **Laser Spot Track (LST).** Enables/disables laser spot track mode. When LST is enabled, the text to the right of OSB 20 will be highlighted in white. (See Laser Spot Track for more information.)

11. **Situation Awareness Indicator.** Indicates the position of the TGP sensor aperture in relation to the aircraft fuselage, with the top of the MFD representing the nose of the aircraft, the bottom of the MFD representing the tail of the aircraft, and the center of the MFD representing directly below the aircraft.

12. **Selected Sensor/Polarity.** Indicates the selected TGP sensor and/or FLIR polarity currently displayed on the TGP MFD format.

    When OSB 6 is pressed, the OSB selection will advance the selected sensor/polarity in a cyclic manner: WHOT → BHOT → TV → WHOT.

    - **WHOT.** The FLIR camera is the selected sensor and is set to "White-Hot" polarity. Hot objects and surfaces will appear bright white and cold objects will appear dark black.
    - **BHOT.** The FLIR camera is the selected sensor and is set to "Black-Hot" polarity. Hot objects and surfaces will appear dark black and cold objects will appear bright white.
    - **TV.** The TV camera is the selected sensor.

    The Target Management Switch (TMS) on the Side Stick Controller (SSC) may also be pressed left while the TGP is SOI to cycle the selected sensor and polarity.

    NOTE: If the TV sensor has been disabled on the TGP Control page, only the FLIR camera will be available and pressing OSB 6 or TMS Left on the SSC will toggle the polarity between WHOT and BHOT.

13. **Polarity Track.** Cycles the selected tracking polarity when the TGP is in Point track mode. (N/I)

    When OSB 7 is pressed, the OSB selection will advance the polarity track in a cyclic manner: NT → WT → BT → NT.

    - **NT.** Tracking polarity is set to Neutral Track. The selected sensor will acquire and track white or black objects captured within the Line-Of-Sight Crosshairs.
    - **WT.** Tracking polarity is set to White Track. The selected sensor will acquire and track white objects captured within the Line-Of-Sight Crosshairs.
    - **BT.** Tracking polarity is set to Black Track. The selected sensor will acquire and track black objects captured within the Line-Of-Sight Crosshairs.

14. **Multi-Target Track (MT).** Enables/disables Multi-Target track mode. When MT is enabled, the text adjacent to OSB 8 will be highlighted in white. (See Multi-Target Track Mode for more information.)

15. **Snowplow (SP).** Enables/disables Snowplow sighting mode. When Snowplow is enabled, the text adjacent to OSB 8 will be highlighted in white. (See Snowplow Sighting Mode for more information.)

16. **Line-Of-Sight Crosshairs.** Indicates the TGP sensor line-of-sight (LOS), which is used as an aiming crosshair for the System Point-of-Interest (SPI), the laser designator/ranger, and the IR pointer. The size of the crosshairs within the MFD display area indicates the current TGP control mode.

    - **Large Crosshairs.** The TGP is in Slave mode.
    - **Small Crosshairs.** The TGP is in Area, Point, or Inertial track modes.
    - **Full-Screen Crosshairs.** The TGP is in Laser Spot Track mode.

17. **Meterstick Length.** Displays the relative ground distance covered by the left or right crosshair lines, based on the estimated range to target and the selected sensor, field-of-view, and zoom settings.

    The meterstick length may be removed from the TGP MFD format on the TGP Control page.

18. **Field-Of-View Brackets.** When WIDE FOV is selected, indicates the relative area that can be seen by the selected sensor if NARO field-of-view is selected. If NARO FOV is selected, the brackets are removed.

19. **Cursor Zero (CZ).** Zeroizes cursor slews. (See Cursor Zero for more information.)

20. Sighting Point. Cycles the selected sighting point. (See Sighting Points and Cursor Corrections for more information.)

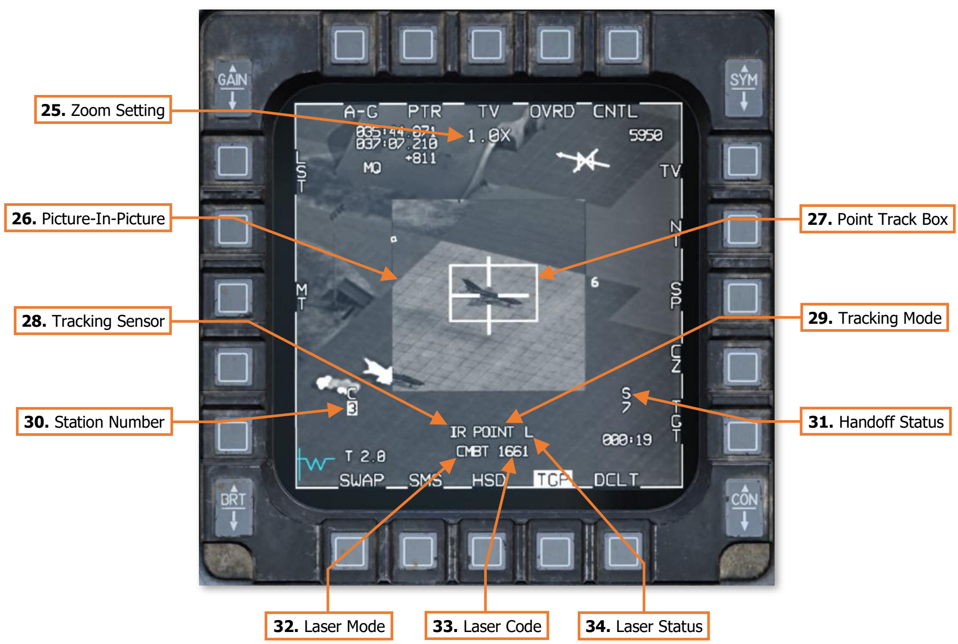
21. Azimuth Steering Line. Displays the relative alignment of the aircraft heading with the bearing to the current steerpoint, System Point-of-Interest (SPI), or weapon release solution. If the line is to the left or right of the watermark, the pilot must turn left or right respectively toward the vertical line to align the aircraft with the desired course or target. If the line is aligned through the center of the watermark, the aircraft is on course toward the selected steerpoint, SPI, or weapon release solution.

22. Range To Target. Displays the slant range to the target or surface location within the Line-Of-Sight Crosshairs, in nautical miles (NM).

- **E.** An estimated low-confidence range is displayed, based on the aircraft position, radar altimeter data, and the TGP sensor orientation in azimuth and elevation.
- **T.** An estimated high-confidence range is displayed, based on the aircraft position, radar altimeter data, the TGP sensor orientation in azimuth and elevation, and the TGP tracking of a target, surface location, or the selected steerpoint location with zero cursor slews.
- **L.** A precise range is displayed, based on measurements provided by the laser designator/ranger.

23. Time To Go. When the master mode is set to Navigation (NAV), displays the time that is estimated to elapse before arriving at the selected steerpoint, based on the current ground speed. When the master mode is set to Air-to-Ground (A-G), displays the time remaining before pull-up or weapon release, based on the current ground speed, or the time remaining before weapon impact.

24. Time Over Target. When the master mode is set to Air-to-Ground (A-G) and the selected weapon type is a laser-guided bomb (GBU-10, GBU-12, or GBU-24), displays the estimated time (HHMM:SS format) at weapon release, based on the current ground speed, or the estimated time at weapon impact.



25. Zoom Setting. Indicates the variable zoom setting, between the minimum zoom setting of 1.0X, or no zoom applied, and the maximum zoom setting of 4.0X, or 4 times the original video size.

26. **Picture-In-Picture.** The optical FOV of the TV camera is overlaid onto the narrow FOV of the FLIR camera, which is twice the width of TV camera's singular, but highly-magnified, field-of-view. This allows the pilot to utilize the TV camera to view the area in greater detail while using the FLIR to retain situational awareness of the immediate surroundings beyond the TV's field-of-view.

27. **Point Track Box.** Indicates the target being optically tracked when the TGP is in Point track mode.

28. **Tracking Sensor.** Displays the sensor that is optically tracking the target when the TGP is in Point or Area track modes. (See Track Modes for more information.)

    - **IR.** The Forward-Looking Infrared (FLIR) camera is the tracking sensor.
    - **TV.** The Television (TV) camera is the tracking sensor.

    NOTE: Toggling the selected sensor between FLIR and TV will not change the tracking sensor. The tracking sensor will maintain optical track on the current target or location until a new target object or location is tracked or the TGP switches to a different tracking mode.

29. **Tracking Mode.** Displays the current TGP tracking mode. If the TGP is in Slave mode, this data field will be blank.

    - **AREA.** The TGP is in Area track mode.
    - **POINT.** The TGP is in Point track mode.
    - **INR.** The TGP is in Inertial track mode.

30. **Station Number.** Indicates the wing stations with one or more AGM-65 missiles loaded if AGM-65 is the selected weapon type. The currently selected wing station is highlighted in white. If AGM-65 is not the selected weapon type or all AGM-65 missiles have been expended, the station numbers are not displayed. (See the AGM-65 Maverick section in the Air-to-Ground Weapons Employment chapter for more information.)

31. **Handoff Status.** Indicates the target handoff status from the AAQ-33 Missile Boresight Correlator (MBC) to the corresponding AGM-65D/G IR seeker. If AGM-65D or AGM-65G is not the selected weapon type, the MBC is not enabled. (See the AGM-65 Maverick section in the Air-to-Ground Weapons Employment chapter for more information.)

32. **Laser Mode.** Displays the selected laser mode when the LASER ARM switch on the MISC panel is set to the ARM position. The displayed laser mode will flash for up to 8 seconds while transitioning between modes. When the laser mode stops flashing, the transition is complete.

    - **CMBT.** Combat mode is selected, which permits ranging of target locations, designation of targets for detection by laser spot tracking systems, and terminal guidance for laser-guided munitions.
    - **TRNG.** Training mode is selected, which permits ranging of target locations in a non-hazardous "eye-safe" mode but cannot designate targets for detection by laser spot tracking systems or provide terminal guidance for laser-guided munitions.

33. **Laser Code.** Displays the PRF code that will be emitted from the targeting pod's laser designator/ranger when set to CMBT mode. When the laser designator/ranger is set to TRNG mode, this data field will be blanked. The laser code may be modified on the LASR DED page.

34. **Laser Status.** Indicates the laser designator/ranger is armed and may be fired. When the laser is firing, the corresponding indicator will flash.

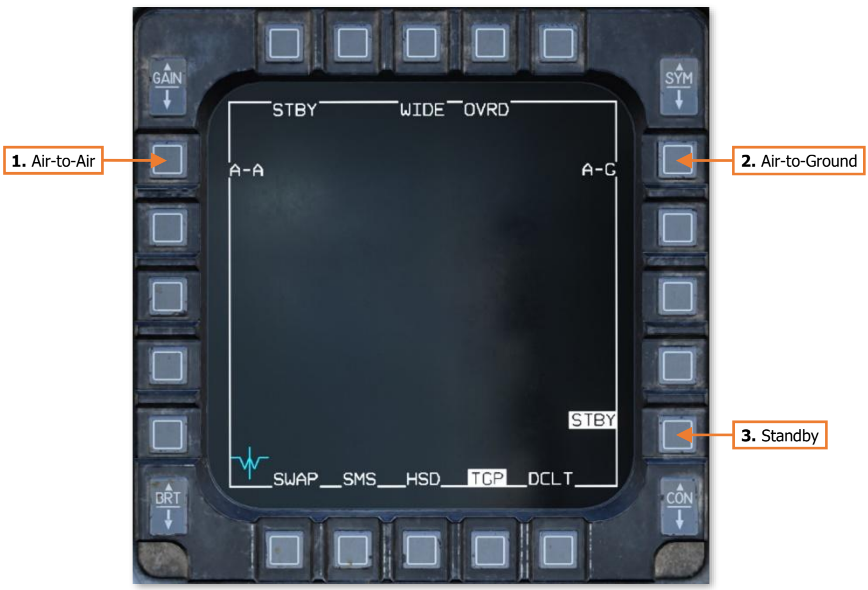
    - **L.** The laser designator/ranger is ready to fire in CMBT mode.
    - **T.** The laser designator/ranger is ready to fire in TRNG mode.

TGP Mode Menu Page

The AAQ-33 may be employed in an Air-to-Ground (A-G) mode or Air-to-Air (A-A) mode; or set to a Standby (STBY) mode in which the sensors are stowed and inactive. The TGP may be set to any of these three modes in each of the Modular Mission Computer (MMC) master modes. When the pilot changes from one master mode to another, the MMC will automatically set the TGP mode to that which was last selected in the corresponding master mode. The current TGP mode is displayed in the top left corner of the TGP MFD format below OSB 1.

By default, the TGP will automatically switch to A-G mode when the master mode is set to Navigation (NAV), Air-to-Ground (A-G), or Selective Jettison (JETT); or A-A mode when the master mode is set to Air-to-Air (A-A), Missile Override (MSL), or Dogfight (DGFT). However, the pilot may manually select a different TGP mode for the current master mode by accessing the TGP Mode Menu page.

The TGP Mode Menu page is accessed by pressing OSB 1 on the TGP MFD format.



1. **Air-to-Air (A-A).** Sets the TGP mode to Air-to-Air and exits the TGP Mode Menu page.
2. **Air-to-Ground (A-G).** Sets the TGP mode to Air-To-Ground and exits the TGP Mode Menu page.
3. **Standby (STBY).** Sets the TGP mode to Standby and exits the TGP Mode Menu page.

TGP Control (CNTL) Page

The TGP Control page is accessed by pressing OSB 5 on the base page of the TGP MFD format. The Control page is used to configure miscellaneous targeting pod settings to suit the tactical situation or individual preferences of the pilot; manually adjust the thermal gain, sensitivity level, and focus of the FLIR camera; or to perform a calibration of the FLIR camera to improve video quality.

1. **FLIR Gain.** Indicates the current gain setting of the FLIR camera, which may be modified using the GAIN rocker switch on the top left corner of the MFD itself if the gain control mode is set to MGC (Manual Gain Control) at OSB 18. If the gain control mode is set to AGC (Automatic Gain Control), the FLIR gain setting is not displayed.

2. **Grayscale.** Enables/disables the grayscale pattern. When grayscale is enabled, a grayscale pattern is displayed along the bottom of the MFD. The grayscale is used to set the appropriate brightness and contrast levels for the video output of the MFD TGP format.

3. **North Pointer/Meterstick (N/M).** Enables/disables the display of the north pointing cue and the SPI coordinates/elevation, coordinate confidence, and meterstick length data fields on the TGP MFD format. When the enabled, the text to the right of OSB 19 will be highlighted in white.

4. **FLIR Gain Control Mode.** Toggles the gain control mode of the FLIR camera.

   - **AGC.** Gain control is set to Automatic. The FLIR camera thermal gain and sensitivity level will be automatically balanced by the TGP electronics based on the measured highest and lowest thermal emissivity levels within the FLIR camera's field-of-view.

   - **MGC.** Gain control is set to Manual. The FLIR camera thermal gain and sensitivity level may be manually adjusted by the pilot.

5. **FLIR Level.** Adjusts the FLIR camera sensitivity level, with the current setting displayed between the arrow buttons if the gain control mode is set to MGC (Manual Gain Control) at OSB 18. If the gain control mode is set to AGC (Automatic Gain Control), the FLIR level adjustment arrows and level setting are not displayed.

6. **Focus Setting.** Indicates the current focus setting (0-99) of the FLIR camera if Focus Control is enabled at OSB 7. If Focus Control is disabled, the focus setting is not displayed.

7. **TV Sensor.** Enables/disables the TV camera. When disabled, only the FLIR camera will be available and pressing OSB 6 or TMS Left on the Side Stick Controller (SSC) will toggle the FLIR polarity between WHOT and BHOT.

8. **Focus Control.** Enables/disables focus control of the FLIR camera. When enabled, the text to the left of OSB 7 will be highlighted in white, slew control will be disabled, and the focus setting may be increased or decreased by pressing the RDR CURSOR/ENABLE switch forward and aft, respectively.

   If the TGP is in a stabilized tracking mode when focus control is enabled, an automatic focus adjustment may be commanded by pressing the RDR CURSOR/ENABLE switch left or right >0.5 seconds, after which the TGP electronics will adjust the focus setting of the FLIR camera to achieve the sharpest picture.

9. **Video Instrumentation (V/INST).** Displays the position of the TGP sensor aperture in degrees of elevation and azimuth in the top left corner of the MFD TGP format, replacing the SPI Coordinates/Elevation and Coordinate Confidence data fields. This option may only be enabled when the aircraft is weight-on-wheels, to facilitate installation and calibration by maintenance personnel.

10. **FLIR Calibration (FLIR CAL).** Enables/disables calibration of the FLIR camera. When enabled, the text to the left of OSB 9 will be highlighted in white and a FLIR camera calibration will be initiated. The TGP video will blank and "FLIR CAL" will be displayed below the Line-Of-Sight Crosshairs with a sequence of asterisks (*) indicating the calibration is in progress.

    The FLIR calibration process requires 30 seconds to complete, after which the TGP video is displayed and FLIR CAL next to OSB 9 is automatically de-selected. However, the FLIR calibration may be interrupted by manually de-selecting OSB 9 or forcing the TGP to Standby mode by pressing OVRD at OSB 4, which will abort the calibration and revert to the previously stored coefficients.

    NOTE: The quality of the FLIR video may degrade over time, which may be resolved by periodically performing a FLIR calibration during the mission. However, interrupting a FLIR calibration before it can successfully complete may result in a slightly worse video quality.

11. **Automatic Boresight (AUTO BORE).** Enables/disables automatic boresight of the TGP sensors to ensure the FLIR camera, TV camera, laser designator/ranger, laser spot tracker, and IR pointer are properly aligned along a common line-of-sight. When enabled, the text to the left of OSB 10 will be highlighted in white and boresighting will be initiated. The TGP video will blank, BORE will be displayed below OSB 1 to indicate the TGP is in boresight mode, and "AUTO BORE" will be displayed below the Line-Of-Sight Crosshairs with a sequence of asterisks (*) indicating the calibration is in progress. This option may only be enabled when the aircraft is weight-on-wheels, to facilitate installation and calibration by maintenance personnel.

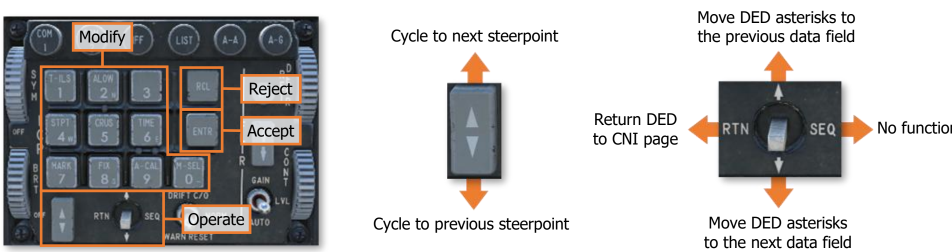
    The boresighting process requires 6 minutes to complete, after which the TGP video is displayed and AUTO BORE next to OSB 10 is automatically de-selected. However, the boresighting process may be interrupted by manually de-selecting OSB 10 or forcing the TGP to Standby mode by pressing OVRD at OSB 4, which will abort the automatic boresight and revert to the previously stored coefficients.

    NOTE: Although the Automatic Boresight process is simulated in DCS: F-16C Viper, this is a procedure normally performed by maintenance personnel after replacement of internal electronic components of the AN/AAQ-33 itself. As such, the operation and function of the AAQ-33 targeting pod will not be adversely affected if Automatic Boresight is not performed in DCS: F-16C Viper.

LASR DED Page

The Laser DED page is accessed by pressing **5/CRUS** on the ICP keypad when the MISC DED page is displayed on the DED. This page is used to configure the targeting pod for laser ranging and designation operations. When autonomously employing laser-guided munitions in which the ownship is providing terminal guidance, the TGP code on this page must match the pre-programmed laser code on the bomb guidance section.

NOTE: The TGP CODE and LST CODE data fields cannot be edited if the targeting pod is powered off or still initializing. When the pod has fully initialized and is in STBY, A-G, or A-A mode, these data fields may be edited.



1. **TGP Designation Code.** Displays the laser PRF code that will be emitted from the targeting pod's laser designator/ranger when set to CMBT mode. May be modified using the ICP keypad and can be set to designate PRF codes 1111-1788 or PIM codes 2111-2888.
2. **Laser Spot Tracker Code.** Displays the laser PRF code that the targeting pod's laser spot tracker (LST) will search for when enabled. May be modified using the ICP keypad and can detect PRF codes 1111-1788 or PIM codes 2111-2888.
3. **Air-to-Ground Laser Mode.** Displays the selected laser mode when the TGP is in A-G mode. May be toggled between CMBT and TRNG by pressing any ICP keypad button 1-9 while the DED asterisks are over the data field. The transition between laser modes may take up to 8 seconds.
   - **CMBT.** The laser may be fired for ranging and designation of targets for laser-guided munitions.
   - **TRNG.** The laser may be fired for ranging of target locations in a non-hazardous "eye-safe" mode.
4. **Laser Start Time.** Displays the Time-To-Impact value at which the targeting pod will automatically begin laser designation for terminal guidance of laser-guided munitions. May be modified using the ICP keypad, with acceptable values between 0 and 176 seconds. A value of 0 will disable automatic laser designation.
5. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.
7. **Air-to-Air Laser Mode.** The laser may only be fired in TRNG mode when the TGP is in A-A mode. This setting cannot be changed.

TGP STANDBY (STBY) MODE

After power is applied to the TGP, the sensor electronics will initialize, perform self-tests, and cool down the FLIR sensor, with the Initiated Built-In-Test (IBIT) completion status displayed on the MFD format. When the IBIT % CMP status reaches 100%, which will take approximately 12 minutes after initial power-on, the TGP will enter STBY mode. Once the pod enters STBY mode, a different mode may be selected from the TGP Mode Menu page.

NOTE: If the AAQ-33 is initialized while the outside air temperature is above 70° Celsius or below -40° Celsius, the IBIT will remain at 0% until the temperature is detected to be within the permissible range for power on.

TGP Off (Left), Initialization (Center), and STBY Mode (Right)

When the TGP is set to STBY mode, the sensor housing will rotate so that the sensor aperture panes are pointed upwards. This will help protect the sensor aperture panes from foreign object damage during taxi, takeoff, and landing operations.

Standby Override (OVRD)

Standby Override (OVRD) allows the pilot to immediately set the TGP to STBY and stow the sensor housing independently of the selected master mode. OVRD may be selected from any page of the TGP MFD format by pressing OSB 4. When OVRD is enabled, the TGP mode will be set to STBY and will remain in STBY throughout any changes to the MMC master mode until OVRD is disabled with a subsequent press of OSB 4.

- If OVRD is disabled while set to the same master mode in which OVRD was enabled, the TGP will return to its previous mode prior to selecting OVRD.
- If OVRD is disabled while set to a different master mode than that in which OVRD was enabled, the TGP will be set to the mode that was last selected in the corresponding master mode.

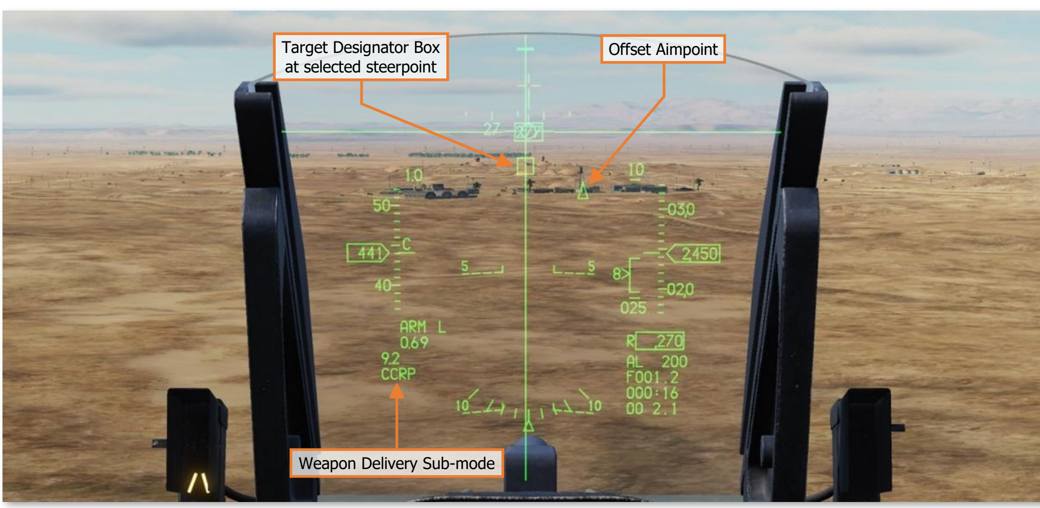
TGP AIR-TO-GROUND (A-G) MODE

When employing the targeting pod in Air-to-Ground (A-G) mode, the TGP MFD format may be used for targeting and designation of stationary or moving ground targets, armed reconnaissance, or updates to the navigation system using pre-defined landmarks and sighting points. The TGP MFD format also includes options for employing the IR pointer or laser spot tracker; and symbology overlaid onto the sensor video that aids in targeting, such as the coordinates and elevation of the surface location within the TGP Line-Of-Sight Crosshairs and a north-pointing arrow to aid the pilot in maintaining orientation of the battlefield.

When the TGP is in A-G mode, the TGP itself will always be aligned to the air-to-ground System Point-of-Interest (SPI), which may be assigned to a pre-planned sighting point, a visual ground designation, or an estimated weapons impact pipper in the HUD, depending on the selected MMC master mode and/or weapon delivery sub-mode. The TGP may also be slaved directly forward in Snowplow sighting mode.

- If the master mode is set to Navigation (NAV), the TGP will be aligned with the selected steerpoint or offset aimpoint, depending on the sighting point selected at OSB 10.
- If the master mode is set to Air-to-Ground (A-G) and the air-to-ground weapon delivery sub-mode is set to any "Pre-planned" sub-mode (such as CCRP) or Manual bombing, or if the selected weapon on the SMS MFD format is set to AGM-88 missiles, the TGP will be aligned with the selected steerpoint, offset aimpoint, VIP initial point, or VRP reference point, depending on the sighting point selected at OSB 10.
- If the master mode is set to Air-to-Ground (A-G) and the air-to-ground weapon delivery sub-mode is set to any "Visual" sub-mode that employs a visual ground designation (such as DTOS), the TGP will be aligned with the Target Designator (TD) box in the HUD/HMCS.
- If the master mode is set to Air-to-Ground (A-G) and the air-to-ground weapon delivery sub-mode is set to any "Visual" sub-mode that employs a dynamic pipper within the HUD to display the weapon impact point (such as CCIP), the TGP will be aligned with the calculated impact point.

(See System Point-of-Interest and Sighting Points in the Tactical Employment chapter for more information.)



If the MMC master mode is set to Air-to-Ground (A-G), the selected weapon on the SMS MFD format is set to AGM-65D or AGM-65G IR-guided missiles, and the weapon delivery sub-mode is set EO-PRE, the TGP may also be used to acquire and handoff targets directly to the AGM-65 missile seeker. (See the AGM-65 Maverick section in the Air-to-Ground Weapons Employment chapter for more information.)

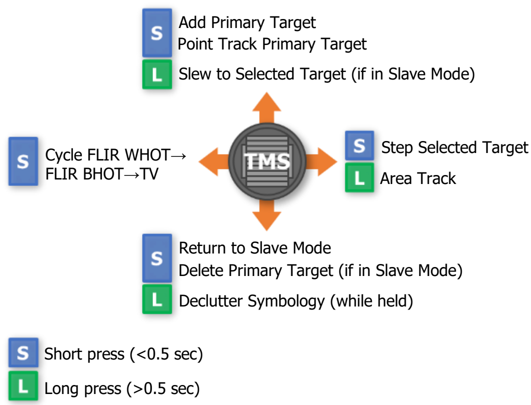
Multi-Target (MT) Track in A-G Mode

The AAQ-33 electronics are capable of tracking multiple targets within the selected sensor's optical field-of-view, regardless of whether the targets are moving or stationary, using the Multi-Target (MT) track mode. This may be used to rapidly reposition the TGP line-of-sight between multiple targets within a small area, particularly if performing handovers to multiple AGM-65 missiles onboard or if using the TGP laser to designate separate targets for multiple friendly aircraft to acquire using their respective laser spot detection sensors.

MT track mode may be enabled by pressing OSB 18 on the TGP MFD format, if Laser Spot Track (LST) is disabled. If the TGP is in A-G mode, up to 10 targets may be added to the MT "Target List" by the pilot.

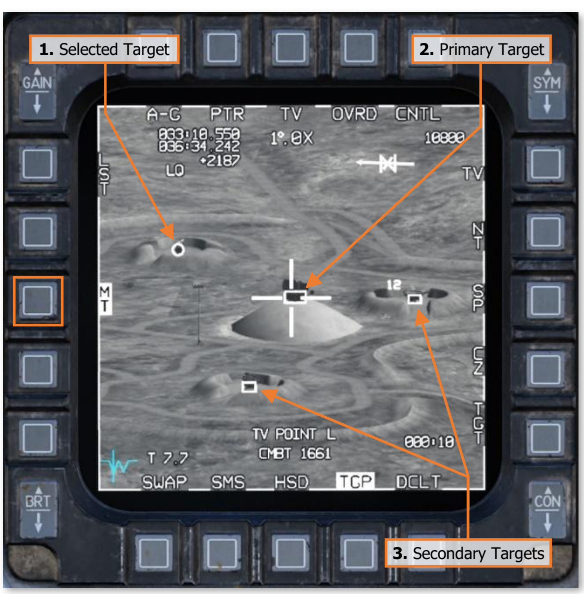
When MT is enabled, the Target Management Switch (TMS) logic is altered as shown in the figure on the right to facilitate interaction with the MT Target List. Point and Area track modes may still be used when MT is enabled; however Inertial track and Laser Spot Track modes will be unavailable.

If the pilot wishes to add a target to the MT Target List, the TGP crosshairs must be placed over the target. The target that is under the crosshairs is referred to as the Primary Target, regardless of whether it has been added to the MT Target List.



A target is added to the MT Target List using a short press of TMS Forward, which will also make it the Selected Target, identified by the circle symbol. If the Primary Target is already on the MT Target List, a short press of TMS Forward will establish a Point track on the Primary Target, even if it is not the Selected Target.

If the TGP is in Slave mode, the TGP line-of-sight may be slewed to the Selected Target using a long press of TMS Forward. The Selected Target may be cycled through the MT Target List using short presses of TMS Right, which will step the circle symbol through each target in the order they were added to the MT Target List.



If the TGP is in Slave mode, the Primary Target may be deleted from the MT Target List with a short press of TMS Aft.

1. **Selected Target.** The target to which the TGP will be slewed using TMS Forward-Long (if in Slave mode).

2. **Primary Target.** The target within the TGP Line-Of-Sight Crosshairs, regardless of whether it is added to the MT Target List.

The Primary Target may be added to the MT Target List using TMS Forward-Short; or Point tracked using TMS Forward-Short if it has already been added to the MT Target List.

The Primary Target may be deleted from the MT Target List using TMS Aft-Short (if in Slave mode).

3. **Secondary Targets.** Targets that are being optically tracked by the TGP that are neither the Selected Target nor the Primary Target.

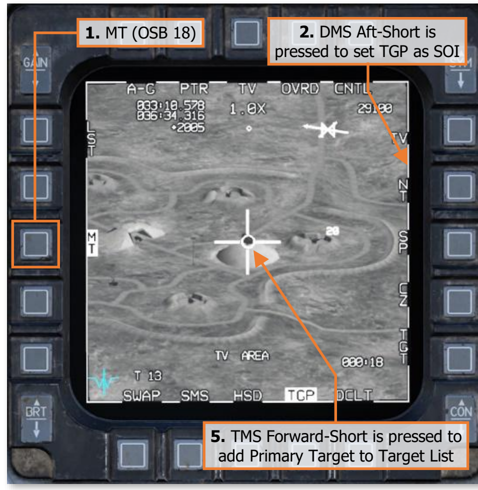
Adding Targets to the MT Target List

If the TGP is set to Air-to-Ground (A-G) mode, Multi-Target (MT) track mode is enabled, and the TGP is SOI, up to 10 targets may be added to the MT Target List.

To add targets to the MT Target List, perform the following:

1. TGP OSB 18 – Select **MT**.
2. DMS Aft – Press as necessary to select the TGP as SOI on the applicable MFD.
3. RDR CURSOR/ENABLE Switch – Slew TGP line-of-sight to the intended Primary Target.
4. **(Optional)** TMS Right-Long (Stick) – Press to switch the TGP to AREA track to stabilize the line-of-sight at the location of the intended target.
5. TMS Forward-Short (Stick) – Press to add the Primary Target to the MT Target List as the Selected Target.
6. RDR CURSOR/ENABLE Switch – Slew TGP line-of-sight to the next intended Primary target.
7. TMS Forward-Short (Stick) – Press to add the next Primary Target to the MT Target List as the Selected Target.

Repeat steps 6 and 7 as necessary until targets have been added to the MT Target List as desired.



Selecting/Slewing to Targets on the MT Target List

If the TGP is set to Air-to-Ground (A-G) mode, Multi-Target (MT) track mode is enabled, and the TGP is SOI, the TGP line-of-sight may be automatically slewed to any target on the MT Target List that has been designated as the Selected Target.

To cycle the Selected Target on the MT Target List and/or command the TGP to slew to the Selected Target, perform the following:

1. DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.

2. TMS Right-Short – Press as necessary to cycle the Seleted Target symbol to the intended target.

If the TGP is in POINT, AREA, or INR track mode, the TGP must be switched to Slave mode to slew to the Selected Target. If the TGP is already in Slave mode (large crosshairs), skip Step 3 and proceed to Step 4.

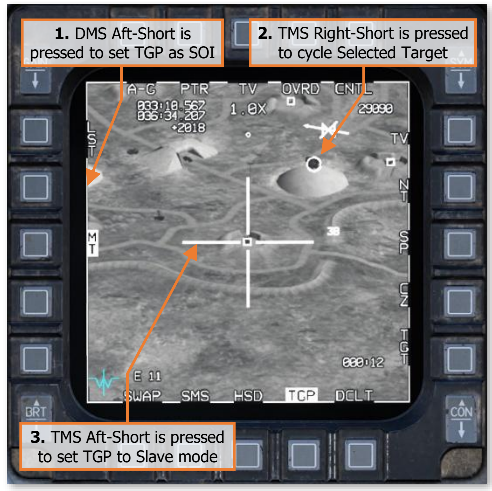
3. TMS Aft-Short – Press (if necessary) to set the TGP to Slave mode.

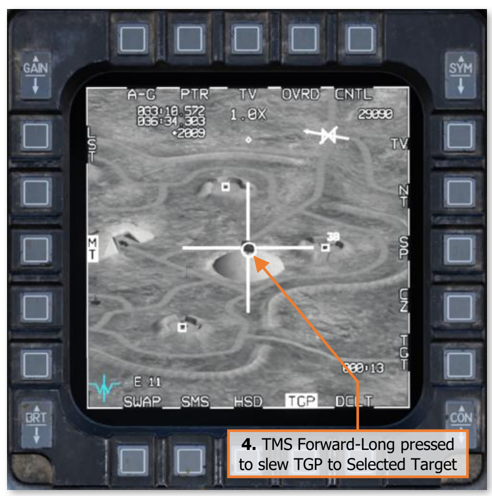
4. TMS Forward-Long – Press to command the TGP to slew to the Selected Target.

5. **(Optional)** TMS Forward-Short (Stick) – Press and release to switch the TGP to POINT track on the Primary Target.

or

5. **(Optional)** TMS Right-Long (Stick) – Press to switch the TGP to AREA track to stabilize the line-of-sight at the location of the Primary Target.





Deleting Targets from the MT Target List

If the TGP is set to Air-to-Ground (A-G) mode, Multi-Target (MT) track mode is enabled, and the TGP is SOI, individual targets may be removed from the MT Target List.

NOTE: If MT track mode is disabled by pressing OSB 18, all targets on the MT Target List will be deleted.

To delete individual targets from the MT Target List, perform the following:

1. DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.

2. RDR CURSOR/ENABLE Switch – Slew TGP line-of-sight to the intended Primary Target.

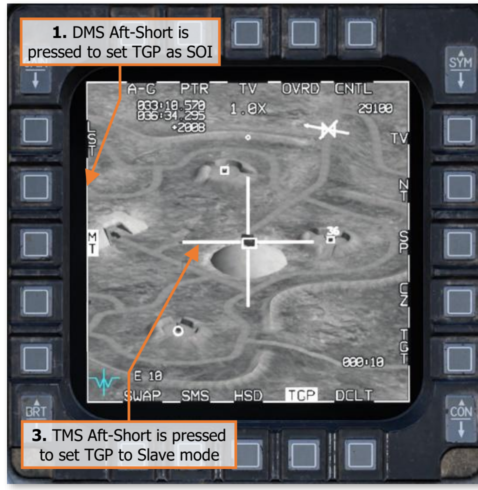
NOTE: Alternatively, the TGP may be commanded to slave to the Selected Target using the procedure described on the previous page.

If the TGP is in POINT, AREA, or INR track mode, the TGP must be switched to Slave mode to delete the Primary Target. If the TGP is already in Slave mode (large crosshairs), skip Step 3 and proceed to Step 4.

3. TMS Aft-Short – Press (if necessary) to set the TGP to Slave mode.

4. TMS Aft-Short – Press to delete the Primary Target from the MT Target List.

Repeat steps 2, 3, and 4 as necessary until targets have been deleted from the MT Target List as desired.



Laser Ranging & Target Designation

The TGP laser designator/ranger uses focused laser energy to precisely measure range to target locations and employs pilot-selectable pulsed repetition frequencies (PRF) to designate targets for laser-guided munitions, such as the Paveway-series laser-guided bombs. In addition to providing terminal guidance for laser-guided munitions, the laser also provides ranging data for ballistic computations of unguided munitions or refining a target location prior to releasing inertially-aided munitions such as Joint Direct Attack Munition (JDAM), Joint Stand-Off Weapon (JSOW), or Wind-Corrected Munitions Dispenser (WCMD). (See the Air-to-Ground Weapons Employment chapter for more information.)

When the TGP is in A-G mode, the laser designator/ranger may be employed in either Training (**TRNG**) or Combat (**CMBT**) mode, which may be selected on the LASR DED page. When the TGP is in A-A mode, the laser designator/ranger is limited to only Training (TRNG) mode.

- When TRNG mode is selected, the laser may be employed for ranging of target locations in a non-hazardous "eye-safe" mode but cannot designate targets for detection by laser spot tracking systems or provide terminal guidance for laser-guided munitions.
- When CMBT mode is selected, the laser may be employed for ranging of targets or designation of targets for laser spot tracking systems or laser-guided munitions.

The TGP MFD format displays an estimated range to the surface (**E** or **T**) when the laser is not firing, based on the radar altimeter and the look-down angle of the TGP. When the laser begins firing, the range is updated (**L**) based on the precise ranging measurements performed by the laser. When the laser ceases firing, the laser range is retained and extrapolated for up to 3 additional seconds before reverting to an estimated range value.

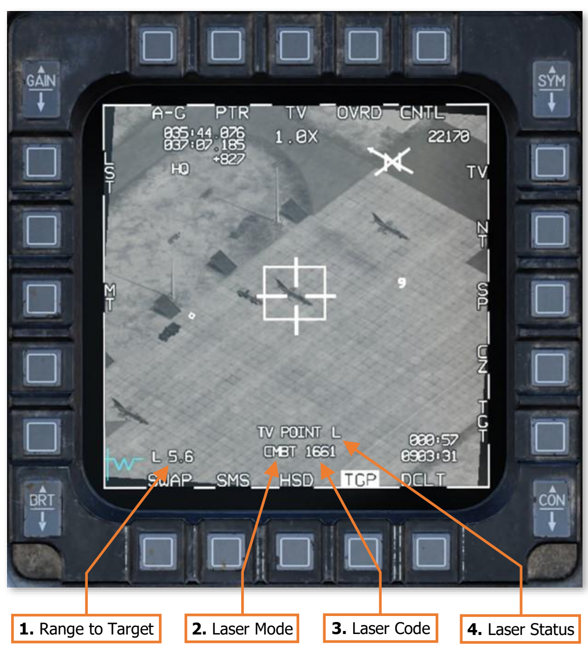
1. **Range To Target.** Displays the slant range to the target or surface location within the Line-Of-Sight Crosshairs, in nautical miles (NM).

   NOTE: Laser returns from vehicles, structures, aircraft, or terrain are limited to a maximum range of 8 NM (14.8 km) in DCS: F-16C Viper.

2. **Laser Mode.** Displays the selected laser mode. The displayed laser mode will flash for up to 8 seconds while transitioning between modes. When the laser mode stops flashing, the transition is complete.
   - **CMBT.** Combat mode is selected.
   - **TRNG.** Training mode is selected.

3. **Laser Code.** Displays the laser PRF code that will be emitted from the targeting pod's laser designator/ranger when set to CMBT mode. When the laser designator/ranger is set to TRNG mode, this data field will be blanked.

4. **Laser Status.** Indicates the laser is armed and may be fired. When the laser is firing, the indicator will flash.
   - **L.** The laser designator/ranger is ready to fire in CMBT mode.
   - **T.** The laser designator/ranger is ready to fire in TRNG mode.



The laser designator/ranger is enabled by setting the LASER ARM switch on the MISC panel to the ARM position. Once armed, it may take up to 8 seconds for the laser module to configure the laser for firing. When the laser is ready for firing, the Laser Mode and Laser Status will be displayed on the MFD TGP format as shown on the previous page. The Laser Status will also be displayed to the right of the Master Arm Status in the Head-Up Display (HUD).

NOTE: The laser is automatically disabled if Laser Spot Track (LST) mode or the IR pointer are enabled, the sighting point is set to anything other than TGT while a laser-guided munition is selected on the SMS MFD format, or the landing gear is deployed.

Manual Laser Firing

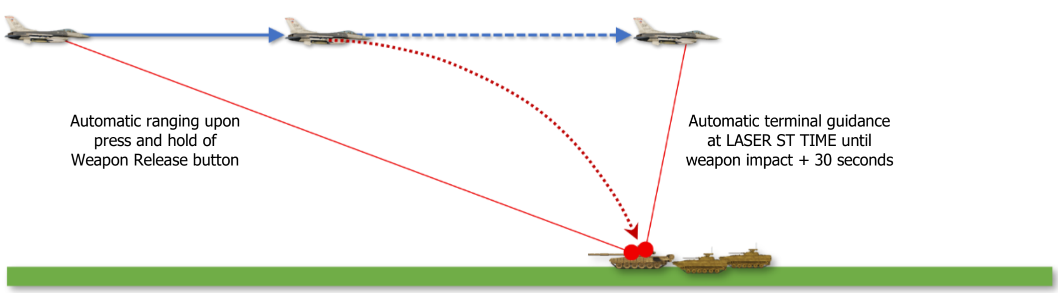
Once armed, the laser may be manually fired by pulling and holding the 2-stage trigger on the Side Stick Controller (SSC) to the first detent. If the trigger is released, the laser will cease firing.

If the MMC master mode is set to Air-to-Ground (A-G) and the weapon delivery sub-mode is set to CCIP, pulling the trigger to the second detent will command the laser to continuously fire for 30 seconds to provide precise range for ballistic computations.

Automatic Laser Firing

If armed, the MMC will automatically command the laser to fire in the following two scenarios.

- The laser automatically fires to obtain precise range data while the pilot presses and holds the Weapon Release button on the Side Stick Controller (SSC) if the following conditions are met.
    - The LASER ARM switch is set to the ARM position.
    - The weapon delivery sub-mode is set to CCRP, LADD, or DTOS (post-designate).
    - The TGP is in Area, Point, or Inertial track mode.
- The laser automatically fires to provide terminal guidance if a laser-guided munition has been released and the following conditions are met.
    - The LASER ARM switch is set to the ARM position.
    - The LASER ST TIME is set to any value other than zero on the LASR DED page.
    - The time-to-impact has decremented below the LASER ST TIME value on the LASR DED page.



Automatic Laser Firing

The MMC will command the laser to stop firing if the following conditions are met.

- If firing prior to weapon release, the laser will stop firing when the selected weapon is released.
- If providing terminal guidance, the laser will stop firing 30 seconds after the time-to-impact has expired.

Regardless of whether the laser is fired manually by the pilot or automatically by the MMC, the laser will cease firing any time the LASER ARM switch is moved to the OFF position or the TGP becomes masked.

Laser Spot Tracker (LST)

The laser spot tracker is capable of detecting offboard laser designations as a means of receiving target handovers from ground-based designators or other aircraft, such as Joint Terminal Attack Controllers (JTACs), Forward Air Controllers (FACs), or Forward Air Controller-Airborne (FAC-A) aircrews. The laser spot tracker may be configured from the cockpit to search for and track pulsed laser designations using standard PRF codes independently of the code assigned to the targeting pod's laser designator/ranger.

To employ the Laser Spot Tracker (LST), the TGP must be set to Air-to-Ground (A-G) mode, Multi-Target (MT) track mode must be disabled, and the code for which the LST will search and track must be input on the LASR DED page.

The laser spot tracker itself has a 3° field-of-view (which is 83% the size of the optical field-of-view of the FLIR when set to WIDE FOV) and will perform a localized scan in the vicinity of the System-Point-of-Interest (SPI) when LST is enabled. Accordingly, the pilot must direct the targeting pod toward the approximate area of the battlefield in which the designated target is located to ensure the offboard laser designation can be captured within the LST scan pattern. This may be accomplished using several methods, depending on the air-to-ground weapon delivery sub-mode.

- If the target coordinates are known, a steerpoint may be input using Latitude/Longitude or MGRS coordinate formats, corresponding with the target location, and then set as the selected steerpoint. If the weapon delivery sub-mode is set to CCRP, LADD, EO-PRE, EO-BORE, PRE, HARM, or MAN, the TGP will be aligned with the selected steerpoint. Snowplow or VRP/VIP sighting methods may also be used to locate the target.
- If the target location can be visually acquired using physical landmarks or other marking methods, the target location can be visually designated. If the weapon delivery sub-mode is set to DTOS, EO-VIS, or VIS, the TGP will be aligned with the Target Designator (TD) box in the HUD/HMCS. Alternatively, if the weapon delivery sub-mode is set to CCIP or STRF, the TGP will be aligned with the weapon pipper within the HUD.

Laser Spot Track mode is enabled by depressing OSB 20 on the TGP MFD format; or by depressing the MAN RNG/UNCAGE knob on the throttle grip while the TGP is SOI. When LST is enabled, the TGP sensor video is momentarily removed from the MFD while the LST is searching, the text to the right of OSB 20 is highlighted in white, and the LST code is displayed immediately adjacent, as illustrated on the following page.

1. **LST Code.** Displays the laser code for which the LST is searching/tracking.
2. **LST Status.** Displays the status of the laser spot tracker.
    - **LSRCH.** The LST is searching for a laser designation.
    - **DETECT.** The LST has detected a laser designation. The TGP is aligning to the target location.
    - **LTRACK.** The LST is tracking a laser designation. The TGP is aligned with the target location.
3. **Line-Of-Sight Crosshairs.** Indicates the TGP sensor line-of-sight (LOS). When full-screen crosshairs are displayed on the MFD, the TGP is in Laser Spot Track mode.

While the LST is searching for a laser designation (LSRCH), the Situational Awareness Indicator will oscillate slightly on the TGP MFD format as the sensor turret scans in the vicinity of the SPI.

If the LST detects a laser spot of the correct code, the LST Status will momentarily display DETECT while the TGP sensor turret is slewed to the detected laser designation. Once the sensor turret is aligned with the laser designation, the TGP sensor video will be displayed on the MFD, the LST Status will display LTRACK, and a Target Identification Set, Laser (TISL) symbol will be displayed in the HUD/HMCS at the corresponding target location.

Target Identification Set, Laser

4. **Target Identification Set, Laser (TISL) Symbol.** Displays the 3-dimensional position of the detected laser designation within the HUD/HMCS (left symbol).

If the TISL Symbol is outside the HUD field-of-view, an X is superimposed across the symbol (center symbol).

If the LST loses track of the laser designation, the TISL symbol will be displayed as a dashed box (right symbol) for 10 seconds while the LST tries to reacquire the laser designation. A Target Locator Line (TLL) will display the relative offset direction from the HUD Boresight Cross or HMCS Aiming Cross to the last detected location of the laser designation.

Acquiring a Laser Designation using LST

If the TGP is set to Air-to-Ground (A-G) mode and the TGP is SOI, an offboard laser designation can be acquired by the laser spot tracker (LST) to locate a target for subsequent engagement.

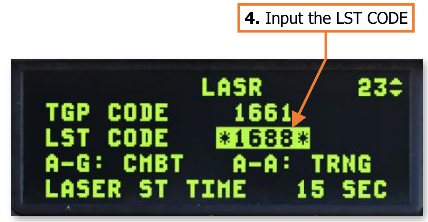
To acquire an offboard laser designation in vicinity of the selected steerpoint, perform the following:

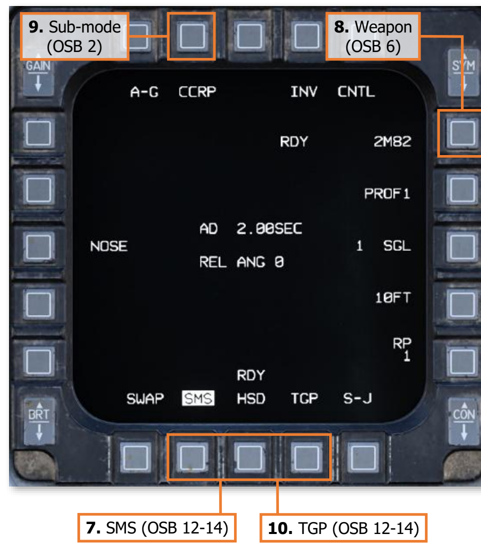
1. ICP **LIST** Button – Press.
2. ICP **0/M-SEL** Button – Press.
3. ICP Keypad – Press **5/CRUS** to display the LASR DED page.
4. ICP DCS Switch – **Down** to move DED asterisks around LST CODE data field.
5. ICP **Keypad** – Input laser code of offboard laser designator.
6. ICP Keypad – Press **ENTR** to accept the laser code or **RCL** to r eject it.
7. MFD format – Select **SMS**.
8. SMS OSB 6 – Select **weapon**, as desired. Verify or modify SMS profile settings for the selected weapon, as necessary.
9. SMS OSB 2 – Select pre-planned weapon delivery sub-mode (CCRP, LADD, EO-PRE, EO-BORE, or PRE), as desired.
10. MFD format – Select **TGP**.
11. Press as necessary to select the TGP as SOI on the applicable MFD.
12. Verify the designating platform is lasing the target.
13. MAN RNG/UNCAGE Knob – Depress.

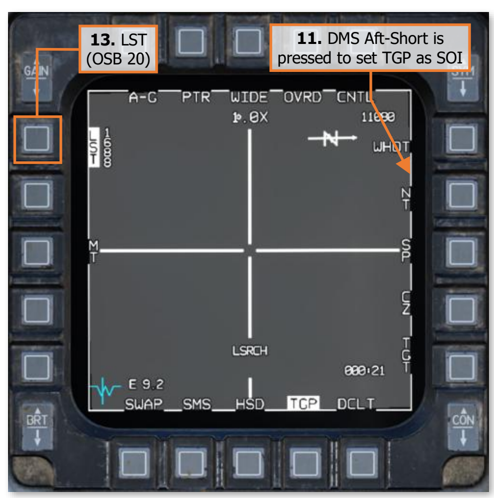
    or

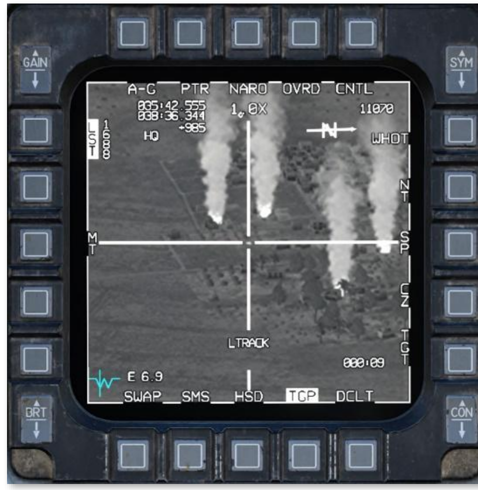
13. TGP OSB 20 – Select **LST**.

When LST is enabled, LSRCH will be displayed at the bottom of the MFD while the TGP sensor turret scans in the vicinity of the SPI for a corresponding laser code.









When the TGP detects and tracks a laser spot of the correct code, LTRACK will be displayed at the bottom of the MFD and the sensor video will be displayed. Once the laser designation is being tracked by the TGP, the pilot may disable the LST and begin autonomously tracking the target.

14. (Optional) TMS Right-Short – Press to enter AREA track.

or

14. (Optional) TMS Forward-Short – Press and release to enter POINT track.

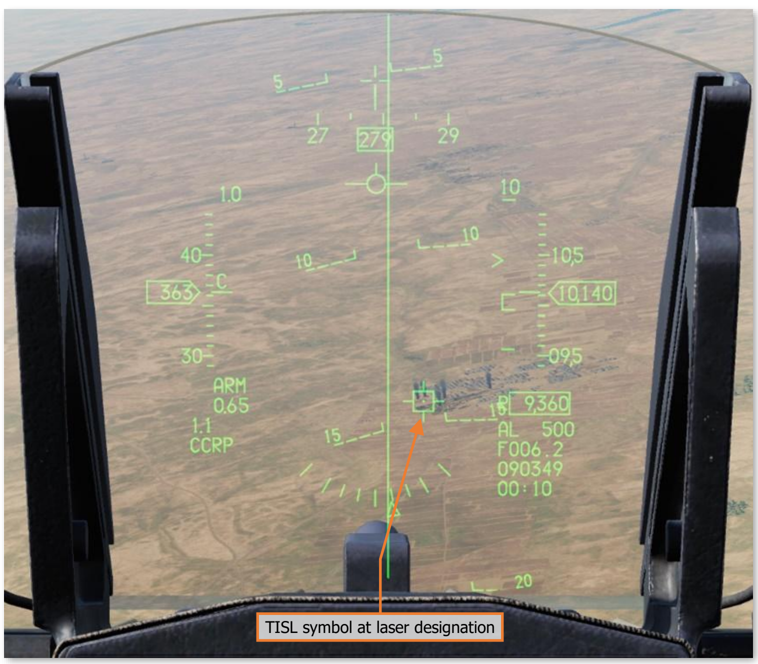
or

14. (Optional) MAN RNG/UNCAGE Knob – Depress.

or

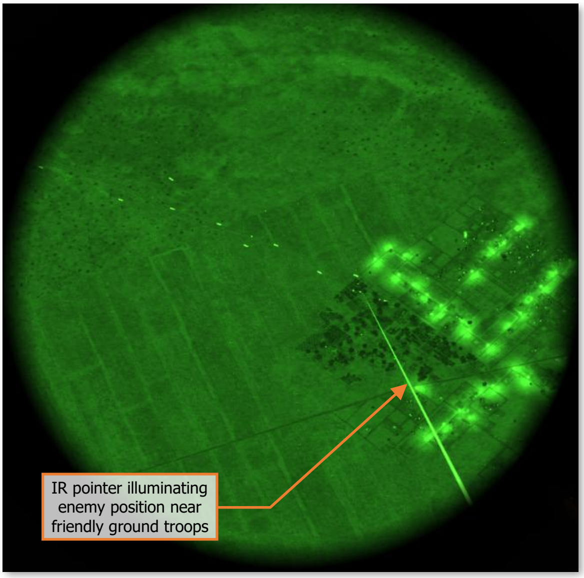
14. (Optional) TGP OSB 20 – De-select **LST**.

NOTE: If the designating platform is marking the target with a laser to perform a target handover to the aircraft, it is advisable that the LST be disabled and the pilot ensures the TGP is correctly tracking the target prior to instructing the designating platform to cease lasing. If the laser designation is lost before the LST is disabled, the TGP video will be removed and the TGP will return to scanning in vicinity of the SPI to acquire a laser spot.



Although the TGP is normally aligned with the HUD weapon pipper when performing a CCIP bombing attack or when using the gun in STRF mode, the TGP will continue to track the laser designation when in LST mode. However, the laser designator/ranger will remain disabled while LST is enabled and will not be available to provide precise ranging measurements for improved ballistic calculations prior to weapon release or firing the gun.

Infrared Pointer (PTR)



AAQ-33 IR Pointer (PTR) as seen through NVGs

When operating in conjunction with other friendly units during hours of darkness, the infrared (IR) pointer may be employed to highlight targets or locations on the battlefield for anybody wearing night vision goggles (NVGs). The IR pointer employs a focused beam of light that continuously emits in the near-infrared spectrum, appearing as a bright line within the field-of-view of NVG's typically worn by ground troops and aircrews.

Unlike the laser designator/ranger, which employs a coded pulse of laser energy, the IR pointer cannot designate targets for laser-guided munitions or sensors with laser spot detection capability.

The IR pointer is enabled by pressing OSB 2 on the TGP MFD format; or by rapidly pressing TMS Right-Short twice within 0.5 seconds while the TGP is SOI. When the IR pointer is enabled, the text below OSB 2 will be highlighted in white and additional symbology and indications will be displayed in the HUD and on the MFD TGP format itself.

NOTE: The IR pointer is automatically disabled if Laser Spot Track (LST) mode is enabled or a laser-guided munition is selected on the SMS MFD format.

When the IR pointer is enabled, a "P" will be displayed to the right of the Master Arm Status in the HUD. If the IR pointer is firing, the "P" will flash.

1. **PTR Tick Marks.** Indicates the IR pointer is enabled.
2. **PTR Indicator.** Indicates the IR pointer is enabled or firing. If the IR pointer is enabled, "PTR" is continuously displayed. If the IR pointer is firing, "PTR" will flash.

The IR pointer is fired in the same manner as the laser designator/ranger, by pulling and holding the 2-stage trigger on the Side Stick Controller (SSC) to the first detent. A slight delay will occur after the trigger is pulled before the IR pointer actually begins firing.

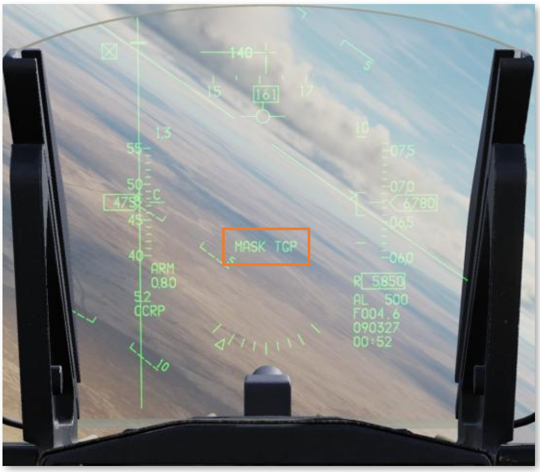
NOTE: The laser designator/ranger is inhibited from firing while the IR pointer is enabled, even if the LASER ARM switch on the MISC panel is set to the ARM position.

TGP Advisory Messages

When the TGP is in Air-to-Ground (A-G) mode, several advisory messages may be displayed in the HUD or on the TGP MFD format to notify the pilot of conditions that may require him to maneuver the aircraft.

MASK TGP Advisory

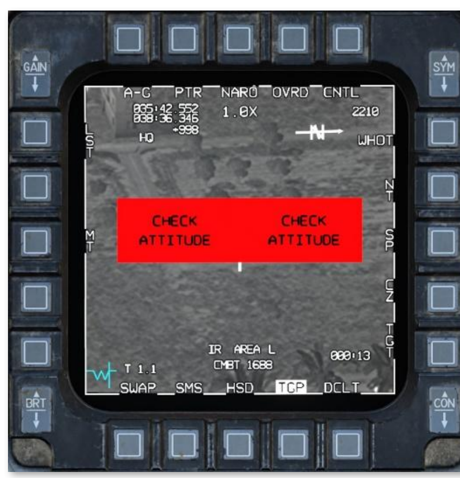
If the TGP sensor turret is approaching a position in which it will be obstructed by the fuselage of the F-16 itself, the crosshairs on the TGP MFD format will flash to warn of an impending sensor mask condition, accompanied by a "MASK TGP" message flashing in the center of the HUD.



If the TGP sensor actually becomes masked by the fuselage, "MASK TGP" will be displayed continuously in the HUD, an "M" will be displayed on the TGP MFD format and the sensor video will blank, and the laser designator/range will be automatically disabled and inhibited from firing.

CHECK ATTITUDE Advisory

If the pilot's attention becomes fixated on the TGP sensor video within the cockpit, an advisory message will appear on the MFDs to advise the pilot to check the aircraft attitude to prevent controlled flight into terrain.



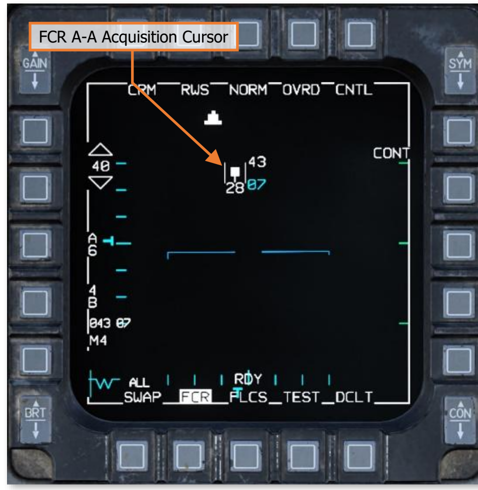
This advisory message is displayed any time the aircraft is below the altitude value set in the MSL FLOOR data field on the ALOW DED page and **all** of the following conditions exist.

- The TGP MFD format is displayed on either MFD.
- The TGP mode is set to A-G.
- The INS attitude data is valid.
- The roll attitude exceeds 75° while the pitch attitude is below the horizon; or the pitch attitude is -20° or more below the horizon regardless of the roll attitude.

The advisory message will flash on both MFDs until the conditions for display no longer exist.

TGP AIR-TO-AIR (A-A) MODE

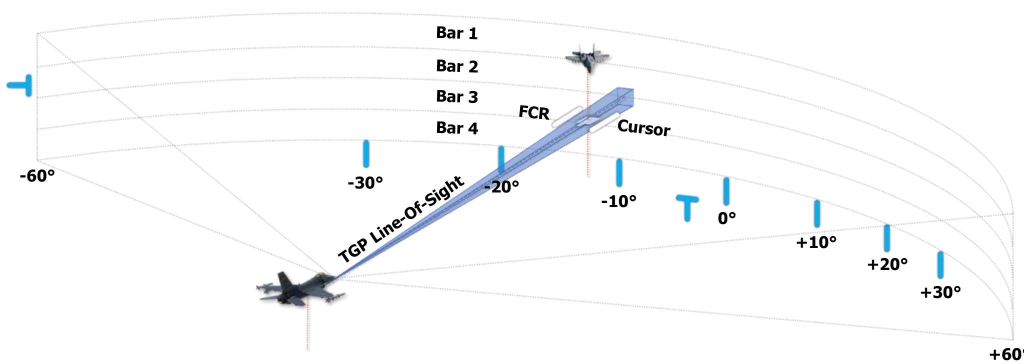
When employing the targeting pod in Air-to-Air (A-A) mode, the TGP MFD format may be used for passively detecting or tracking other aircraft or performing visual identification of unknown aircraft at distances beyond the range of normal eyesight. However, when the TGP is set to A-A mode, the laser spot tracker and IR pointer will be disabled and the laser designator/ranger will be limited to TRNG mode only and cannot be switched to CMBT. (See LASR DED page for more information.)



When the FCR is in Combined Radar Mode (CRM) or Air Combat Mode (ACM), the FCR and TGP may be used to detect and track airborne targets independently of each other. However, if the TGP is not in Point track mode and the FCR is the Sensor-Of-Interest (SOI), the TGP sensor will either be slaved to the 2-dimensional position of the FCR A-A Acquisition Cursor on the FCR MFD format or the 3-dimensional position of the FCR Target-Of-Interest (FCR TOI), referred to as the Bugged Target.

If no FCR TOI has been designated, the TGP line-of-sight will be slaved to the FCR Acquisition Cursor and the FCR antenna elevation setting, effectively centering the TGP line-of-sight within the vertical search volume of the FCR along the same azimuth of the Acquisition Cursor relative to the aircraft nose. As the pilot slews the Acquisition Cursor using the RDR CURSOR/ENABLE switch and/or adjusts the FCR antenna elevation using the ANT ELEV knob, the TGP line-of-sight will follow accordingly.

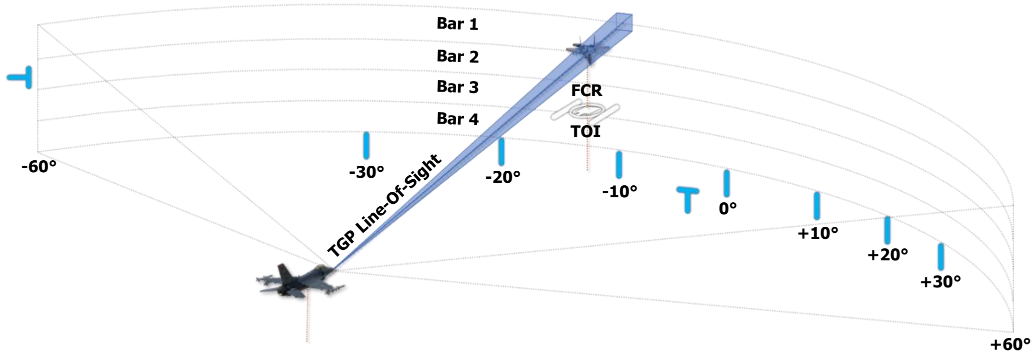
This allows the pilot to use the FCR search volume to aid in visually acquiring aircraft with the TGP sensor by simply slewing the Acquisition Cursor over the corresponding Search Target symbol on the FCR MFD format. However, when using a multiple bar search pattern with the FCR, the TGP may not be aligned with the detected aircraft in elevation, since the TGP simply maintains a position within the center of the vertical search volume.



TGP slaved to FCR Acquisition Cursor

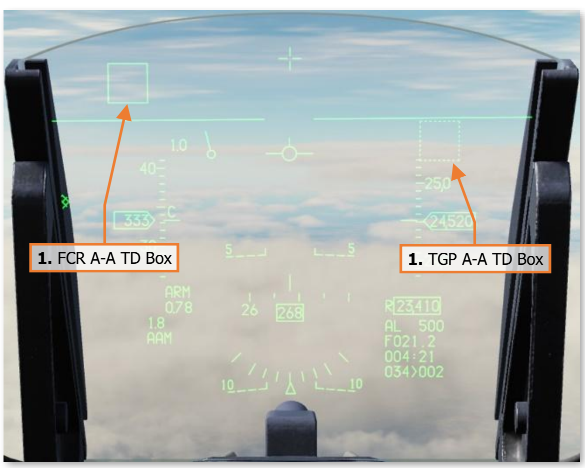
In the figure above, an aircraft has been detected by the FCR within the first bar of the FCR search pattern. The pilot has slewed the FCR Acquisition Cursor over the Search Target symbol on the FCR MFD format, but the TGP line-of-sight remains centered within the vertical search volume while the FCR is SOI. The pilot may adjust the FCR antenna elevation to center the target within the vertical search volume until the target aircraft is within the TGP sensor's field-of-view; or the pilot may set the TGP as SOI and slew the TGP sensor itself in elevation until the target aircraft is acquired within the TGP sensor video.

If a FCR Target-Of-Interest (TOI) is designated, or "bugged", on the FCR MFD format, the TGP line-of-sight will be slaved to the 3-dimensional position of the FCR TOI, unless the TGP is already tracking another aircraft in Point track mode. However, the pilot may set the TGP as SOI and slew the TGP sensor itself in another direction to acquire another aircraft while the FCR continues to track the aircraft designated as TOI. In addition, the TGP may be used to independently track the target aircraft, or any other aircraft visually detected within the TGP sensor video, by commanding the TGP into Point track mode.

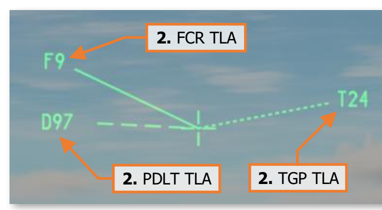


TGP slaved to FCR Target-Of-Interest

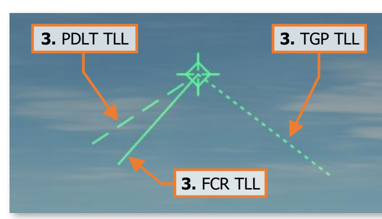
If the TGP is tracking a target in Point track mode independently of the FCR TOI, additional symbology will be displayed within the HUD and HMCS to distinguish between each aircraft being tracked by the FCR and TGP.



HUD/HMCS A-A Target Designator (TD) Boxes



HUD TLL and TLA Symbology



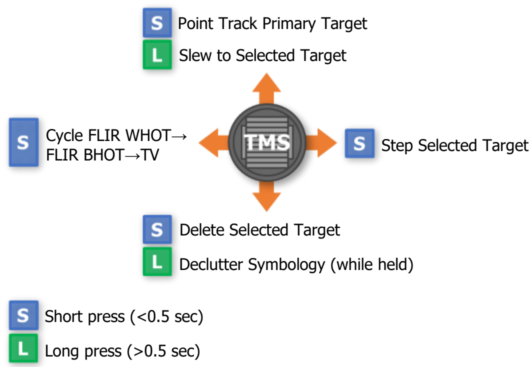
HMCS TLL Symbology

1. **A-A Target Designator (TD) Box.** Displays the position in azimuth and elevation of the aircraft designated as the FCR TOI (solid box) and/or the TGP-tracked aircraft (dotted box).
2. **Target Locator Angle (TLA).** Displays the relative offset angle (in degrees) from the nose to the FCR TOI, PDLT, and/or the TGP-tracked aircraft when the corresponding A-A TD Box or PDLT Octagon is outside the field-of-view of the HUD. TLA symbology is not displayed within the HMCS.
3. **Target Locator Line (TLL).** Displays the relative offset direction from the HUD Boresight Cross or HMCS Aiming Cross to the FCR TOI (solid line), PDLT (dashed line), and/or the TGP-tracked aircraft (dotted line) when the corresponding A-A TD Box or PDLT Octagon is outside the field-of-view of the HUD or HMCS.

Multi-Target (MT) Track in A-A Mode

The AAQ-33 may be used to passively detect and track multiple aircraft within the FLIR sensor's field-of-view using the Multi-Target (MT) track mode. When MT is enabled while the TGP is in A-A mode, the FLIR automatically detects the infrared signatures of aircraft as they move across the more distant background. This may be used to accelerate the process of acquiring airborne targets with the targeting pod by highlighting the positions of detected aircraft within the sensor video displayed on the MFD, or to minimize FCR emissions to avoid detection.

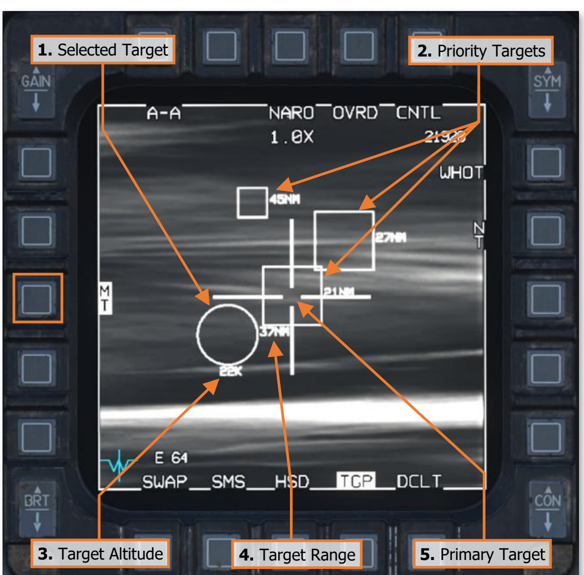
MT track mode may be enabled by pressing OSB 18 on the TGP MFD format. When MT is enabled, the Target Management Switch (TMS) logic is altered as shown in the figure on the right to facilitate interaction with the MT "Target List". If the TGP is in A-A mode, up to 50 airborne targets may be automatically detected and tracked. If a target momentarily exits the FLIR field-of-view, the target will be inertially tracked for 2 seconds to augment re-detection before it is deleted from the MT Target List.



After initial detection, the TGP will passively estimate the target's range based on relative motion between the target and the ownship, which may be increased by maneuvering the aircraft. When the range uncertainty drops below ±10%, the range will be displayed next to the corresponding target symbol.

Targets are ranked in priority, with the 10 highest priority targets highlighted by symbols on the TGP MFD format. Priority ranking is based on range, with closer targets outranking targets that are further away. However, targets that have a range uncertainty <±10% will automatically be ranked above those with a range uncertainty >±10%.

Regardless of whether an airborne target is being tracked on the MT Target List or highlighted by a target symbol as one of the 10 priority targets, a Point track may be established on any Primary Target within the crosshairs by pressing TMS Forward-Short. However, entering Point track will automatically disable MT track mode altogether.



1. **Selected Target.** The Priority Target to which the TGP will be slewed using TMS Forward-Long.

The Selected Target may be deleted from the Target List using TMS Aft-Short.

2. **Priority Targets.** The 9 highest priority targets that are not the Selected Target.

3. **Target Altitude.** The estimated altitude of the Selected Target, in tens of thousands of feet (e.g., 23K is 23,000 feet).

4. **Target Range.** The estimated range (±10%) to the corresponding Priority Target, in nautical miles (NM).

5. **Primary Target.** The target within the TGP Line-Of-Sight Crosshairs, regardless of whether it is highlighted by a target symbol.

The Primary Target may be Point tracked using TMS Forward-Short.

Laser Ranging

The TGP laser designator/ranger may be fired in A-A mode to measure the range to a targeted aircraft. This may be employed to measure the range to an aircraft that is being tracked by the TGP sensors independently of the FCR Target-Of-Interest (TOI) or to measure the range to an aircraft while FCR emissions are being minimized to avoid detection. However, it is important to be aware that if the targeted aircraft is equipped with laser warning sensors, firing the TGP laser may also reveal your presence.

When the TGP is in A-A mode, the laser designator/ranger is limited to Training (TRNG) mode. When TRNG mode is selected, the laser may be employed for ranging of targets in a non-hazardous "eye-safe" mode but cannot designate targets for detection by laser spot tracking systems or provide terminal guidance for laser-guided munitions.

The laser designator/ranger is enabled by setting the LASER ARM switch on the MISC panel to the ARM position. Once armed, it may take up to 8 seconds for the laser module to configure the laser for firing. When the laser is ready for firing, the Laser Mode and Laser Status will be displayed on the MFD TGP format as shown below. The Laser Status will also be displayed to the right of the Master Arm Status in the Head-Up Display (HUD).

Once armed, the laser must be manually fired by pulling and holding the 2-stage trigger on the Side Stick Controller (SSC) to the first detent. If the trigger is released, the laser will cease firing.

The TGP MFD format displays an estimated range to the surface (**E** or **T**) when the laser is not firing, based on the radar altimeter and the look-down angle of the TGP. When the laser begins firing, the range is updated (**L**) based on the precise ranging measurements performed by the laser, assuming the laser actually strikes the surface of the targeted aircraft. When the laser ceases firing, the range reverts to an estimated range value.

1. **Range To Target.** Displays the laser-measured slant range to the target aircraft within the Line-Of-Sight Crosshairs, in nautical miles (NM).

   NOTE: Laser returns from vehicles, structures, aircraft, or terrain are limited to a maximum range of 8 NM (14.8 km) in DCS: F-16C Viper.

A laser range is a higher priority than an FCR range and will be displayed in the HUD any time the laser is firing and receiving a valid range return when the TGP is in A-A mode.

If the range to the target aircraft is 1 nautical mile or greater, the range in the HUD is displayed in nautical miles in LXXX.X format (e.g., L003.6 is 3.6 NM). If the range to the target aircraft is less than 1 nautical mile, the range is displayed in hundreds of feet in L XXX format (e.g., L 045 is 4,500 ft).

2. **Laser Mode.** Displays the laser mode.

3. **Laser Status.** Indicates the laser is armed and may be fired. When the laser is firing, the indicator will flash.

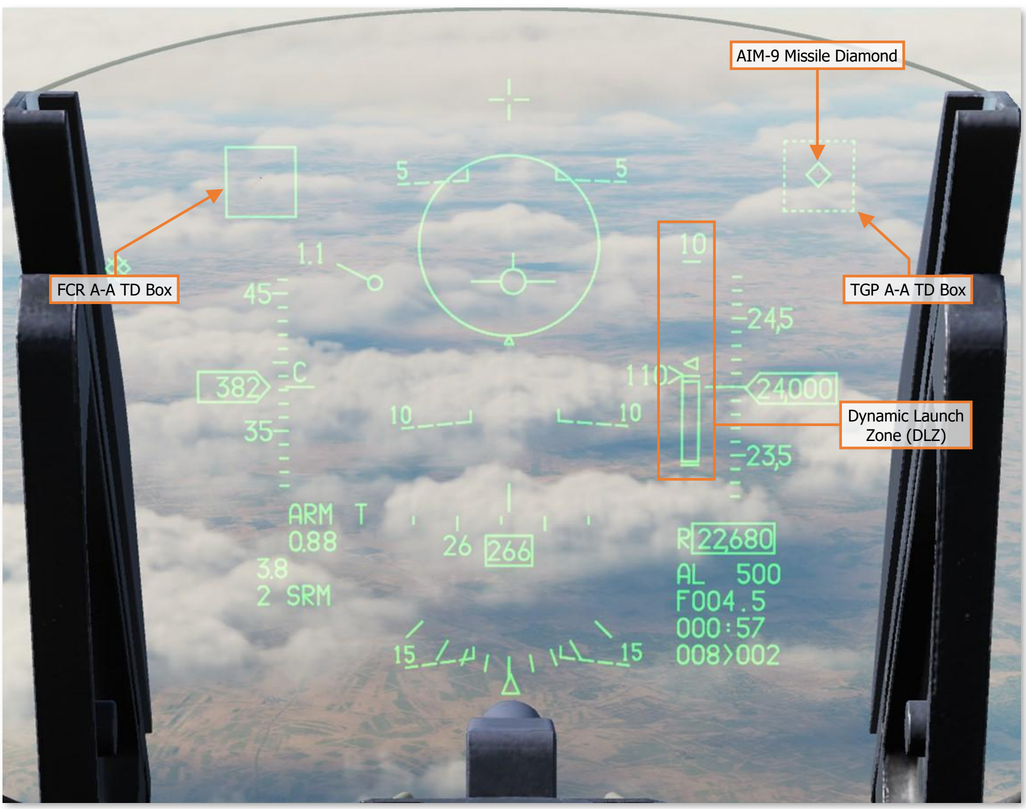
AIM-9 Slave to TGP

The AAQ-33 targeting pod may be used to direct the infrared seeker of the AIM-9 air-to-air missile to an aircraft being tracked by the TGP prior to launch.

When the MMC master mode is set to Air-to-Air (A-A), Missile Override (MSL), or Dogfight (DGFT), and the AIM-9 Line-Of-Sight option is set to SLAVE at OSB 19 on the SMS MFD format, the selected AIM-9 missile will remain slaved to the FCR Target-Of-Interest (FCR TOI), or slaved ahead in the boresight position if no FCR TOI has been bugged. However, the AIM-9 will be slaved to the TGP line-of-sight under the following conditions.

- TGP is set to A-A mode.
- TGP is in Point track mode.
- TGP is set as the Sensor-Of-Interest (SOI).

If two airborne targets are being independently tracked by the FCR and TGP, as shown in the image below, the AIM-9 missile may be selectively slaved to either target by toggling the SOI between the FCR and TGP. However, the Dynamic Launch Zone (DLZ) will remain referenced to the FCR TOI, or absent if an FCR TOI does not exist.



AIM-9 seeker slaved to TGP Line-Of-Sight (LOS)

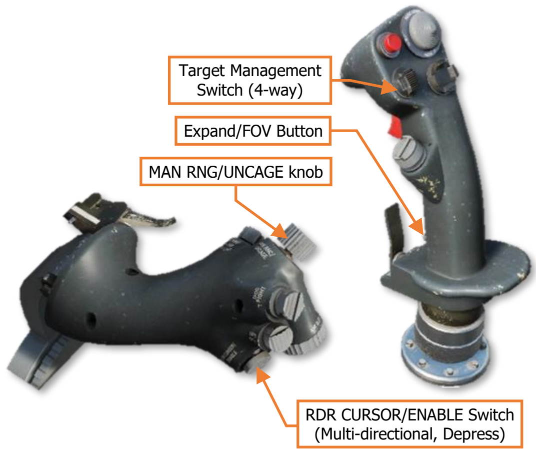
NOTE: AIM-9P and AIM-9P3 missile variants cannot be slaved to the FCR TOI or the TGP line-of-sight. Only the AIM-9L, -9M, -9P5, and -9X missile variants may be slaved as described above.

(See the AIM-9 Sidewinder section in the Air-to-Air Weapons Employment chapter for more information.)

HANDS-ON CONTROLS

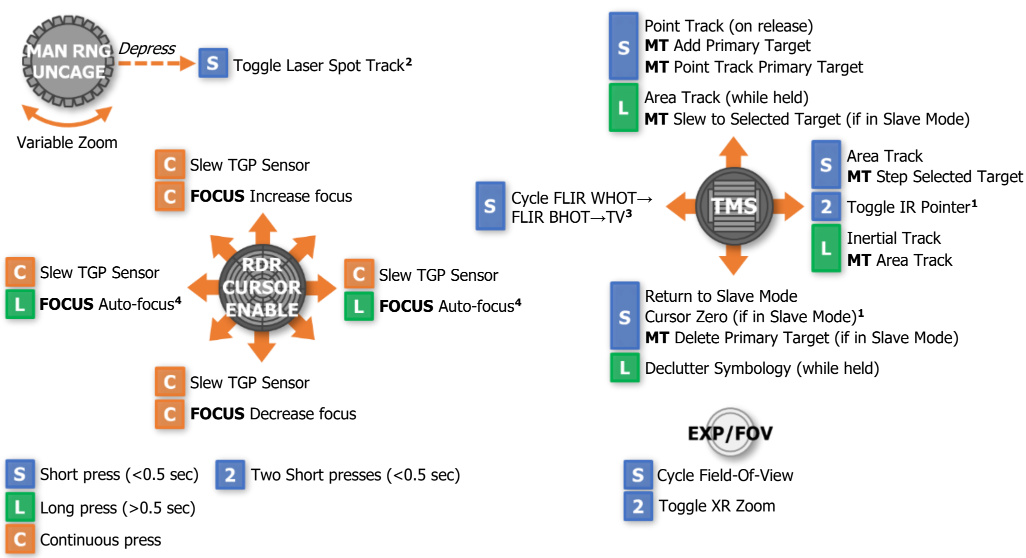
The Target Management Switch (TMS) and Expand/FOV button on the Side Stick Controller (SSC), along with the RDR CURSOR/ENABLE switch and MAN RNG/UNCAGE knob on the throttle grip, are the pilot's controls for slewing the targeting pod, managing the targeting pod's sensors, or entering or exiting tracking modes.

If AGM-65 is the selected weapon type, the TMS Forward and TMS Right commands on the SSC will initiate a target hand-off from the TGP sensor to the AGM-65 missile seeker on the selected wing station and/or automatically transition the Sensor-Of-Interest (SOI) from TGP to WPN when TMS Forward is released if the WPN MFD format is displayed. (See AGM-65 Maverick in the Air-to-Ground Weapons Employment chapter for more information.)



Throttle Grip Commands. The RDR CURSOR/ENABLE switch is multi-directional, allowing the TGP sensor to be slewed in in any direction. The MAN RNG/UNCAGE knob controls the variable zoom and LST mode.

Side Stick Controller (SSC) Commands. The Target Management Switch (TMS) and Expand/FOV button commands are contextual, based on the TGP mode, whether Multi-Target (**MT**) tracking is enabled, and whether an MT target is beneath the TGP crosshairs.



5. Cursor Zero and IR Pointer commands will not be available via the Side Stick Controller if MT is enabled.
6. LST and MT are mutually exclusive, in that enabling one will inhibit the other.
7. TV must be enabled (OSB 6) on the TGP CNTL page for the TV camera to be selectable as a sensor.
8. TGP must be in a stabilized tracking mode to enable an automatic focus adjustment.

ASQ-213 HARM TARGETING SYSTEM

USAF Photo
by TSgt Gregory Brook

AN/ASQ-213 HARM TARGETING SYSTEM

The ASQ-213 HARM Targeting System (HTS), manufactured by Raytheon, provides a significant enhancement to the F-16C for performing the Suppression of Enemy Air Defenses (SEAD) mission. The ASQ-213 detects and classifies hostile radar emissions and then utilizes signals triangulation to passively range threat radar systems on the battlefield, the locations of which can be transmitted to wingmen and engaged by onboard weapons.

AN/ASQ-213 Detection, Classification, and Triangulation

The ASQ-213 HARM Targeting System is not required to employ the AGM-88 HARM missile. However, it does facilitate the targeting of enemy radar systems more efficiently and dramatically increases the pilot's situational awareness of the threat radar environment within the surrounding battlespace, allowing the pilot to make critical decisions regarding which threats may be avoided and which threats must be engaged to accomplish the mission.

In addition to passively ranging air defense radar locations, the HTS retains these locations within its onboard memory, allowing the pilot to coordinate attacks against enemy air defenses even if they are no longer transmitting or the radar signals themselves are obstructed by terrain. Although the ASQ-213 was designed to enhance the tactical employment of AGM-88 anti-radiation missiles against air defense systems, the HTS can be used to designate enemy air defense locations for acquisition by other onboard sensors or engagement using other types of weapons.

HARM Targeting System Activation

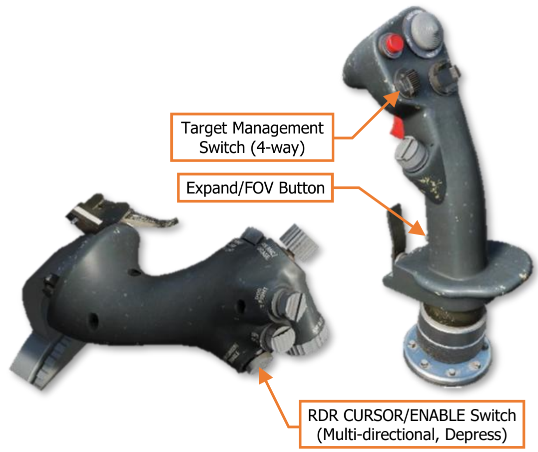
The HTS pod (if equipped) is powered through the left "chin" hardpoint along the center fuselage, just aft of the engine intake. This is accomplished by positioning the LEFT HDPT switch to the forward position on the SNSR PWR control panel on the right console.

The HTS pod will require approximately 30 seconds to initialize.

The HARM Targeting System cannot function without the MMC, ST STA, or MFD avionics systems, or without a properly aligned INS.

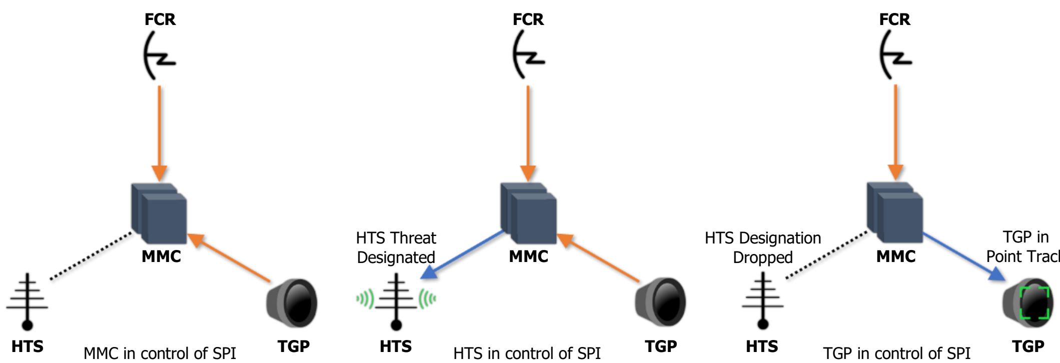
Slew and Designation Controls

The ASQ-213 HARM Targeting System, otherwise referred to as simply the HTS in the F-16C avionics lexicon when installed, is integrated with the cockpit Hands-On Controls. The HTS functions are primarily controlled using the Target Management Switch (TMS) and the Expand/Field-Of-View button on the Side Stick Controller (SSC), and the RDR CURSOR/ENABLE switch on the throttle grip to slew the cursor on the HARM Attack Display MFD format.



When installed, the HTS is integrated into the F-16 avionics and cockpit interface as an additional sensor. When operating in their respective air-to-ground modes, each of the F-16's sensors are focused onto a single geographic location in the battlespace known as the System-Point-of-Interest (SPI). The SPI may be controlled by the Modular Mission Computer (MMC) or any of the aircraft sensors themselves.

When the MMC is in control of the SPI, each of the aircraft sensors will remain slaved to the SPI. If the FCR is in GM, GMT, or SEA mode, the FCR A-G Acquisition Cursor coincides with the 3-dimensional location of the SPI. Likewise, if the TGP is in Slave mode, the TGP sensor line-of-sight is slaved to the SPI. If the SPI moves, the FCR Acquisition Cursor and the TGP line-of-sight will automatically slew to remain aligned with the SPI.



F-16C Sensor Slave & Tracking Logic

If a radar threat is designated on the HAD MFD format, the HTS itself will determine the position of the SPI. If the FCR is in GM, GMT, or SEA mode and was tracking a surface target or location, the FCR will break track and the A-G Acquisition Cursor on the FCR MFD format will be slewed to the HTS-controlled SPI. If the TGP is in A-G mode and was tracking a surface target or location, the TGP will break track and the sensor turret's line-of-sight will slave to the HTS-controlled SPI.

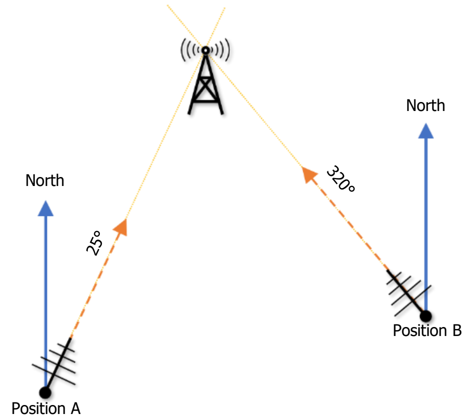
Accordingly, if the FCR is in GM, GMT, or SEA mode and enters a tracking state, or the TGP is in A-G mode and enters a tracking state, the designation on the HAD MFD format will be dropped.

It is worth noting that the singular SPI logic only applies when the F-16 sensors are operating in their respective air-to-ground modes. If the FCR and/or TGP are operating in air-to-air modes, they may be commanded to track an airborne target independently of the other sensors, to include simultaneously tracking two separate aircraft.

Radio Direction Finding and Triangulation

Just as radio signal-based aeronautical navigational aids, such as TACAN stations, can be received by navigation radios onboard an aircraft to determine their bearing relative to the aircraft, other forms of radio signals can be received and measured when using specialized radio antennas. Using such antennas, an "angle-of-arrival" can be determined within a margin of error that is predicated on the sophistication of the equipment and the receiving antenna. This process of measuring angle-of-arrival is known as radio direction finding.

If the same radio signal can be received and measured using radio direction finding equipment at multiple locations, the corresponding bearings from each measured location to the source of the radio signal can be used to triangulate the geographical position of the radio emitter. This technique is known as radio triangulation. Using such techniques, the location of any emitter of electromagnetic signals can be determined using passive radio receivers.

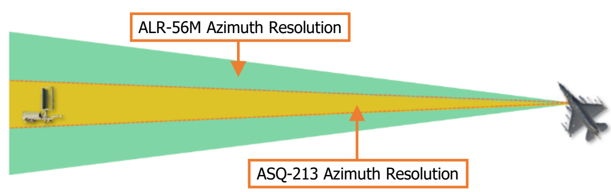


Radio triangulation from two known positions

As with other forms of radio signals, radar emissions can likewise be received by an antenna that is specifically tuned to process such radar signals. Many military aircraft are equipped with radar warning receivers (RWR) that are not only able to measure the relative azimuth of radar signals around the aircraft in 360 degrees but are also capable of warning the aircrews of the type of threat and when the radar's signal characteristics have changed in such a way that indicates that the aircraft may be under attack.

Like other angle-of-arrival measurements, the accuracy of these radar warning receivers are subject to the sensitivity of their radar receivers, the sophistication of their associated electronic processors, and the nature of the RWR display itself within the cockpit. In many instances, the azimuth resolution of an RWR is only necessary to the extent of warning the aircrew of the general threat direction for the purposes of determining appropriate defensive actions or evasive maneuvers to be performed.

If radio direction finding devices onboard an aircraft are designed to calculate precise angle-of-arrival data in order to triangulate the geographical position of enemy radar emitters, such specialized devices will typically possess a higher azimuth resolution for determining the precise angle-of-arrival of such radar signals compared to a radar warning receiver.



Angle-of-arrival azimuth resolution of radar signals

The F-16C is equipped with an ALR-56M radar warning receiver in addition to the HARM Targeting System. Unlike the ALR-56M, which is a defensive system intended to warn the pilot of an impending attack on the aircraft, the HARM Targeting System is designed as an offensive system for passively locating enemy air defense radar sites. As such, in the case of the F-16C, the HTS is more capable than the F-16's own ALR-56M for determining precise threat direction.

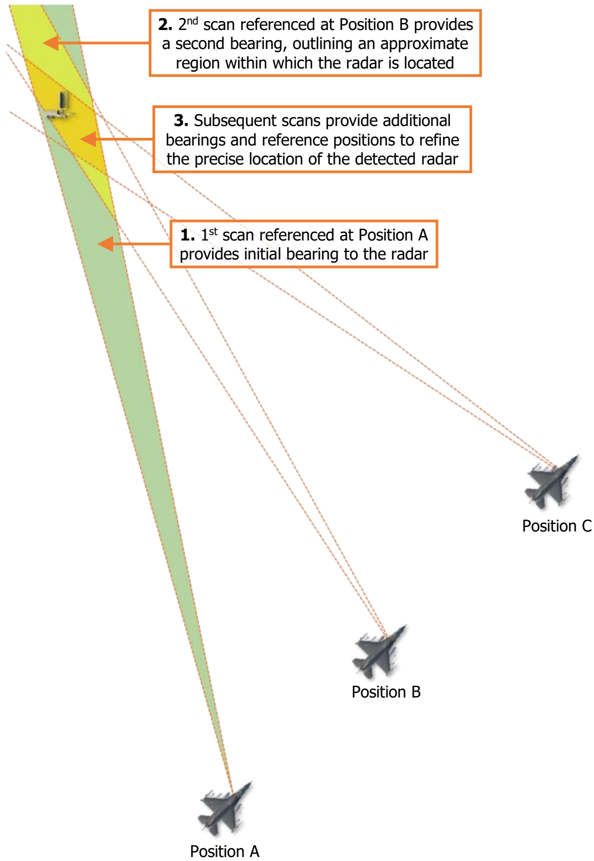
However, like the ALR-56M, the HARM Targeting System is subject to the same negative impacts to accuracy that occur while the aircraft is performing aggressive maneuvers or is flying at extreme attitudes in pitch and roll.

Passive ranging and geo-location using Angle-Of-Arrival (AOA)

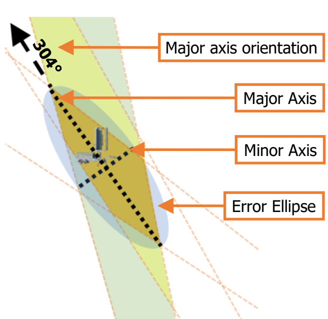
The ASQ-213 HTS passively provides ranging and position data of threat radars by calculating the angle-of-arrival (AOA) of radar signals detected over the course of multiple scans. Using the known position of the aircraft during each scan, the HTS triangulates a threat radar's location within an area of probability called an "error ellipse".

As the radar signal data is processed, the location and size of the error ellipse is determined based on several angle-of-arrival measurements; and is continuously updated with subsequent measurements provided by each scan in which the radar signal is received. As the size of the error ellipse shrinks, the accuracy of the calculated geographic position of the threat radar improves. The error ellipse will rarely be re-calculated in a uniform manner following each scan, with the computed major and minor axes changing in size and orientation. This may sometimes lead to intermittent "jumps" of the threat radar's computed geographic position.

The accuracy, or position quality, of this passive ranging is based on the relative offset between each measured angle-of-arrival and the number of scans within which the same radar signal was received. If the threat radar is at a long distance or if the aircraft is flying directly toward or away from it, the relative difference between each subsequent angle-of-arrival measurement will be very narrow and the error ellipse will be very large. Flying at oblique angles relative to the radar's angle-of-arrival will improve the HTS pod's ability to reduce the size of the error ellipse.



Geo-location of radar emissions using AOA ranging



Geo-location Error Ellipse

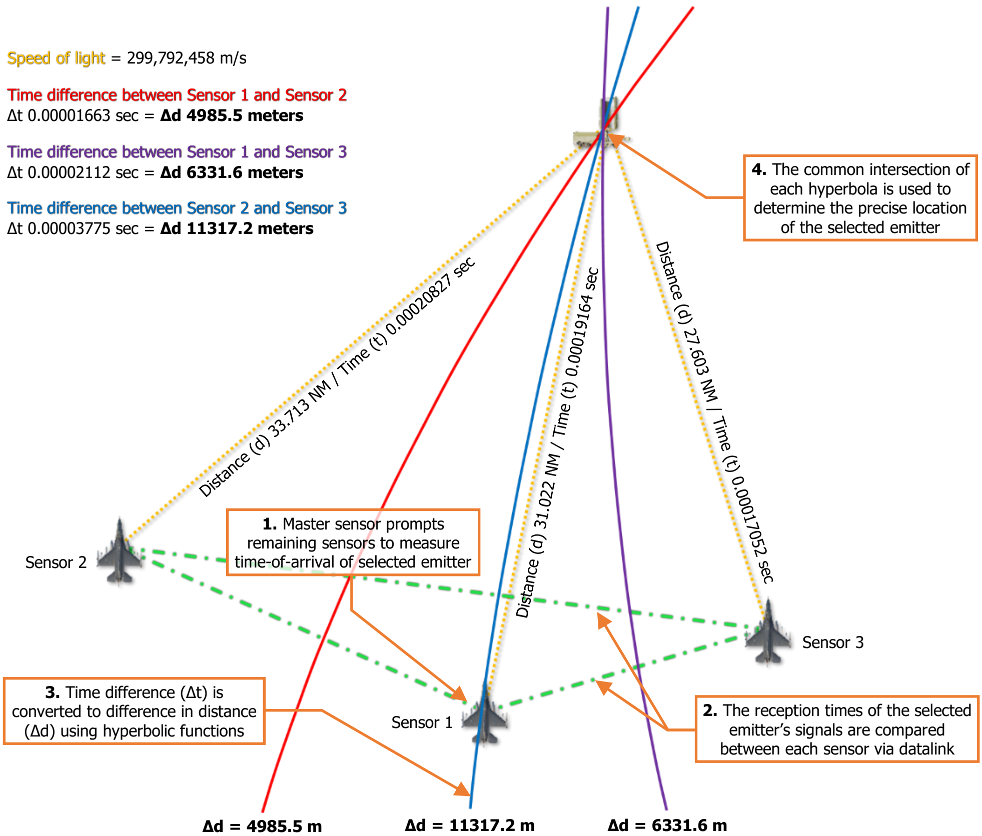
The size of the error ellipse is categorized by the HARM Targeting System within five PGM classification levels, which represents the position quality of the ranging data for employing precision guided munitions. These PGM levels are ranked PGM 1 through PGM 5, with PGM 5 being the least accurate with a large error ellipse, and PGM 1 being the most accurate with a small error ellipse.

When attempting to electro-optically acquire an air defense battery through the targeting pod, position quality data that is categorized as PGM 2 will typically generate a SPI location quite close to the radar's true location. In these instances, a brief search in the vicinity of the SPI is usually all that is required to visually acquire the air defense battery. To achieve PGM 1 position quality, more precise measurements are required using time-difference-of-arrival (TDOA) ranging using multiple HTS-equipped aircraft, as described on the following page.

Passive ranging and geo-location using Time-Difference-Of-Arrival (TDOA)

In addition to angle-of-arrival calculations, the ASQ-213 HTS is capable of calculating the time-of-arrival of a singular radar emitter and comparing the time-of-arrival measurement between other HTS pods across the TNDL network. This method of geo-location is known as time-difference-of-arrival, or TDOA, and requires a minimum of three HTS-equipped F-16s working cooperatively to geo-locate the position of a single radar threat. Although this method of geo-location is more limited in scope and requires multiple aircraft in the flight to calculate the radar's position, the calculations are more precise and the geo-location process is accomplished more quickly.

When a radar threat is designated on the HARM Attack Display (HAD), the pilot may initiate the TDOA process on the designated radar, which will send TDOA instructions to other F-16 Flight/Team members that are available for TDOA ranging. The other HTS pods will be "slaved" to the "master" HTS pod that initiated the TDOA ranging process and will begin communicating time-of-arrival data from the designated radar's emissions.



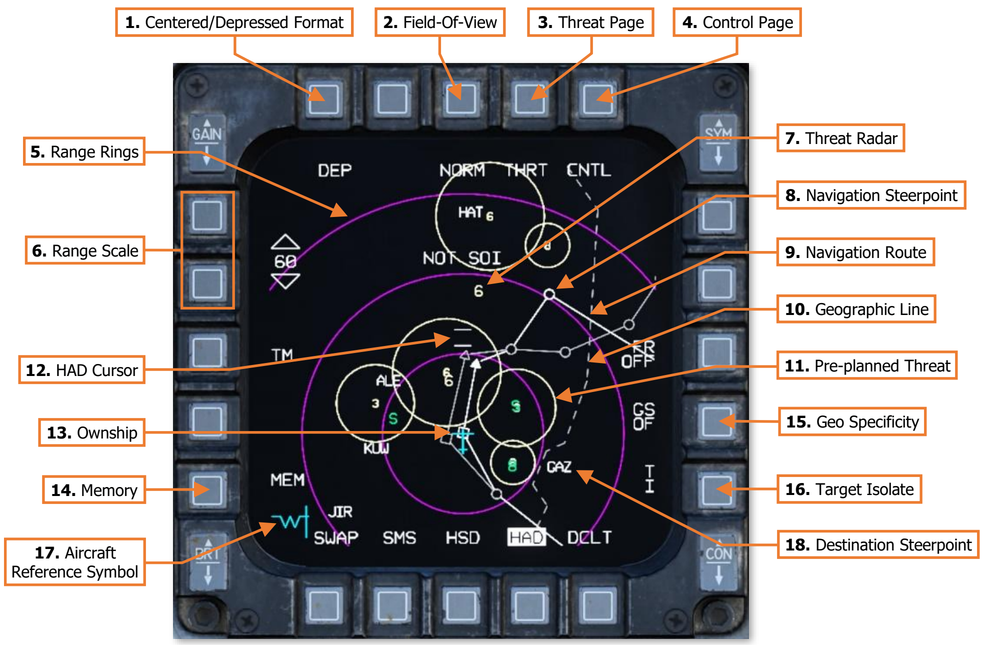
Geo-location of radar emissions using TDOA ranging

Each unique time-of-arrival is recorded and transmitted between the HTS pods. Since the time at which the radar transmissions began are unknown, the differences between each time-of-arrival are converted to differences in distance (Δd) by multiplying the time difference (Δt) by the speed of light. Once these calculations are performed, hyperbolic functions are employed to plot these differences in distance between each TDOA sensor, based on the known positions of each HTS-equipped F-16 contributing to the TDOA ranging process. The location at which each individual hyperbola intersects with the others is the geo-located position of the radar emitter.

HARM Attack Display (HAD) Format

The HAD MFD format overlays the geographic positions and emission states of HTS-detected radar systems onto a top-down, plan-view depiction of the navigation and tactical situation around the aircraft. The HAD fuses pre-planned air defense threat locations with HTS-detected radar emitters in real-time, presenting a unified picture of the air defense environment for performing the Suppression of Enemy Air Defenses (SEAD) mission.

The HAD is very similar to the HSD MFD format, but with some slight differences. Like the HSD, pre-planned mission data such as steerpoints and routes are displayed, which may be selectively toggled on the HAD Control page, along with the positions of flight members and other friendly aircraft received through the datalink. However, unlike the HSD, the HAD does not display non-friendly Air Target tracks or non-friendly Air Surveillance tracks received via the datalink; nor does it display airborne targets detected by the onboard FCR, and it cannot be coupled to the FCR range scale.



1. **Centered/Depressed Format.** Toggles between Depressed (DEP) and Centered (CEN) HAD formats. When set to Depressed, the ownship is biased to the bottom portion of the HAD, allowing the HAD to primarily depict battlespace in front of the aircraft. When set to Centered, the ownship is displayed in the center of the HAD, depicting battlespace in all directions around the aircraft equally.

2. **Field-Of-View.** Cycles the HAD between NORM, EXP1, and EXP2 fields-of-view when the HAD is SOI. The Expand/FOV button on the Side Stick Controller (SSC) may also be pressed to cycle between the HAD fields-of-view when the HAD is SOI. (See Expand Field-Of-View for more information.)

3. **Threat Page (THRT).** Toggles the MFD between the HAD base page and the Threat page.

4. **Control Page (CNTL).** Toggles the MFD between the HAD base page and the Control page.

5. **Range Rings.** Depicts range from the ownship. When the HAD is set to Depressed (DEP) format, the outer ring will correspond with the HAD range scale, with two additional inner rings at ⅔ and ⅓ of the range scale. When the HAD is set to Centered (CEN) format, the outer ring will correspond with the HAD range scale, with an inner ring at ½ the range scale.

6. **Range Scale.** Adjusts the scale of the HAD up or down, with the current range scale setting (in nautical miles) displayed between the arrow buttons. The HAD range scale corresponds with the outermost range ring depicted on the HAD and is scaled based on the DEP/CEN format selection. The available HAD scales are shown below:

Depressed (DEP)	15 NM	30 NM	60 NM	120 NM	240 NM
Centered (CEN)	10 NM	20 NM	40 NM	80 NM	160 NM

When the HAD is set to its highest or lowest range scales, the upper or lower range scale arrows are removed, respectively.

7. **Threat Radar.** Displays the geo-located position of radar emitters detected by the ASQ-213 HTS pod, based on angle-of-arrival or time-difference-of-arrival measurements. Threat radar symbols are displayed using a combination of alphanumeric codes to identify the type of radar (e.g., "6" for an SA-6 radar) and colors to indicate the emission state of the radar.

6 Radar is emitting in Search mode.

6 Radar is emitting in Track mode.

6 **(Flashing)** Radar is emitting in Launch mode.

6 Radar emissions have not been detected for at least 2 minutes and radar is stored in HTS memory. If radar emissions are not detected for 4 minutes, the symbol will be removed from the HAD.

A complete list of threat radar symbols can be viewed in Appendix C.

8. **Navigation Steerpoint.** Steerpoints 1-25 composing a navigation route are displayed as circles for normal steerpoints, squares for initial points, and triangles for targets. The steerpoint selected for navigation is displayed as a solid symbol; all other steerpoints are displayed as hollow symbols. Navigation steerpoints are displayed as white within the active navigation route and gray within the non-active navigation routes, if present.

Navigation steerpoints that are not part of a navigation route are not displayed on the HSD unless they are the selected steerpoint.

9. **Navigation Route.** Navigation routes are displayed as solid lines linking sequential steerpoints 1-25. The active navigation route is displayed as white and the non-active navigation routes, if present, are displayed as gray. (See Navigation Routes for more information.)

10. **Geographic Line.** Geographic lines are depicted as dashed lines linking sequential steerpoints 31-55. These lines may be used to depict airspace boundaries, kill boxes, the Forward Line of Own Troops (FLOT) or a variety of other uses. All geographic lines are displayed as gray.

11. **Pre-planned Threat.** Locations of pre-planned air defense threats are displayed using up to three alphanumeric characters and a ring that corresponds to the approximate Weapon Engagement Zone (WEZ) of the air defense threat. Pre-planned threats and their range rings are displayed as yellow but will become red if the ownship enters the WEZ of the corresponding threat.

NOTE: These are static locations of air defenses and do not reflect whether the air defense threat is operational or destroyed, or if any new threats have been detected.

12. **HAD Cursor.** When the HAD is selected as the Sensor-Of-Interest (SOI), the HAD cursor will appear in the center of the HAD MFD format. If SOI is assigned to another MFD format or the HUD, the HAD cursor is removed.

The HAD cursor is slewed using the RDR CURSOR/ENABLE switch on the throttle grip when the HAD is SOI and may be used to view expanded information of an HTS-detected radar when placed over a threat radar symbol, designate a radar for tracking and/or handoff to an AGM-88 missile, or used in conjunction with the Expand (EXP1/EXP2) fields-of-view.

13. **Ownship.** Depicts the location of the ownship.

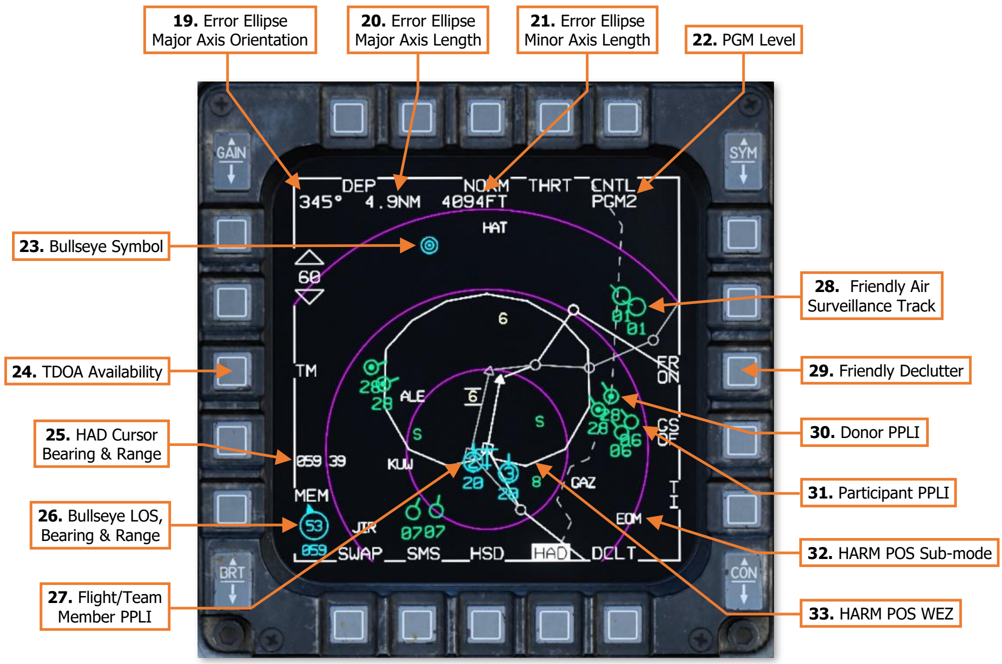
14. **Memory (MEM).** Not implemented.

15. **Geo Specificity (GEO).** Not implemented.

16. **Target Isolate (TI).** Not implemented.

17. **Aircraft Reference Symbol.** Displays the relative alignment of the aircraft heading with the selected steerpoint, System Point-of-Interest (SPI), or weapon release solution. If the line is to the left or right of the watermark, the pilot must turn left or right respectively toward the vertical line to align the aircraft on course toward the selected steerpoint, SPI, or weapon release solution.

18. **Destination Steerpoint.** Steerpoints 81-99 are displayed using up to three alphanumeric characters and may be used to depict airfield locations, geographic landmarks, or other points of interest.



19. **Error Ellipse Major Axis Orientation.** Displays the orientation (in degrees magnetic) of the major axis of the error ellipse for the radar threat under the HAD cursor or the designated SEAD target.

20. **Error Ellipse Major Axis Length.** Displays the length, in nautical miles (NM) or feet (FT), of the major axis of the error ellipse for the radar threat under the HAD cursor or the designated SEAD target.

21. **Error Ellipse Minor Axis Length.** Displays the length, in nautical miles (NM) or feet (FT), of the minor axis of the error ellipse for the radar threat under the HAD cursor or the designated SEAD target.

22. **PGM Level.** Displays the quality of the ranging data for employing precision guided munitions. PGM levels are ranked 1 through 5, with PGM 5 being the least accurate and PGM 1 being the most accurate.

23. **Bullseye Symbol.** Depicts the location of the Bullseye point. The Bullseye point is normally set to steerpoint 25 but can be set to a different steerpoint on the BULL DED page.

24. **TDOA Availability.** Determines the Flight/Team members from which TDOA messages will be accepted. When a TDOA message is received via TNDL, the ownship HTS pod will be slaved to the Flight/Team member's HTS pod that initiated a TDOA sequence against a radar emitter.
    - **TM (Team).** TDOA messages will only be accepted from Flight/Team members that are added to the TDOA sub-team. (See TNDL STN DED page for more information.)
    - **AL (All).** TDOA messages will be accepted from any Flight/Team member and Donor.
    - **NO (None).** TDOA messages will not be accepted from any Flight/Team members or Donors.
25. **HAD Cursor Bearing & Range.** If Bullseye is enabled on the BULL DED page, displays the bearing (in degrees magnetic) and range (in nautical miles) from the Bullseye steerpoint to the HAD cursor.
26. **Bullseye LOS, Bearing & Range.** Displays a pointer symbol that indicates the relative direction (line-of-sight or LOS) to the Bullseye steerpoint from the nose of the ownship; and displays the ownship's range (in nautical miles) and bearing (in degrees magnetic) from the Bullseye steerpoint, with the range displayed inside the pointer symbol and the bearing from Bullseye displayed below it.
27. **Flight/Team Member PPLI.** A TNDL-participant aircraft that is set as a Flight member (1-4) or a Team member (5-8) of the ownship.
28. **Friendly Air Surveillance Track.** A friendly aircraft that has been detected by an AWACS aircraft and distributed across the TNDL network as an air surveillance track.
29. **Friendly Declutter.** Controls the display of PPLI symbols received over TNDL datalink. Each press will cycle through the three declutter settings.
    - **FR ON.** All PPLI symbols are displayed.
    - **FL ON.** Only Flight member (1-4), Team member (5-8), and Donor PPLI symbols are displayed. All other participant PPLI symbols are hidden.
    - **FR OFF.** All PPLI symbols are hidden.
30. **Donor PPLI.** A TNDL-participant aircraft that is set as a Donor to the ownship.
31. **Participant PPLI.** A TNDL-participant aircraft that is neither a Flight/Team member nor a Donor.
32. **HARM POS Sub-mode.** Displays the POS sub-mode when the selected weapon on the SMS MFD format is AGM-88 missiles and the HARM operational mode is set to POS. If TMS Forward is pressed and held while the HAD is SOI, the POS sub-mode will be cycled in the following manner: EOM → RUK → PB → EOM.
    - **EOM.** The POS sub-mode is set to Equations Of Motion.
    - **RUK.** The POS sub-mode is set to Range Unknown.
    - **PB.** The POS sub-mode is set to Pre-Briefed.

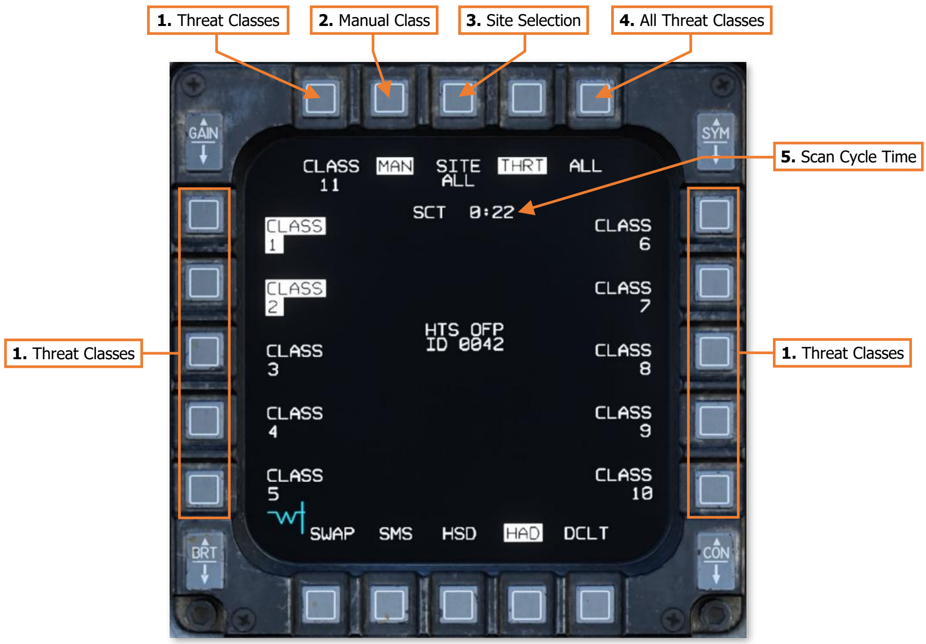
    The POS sub-mode may also be changed on the WPN MFD format when AGM-88 is the selected weapon.
33. **HARM POS WEZ.** Depicts the HARM weapon engagement zone (WEZ) when the master mode is A-G, the selected weapon on the SMS MFD format is AGM-88 HARM missiles, and the HARM operational mode is set to POS. The WEZ shape is based on the selected POS sub-mode and will dynamically change in size based on real-time calculations of the aircraft's current attitude, altitude, and velocity.

    If the entire WEZ is displayed within the boundaries of the HAD MFD format at the selected range scale and/or EXP field-of-view, the WEZ outline will be solid. If any portion of the WEZ extends beyond the boundaries of the HAD, the WEZ outline will be dashed.

    (See the Air-to-Ground Weapons Employment chapter for more information regarding AGM-88 missile employment.)

HAD Threat (THRT) Page

The HAD Threat page is accessed by pressing OSB 4 on the base page of the HAD MFD format. The HARM Targeting System includes several threat "classes" with specific radar types grouped within each class, allowing the pilot to optimize the HTS scan intervals for more efficient detection and geo-location of the threat radars. Each HAD threat class is pre-programmed into the HARM Targeting System software and cannot be configured from the cockpit. However, the HTS can be configured to utilize a Manual threat class, which can be edited from the HTS DED page at any point during the mission.



1. **Threat Classes.** When these options are highlighted, radar types within the corresponding threat class are added to each HTS scan cycle. Threat classes 1-5 along the left side of the MFD include ground and naval air defense systems of Russian or Chinese design. Threat classes 6-10 along the right side of the MFD include ground and naval air defense systems of American or western European design.

   A complete list of each threat class can be viewed in Appendix C.

2. **Manual Class (MAN).** When this option is highlighted, radar types within the Manual threat class are added to each HTS scan cycle. This option is only displayed on the THRT page when threat radars have been added to the Manual threat class on the HTS DED page.

3. **Site Selection (SITE).** Not implemented.

4. **All Threat Classes (ALL).** Highlights/de-highlights all threat classes simultaneously. If some threat classes are highlighted while others are not, the first press of this button will highlight all threat classes. Each subsequent press will highlight/de-highlight all threat classes at once. If MAN is displayed at OSB 2, each subsequent press of ALL at OSB 5 will alternate between enabling classes 1-11 and the Manual threat class.

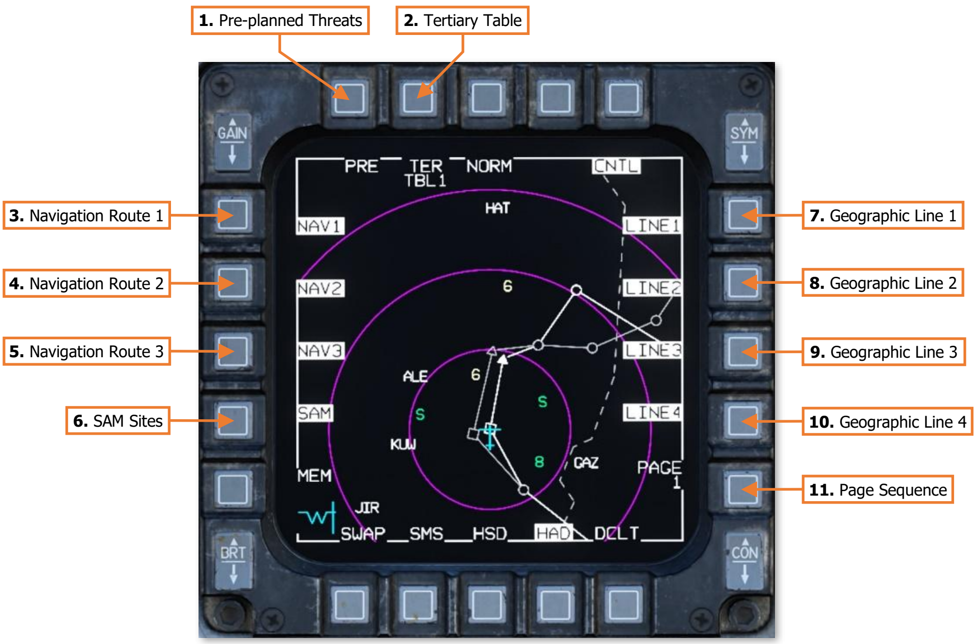
5. **Scan Cycle Time (SCT).** Displays the time the HTS requires to perform one complete scan cycle and refresh the HAD with the estimated locations and emission status of each detected threat radar. The scan cycle time is dependent on the number of threat radar types for which the HTS must scan. Highlighting only those threat classes that are needed to perform the mission will reduce the time required to accurately determine the location of detected radar systems.

HAD Control (CNTL) Page

The HAD Control page is accessed by pressing OSB 5 on the base page of the HAD MFD format. The Control page is used to configure which graphic elements are displayed to suit the tactical situation or individual preferences, or to configure specific functions of the HTS pod itself.

HAD Control Page 1

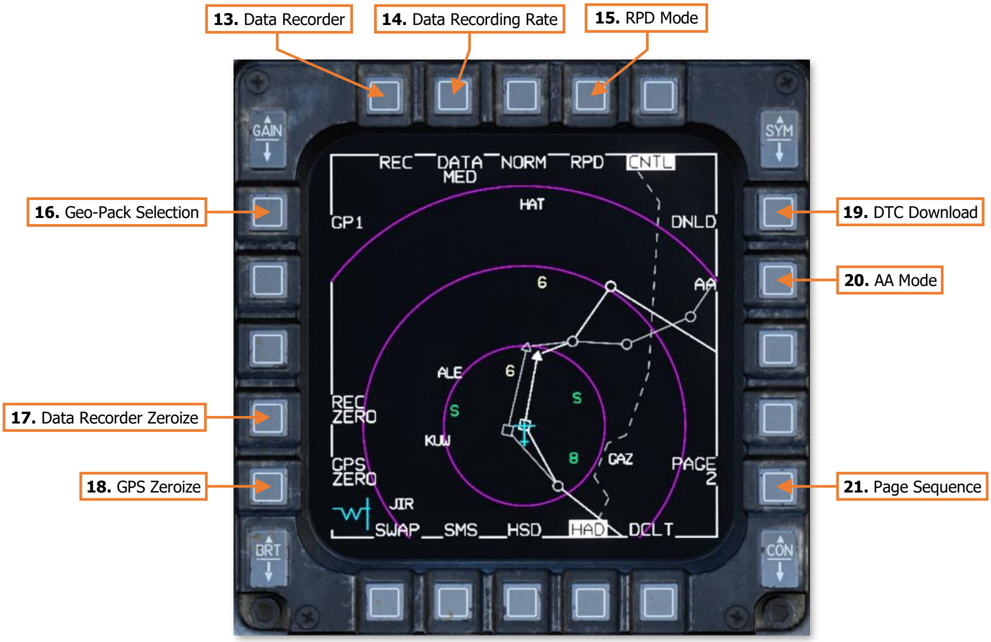
The first page presents options regarding which base level graphics uploaded from the DTC are displayed on the HAD. Enabling/disabling these options will also enable/disable the corresponding option on the HSD Control page, with the exception of PRE (OSB 2), which may be independently toggled on the HSD and HAD Control pages.



1. **Pre-planned Threats (PRE).** Toggles the display of pre-planned threats uploaded from the DTC.
2. **Tertiary Table (TER).** Not implemented.
3. **Navigation Route 1 (NAV1).** Toggles the display of the navigation route 1 loaded from the DTC.
4. **Navigation Route 2 (NAV2).** Toggles the display of the navigation route 2 loaded from the DTC.
5. **Navigation Route 3 (NAV3).** Toggles the display of the navigation route 3 loaded from the DTC.
6. **SAM Sites (SAM).** Toggles the display of SEAD targets received via TNDL.
7. **Geographic Line 1 (LINE1).** Toggles the display of geographic line/shape 1 loaded from the DTC.
8. **Geographic Line 2 (LINE2).** Toggles the display of geographic line/shape 2 loaded from the DTC.
9. **Geographic Line 3 (LINE3).** Toggles the display of geographic line/shape 3 loaded from the DTC.
10. **Geographic Line 4 (LINE4).** Toggles the display of geographic line/shape 4 loaded from the DTC.
11. **Page Sequence.** Cycles the MFD to Page 2 of the HAD Control page.

HAD Control Page 2

The second page displays additional options and functions of the AN/ASQ-213 HARM Targeting System.



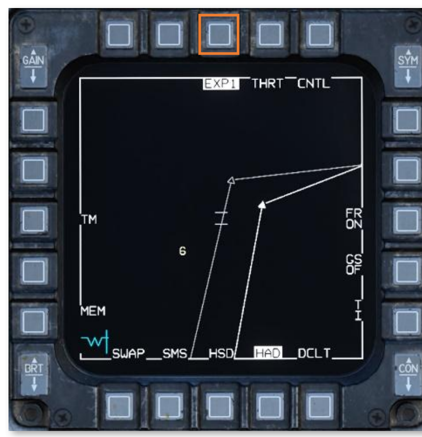
12. **Data Recorder (REC).** Not implemented.
13. **Data Recording Rate (DATA).** Not implemented.
14. **RPD Mode (RPD).** Not implemented.
15. **Geo-Pack Selection (GP).** Not implemented.
16. **Data Recorder Zeroize (REC ZERO).** Not implemented.
17. **GPS Zeroize (GPS ZERO).** Not implemented.
18. **DTC Download (DNLD).** Not implemented.
19. **AA Mode (AA).** Not implemented.
20. **Page Sequence.** Cycles the MFD to Page 1 of the HAD Control page.

Expand (EXP) Fields-Of-View

If threat radar symbols are in close proximity to other symbols or graphics on the HAD MFD format, making it difficult to determine the type of radar or designate a specific threat radar symbol, a portion of the HAD may be enlarged to assist the pilot with target sorting. If the HAD is the Sensor-Of-Interest (SOI), the HAD Expand fields-of-view may be entered by pressing OSB 3 on the base page of the HAD MFD format or by pressing the Expand/FOV button on the Side Stick Controller (SSC).

When OSB 3 or the Expand/FOV button is pressed, the HAD will advance to the next field-of-view in a cyclic manner: NORM → EXP1 → EXP2 → NORM. The current field-of-view is displayed below OSB 3.

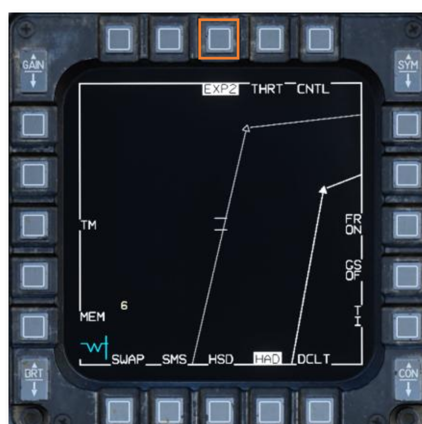
- **NORM.** The HAD is centered/depressed as selected at OSB 1 and is displayed in a normal, 1:1 zoom ratio.
- **EXP1.** The HAD is centered on the current position of the HAD cursor and switches to a 2:1 zoom ratio. The Range Rings are removed from the HAD.
- **EXP2.** The HAD is centered on the current position of the HAD cursor and switches to a 4:1 zoom ratio. The Range Rings are removed from the HAD.



Additionally, the following options are removed from the HAD when EXP1 or EXP2 fields-of-view are entered:

- Centered/Depressed option at OSB 1.
- Range Scale and Range Scale Increase/Decrease options at OSB 19 and OSB 20.

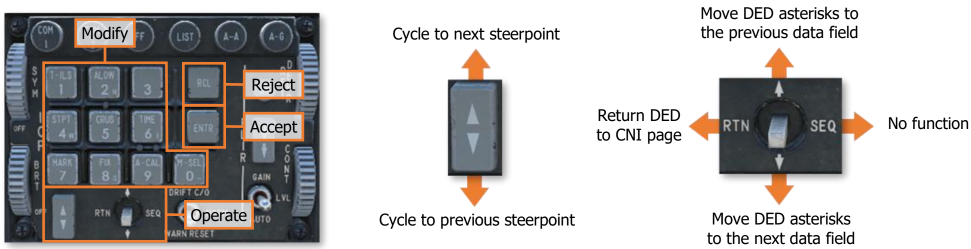
The Expand fields-of-view may be exited by pressing OSB 3 or the Expand/FOV button on the SSC to cycle back to NORM. The HAD will automatically return to NORM field-of-view if the SOI is assigned to another MFD format or the HUD.



HTS DED Page

The HARM Targeting System DED page is accessed by pressing **ENTR** on the ICP keypad when the MISC DED page is displayed on the DED. This page is used to configure a Manual threat class for use on the HARM Attack Display MFD format. The Manual threat class can be utilized to better tailor the HTS scan cycles to the radar signals that are anticipated to be encountered during the mission.

The HTS DED page will only be displayed on the MISC page list when an ASQ-213 HTS pod is installed on the aircraft and powered using the SNSR PWR control panel.



1. **Threat Number.** Up to eight radar types may be added to the HAD Manual threat class.

2. **Threat ALIC Code.** Displays the ALIC code representing a specific radar type that is loaded into the corresponding threat entry. May be modified by placing the DED asterisks over the data field, inputting an ALIC code using the ICP keypad, and pressing ENTR. An empty ALIC code slot will be displayed as four X characters.

3. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.

4. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

SEAD TARGET DESIGNATION & RANGING

Designating an HTS-detected radar as a SEAD target on the HAD MFD format allows the pilot to establish a steerpoint or the System-Point-of-Interest (SPI) at that location, transmit SEAD Target messages to other F-16s across the datalink, or handoff a radar threat to an onboard AGM-88 missile for engagement, depending on the selected MMC master mode and/or weapon delivery sub-mode.

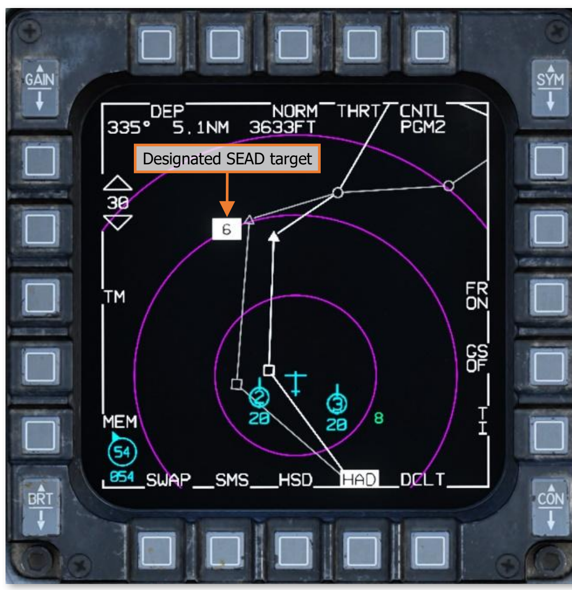
- If the master mode is set to Navigation (NAV) or Air-to-Ground (A-G) and the air-to-ground weapon delivery sub-mode is set to any "Pre-planned" sub-mode (such as CCRP) or Manual bombing, designating a SEAD target slaves the selected steerpoint, offset aimpoint, VIP initial point, or VRP reference point to the designated radar threat, depending on the sighting point selected at OSB 10.

  If the selected weapon on the SMS MFD format is AGM-88 missiles, designating a SEAD target also sets the HARM mode to POS, hands off the designated radar type and position to the selected AGM-88 missile, and automatically sets the sighting point to TGT. (See the Air-to-Ground Weapons Employment chapter for information regarding AGM-88 missiles.)

- If the master mode is set to Air-to-Ground (A-G) and the air-to-ground weapon delivery sub-mode is set to any "Visual" sub-mode that employs a visual ground designation (such as DTOS), designating a SEAD target slaves the Target Designator (TD) box in the HUD/HMCS to the designated radar threat and transitions the weapon delivery sub-mode to a post-designate state.

- If the master mode is set to Air-to-Ground (A-G) and the air-to-ground weapon delivery sub-mode is set to CCIP or STRF, designating a SEAD target slaves the selected steerpoint to the designated radar threat.

A radar threat is designated as the SEAD target by slewing the HAD cursor over the intended radar threat using the RDR CURSOR/ENABLE switch on the throttle grip and pressing TMS Forward on the Side Stick Controller (SSC).



Once designated, the SEAD target is highlighted within a box to indicate the HTS is in control of the SPI and weapon symbology in the HUD and HMCS are referenced to the SEAD target. The format of the SEAD target box indicates the ranging method and whether a handoff of the SEAD target to the selected AGM-88 missile has occurred.

6	AOA-ranged radar is designated.
+6	TDOA-ranged radar is designated.
6 (red)	AOA-ranged radar is designated and handed off to an AGM-88 missile.
+6 (red)	TDOA-ranged radar is designated and handed off to an AGM-88 missile.

Pressing TMS Right will step the SEAD target designation to the next HTS-detected radar threat.

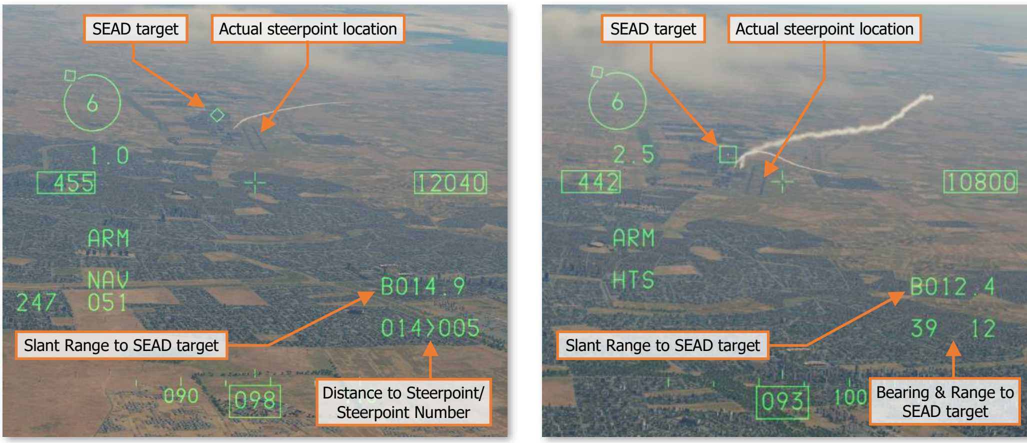
Pressing TMS Left (<0.5 seconds) while a SEAD target is designated will display the SEAD DED page.

Pressing TMS Left (>0.5 seconds) while a SEAD target is designated will initiate TDOA ranging of the SEAD target.

Pressing TMS Aft will reject the designated SEAD target but will not remove any cursor slews that have accumulated following the SEAD target designation. Cursor Zero may be used to remove any cursor slews.

Once a SEAD target has been designated, the A-G Acquisition Cursor on the FCR MFD format and the TGP sensor turret's line-of-sight will be slaved to the new SPI location, allowing the pilot to electro-optically confirm the accuracy of the target location with the TGP from long-range, or visually through the HUD or HMCS from short-range. However, depending on the tactical situation and the nature of the air defenses, this may not always be possible.

When and if the accuracy of the SEAD target's location is confirmed, the pilot may use other onboard sensors to store a markpoint at that location; or engage the radar itself or associated air defenses with onboard weapons besides the AGM-88 HARM, such as cluster munitions, AGM-154 JSOW glide bombs, or AGM-65 missiles.



SEAD target designation in NAV (left) and A-G (right) master modes

Regardless of whether a SEAD target is designated, the HTS pod will continue to passively geo-locate any radar emitters detected within its field-of-regard using AOA ranging. However, if at least two additional HTS-equipped F-16s are in the flight, cooperative TDOA ranging may be initiated to more precisely refine the location of the designated SEAD target, as described on the following pages. Whereas AOA ranging can refine the general location of a radar emitter to the extent that it can be acquired using other sensors such as a targeting pod the precision of TDOA ranging permits direct targeting of a radar emitter using the HTS alone, achieving a position quality of PGM1. PGM1 will typically be well within the blast radius of the Mk80-series general purpose bombs or their inertially-aided JDAM equivalents.

Angle-Of-Arrival (AOA) Ranging

The primary method of passive ranging the ASQ-213 employs for geo-locating radar emitters is AOA ranging. AOA ranging is performed autonomously and continuously any time the pod itself is powered and operational.

AOA ranging allows the HTS pod to scan for multiple radar emitters within its field-of-regard during each scan cycle. However, AOA ranging requires more time to achieve an accurate position of each emitter, requires that the F-16 be flown at an oblique angle relative to the bearing of the radar emitter, and can only achieve a position quality of PGM2. Further, the time required to geo-locate each emitter within the field-of-regard is directly proportional to how many types of radar emitters are included in the HTS pod's scan cycles. As more types of radar emitters are included in each scan cycle, the efficiency of the HTS pod decreases as the length of each scan cycle lengthens. The pilot can optimize the HTS scan cycle via the HAD THRT page and/or the HTS DED page.

In the first image on the right, the HTS field-of-regard is illustrated as the shaded region, with the designated SEAD target located directly in front of the ownship. Since AOA ranging cannot be accurately performed for radar emitters that are directly in front of the aircraft, the size of the error ellipse is quite large and the position quality of the designated SEAD target will typically remain at PGM4 or PGM5.

If the pilot maneuvers the aircraft to place the designated SEAD target to either side of the nose as illustrated in the second image on the left, the relative offset between each measured angle-of-arrival of the radar's emissions will increase during subsequent HTS scan cycles, reducing the size of the error ellipse and improving the position quality to PGM3 or PGM2.

It is worth noting that the position quality of any HTS-detected radar emitter can be viewed without designating the radar as the SEAD target, by simply placing the HAD cursor over the radar symbol and viewing the expanded target data along the top of the HAD format.

Additionally, although AOA ranging is less accurate and less efficient compared to TDOA ranging, AOA ranging can be employed by a single F-16 without relying on additional HTS-equipped F-16 flight members for cooperative geo-location via datalink.

Time-Difference-Of-Arrival (TDOA) Ranging

An alternative method of passive ranging the ASQ-213 may employ for geo-locating radar emitters is TDOA ranging. TDOA ranging is performed on command by the pilot to refine the location of the designated SEAD target.

TDOA ranging allows a specific radar emitter to be located more precisely and more rapidly than is possible using AOA ranging and can do so with any radar emitter detected within the field-of-regard of the HTS pod. Further, TDOA ranging does not require the F-16 to be flown at an oblique angle relative to the bearing of the radar emitter. However, TDOA ranging requires at least three HTS-equipped F-16s to contribute ranging data and cooperatively calculate the location of the designated TDOA target, and can only be performed on a single designated radar emitter at a time.

TDOA Master

In the images shown on this page, a SEAD target is designated on the HAD MFD format and the pilot presses TMS Left for greater than 0.5 seconds to initiate the TDOA ranging process. "TDOA" is displayed in the center of the HUD and a TDOA message is transmitted across the TNDL network containing information identifying the signal characteristics of the TDOA target and a request to other HTS-equipped F-16s to support TDOA ranging. If at least two other HTS-equipped F-16s are available to support TDOA ranging, the TDOA process begins and "TD-M" is displayed above OSB 15 on the HAD, identifying the ownship as the TDOA master.

Once the HTS pods onboard the F-16s supporting the TDOA ranging processes begin contributing ranging data, a dashed white lock line is displayed on the HAD between the TDOA target and the PPLIs of each TDOA slave. The "TDOA" notification may be removed from the HUD by momentarily placing the Drift Cut-Out/Warning Reset switch on the ICP to the WARN RESET position after the TDOA ranging process begins.

The size of the error ellipse and the quality of the position data will be dynamically updated within the expanded target data along the top of the HAD format. When the position quality reaches PGM1, the HTS pod utilizes the F-16's Digital Terrain System (DTS) to precisely calculate the 3-dimensional location of the TDOA target, after which the target symbol is appended with a **+** character (e.g., **+6** for a TDOA-ranged SA-6 radar) and the PGM level is displayed in the bottom right corner of the HAD of the TDOA master, replacing the HARM POS sub-mode status.

Pressing TMS Aft (<0.5 seconds) will reject the designated SEAD target and terminate TDOA ranging. A TDOA cancellation message will be transmitted to each TDOA slave and the lock lines will be removed from the HAD.

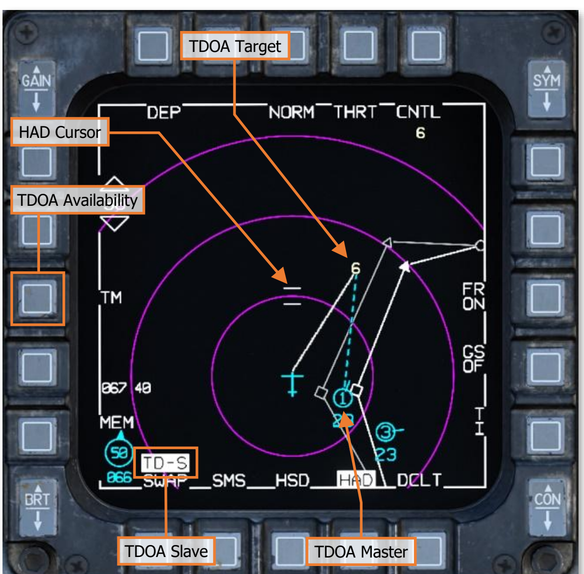
Pressing TMS Aft (>0.5 seconds) will terminate TDOA ranging and transmit a TDOA cancellation message to each TDOA slave in the same manner but will not reject the designated SEAD target.

TDOA Slave

If an HTS-equipped F-16 is available to support TDOA ranging initiated by another HTS-equipped F-16 (TDOA Availability at OSB 18 is set to TM or AL on the HAD MFD format), and a TDOA message is received across the TNDL network, a "Data" voice message will be heard and "TDOA" will be displayed in the center of the HUD. The "TDOA" notification may be removed from the HUD by momentarily placing the Drift Cut-Out/Warning Reset switch on the ICP to the WARN RESET position.

When the HTS pod processes the target information contained within the TDOA message, the TDOA process begins and "TD-S" is displayed above OSB 15 on the HAD, identifying the ownship as a TDOA slave. A dashed cyan lock line is displayed on the HAD between the TDOA target and the PPLI of the TDOA master that designated the TDOA target, and a solid white assignment line is displayed between the ownship and the TDOA target. If the range to the TDOA target is unknown, a solid red line will be displayed between the PPLI of the TDOA master and the edge of the MFD display area along the bearing to the TDOA target until the range can be measured.

If the TDOA target is outside the field-of-regard of the HTS pod when a TDOA message is received, <--TDOA or TDOA--> will be displayed in the center of the HUD, indicating the direction to which the pilot must turn to orient the HTS pod toward the TDOA target in order to support the TDOA ranging process. In the first image on the right, the aircraft is oriented to the south and receives a TDOA message for a radar that is at the 4 o'clock position. After hearing "Data", the pilot views the TDOA--> notification in the center of the HUD and performs a right turn to orient the aircraft toward the TDOA target. Once the TDOA target is within the HTS field-of-regard, the arrow characters are removed from the HUD and TDOA remains displayed.



In the second image on the left, the pilot of Flight member 2 performed a right turn to orient the HTS pod field-of-regard toward the TDOA target, which has been designated by Flight member 1 as the TDOA master.

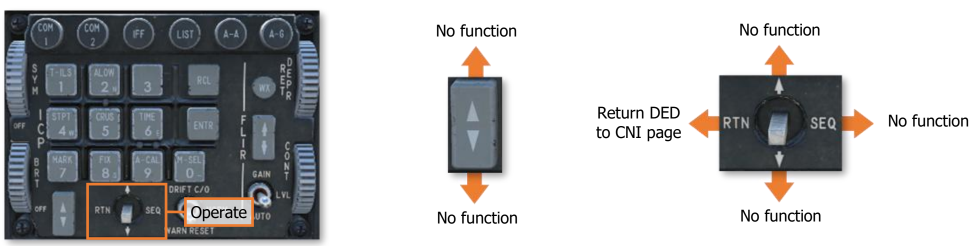
If desired, the size of the error ellipse and the quality of the position data may be monitored within the expanded target data along the top of the HAD format by placing the HAD cursor over the TDOA target symbol. When the position quality reaches PGM1, the target symbol is appended with a **+** character (e.g., **+6** for a TDOA-ranged SA-6 radar).

NOTE: The target information contained within the TDOA message temporarily overrides the settings on the HAD THRT page. If the designated radar type is not included within the HTS scan cycle, the TDOA target information will include the radar type within the HTS scan cycle for the duration of the TDOA ranging process until TDOA ranging is terminated.

SEAD DED Page

The Suppression of Enemy Air Defenses DED page is accessed by pressing TMS Left (<0.5 seconds) on the Side Stick Controller (SSC) when a radar threat on the HAD MFD format has been designated as the SEAD target and the HAD is the Sensor-Of-Interest (SOI). This page is used to view the coordinates of the designated radar based on angle-of-arrival (AOA) or time-difference-of-arrival (TDOA) passive ranging measurements and geo-location. This information may be used to verbally communicate the location of enemy radar emitters to other friendly aircraft in the vicinity for subsequent targeting or avoidance.

NOTE: Due to the passive ranging nature of the HARM Targeting System, the accuracy of the coordinates displayed on the SEAD DED page is dependent on the position quality of the ranging data for that specific radar threat. The size of the error ellipse and corresponding PGM level should be taken into consideration when using these coordinates for reconnaissance or targeting purposes.



1. **SEAD Target Latitude.** Displays the latitude (in DD° MM.M' format) of the designated SEAD target.

2. **SEAD Target Longitude.** Displays the longitude (in DDD° MM.M' format) of the designated SEAD target.

3. **SEAD Target Elevation.** Displays the elevation (in feet above Mean Sea Level, MSL) of the designated SEAD target.

4. **Time On Target.** Displays the time remaining to travel from the current position of the ownship to the designated SEAD target based on the current ground speed.

The SEAD DED page will always display the coordinates of the designated SEAD target. If TMS Right is used to step the SEAD target designation to another radar threat on the HAD, or the calculated position of the designated SEAD target changes during the passive ranging process, the coordinates displayed on the SEAD DED page will be updated to reflect the location of the currently designated SEAD target.

Pressing TMS Aft will return the DED to the CNI page and reject the designated SEAD target but will not remove any cursor slews that have accumulated following the SEAD target designation. Cursor Zero may be used to remove any cursor slews.

Configuring a TDOA Sub-team

The TDOA sub-team determines the Flight/Team members from which TDOA messages will be accepted when the TDOA Availability option (OSB 18) on the HAD MFD format is set to TM. If any Flight/Team member not designated as the TDOA sub-team transmits a TDOA message, the message will be rejected by the ownship unless the TDOA Availability option is set to AL. The TDOA sub-team may be configured from the DLNK DED pages, which are accessed by pressing the **ENTR** button on the ICP keypad when the LIST DED page is displayed.

To configure the TDOA sub-team amongst the Flight/Team members, perform the following:

1. ICP DCS Switch – **SEQ** to cycle to the TNDL STN DED page (P3>).
2. ICP DCS Switch – **Up/Down** as necessary to place the DED asterisks adjacent to the STN of the corresponding Flight/Team member.
3. ICP Keypad – Press any button **1-9** to add or remove the Flight/Team member from the TDOA sub-team. (i.e., "T" indicates TDOA sub-team.)
4. Repeat steps 2 and 3 as necessary.

(See the Tactical Net Datalink chapter for more information regarding editing the Flight/Team member STN network.)

TDOA Ranging a SEAD Target (Master)

To initiate TDOA ranging of an HTS-detected radar, perform the following:

1. MFD format – Select **HAD**.
2. DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HAD MFD format.
3. RDR CURSOR/ENABLE Switch – Slew the HAD cursor to the symbol of the HTS-detected radar intended for TDOA ranging.
4. TMS Up-Short – Press to designate the radar symbol as the SEAD Target.
5. TMS Left-Long – Press to initiate TDOA ranging of the designated SEAD Target.
6. **(Optional)** TMS Aft-Short – Press to terminate TDOA ranging and drop target designation.

   or

6. **(Optional)** TMS Aft-Long – Press to terminate TDOA ranging without dropping target designation.

NOTE: TDOA ranging requires a minimum of three HTS-equipped F-16s within the flight.

TDOA Ranging a SEAD Target (Slave)

To support TDOA ranging of an HTS-detected radar designated by another Flight/Team member, perform the following:

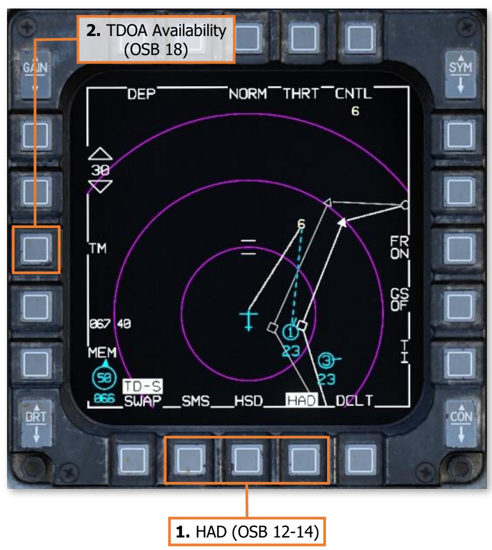
1. MFD format – Select **HAD**.
2. TDOA Availability (OSB 18) – Select **TM** to accept TDOA messages from TDOA sub-team only. (See TNDL STN DED page for more information.)

   or

2. TDOA Availability (OSB 18) – Select **AL** to accept TDOA messages from any Flight/Team members.
3. If necessary, maneuver the aircraft in the direction of the TDOA steering displayed in the center of the HUD until the designated TDOA target is within the field-of-regard of the HTS pod.
4. **(Optional)** Maneuver the aircraft to gain separation from other Flight/Team members that are supporting TDOA ranging. This will increase the measured time-difference-of-arrival between the other Flight/Team members and accelerate the TDOA ranging process.

To terminate support of TDOA ranging, perform the following:

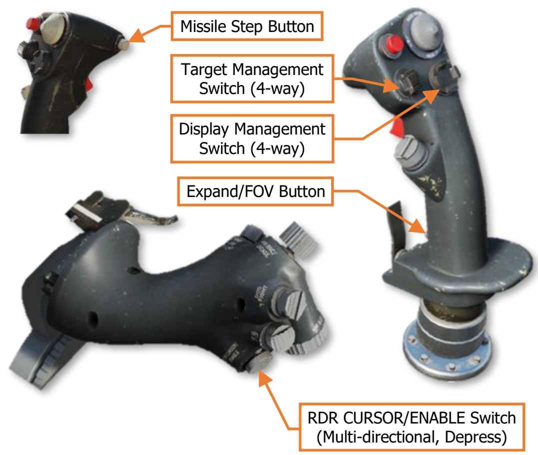
1. TDOA Availability (OSB 18) – Select **NO** to reject TDOA messages from all Flight/Team members.



HANDS-ON CONTROLS

The Target Management Switch (TMS) and Expand/FOV button on the Side Stick Controller (SSC), along with the RDR CURSOR/ENABLE switch on the throttle grip, are the pilot's controls for interacting with the HARM Attack Display (HAD) and designating radar threats for targeting by the aircraft's sensors or engagement by AGM-88 HARM anti-radar missiles.

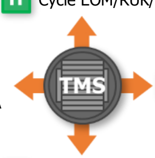
NOTE: These commands are only active when the Display Management Switch (DMS) is used to set the HAD MFD format as the Sensor-Of-Interest (SOI). (See the Tactical Employment chapter for more information.)



Throttle Grip Commands. The RDR CURSOR/ENABLE switch is multi-directional, allowing the HAD cursor to be moved in any direction.

C Slew HAD Cursor

Side Stick Controller (SSC) Commands. The Target Management Switch (TMS) and Expand/FOV button commands are contextual, based on the SOI and whether a threat radar has been designated as a target on the HAD MFD format.



TMS Forward:
- S Designate Target
- H Cycle EOM/RUK/PB Sub-modes

TMS Left:
- S Display SEAD DED page [1]
- L Initiate TDOA Ranging

TMS Right:
- D Target Step [1]

TMS Aft:
- S Target Reject
- D Display CNI DED page [2]
- L Terminate TDOA Ranging [3]

- S Cycle HAD EXP Modes
- C Display HSD ZOOM Mode

Legend:
- S Short press (<0.5 sec)
- L Long press (>0.5 sec)
- C Continuous press
- D Short press, SEAD DED page displayed
- H Long press, AGM-88 selected

1. TMS Left and TMS Right commands are only available when a radar threat is designated as a SEAD target on the HAD MFD format.
2. TMS Aft will only return the DED to the CNI page from the SEAD DED page.
3. Pressing TMS Aft (>0.5 sec) while TDOA ranging a radar threat will terminate TDOA ranging but retain the designated SEAD target.

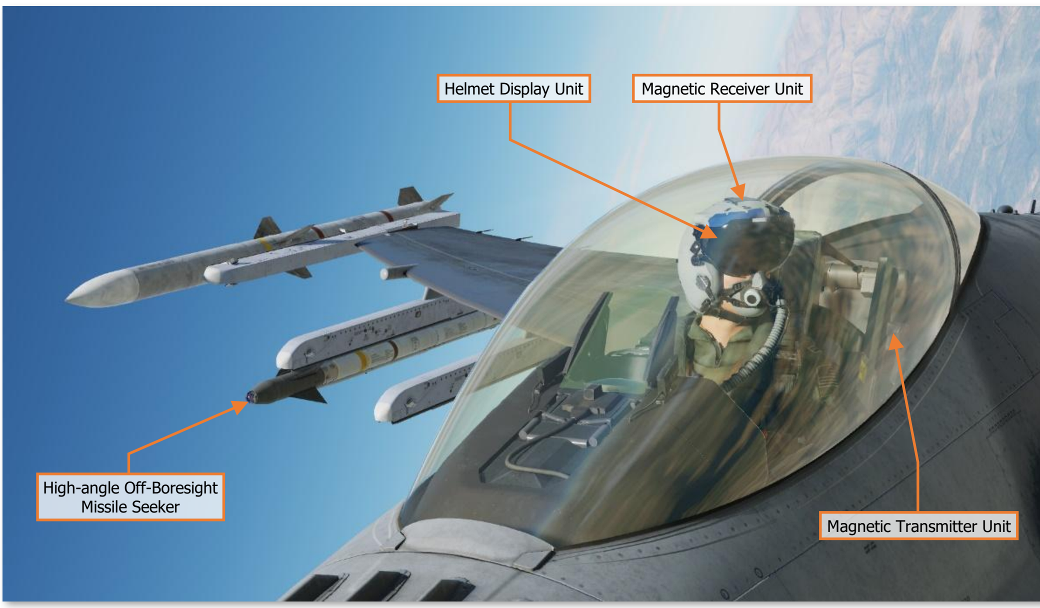
JOINT HELMET-MOUNTED CUEING SYSTEM

USAF Photo
by A1C Kevin Tanenbaum

HELMET MOUNTED CUEING SYSTEM

The Joint Helmet Mounted Cuing System (JHMCS) features a Helmet Display Unit (HDU) that can be attached to the pilot's flight helmet, which projects aircraft, sensor, and weapon information directly onto the helmet visor, without needing to look forward through the HUD or down inside the cockpit. The JHMCS system, which is installed on various military aircraft, is simply referred to as the Helmet Mounted Cueing System (HMCS) in the F-16C avionics.

The HMCS also allows sensors and weapons to be slaved, or "cued", to the pilot's helmet line-of-sight, up to 80° off-boresight. This is a particularly effective system when paired with the AIM-9X missile, which contains a high-angle off-boresight (HOB) seeker that is capable of tracking targets that are significantly outside of the HUD field-of-view. This capability can be quite lethal during air-to-air engagements that occur within visual range (WVR).



Joint Helmet Mounted Cueing System (JHMCS)

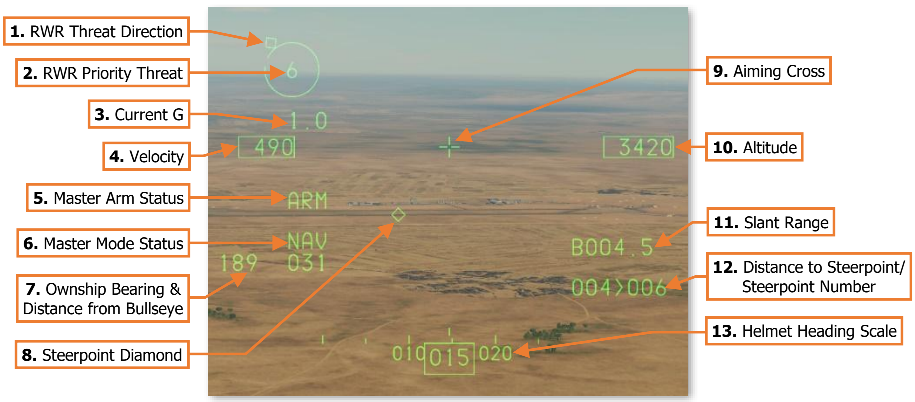
The JHMCS visor itself contains a Magnetic Receiver Unit (MRU), which detects magnetic signals emitted by the Magnetic Transmitter Unit (MTU) to relay helmet position and orientation to the aircraft electronics. These signals are used by the aircraft electronics to steer sensors and weapons when commanded, and to determine the appropriate virtual symbology to augment the pilot's vision in order to increase situational awareness.

In realty, JHMCS symbology is projected onto the helmet visor in front of the right eye only. However, for some DCS players, this may cause discomfort in VR. DCS: F-16C Viper allows players to selectively project the JHMCS symbology onto either eye or both eyes, depending on player preference. This option may be set on the SPECIAL Tab within the DCS: World Options.

HMCS Symbology

The HMCS is enabled using the SYMBOLOGY INT knob on the HMCS control panel. Rotating the knob clockwise increases the brightness intensity of the symbology and rotating it to the OFF position removes the HMCS symbology from the visor and disables the system.

Some elements of the HMCS symbology are always present, others will be displayed or removed based on the selected master mode, available sensor(s), or weapon profile; and some elements can be optionally displayed or removed based on pilot preference. (See HMCS DED Settings for more information.)



1. **RWR Threat Direction.** Displays the relative azimuth of the priority threat detected by the RWR, indicated by a diamond. If the diamond is located at the top of the circle, the priority threat is directly in front of the aircraft. If the diamond is located at the bottom of the circle, the priority threat is directly behind the aircraft. If no priority threat is present, this symbology element will blank.

   A gap in the circle indicates the azimuth of the HMCS line-of-sight (LOS) to cue the pilot to the priority threat direction. If the threat direction diamond is centered within the gap, the HMCS LOS is aligned with the priority threat direction (in azimuth only), aiding the pilot in visually acquiring the threat aircraft, air defense system, or weapon's signature.

   NOTE: The directional accuracy of this symbology is subject to the same limitations as the ALR-56M Threat Warning Azimuth Display.

2. **RWR Priority Threat.** Displays the priority threat detected by the RWR. If no priority threat is present, this symbology element will blank.

3. **Current G.** Displays the current aircraft G-load value. The G value is displayed to the nearest tenth of a G, and ranges from +9.9 to -9.9 G's.

4. **Velocity.** Velocity is displayed in knots, between 60 to 900 knots CAS. When below 60 knots CAS, the HMCS will display 48 knots.

   The Velocity may be set to calibrated airspeed (CAS), true airspeed (TAS), or ground speed (GND SPD) using the Velocity Switch on the HUD Control Panel. The Velocity will automatically revert to calibrated airspeed if in Dogfight mode or if the landing gear is deployed.

5. **Master Arm Status.** Displays the position of the MASTER ARM Switch on the MISC panel.
   - **ARM.** The MASTER ARM Switch is in the MASTER ARM position.
   - **(Blank).** No text is displayed if the MASTER ARM Switch is in the OFF position.
   - **SIM.** The MASTER ARM Switch is in the SIMULATE position.
6. **Master Mode Status.** Displays the current master mode or sub-mode.
   - **NAV.** Navigation master mode.
   - **AAM.** Air-to-Air Missile sub-mode with no missile type selected.
   - **MSL.** Missile Override master mode with no missile type selected.
   - **DGFT.** Dogfight master mode.
   - **MRM.** Medium Range Missile type selected (AIM-120B/C) while in A-A or MSL master modes.
   - **SRM.** Short Range Missile type selected (AIM-9L/M/P/P3/P5) while in A-A or MSL master modes.
   - **HOB.** High-Angle Off-Boresight missile type selected (AIM-9X) while in A-A or MSL master modes.
   - **EEGS.** Enhanced Envelope Gun Sight for employing the M61 cannon while in A-A master mode and GUN sub-mode.
   - **JETT.** Selective Jettison or Emergency Jettison master modes.
   - **HARM.** HARM Missile designation sub-mode while in A-G master mode.
   - **HTS.** HARM Targeting System designation sub-mode while in A-G master mode.
   - **CCIP.** Continuously Computed Impact Point weapon delivery sub-mode while in A-G master mode.
   - **CCRP.** Continuously Computed Release Point weapon delivery sub-mode while in A-G master mode.
   - **DTOS.** Dive/Toss weapon delivery sub-mode while in A-G master mode.
   - **LADD.** Low Altitude Drogue Delivery weapon delivery sub-mode while in A-G master mode.
   - **MAN.** Manual weapon delivery sub-mode for manual bomb delivery while in A-G master mode.
   - **VIS.** Visual weapon delivery sub-mode for employing AGM-65 (EO-VIS) or JDAM (VIS) while in A-G master mode; or when the HUD Mark Cue is active**.**
   - **PRE.** Pre-planned weapon delivery sub-mode for employing AGM-65 (EO-PRE) or JDAM (PRE) while in A-G master mode.
   - **BORE.** Boresight weapon delivery sub-mode for employing AGM-65 while in A-G master mode.
   - **STRF.** Strafe weapon delivery sub-mode for employing the 20mm M61 rotary cannon while in A-G master mode.
7. **Ownship Bearing & Distance from Bullseye.** Displays the azimuth and distance as measured from the Bullseye location to the aircraft.

   The Ownship Bearing & Distance from Bullseye can be toggled using the BULL DED page.
8. **Diamond Symbol.** Displays the 3-dimensional position of the selected steerpoint, in both position and altitude. When the Diamond Symbol is out of the HMCS field-of-view (FOV) an X is superimposed across the symbol. (See Steerpoint Navigation for more information.)
9. **Aiming Cross.** Displays the HMCS line-of-sight (LOS) for sensor cueing and target designation. If in Air-to-Air, Dogfight, or Missile Override master modes, the Aiming Cross becomes dynamic to aid the pilot in designating a target during high look-up angles and/or high-G conditions.

   If the pilot aims the HMCS LOS greater than 30° above the horizontal plane, relative to the aircraft's fuselage, the Aiming Cross will be increasingly re-positioned higher in within the vertical plane of the HMCS FOV. The Aiming Cross will reach its maximum vertical deflection at an 80° look-up angle.

10. Altitude. The Altitude is in feet, to the nearest 10 feet.

11. Slant Range. The Slant Range is the direct, straight-line distance from the aircraft to the current target or SPI location. For range values greater than 1.0 NM, the range is displayed as a four-digit value to the nearest tenth of a nautical mile (e.g., 15.2 NM is displayed as "015.2"). For range values less than 1.0 NM, the range value is displayed as a three-digit value to the nearest hundred feet (e.g., 5500 feet is displayed as "055"). The letter on the left of the display indicates the method the range is determined.

- **B.** The slant range is determined based on the barometric altitude and steerpoint elevation.
- **R.** The slant range is determined based on the radar altimeter.
- **F.** The slant range is determined based on ranging data from the FCR.
- **M.** A Manual range is being used in an air-to-air mode or in air-to-ground CCIP mode.

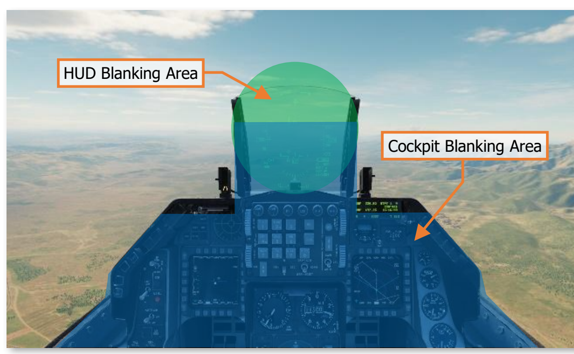
12. Distance to Steerpoint/Steerpoint Number. The distance to the selected steerpoint is displayed to the left of the chevron in 1 nautical mile increments. The selected steerpoint number is displayed to the right of the chevron. (See Steerpoint Navigation for more information.)

13. Helmet Heading Scale. The Helmet Heading Scale indicates the magnetic heading of the HMCS line-of-sight (LOS). A fixed lubber line along the top of the scale and a digital readout below the scale displays the HMCS LOS. Each major tick mark on the tape represents 10° of magnetic heading and is accompanied by a 2-digit label, and each minor tick mark represents 5° of magnetic heading.

Additional HMCS symbology elements associated with the various sensors and weapons are described in the applicable chapters of this manual.

HMCS DED Settings

The HMCS symbology is designed to work in conjunction with the existing cockpit structure and Head-Up Display (HUD). As such, the avionics is configured to removed (or "blank") the HMCS display when the pilot's helmet line-of-sight (LOS) is detected to be within specifically configured blanking areas.



HMCS Blanking Areas

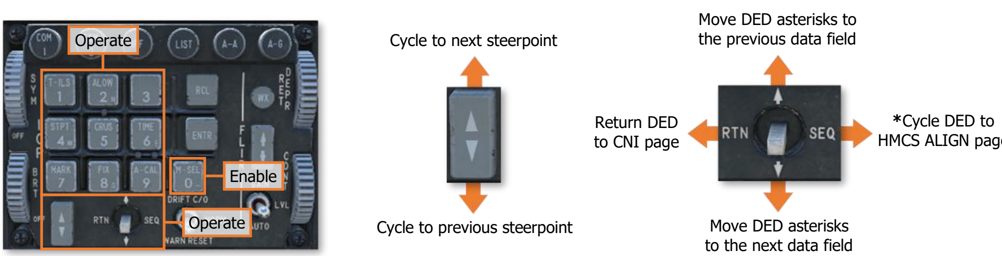
The F-16C has two blanking areas, one for the HUD and the other for the cockpit itself, with some overlap. If HMCS is enabled, whenever the pilot's helmet LOS is detected to be outside of these boundaries, the HMCS symbology will appear within the pilot's visor. However, each of these blanking areas can be individually toggled off, should the pilot choose to do so.

The HMCS must be aligned prior to takeoff. This ensures that sensors and weapons are precisely cued to the HMCS Aiming Cross and virtual symbology elements are accurately placed within the pilot's field-of-view. If the mission begins with the aircraft already operating (engine running and systems initialized), the HMCS alignment is completed for you. However, if performing a start sequence yourself (i.e. "cold start"), the HMCS alignment will need to be completed to ensure precise cueing and display during your mission.

HMCS DISPLAY DED Page

The Helmet Mounted Cueing System DED page is accessed by pressing **RCL** on the ICP keypad when the MISC DED page is displayed on the DED. This page is used to configure the HMCS display settings and perform an alignment to ensure the helmet LOS measurements are calibrated to the individual pilot.

The first HMCS DED page is the HMCS Display page, which allows the pilot to tailor the display elements to individual preferences and toggle the HMCS blanking areas, if desired.

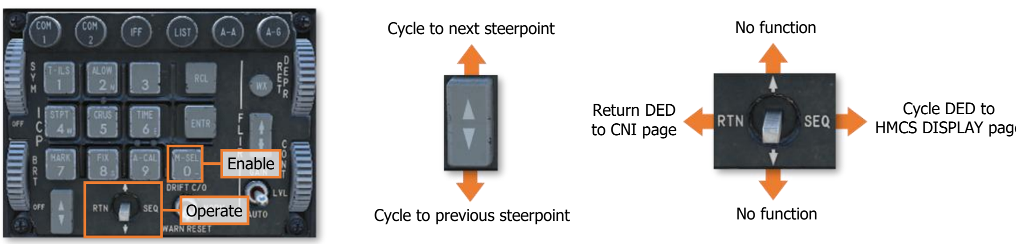


* HMCS ALIGN page is only accessible when the master mode is set to NAV.

1. **HUD Blanking.** Displayed in highlighted text when enabled using the 0/M-SEL button. When enabled, the HMCS will blank when the helmet LOS is within the boundaries of the HUD blanking area.
2. **Cockpit Blanking.** Displayed in highlighted text when enabled using the 0/M-SEL button. When enabled, the HMCS will blank when the helmet LOS is within the boundaries of the cockpit blanking area.
3. **Declutter Level.** Displays the HMCS declutter level. May be changed by placing the DED asterisks around the data field and pressing any ICP keypad button 1-9 to cycle between LVL1, LVL2, and LVL3.
   - **LVL1.** All symbology elements are displayed.
   - **LVL2.** Altitude, Distance to Steerpoint/Steerpoint Number, and Helmet Heading Scale are removed.
   - **LVL3.** Current G, Velocity, and Master Arm Status are removed, in addition to LVL2 removed elements.
4. **RWR Display.** Enables/Disables the display of the RWR priority threat and direction. May be changed by placing the DED asterisks around the data field and pressing the 0/M-SEL button to toggle between ON and OFF.
5. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

HMCS ALIGN DED Page

The second HMCS DED page is the HMCS Align page, which allows the pilot to ensure the HMCS is calibrated to the correct helmet position for accurate LOS cueing and to ensure virtual symbology elements are displayed at their correct positions within the pilot's vision.



1. **Coarse Alignment.** Initiates a coarse alignment of the HMCS. To initiate the alignment sequence, set the SYMBOLOGY INT knob on the HMCS control panel to any position other than OFF and press the 0/M-SEL button.
2. **Azimuth/Elevation Alignment.** Initiates a fine alignment of the HMCS in the azimuth and elevation axes. To initiate the alignment sequence, complete a COARSE alignment, and then press the 0/M-SEL button when the DED asterisks sequence to the AZ/EL data field.
3. **Roll Alignment.** Initiates a fine alignment of the HMCS in the roll axis. To initiate the alignment sequence, complete an AZ/EL alignment, and then press the 0/M-SEL button when the DED asterisks sequence to the ROLL data field.
4. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
5. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Performing an HMCS Alignment

A HMCS alignment is initiated with the COARSE alignment function on the HMCS ALIGN page. Ensure the HMCS SYMBOLOGY INT knob on the HMCS control panel is rotated out of the OFF position.

To perform an HMCS alignment, perform the following:

1. ICP Keypad – Press **0/M-SEL** to initiate the COARSE alignment.

The COARSE data field on the DED will become highlighted and the HUD will display an Alignment Cross. The HMCS will display a Coarse Alignment Cross and a "READY" message in the lower portion of the HMCS field-of-view (FOV).

2. Use head movements to adjust the position of the HMCS so that both alignment crosses are aligned with each other.

3. RDR CURSOR/ENABLE switch (Throttle) – Depress.

The "READY" message will change to an "ALIGNING" message. After several seconds, during which both crosses must remain aligned, the "ALIGNING" message will be replaced with an "ALIGN OK" message.

4. ICP Keypad – Press **0/M-SEL** to accept the alignment.

The COARSE data field will be de-highlighted and the DED Asterisks will automatically move to the AZ/EL data field.

5. ICP Keypad – Press **0/M-SEL** to initiate the AZ/EL alignment.

The AZ/EL data field on the DED will become highlighted and the HUD will display an Alignment Cross. The HMCS will display a DX/DY Cross in the center, and a DROLL Cross and an "FA DX/DY" message in the lower portion of the HMCS FOV.

6. RDR CURSOR/ENABLE switch (Throttle) – Position the DX/DY cross so that it is aligned with the HUD Alignment Cross.

7. ICP Keypad – Press **0/M-SEL** to accept the alignment.

The AZ/EL data field will be de-highlighted and the DED Asterisks will automatically move to the ROLL data field.

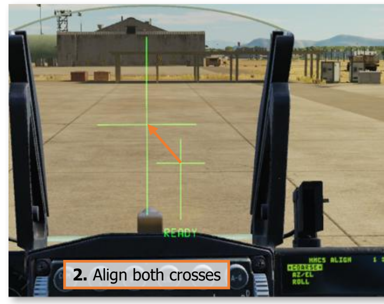
8. ICP Keypad – Press **0/M-SEL** to initiate the ROLL alignment.

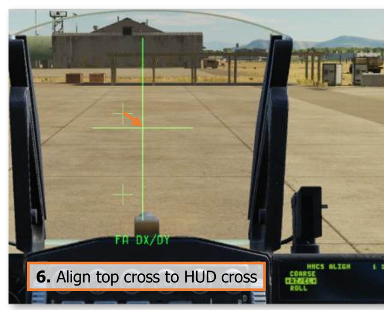
The ROLL data field on the DED will become highlighted and the HUD will display an Alignment Cross. The HMCS will display a DROLL Cross and an "FA DROLL" message in the lower portion of the HMCS FOV.

9. RDR CURSOR/ENABLE switch (Throttle) – Position the DROLL cross so that it is aligned with the lower vertical stadia line of the HUD Alignment Cross.

10. ICP Keypad – Press **0/M-SEL** to accept the alignment.

The ROLL data field will be de-highlighted and the DED Asterisks will automatically move back to the COARSE data field, indicating the HMCS alignment is complete.





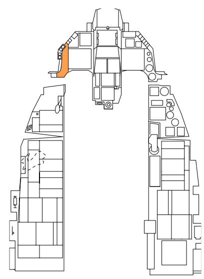
AIR-TO-AIR
WEAPONS EMPLOYMENT

AIR COMBAT PREPARATION

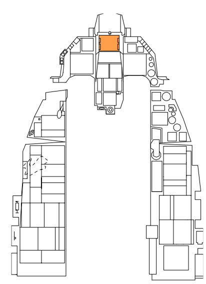
Remember to anticipate what is coming up next and stay ahead of the curve. You do not have to wait until you are about to make an attack to set the aircraft up.

When entering an area where you expect to encounter enemy aircraft, you will want to take the following steps.

1. Position the Master Arm Switch to ARM. Weapons may be released normally when in the ARM position. If the Master Arm switch is placed in the OFF position, weapon release is inhibited.



2. Press the A-A Button on the ICP to place the fire control system in Air-to-Air (A-A) Mode.



This is one method for preparing the aircraft for an air-to-air attack. There are also two air-to-air override modes that can be quickly selected using HOTAS commands. Those are described below.

DOGFIGHT AND MISSILE OVERRIDE MODES

Two override modes are available to quickly configure the aircraft for an air-to-air engagement: **Dogfight** and **Missile Override**. These modes are selected using the DOGFIGHT switch located on the throttle grip. It is a three-position switch that overrides any mode except emergency jettison.

- DOGFIGHT (outboard). This mode provides symbology on the HUD for both 20mm gun firing and AIM-9 Sidewinder missile delivery.
- MSL OVRD (inboard, unlabeled). This provides symbology for AIM-120 missile firing only. If no AIM-120 is loaded, AIM-9s are selected.
- Center position. Returns to the last selected master mode.

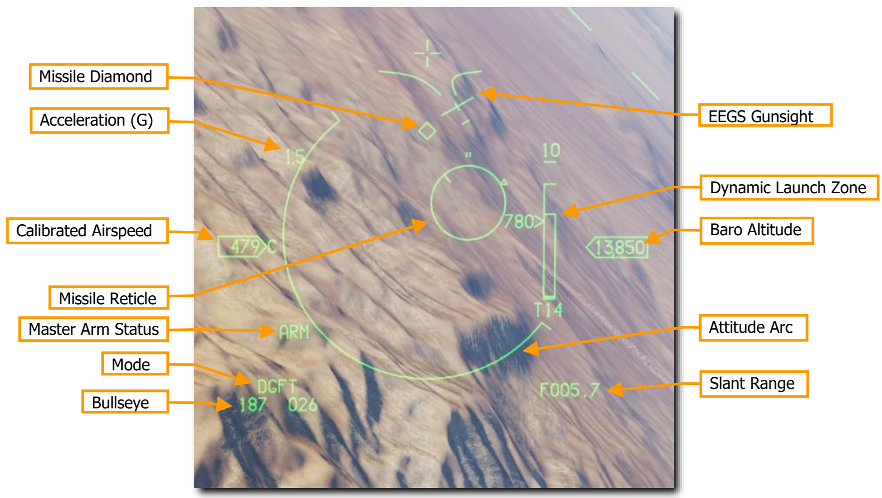
Requests for master mode changes made using the ICP will be ignored while either of these modes are active.

Changes to missile or radar settings made while either override mode is active will be saved throughout the mission. A common technique is to configure the displays, radar, and missiles for each mode as desired during ground operations. This provides three distinct weapon delivery options (Dogfight, Missile Override and Default) without the need to remove your hands from the controls.

Dogfight Mode

With the switch in the DOGFIGHT (outboard) position, the HUD is configured for Gun and AIM-9 missile firing. The left MFD is configured with the radar in ACM Boresight mode and the right MFD is configured with the Dogfight SMS page.

The Dogfight HUD combines elements of the Missile and Guns HUD modes into one decluttered display. Note that the heading bar, flight path marker and attitude bars are removed.



See the sections on Air to Air Gunnery and AIM-9 Sidewinder Employment for details on each display and how to use them.

Missile Override Mode

With the switch in the Missile Override (inboard) position, the HUD is configured for AIM-120 missile firing. The left MFD is configured with the radar in RWS mode and the right MFD is configured with the Missile SMS page.

See the section on AIM-120 AMRAAM Employment for details on each display and how to use them.

M61A1 20MM CANNON

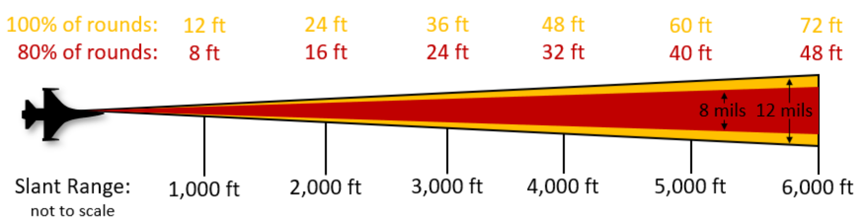
The M61A1 20mm automatic gun system provides the pilot with a formidable weapon capability. It is a six-barrel Gatling type gun mounted in the left strake of the aircraft. The system has a capacity of 512 rounds of ammunition fired at 6,000 rounds per minute.

Gun Dispersion

Rounds fired from any gun system do not follow a perfectly straight path but are dispersed in a cone shaped pattern after they leave the gun's muzzle. The dispersion pattern becomes a larger and larger cone as slant range increases. The density of rounds within the cone becomes less and less as the edge of the cone is approached.

The average dispersion of the M61A1 is 8 mils diameter for 80% of the rounds fired and 12 mils for 100% of the rounds fired.[1] USAF units maintain a boresight program to ensure gun systems installed on aircraft continue to meet these specifications while in operational use.

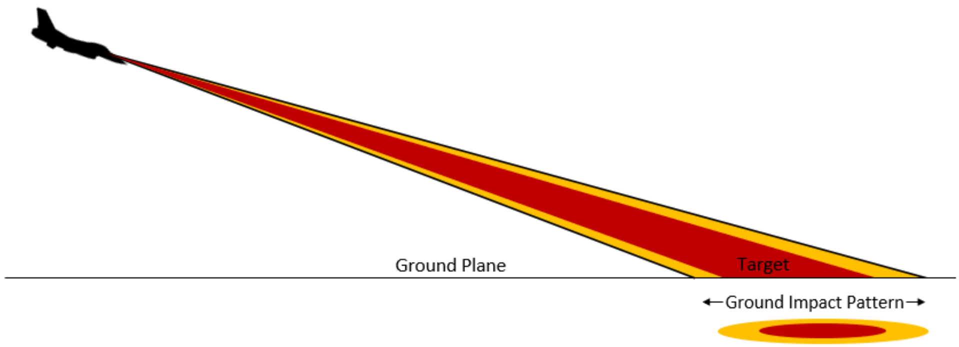
One mil is equal to 1/1000 of a radian so 8 mils equals an 8 foot diameter circle at 1,000 feet range and 12 mils equals a 12 foot diameter circle. The size of the circle continues to increase with range.



In practical terms, this means you have some leniency in accuracy when firing the gun. In this example, the green gun pipper is a 4-mil diameter circle. This is where bullets are most dense within the cone. The red shaded area is the 8-mil circle 80% of the rounds will pass through at the target range. The orange shaded area is the 12-mil circle that 100% of the rounds will pass through at the target range.

The dispersion pattern of rounds fired from the gun is a circle only if the target is perpendicular to the flight path. It resembles an ellipse when firing against a horizontal target on the ground.

[1] This is based on MIL-DTL-45500/1A that states "At a range of 1,000 inches, 80 percent of a 75 round (min.) burst shall be completely within an 8.0 inch diameter circle for accuracy" and the manufacturer's data sheet that states "8 milliradians diameter, 80 percent circle".

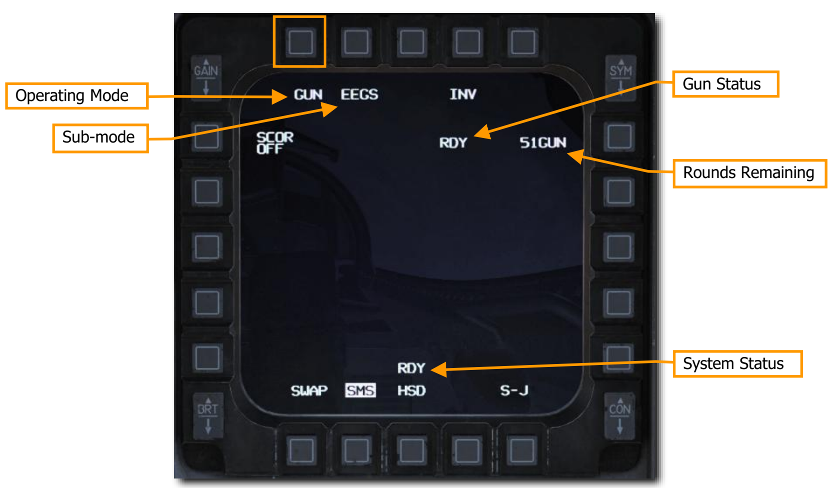


> *Summary*
>
> 1. Select A-A master mode **[1]** or DGFT override mode **[3]**
> 2. Set Master Arm Switch to Arm
> 3. Acquire target using ACM radar mode (optional)
> 4. Fly the EEGS funnel and pipper onto the target
> 5. Squeeze the Trigger **[Space]** to the second detent to fire the gun

Air to Air Gunnery

1. There are two ways to get into the correct SMS configuration for air-to-air gunnery. They are:
   - **Select the Air-to-Air Gunnery operating mode on the MFD by pressing OSB 1 until GUN is displayed, or**
   - **Position the Dogfight/Missile Override (DOGFIGHT) Switch to DGFT.**

   This provides symbology on the HUD for both 20mm gun firing and A-A missile delivery.



2. **Verify A-A GUN symbology is displayed in the HUD.**

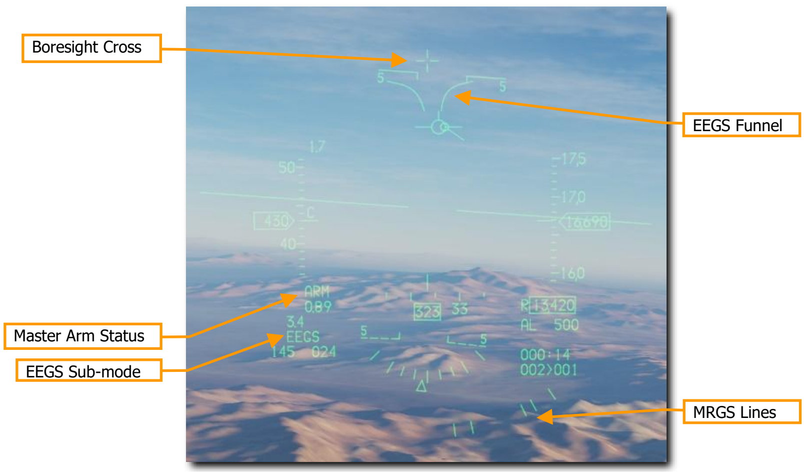
The Enhanced Envelope Gun Sight (EEGS) provides different levels of information depending on whether the radar is locked on the target.

Level I is a failure mode that only displays the **Boresight Cross** in the event of a Rate Sensor Unit (RSU) and INS failure. It should almost never be encountered.

Level II provides a prediction of the bullet path when there is no radar lock. The **Boresight Cross**, **EEGS Funnel** and **Multiple Reference Gunsight (MRGS) Lines** are provided.

Level III and IV are intermediate levels that lead to the Level V display. These are usually not seen by the pilot.

Level V is displayed after radar lock-on and a firing solution has been computed using that data. Additional references in the HUD include the **Target Designator, T-Symbol, Range to Target, Closure Rate** and **Level V Pipper.**



Level II Symbology (no radar lock)

Boresight Cross. This symbol is always available and shows the boresight direction. This is the direction rounds will travel before other influences like gravity or air resistance take effect.

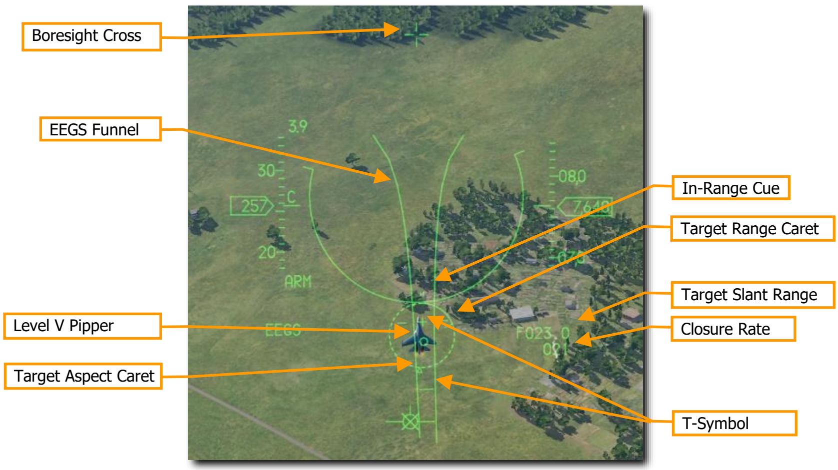
EEGS Funnel. Each point along the funnel represents the target at a specific range for which the gun is correctly aimed. In other words, an aircraft whose wings are the same width as the funnel is at the correct range to be hit by rounds fired at that moment.

As the range decreases, the target size will increase. As this occurs, you must place the target higher in the funnel to keep the target wingspan just touching the sides of the funnel. This results in placing the target higher in the HUD or, more importantly, closer to the Boresight Cross which results in reduced lead for the reduced range.

The target aircraft wingspan must be known for the funnel to provide accurate range information.

Multiple Reference Gunsight Lines. The MRGS sight is composed of a series of five line segments pointing toward the Gun Bore Line, and spaced in an arc near the bottom of the HUD. They aid in lining up long range, high aspect shots by providing the correct lateral aiming solution so the target flies up the funnel.

When using an MRGS line, if the target is smaller than the line, it is either out of range or moving faster than anticipated and requires extra lead. If the target is larger than the MRGS line, the target is moving slower than anticipated and will require less lead.



Level V Symbology (with radar lock)

Target Designator. This symbol is centered on the locked radar target. The triangular **Target Aspect Caret** shows the target's aspect angle. Maximum effective gun range is shown by an **In-Range Cue**, two small lines on the outside of the symbol. The position of the **Target Range Caret** indicates the range to the locked target. Each o'clock position represents 1,000 feet of range, so:

- 12 o'clock = 12,000 ft
- 9 o'clock = 9,000 ft
- 6 o'clock = 6,000 ft
- 3 o'clock = 3,000 ft

Target Range. The distance to the locked target. Tenths of a mile are displayed for ranges greater than one mile. Hundreds of feet are displayed at ranges less than one mile.

Closure Rate. The rate of closure with the target in knots.

T-Symbol. This symbol shows two firing solutions for the locked target. The + symbol, or 'one-G pipper' shows the lead angle against a non-maneuvering target. The small horizontal bar, or 'nine-G pipper' shows the lead angle for a target turning at maximum sustained rate. These may be used as a backup in situations the Level V Pipper is not displayed.

Two maneuver potential lines are displayed on either side of the 1g pipper. The longer the lines, the greater the out-of-plane maneuver potential of the target.

Level V Pipper. This represents the gunfire solution computed for the target's current range and rates. The goal is to stabilize this pipper over the target and fire.

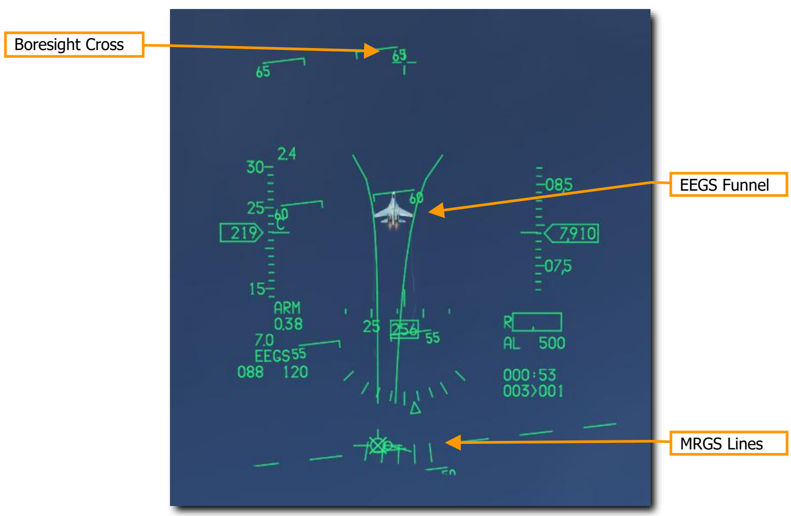
3. **Maneuver your aircraft to frame the target aircraft within the EEGS funnel.**

Each point along the funnel represents the target at a specific range for which the gun is correctly aimed. In other words, an aircraft whose wings are the same width as the funnel is at the correct range to be hit by rounds fired at that moment.

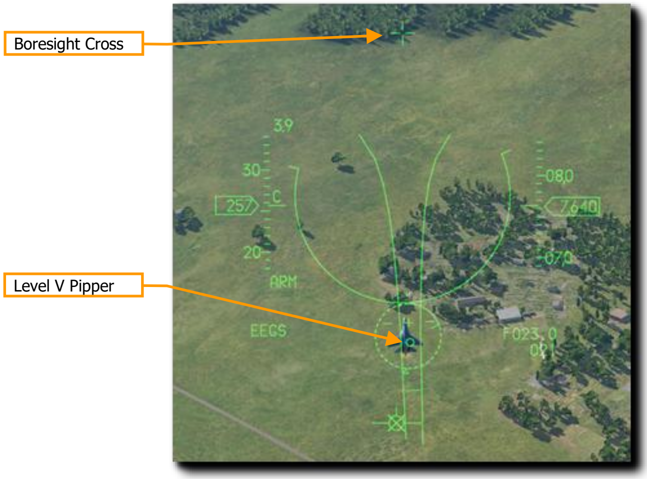
Place the enemy aircraft in the funnel so that the wingtips touch the edges or the Level V Pipper is stabilized over the target.

4. **Squeeze the trigger all the way to the second detent to fire the gun when the wingtips touch the funnel (Level II) or Pipper is over the target (Level V).**

   Target range greatly affects gun effectiveness. As the rounds come out of the gun, they will gradually disperse and lose velocity. Increased dispersion and loss of velocity reduce the accuracy and effectiveness of the gun. The top of funnel represents the minimum range of approximately 600 feet. The bottom of the funnel represents the maximum range of approximately 3,000 feet. If the target is smaller than the bottom of the funnel, it is out of range.

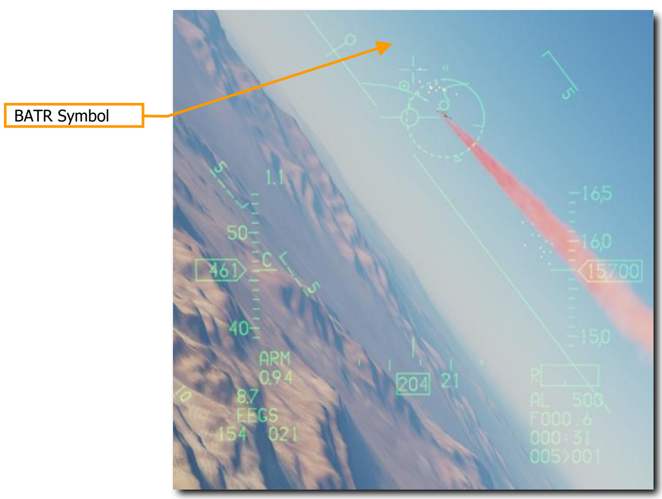


Level II Symbology (no radar lock)



Level V Symbology (with radar lock)

An additional symbol known as the **Bullets at Target Range (BATR) Symbol** is displayed after rounds are fired. The BATR is displayed as the first real or simulated round passes the target range and is removed after the last round has passed. This is only available with a radar lock and EEGS Level III, IV or V symbology displayed.



AIM-9M/X SIDEWINDER

The AIM-9 is a short-range, infrared-guided missile best used in a dogfight. It is fire-and-forget and can be used with or without a radar lock. The primary indication of a seeker lock is a higher-pitched lock tone. The seeker can also be uncaged to ensure the seeker is tracking the target when it has first been sensor-slaved to the target.

Note that the AIM-9 can be decoyed by flares and it's a good idea to ensure you have a good seeker lock before launching an AIM-9 with flares in the seeker field of view.

Summary

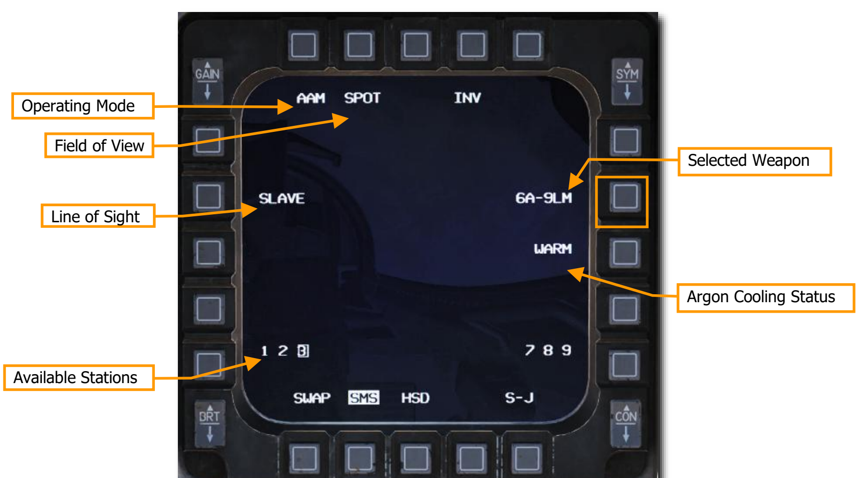
1. Select A-A [4] or DGFT [3] master mode
2. Set Master Arm Switch to Arm
3. Acquire target using radar (optional)
4. Maneuver until target is in launch zone
5. Depress Uncage switch [C] to command missile track (if required)
6. Verify missile diamond is on target and lock tone is audible
7. Depress Weapon Release [RAlt]+[Space] switch to fire missile

AIM-9M/X Employment

1. There are two ways to get into the correct SMS configuration for firing an AIM-9. They are:

- **Select AIM-9s on the MFD by pressing OSB 7 until AIM-9s are displayed, or**
- **Position the Dogfight/Missile Override (DOGFIGHT) Switch to DGFT.**

This overrides any other master mode and configures the displays for air combat. The DOGFIGHT position provides symbology on the HUD for both 20mm gun firing and A-A missile delivery. The MSL position provides symbology on the HUD for A-A missile delivery only.



The number and type of missiles is displayed next to OSB 7. The stations with missiles loaded are displayed at the bottom and the selected station is boxed. Step through available stations with the Missile Step button or by selecting the adjacent OSB.

SPOT/SCAN commands the missile seeker to either scan in a narrow field of view (SPOT) or wide field of view (SCAN). The wider field of view is achieved by seeker nutation around the line of sight. Detection range is decreased when SCAN is used. SCAN mode is not currently implemented.

SLAVE/BORE commands the missile to either follow the radar line of sight (SLAVE) or keep looking straight ahead down the boresight (BORE). Pressing and holding the **RDR CURSOR/ENABLE switch** overrides the current selected option. Releasing the control returns to the option selected on the MFD.

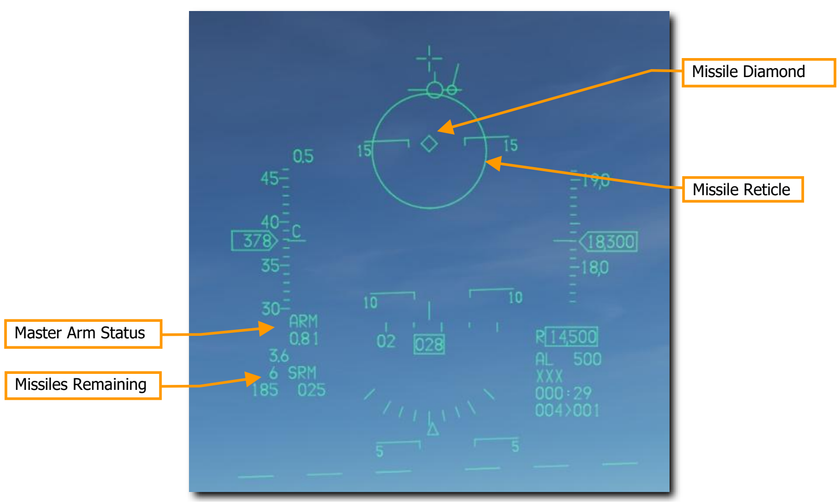
WARM/COOL activates or deactivates argon cooling of the seeker. **This should be set to COOL prior to an engagement to cool the seeker and increase detection sensitivity**. COOL is selected automatically when entering DGFT or MSL Override mode. Argon supply duration varies depending on outside air temperature, pressure, and bottle charge level at installation, but the average duration is 90 minutes.

2. Verify A-A Missile symbology is displayed in the HUD.

The air-to-air HUD provides information on the status and targeting of air-to-air missiles. Most of the symbology from the NAV mode is retained but several new features are added to aid in target acquisition and missile launch.

The **Missile Diamond** indicates the position of the AIM-9 seeker head. This starts at the seeker boresight position but unlatches to follow the radar line of sight or track a locked target when a lock is achieved.

The **Missile Reticle** shows the seeker field of view. This will be shown as different sizes depending on the SPOT/SCAN field of view setting chosen on the MFD.



3. Acquire target using radar (optional).

Perhaps the most common and easiest way to target an aircraft with the AIM-9 is to acquire a target with one of the ACM Radar Modes. This slews the AIM-9 seeker to the radar target if SLAVE is selected on the missile. This results in an AIM-9 lock if the target is in range and other IR detection conditions are met.

4. **Maneuver until target is in launch zone.**

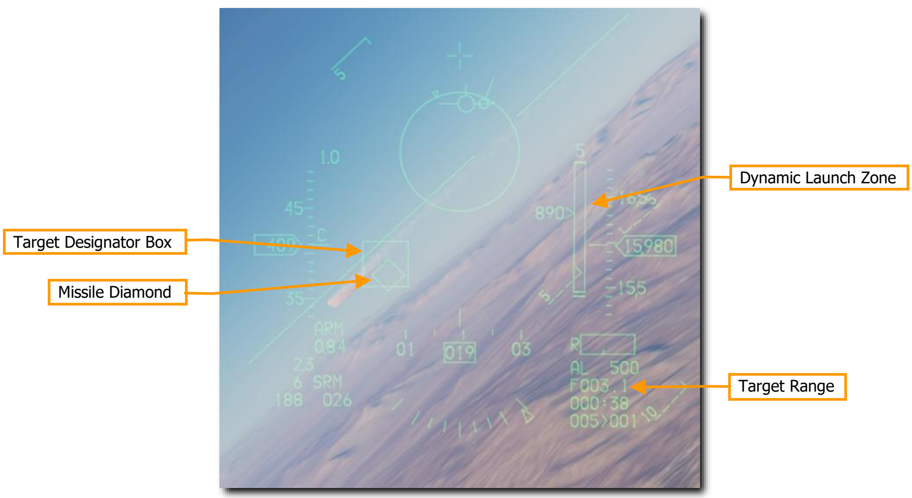
   Fly the missile reticle in the HUD over a target. If the missile detects enough IR energy from the target, target detection is indicated by an audio missile detection tone (growling sound).

5. **Press Uncage switch to command missile self-track.**

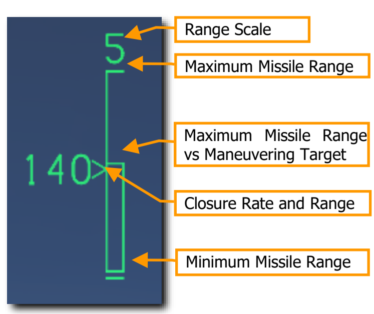
   When the AIM-9 seeker detects a target, it can be uncaged by pressing the **Cage/Uncage button** to allow the seeker lock on and follow the target within the confines of the missile seeker's field of view. The M**issile Diamond** latches to the target when locked.

6. **Verify missile diamond is on target and lock tone is audible.**

   The missile growl will become high pitched when the target is locked. A **Target Designator Box** will be present over a target locked with radar. If firing against a radar target, the **Missile Diamond** should be over the Target Designator box. The **Target Range** is displayed if radar is used.



The **Dynamic Launch Zone** (DLZ) will be displayed on the right side of the HUD when a target is designated with the radar. Monitor the DLZ and assess the threat situation to determine the optimal missile firing point. The missile diamond flashes when the target is within maximum aerodynamic range (Raero). The missile reticle flashes when the target is within maximum maneuvering range (Rtr, when the missile would be effective against even a target that immediately turns and runs).



7. **Press the Weapon Release switch to fire the missile.**

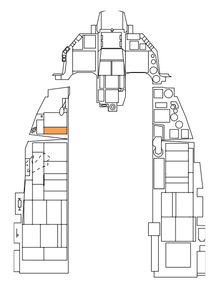
   The missile will attempt to intercept the target and the next missile in sequence will be selected. The AIM-9 is a fire and forget weapon so there is no need to continue tracking the target.

AIM-9M/X HMCS Missile BORE Employment

The Helmet Mounted Cueing System (HMCS) allows the AIM-9M or AIM-9X missiles to slave to the HMCS Aiming Cross when BORE mode is selected on the missile. This is useful in situations where no radar lock is possible or desired. This can be thought of as normal AIM-9 employment, except the HMCS line of sight is used instead of the HUD line of sight. The mechanization is otherwise the same.

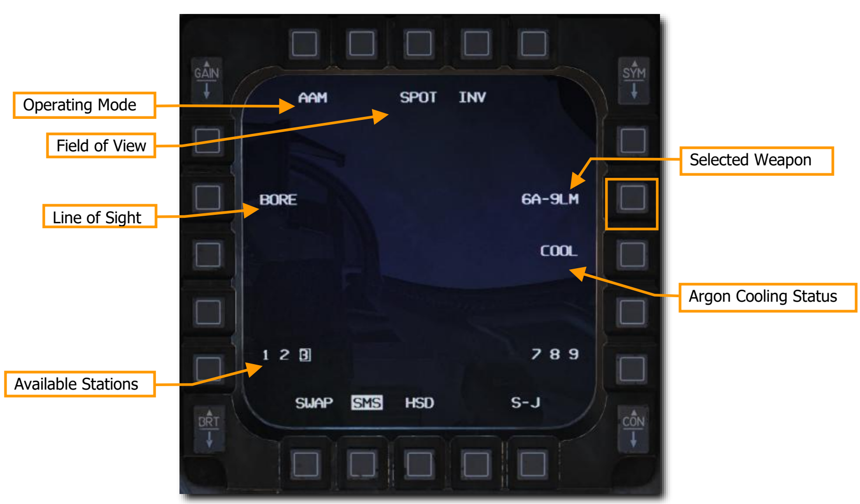
1. **Turn on the Helmet Mounted Display (HMCS) symbology.**

   Power to the HMCS is selected from the **HMCS Symbology** control knob on the left auxiliary console. Rotating the knob clockwise from the OFF position to INC (increase) provides power to the HMCS. Continued clockwise rotation increases symbology brightness.



2. **Select AIM-9s on the MFD by pressing OSB 7 until AIM-9s are displayed, or position the Dogfight/Missile Override (DOGFIGHT) Switch to DGFT.**

   Symbology and functions are identical to non-HMCS employment. Set the **Line-of-Sight** mode to **BORE** to use the HMCS for AIM-9M/X targeting without radar.

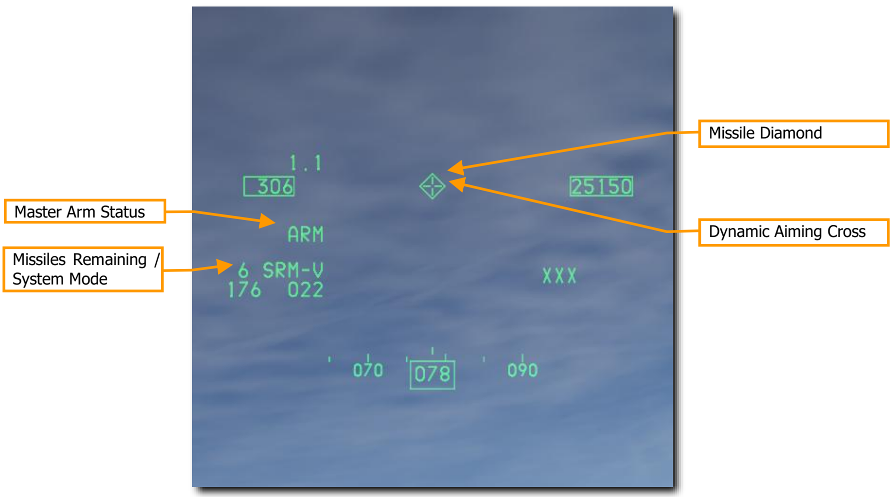


3. Acquire the target in the HMCS.

With the AIM-9 set to BORE and the HMCS on, the seeker will follow the **Dynamic Aiming Cross** in the HMCS display. The aiming cross is treated as the boresight position. Simply look at the target instead of flying the aircraft all the way into position for an AIM-9 lock.

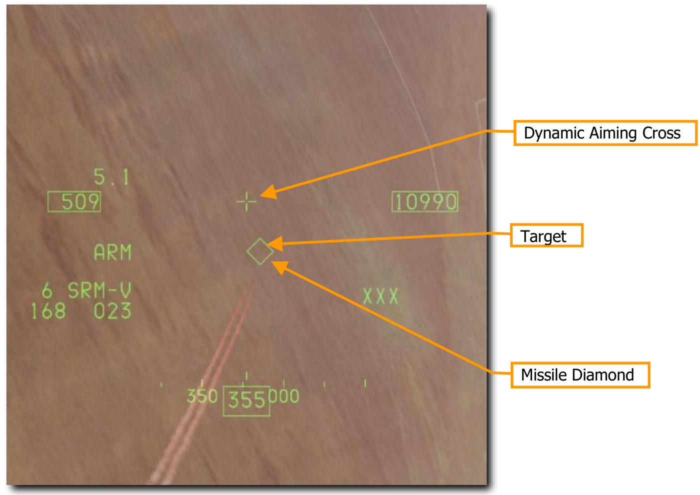
Remember, you will still be constrained by the missile seeker gimbal limits when looking around. The **Missile Diamond** shows where the missile seeker is looking. If you look beyond the missile seeker gimbal limits, the diamond symbol will be displayed with an "X" through it and will be clamped to the edge of the HMCS display area.

The other symbology on the display intentionally mimics the symbology from the HUD.



4. Press Uncage switch to command missile seeker track.

When the AIM-9 seeker detects a target, it can be uncaged by pressing the **Cage/Uncage button**. This allows the seeker to lock on and follow the target within the confines of the missile seeker's gimbal limits. The **Missile Diamond** latches to the target when the seeker has locked on.



5. **Verify missile diamond is on target and lock tone is audible.**

   The missile growl will become high pitched when the target is locked. The **Missile Diamond** should be latched to the target and no longer follow the **Aiming Cross**.

6. **Press the Weapon Release switch to fire the missile.**

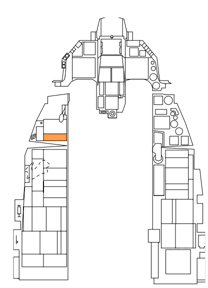
   The missile will track the target and the next missile in sequence will be selected. The AIM-9 is a fire and forget weapon so there is no need to continue tracking the target.

AIM-9M/X HMCS Radar BORE Employment

The Helmet Mounted Cueing System (HMCS) allows the Fire Control Radar to slave to the HMCS Aiming Cross when ACM BORE radar mode is selected. This can be thought of as normal AIM-9 employment, except the HMCS line of sight is used instead of the HUD line of sight. The mechanization is otherwise the same.

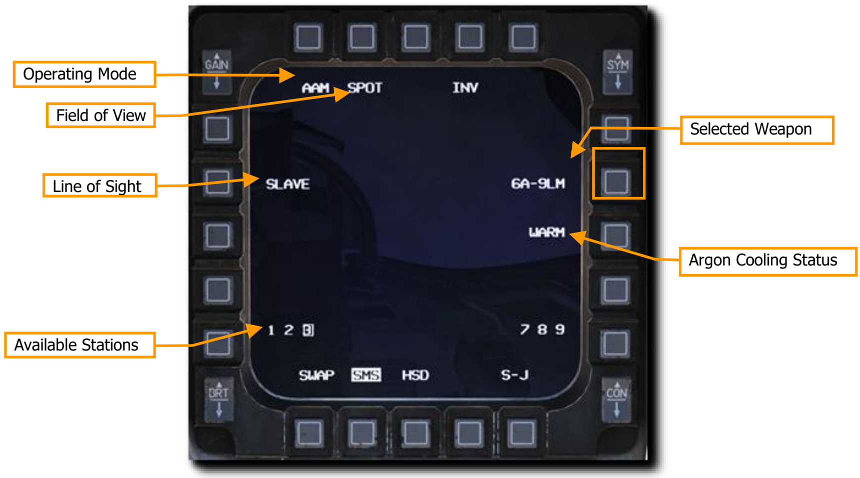
1. **Turn on the Helmet Mounted Display (HMCS) symbology.**

   Power to the HMCS is selected from the **HMCS Symbology** control knob on the left auxiliary console. Rotating the knob clockwise from the OFF position to INC (increase) provides power to the HMCS. Continued clockwise rotation increases symbology brightness.



2. **Select AIM-9s on the MFD by pressing OSB 7 until AIM-9s are displayed, or position the DOGFIGHT Switch to DGFT.**

Symbology and functions are identical to non-HMCS employment. Set the **Line-of-Sight** mode to **SLAVE** to use the HMCS and radar for AIM-9M/X targeting.

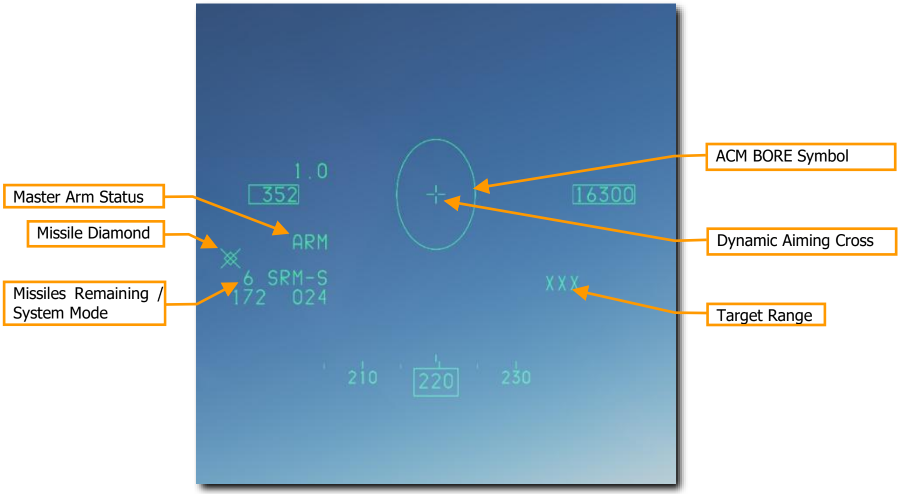


3. Select ACM BORE radar mode, press TMS forward, and acquire the target in the HMCS.

With the **ACM BORE** radar mode selected and the HMCS on, the radar will follow the **Dynamic Aiming Cross** in the HMCS display. The aiming cross is treated as the boresight position. Press TMS Forward once, then simply look at the target instead of flying the aircraft all the way into position for a radar lock.

Remember, you will still be constrained by the radar gimbal limits when looking around. The **ACM BORE Symbol** shows where the radar is pointing. If you look too far off the aircraft boresight, the radar will not be able to follow.

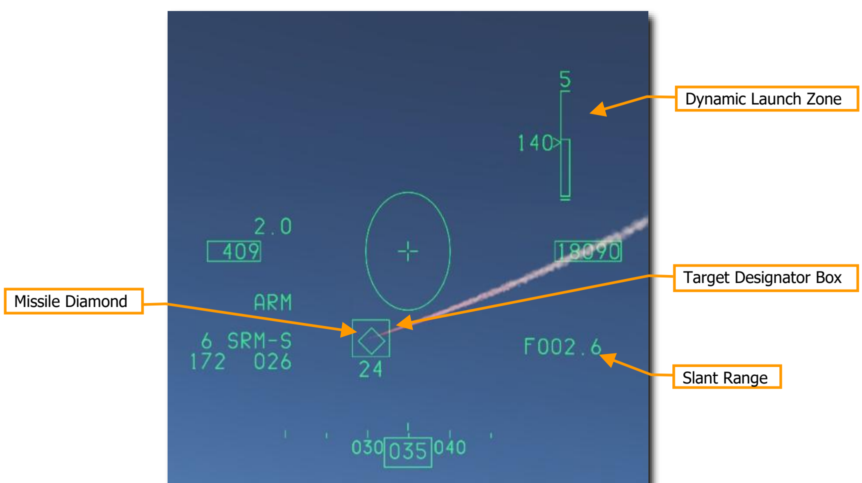
The **Target Range** is displayed after radar lock. The other symbology on the display intentionally mimics the symbology from the HUD.



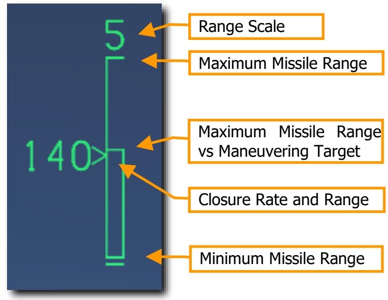
4. Achieve radar lock in ACM BORE Mode.

The radar will lock the first target detected within the **ACM Bore Symbol**. A **Target Designator Box** will be present over a target locked with radar.

With the AIM-9 line of sight set to SLAVE, the seeker will slew to the radar line of sight. When the AIM-9 seeker detects a target, it can be uncaged by pressing the **Cage/Uncage button**. This allows the seeker to lock on and follow the target within the confines of the missile seeker's gimbal limits. The **Missile Diamond** latches to the target when the seeker has locked on.



The **Dynamic Launch Zone** (DLZ) will be displayed on the right side of the HMCS when a target is designated with the radar. Monitor the DLZ and assess the threat situation to determine the optimal missile firing point. The missile diamond flashes when target is within maximum range against a maneuvering target.



5. **Verify missile diamond is on target and lock tone is audible.**

   The missile growl will become high pitched when the target is locked. The **Missile Diamond** should be latched to the target.

6. **Press the Weapon Release switch to fire the missile.**

   The missile will attempt to intercept the target and the next missile in sequence will be selected. The AIM-9 is a fire and forget weapon so there is no need to continue tracking the target.

AIM-120 AMRAAM

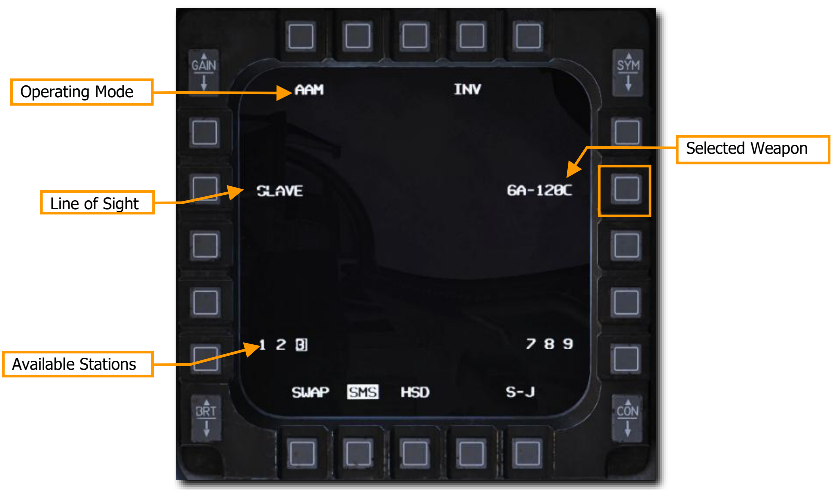
The AIM-120 AMRAAM is an Active Radar-Homing (ARH) air-to-air missile that can self-guide to a target using an active radar seeker in its nose. The missile is guided initially via datalink commands from the launching aircraft, and transitions to onboard active radar homing once within range. Because of the active seeker, the pilot can engage multiple targets at once without needing to support the missile for its entire time of flight.

The AIM-120 is a medium range missile and can engage targets outside 20 nm. However, engagement range is highly dependent on target aspect, engagement altitude, launch speed, and target post-launch maneuvering. As such, the engagement range of the AIM-120 can be less than 10 nm in some situations.

In WVR combat, the AIM-120 can also be launched in BORE mode without a radar lock. Once the missile is launched, it will track and attempt to hit the first target it detects within the AIM-120 reticle on the HUD.

SMS Format

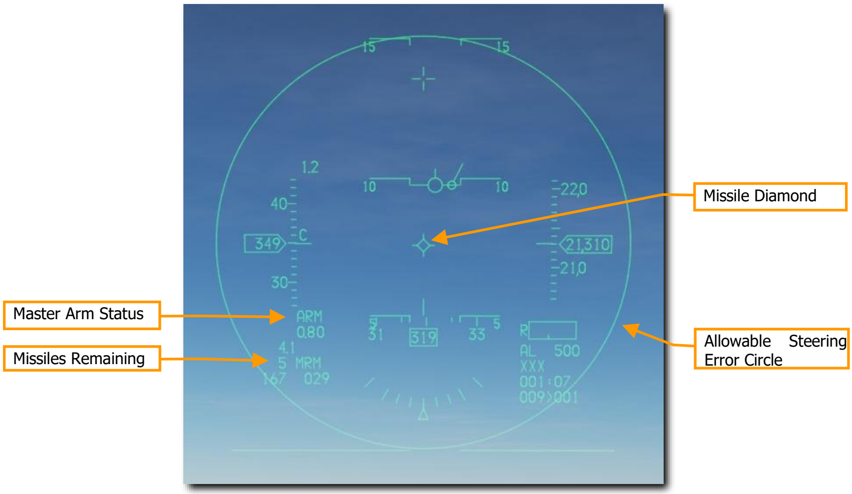
With AIM-120s selected, the SMS format appears as shown:



Line of Sight. When set to SLAVE, missile radar line of sight is slaved to the aircraft's radar. The missile will receive datalink steering from the launching aircraft until it's within radar range, then it will attempt to track the target. When set to BORE, the missile's radar scans straight ahead. It will track the first detected target after launch. Depressing the RDR CURSOR/ENABLE switch also cycles between SLAVE and BORE modes.

HUD Symbology

No Target Lock



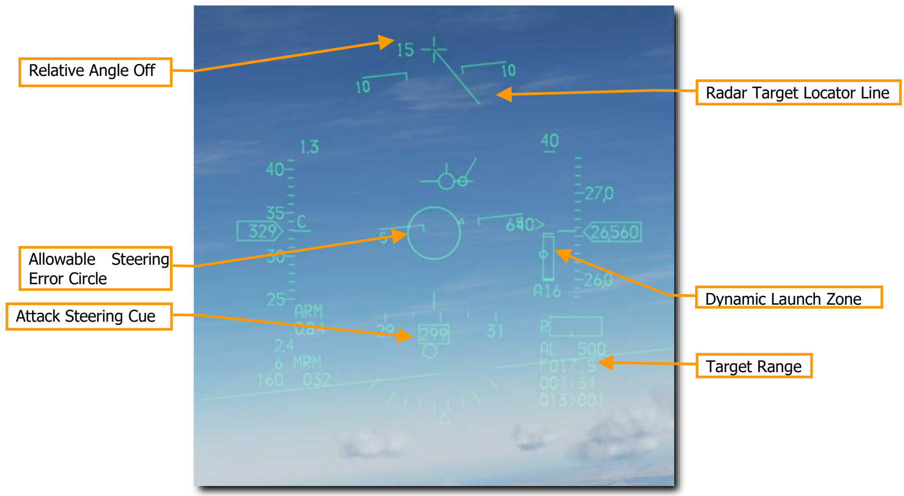
Master Arm Status. Displays "ARM" when Master Arm is on.

Missiles Remaining. Displays the number of missiles remaining and "MRM" for medium-range missile.

Missile Diamond. Indicates missile radar line of sight. This is initialized at seeker boresight position but will slew to target LOS when SLAVE mode is selected, and a target is locked.

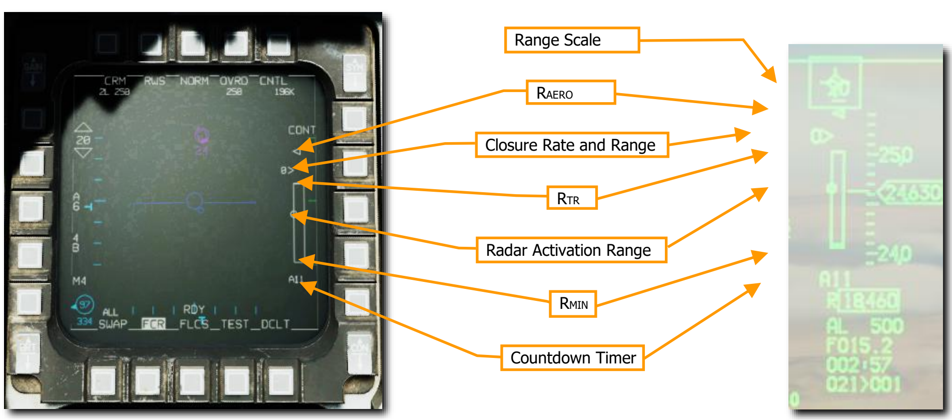
Allowable Steering Error Circle (ASEC). Indicates the zone in which the **Attack Steering Cue (ASC)** should be located prior to launch to hit the target with a high probability kill (PK). The ASC is displayed after radar lock. The **ASEC** shows the maximum angular steering error probability. In other words, the circle increases in size when the distance to the target intercept point decreases, which means that as the distance decreases, the missile can be launched with greater steering error.

With Target Lock



Relative Angle-Off. Displays the angular difference between aircraft heading and target bearing.

Dynamic Launch Zone. Displays information about the missile's capabilities against a target at its current range.



Range Scale. Indicates the range represented by the highest tick mark.

RAERO (aerodynamic range). The maximum kinematic range of the missile. A shot at this distance would only be effective against a target that continues its current course and speed and does not maneuver.

Closure Rate and Range. The caret indicates the current target range against the DLZ, and the adjacent number is the closure rate in knots.

RTR (turn-and-run range). The maximum range where the missile is guaranteed to reach the target regardless of target maneuvering. A shot at this distance would hit a target that immediately turns 180° away from the missile while maintaining speed.

Radar Activation Range. The range at which the missile will activate its own radar, and no longer needs continued support from the launching aircraft.

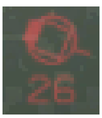
R_{MIN} (minimum range). The closest range that allows the missile to activate its seeker, lock a target, arm, and detonate safely.

Countdown Timer. Displayed after missile launch. Displays "A" followed by the number of seconds until the missile activates its seeker, then "T" followed by the number of seconds until predicted impact.

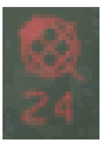
FCR Post-Launch Symbology

Following AIM-120 launch, the FCR format will display different symbols to indicate different missile employment statuses:

A target with an AMRAAM in flight is displayed in magenta with a solid "tail" opposite its trend vector.



A target with at least one AMRAAM in flight that has gone active is displayed in red, and the tail flashes.



A target with at least one AMRAAM that has reached predicted time of impact is displayed with a flashing "X" through it.

AIM-120 Employment

Summary

1. Select A-A master mode **[1]** or MSL override mode **[4]**
2. Set Master Arm Switch to Arm
3. Acquire target using radar (optional but recommended)
4. Maneuver until target is in launch zone
5. Depress Weapon Release **[RAlt]+[Space]** switch to fire missile

1. **There are two ways to select the AIM-120 for employment:**
   - Select AIM-120s on the MFD by pressing OSB 7 until AIM-120s are displayed, or
   - Position the Dogfight/Missile Override Switch to MSL OVRD. This overrides any other master mode and configures the displays for air combat. The MSL position provides symbology on the HUD for A-A missile delivery and selects the longest-range missile type loaded.
2. **Verify A-A Missile symbology is displayed in the HUD.**

   The air-to-air HUD provides information on the status and targeting of air-to-air missiles. Most of the symbology from the NAV mode is retained but several new features are added to aid in target acquisition and missile launch.

3. **Acquire target using the radar**

   Typically, a target will be locked using RWS, TWS, or any ACM radar sub-mode and the AIM-120 set to SLAVE.

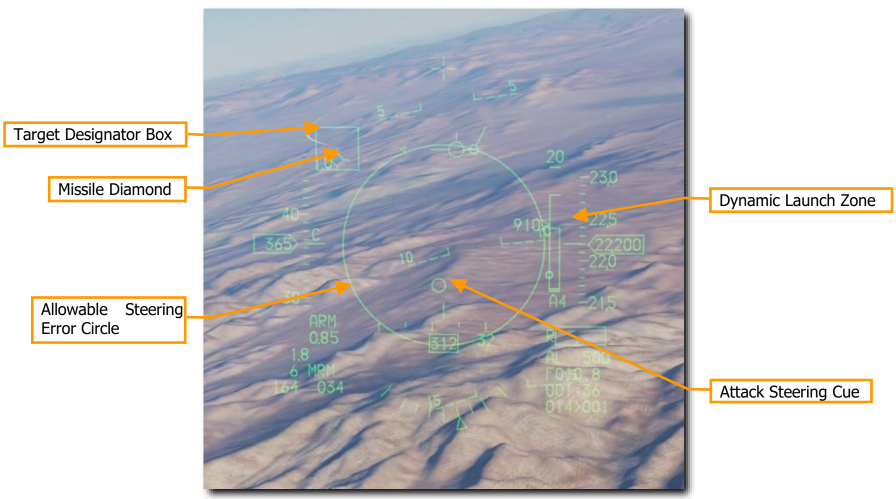
   When the locked target is outside the HUD field on view as shown below, a **Target Locator Line (TLL)** extends from the Gun Cross and points directly at the target. The **Relative Angle** is displayed next to the Gun Cross showing the angle in degrees between the cross and the target.

   The **Allowable Steering Error Circle (ASEC)** changes size and the **Attack Steering Cue (ASC)** becomes visible. The **Target Range** is displayed after target radar lock.

4. **Maneuver until Attack Steering Cue (ASC) is inside the Allowable Steering Error Circle (ASEC)**

   The size of the **Allowable Steering Error Circle** will vary depending on the target range and aspect. Ensure that the **Attack Steering Cue** is located as close to the **Allowable Steering Error Circle** center as possible when firing to achieve the best performance out of the missile.

   When the target enters the HUD, the **Target Designator Box** will be displayed over the target and the **Missile Diamond** will track that location.



   Monitor the **Dynamic Launch Zone** and assess the threat situation to determine the optimal missile firing point.

5. **Press and hold the Weapon Release switch to fire the missile.**

   The missile will track the target and the next missile in sequence will be selected.

   The AIM-120 may also be employed in BORE mode without a radar lock on the target. This is used when a quick shot must be taken, or no radar emissions are desired. The missile radar will go active at launch and guide on the first target it detects so use this mode with care.

Simultaneous Employment Against Multiple Targets

The F-16C FCR can support up to four simultaneous in-flight AMRAAMS against up to four targets. Simultaneous employment is accomplished in TWS or RWS DTT mode.

Summary

8. Select A-A master mode [1] or MSL override mode [4]
9. Set Master Arm Switch to Arm
10. Acquire at least two targets using TWS or DTT
11. Maneuver until all targets are in launch zone
12. Depress Weapon Release [RAlt]+[Space] to fire first missile
13. Press TMS Right to cycle bug to next target
14. Depress Weapon Release [RAlt]+[Space] to fire second missile

1. **Select AIM-120s for employment:**

   - Activate A-A master mode using the ICP, then on the SMS format, press OSB 6 until AIM-120 is selected; or

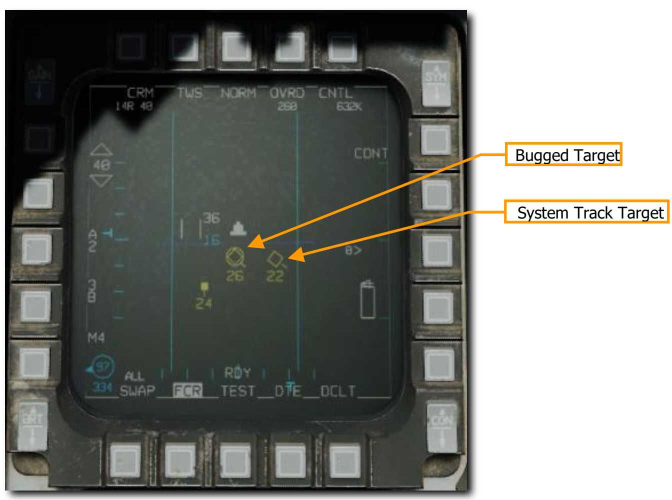
   - Place the Dogfight/Missile Override switch in MSL OVRD.

2. **Set the Master Arm switch to Arm.**

3. **Acquire at least two targets using TWS or DTT.**

   In RWS mode, move the acquisition cursor over the first target and press TMS Forward to designate it. Then, move the acquisition cursor over the second target and press TMS Forward to designate it.

   In TWS mode, move the acquisition cursor over each target and press TMS Forward to designate it as a System Track Target. You may designate up to four System Track Targets for AMRAAM employment.



4. **Maneuver until all targets are within the launch zone.** DLZ information is only displayed for the current bugged target. Use TMS Right to cycle between bugged targets and track DLZ status for each.

5. **Depress Weapons Release to fire first missile**, then press TMS Right to cycle the bug to the next target, and press Weapons Release again to fire the second missile. If using TWS, you can repeat this process up to four times total.

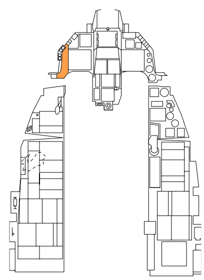
AIR-TO-GROUND WEAPONS EMPLOYMENT

USAF Photo
by TSgt Robert Cloys

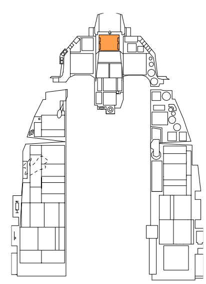
ATTACK PREPARATION

Prior to reaching the target area and conducting your attack, you will want to configure several aircraft systems ahead of time so that you can most efficiently communicate and set up your attack. When at a minimum of 40 nm from the target, you will want to take the following steps.

1. Position the Master Arm Switch to ARM. Weapons may be released normally when in the ARM position. If the Master Arm switch is placed in the OFF position, weapon release is inhibited.
2. Position the Laser Arm Switch to ARM. This is required to enable firing of the laser designator. Laser firing is inhibited with the switch set to OFF.



3. Place the fire control system in A-G mode by pressing the A-G Master Mode Button on the ICP.



M61A1 20MM CANNON STRAFE

The M61A1 20MM automatic gun system provides the pilot with a formidable weapon capability. It is a six-barrel Gatling type gun mounted in the left strake of the aircraft. The system has a capacity of 512 rounds of ammunition fired at 6,000 rounds per minute.

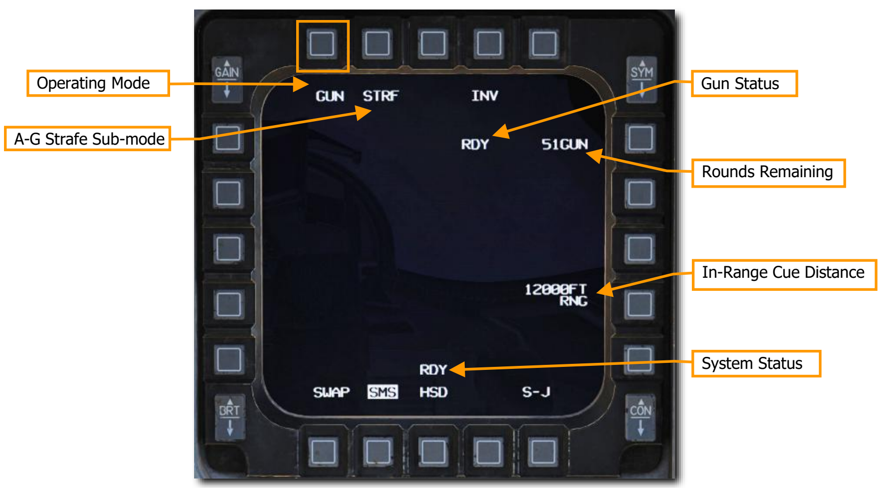
Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Set Laser Arm Switch to Arm if laser ranging updates are desired
4. Select STRF sub-mode on SMS MFD
5. Fly the Pipper onto the target
6. Squeeze the Trigger **[Space]** to the second detent to fire the gun

Target Attack

Upon selection of the A-G master mode, the SMS Air-to-Ground (SMS A-G) page is displayed on the right MFD. Based on the priority weapon, the information on the SMS A-G page can vary. Follow these steps to achieve the correct configuration and attack ground targets with the gun:

1. **Select the STRF sub-mode on the MFD by pressing OSB 1 until GUN is displayed.**



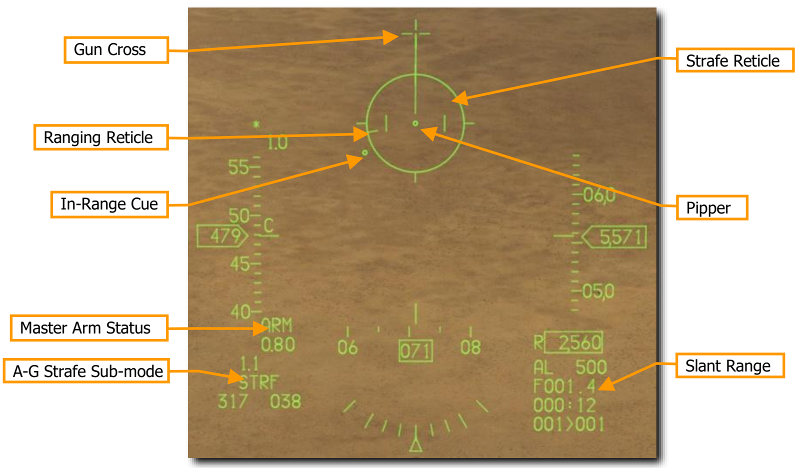
2. **Verify STRF symbology is displayed in the HUD.**

   The Strafe Reticle is the default air to ground gunsight and provides aiming information required to fire the gun effectively. The center of the reticle is the aiming pipper and represents where the gun rounds will go assuming the target is within range. Using the pipper, it is simply a case of "putting the thing on the thing" and pulling the trigger.

   Line of sight range is indicated by the digital range numeric on the bottom right of the HUD and the ranging reticle that winds or unwinds within the reticle. The position of the ranging reticle indicates the slant range to the pipper's position on the ground. Each quarter circle tick on the strafe reticle represents 3,000 feet of slant range, so:

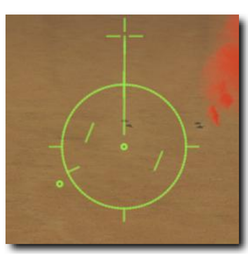
- 12 o'clock = 12,000 ft
- 9 o'clock = 9,000 ft
- 6 o'clock = 6,000 ft
- 3 o'clock = 3,000 ft

The in-range cue position may be set by the pilot provide an additional visual cue for the effective range against the planned target.



3. Maneuver your aircraft to position the pipper on target.

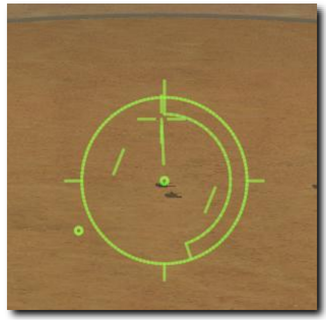
One technique is to place the pipper short of the target and allow it to track along the ground until it reaches the target. This will happen naturally as slant range decreases.




Laser ranging may be performed to improve the computed firing solution if a targeting pod is installed. (See Laser Ranging & Target Designation in the AAQ-33 Advanced Targeting Pod chapter for more information.)

4. Squeeze the trigger all the way to the second detent to fire the gun when the pipper is over the target and you are within effective range.

In this example, the pipper is on-target at a slant range of about 5,500 feet as shown by the position on the ranging reticle.



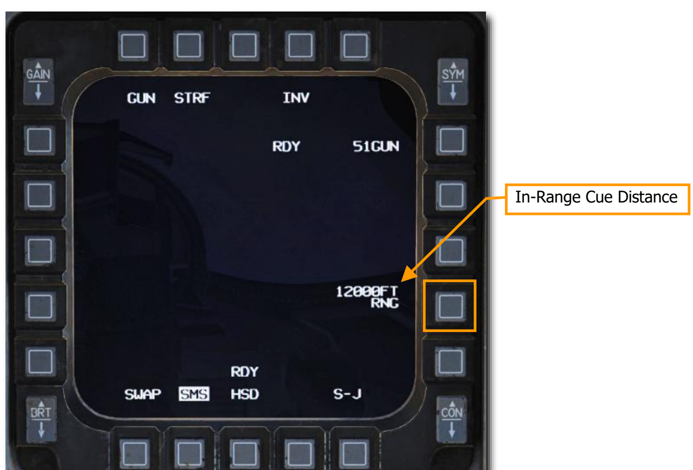
Slant range greatly affects gun effectiveness. As the rounds come out of the gun, they will gradually disperse and lose velocity. Increased dispersion and loss of velocity reduce the accuracy and effectiveness of the gun. Effective engagement range is generally from 2,500 to 7,000 feet. For armored vehicles, closer is better, and you should attack from behind the target where its armor is weakest.

When lining up a shot, be careful to avoid target fixation. Target fixation can lead to you not noticing an unseen threat or pressing the attack too close. Don't make yourself an easy target for the machine gun on the top of that APC!

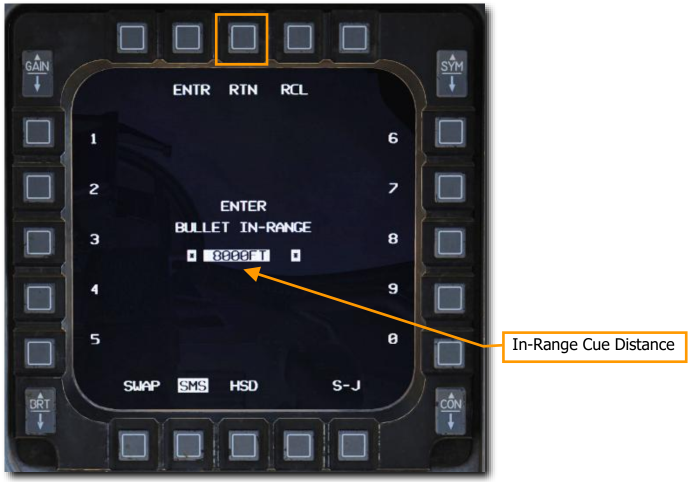
Once you have reached the minimum attack range, break off in both the horizontal and vertical to avoid hostile return fire. You may also wish to release flares in case an infrared-SAM near the enemy target has been launched at you, but you did not see it.

In-Range Cue Update

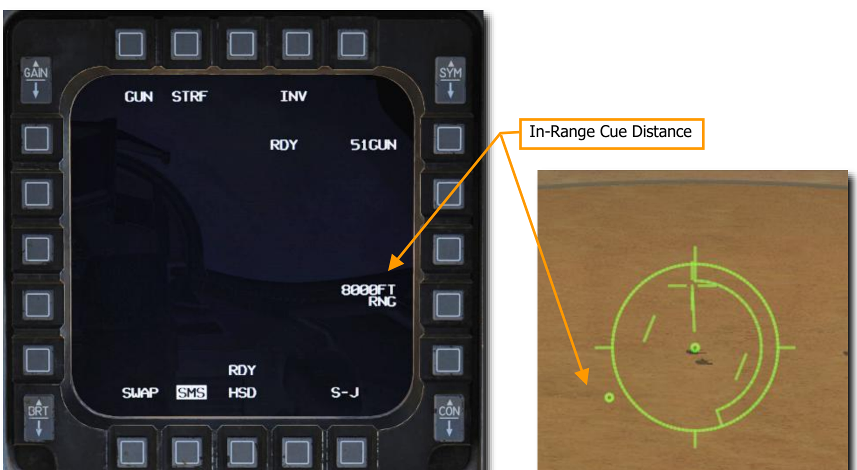
The position of the In-Range Cue on the reticle may be updated by selecting the OSB next to the In-Range Cue distance on the GUN SMS page.



Type in the new in-range cue distance using the OSBs on the left and right of the display and select ENTR. You may correct numbers entered in error by selecting RCL or return to the GUN SMS page without making changes by selecting RTN.



You will be returned to the GUN SMS page and the new value will be displayed. The cue will be placed on the HUD Strafe Reticle at that new distance.



2.75-INCH ROCKETS

Aerial rockets pack more punch than the 20mm gun but are still best used as an area suppression weapon. These come with different warhead options for different purposes including High Explosive (HE), High Explosive Anti-Tank (HEAT), and Armor Piercing (AP). White Phosphorus (WP) rounds may also be used for incendiary effect or to mark targets on the ground with their distinctive white smoke.

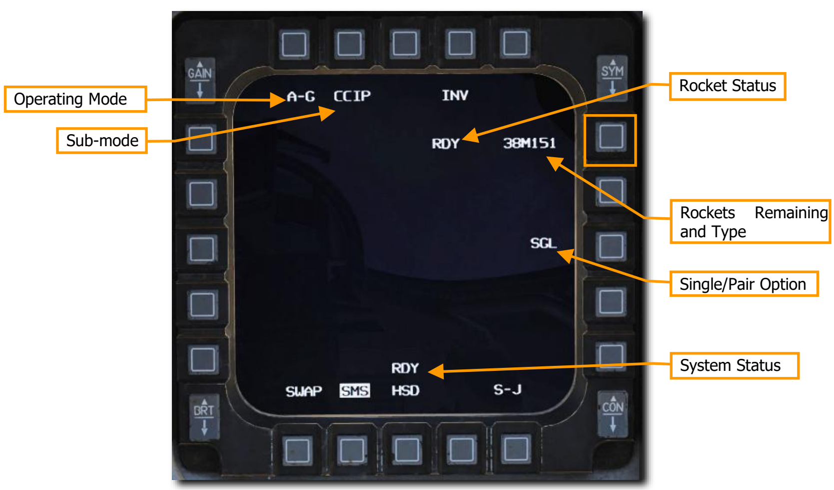
Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Set Laser Arm Switch to Arm if laser ranging updates are desired
4. Select Rockets and desired options on SMS MFD
5. Fly the Pipper onto the target
6. Depress the Weapons Release button **[RAlt]+[Space]** to fire the rockets

Target Attack (CCIP)

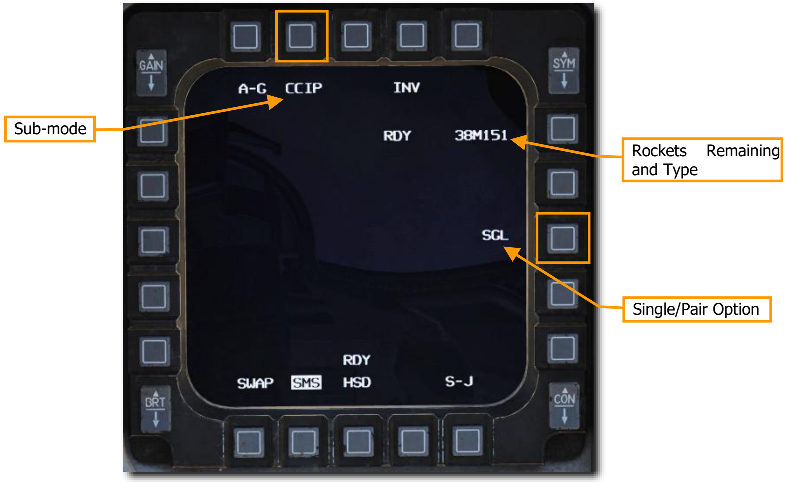
Upon selection of the A-G master mode, the SMS Air-to-Ground (SMS A-G) page is displayed on the right MFD. Based on the priority weapon, the information on the SMS A-G page can vary. Follow these steps to achieve the correct configuration and attack ground targets with rockets in CCIP mode:

1. **Select the Rockets on the MFD by pressing OSB 6 until rockets are displayed.**



2. **Verify CCIP release mode is selected (OSB 2) and set desired Single/Pair option (OSB 8).**

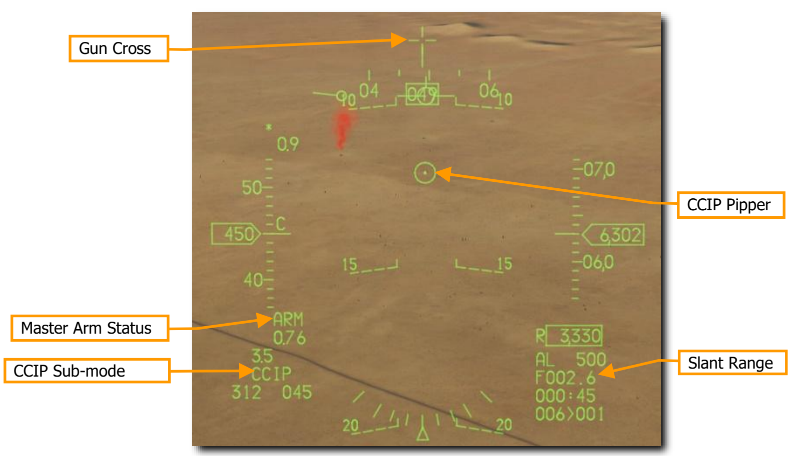
   Rockets may be fired with either Single (SGL) or Pair (PAIR) selected. With SGL selected, rockets will be fired from only one launcher. With PAIR selected, rockets will be fired from each rocket launcher, assuming launchers are loaded on station 3 and 7.



3. Verify CCIP Rockets symbology is displayed in the HUD.

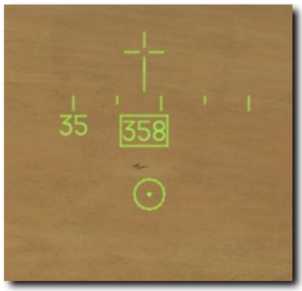
CCIP mode is perhaps the most intuitive means to put a weapon on target and mostly involves placing the "death dot" of the CCIP pipper over the target and releasing the weapon… put the thing on the thing.

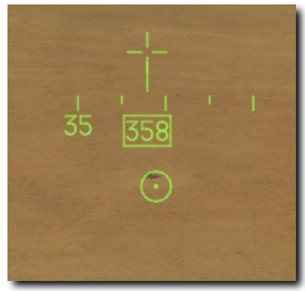
The center of the CCIP pipper represents where the rockets will go assuming the target is within range. Line of sight range is indicated by the digital range numeric on the bottom right of the HUD. An In-Range Cue will be displayed over the CCIP pipper when slant range is less than 8,000 feet and rockets are most effective.



4. Maneuver your aircraft to position the CCIP pipper on target.

One technique is to place the pipper just short of the target and allow it to track along the ground until it reaches the target. This will happen naturally as slant range decreases. Monitor slant range displayed in the bottom right of the HUD and watch for the in-range cue to appear over the pipper.

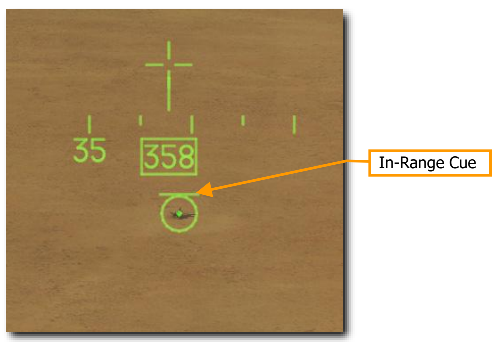




Laser ranging may be performed to improve the computed firing solution if a targeting pod is installed. (See Laser Ranging & Target Designation in the AAQ-33 Advanced Targeting Pod chapter for more information.)

5. **Press the Weapon Release button to fire the rockets when the CCIP pipper is over the target and you are within effective range.**

The In-Range Cue is a line over the CCIP pipper that is displayed when slant range is less than 8,000 feet. In this example, the pipper is on-target and the in-range cue is displayed.



When lining up a shot, be careful to avoid target fixation. Target fixation can lead to you not noticing an unseen threat or pressing the attack too close. Don't make yourself an easy target for the machine gun on the top of that APC!

Once you have reached the minimum attack range, break off in both the horizontal and vertical to avoid hostile return fire. You may also wish to release flares in case an infrared-SAM near the enemy target has been launched at you, but you did not see it.

UNGUIDED BOMBS

Unguided bombs that the F-16C can employ fall into three categories: General Purpose (GP), Cluster, and Training.

General Purpose Bombs

Mk-82 LDGP. The standard Mk-82 is a low drag "slick" bomb, also referred to as a Low Drag General Purpose (LDGP) bomb. The bomb is aerodynamically streamlined with four conical tail fins for flight stability. The bomb has a thin steel jacket that contributes to fragmentation effects.

The Mk-82 may be carried singly on a Wing Weapons Pylon (WWP) or three may be loaded on a Triple Ejector Rack (TER)

The Mk- 82 serves as the basis for several other bombs including the Mk-82 AIR, GBU-12, and GBU-38.

Mk-82 AIR. This version of the Mk-82 adds the BSU-49/B high drag tail assembly, also called a "ballute". This allows the bomb to rapidly slow down after release. By slowing down, you can release such a retarded weapon at low altitude and not be caught in the blast effect of the weapon. You can choose to release the Mk-82AIR in either retarded or "slick" (no ballute deployed) modes. To drop as a slick, select only a nose fuze, and to release retarded, select nose/tail or tail fuze setting on the SMS MFD format.

Mk-82 SE. This 'Snake Eye" version of the Mk-82 pre-dates the Mk-82 AIR and uses fins that deploy from the Mk-15 tail assembly to slow the bomb's fall. You can choose to release the Mk-82 Snakeye in either retarded or "slick" modes. To drop as a slick, select only a nose fuze, and to release retarded, select nose/tail or tail fuze setting on the SMS MFD format.

Mk-84 LDGP. The Mk-84 is the big brother of the Mk-82 and it weighs 2,039 lbs. with 945 lbs. of H-6 or Tritonal high explosive. Although most effective against unarmored and lightly armored targets, the Mk-84 can also be effective against armored targets when dropped in proximity. The Mk-84 can only be mounted on a WWP and cannot be loaded on a TER.

The Mk-84 forms the basis for other bombs including the GBU-10 and GBU-31 that the F-16C also carries.

Cluster Bombs

CBU-87. The CBU-87 Combined Effects Munitions (CEM) weighs 950 lbs. and is an all-purpose cluster bomb. The SUU-65 Tactical Munitions Dispenser that makes the body of the bomb contains 202 BLU-97/B Combined Effects Munitions (CEM) bomblets and they are effective against lightly armored and unarmored targets. The dispersal footprint of the bomblets depends on the Height of Function (HOF) and RPM spin setting set with dials on the bomb and displayed on the SMS MFD format. However, the general bomblet footprint coverage is 200 by 400 meters.

The CBU-87 can be mounted singly on a WWP. Only two may be loaded on a TER when wing external fuel tanks are installed due to clearance constraints. This is commonly referred to as a 'slant load'.

Each BLU-97/B CEB consists of a shaped charge, a scored steel casing, and a zirconium ring, for anti-armor and anti-personnel fragmentation and incendiary effects. Each CEB is designed to fragment into 300 fragments. Given the top attack angle of the weapon, the CEB can be effective against the generally light armor covering the top of an armored vehicle such as a tank.

CBU-97. The CBU-97 is a 1,000-pound class weapon containing sensor-fuzed sub-munitions in a SUU-66B Dispenser for specifically attacking armor. This Sensor Fuzed Weapon (SFW) contains 10 BLU-108/B sub-munitions, and 40 "hockey puck" shaped skeet infrared sensing projectiles.

As with the CBU-87, the dispersal footprint of the bomblets depends on the Height of Function (HOF) set with dials on the bomb and displayed on the SMS MFD format. The RPM is not applicable on this dispenser. The same carriage restrictions as the CBU-87 apply: one per WWP and two per TER.

Training Bombs

BDU-33. The BDU-33 is a miniaturized training bomb that mimics the ballistics of larger general-purpose bombs. The BDU-33 contains a small smoke charge to help round spotting.

Unguided/Laser Guided Bombs SMS Page

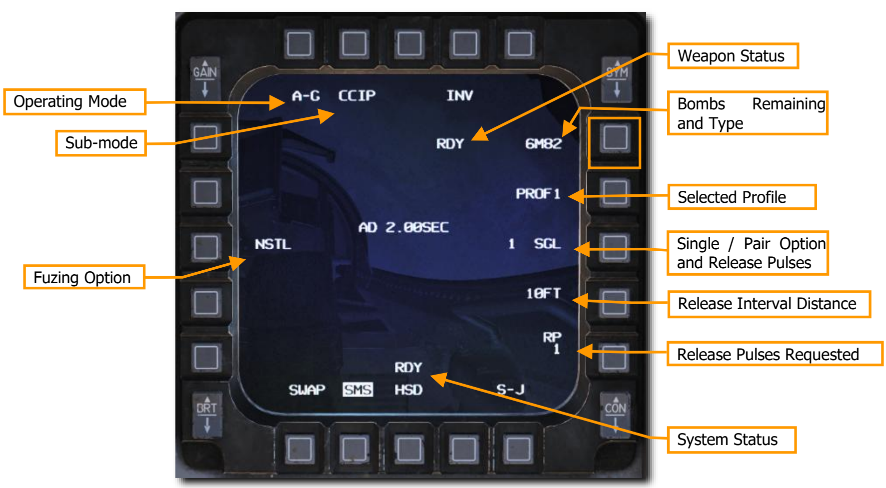
The A-G SMS display and procedure for setting up an attack with guided or unguided bombs is very similar for all types. The initial set-up will only be covered once, with differences in CCIP, CCRP sub-modes covered in separate sections below.

Summary

1. Select A-G Master Mode **[2]**
2. Select bombs and set desired options on SMS A-G MFD

Upon selection of the A-G master mode, the SMS Air-to-Ground (SMS A-G) page is displayed on the right MFD. Based on the priority weapon, the information on the SMS A-G page can vary. Follow these steps to achieve the correct configuration and attack ground targets with GP bombs in CCIP mode:

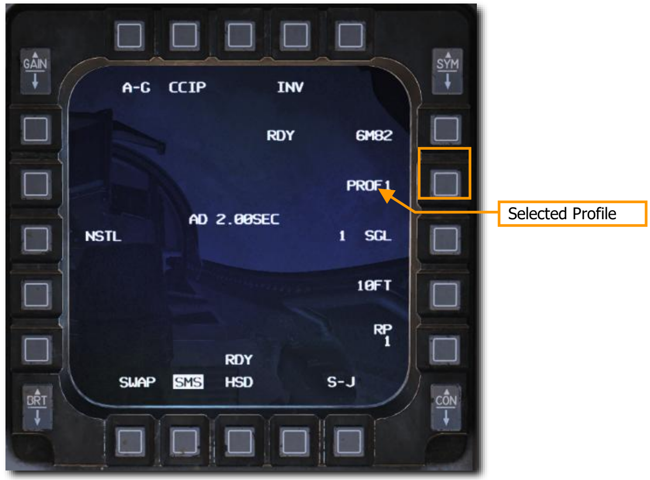
1. **Select the desired weapons on the MFD by pressing OSB 6 until the weapons you want to release are displayed.**



2. **Select the desired profile for the selected weapons.**

   Two different profiles are pre-set by default. These include typical settings for delivery mode, fuze arming option, bomb impact spacing, and release quantity. If a profile already matches your planned attack profile, you are all set; no more changes are required! If not, follow the steps that follow in this section to set the profile up to your liking.

Selecting the OSB next to the current profile to cycle between the two options: PROF1 and PROF2.



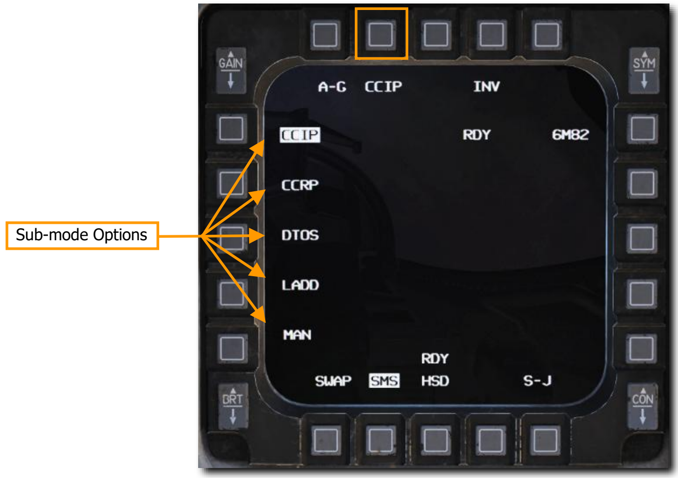
Changes to settings made while a profile is selected are saved for later use. These should typically be set or verified as part of aircraft startup, although they may be changed at any time.

3. Select your desired release sub-mode. (OSB 2)

If a sub-mode other than the one you want is selected, you may press OSB 2 to display the following options.

- CCIP – Continuously Computed Impact Point
- CCRP – Continuously Computed Release Point
- DTOS – Dive Toss
- LADD – Low Altitude Drogue Delivery
- MAN – Manual

Then, select the OSB next to your desired sub-mode. That will set the new active sub-mode and return you to the SMS A-G page.

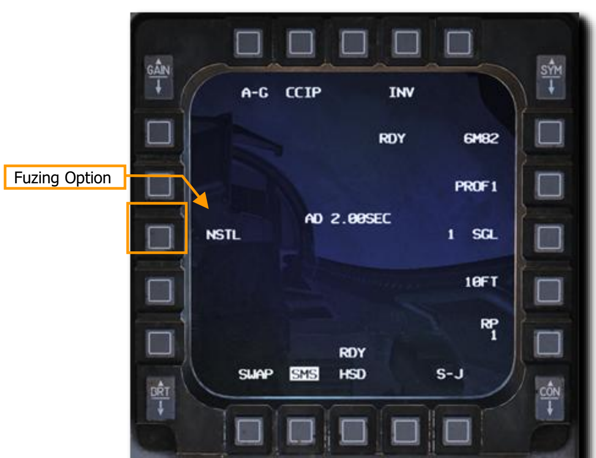


You may also cycle between sub-modes by pressing the Missile Step button on the Side Stick Controller (SSC).

4. Set desired bomb fuzing option. (OSB 18)

Bombs are typically equipped with two fuzes, one in the nose and one in the tail. These are sometimes set with different impact delay settings to provide the pilot with the choice of how the fuze functions and when the bomb detonates after impact. Sometimes an instantaneous detonation is desired for fragmentation effects and sometimes a delayed detonation is desired to allow target penetration or cratering.

Selecting OSB 18 cycles between three fuze arming options: NOSE, TAIL and NSTL (Nose/Tail). This is typically set to NSTL (Nose/Tail) for redundancy unless a specific effect is desired when the weapon detonates.

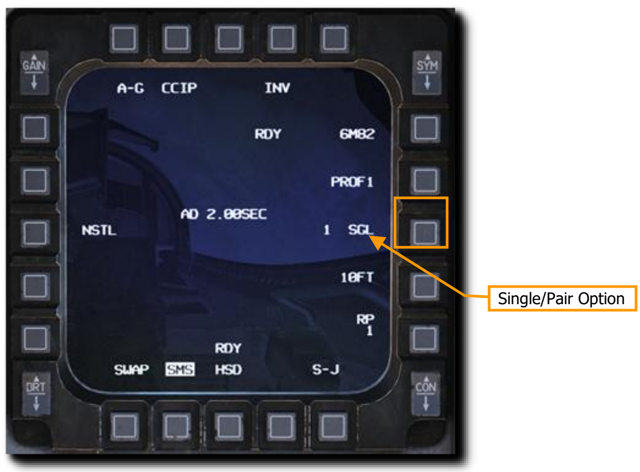


There are also some special cases where the fuze option changes how the weapon behaves after release:

- Mk-82 AIR/SE
  - NSTL – High Drag
  - NOSE – Low Drag
  - TAIL – High Drag
- CBU-87/97
  - NSTL – Bomblets dispense using settings displayed on SMS MFD format
  - NOSE – Bomblets dispense immediately after release
  - TAIL – Dud

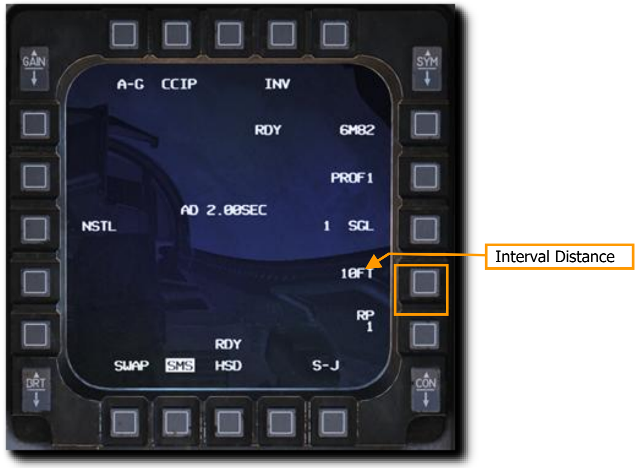
5. Set desired Single/Pair option. (OSB 8)

Bombs may be released with either Single (SGL) or Pair (PAIR) selected. With SGL selected, bombs will be released from only one station. With PAIR selected, bombs will be released from both opposite stations, assuming identical bombs are loaded on stations 4 and 6 or 3 and 7.

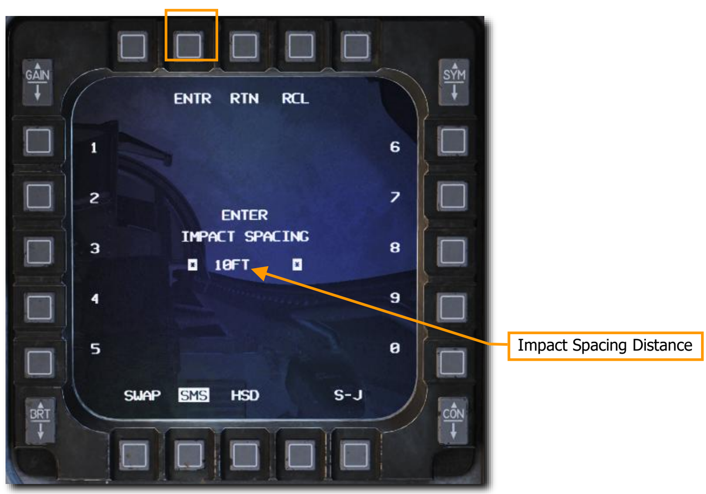


6. Set the desired release interval distance if more than one bomb is to be released. (OSB 9)

The timing between release pulses is computed by the aircraft to space multiple weapons in a 'stick' along the ground at the specified distance. Valid distances range from 10-999 feet. This setting has no effect if only one bomb or one pair of bombs is released.

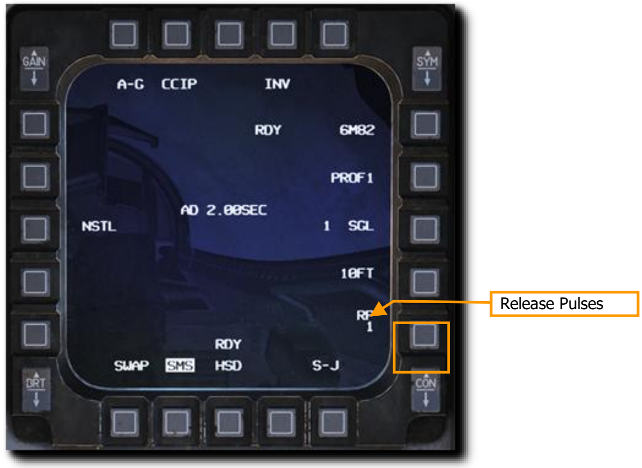


Type in the new impact spacing distance using the OSBs on the left and right of the display and select ENTR. You may correct numbers entered in error by selecting RCL or return to the A-G SMS page without making changes by selecting RTN.

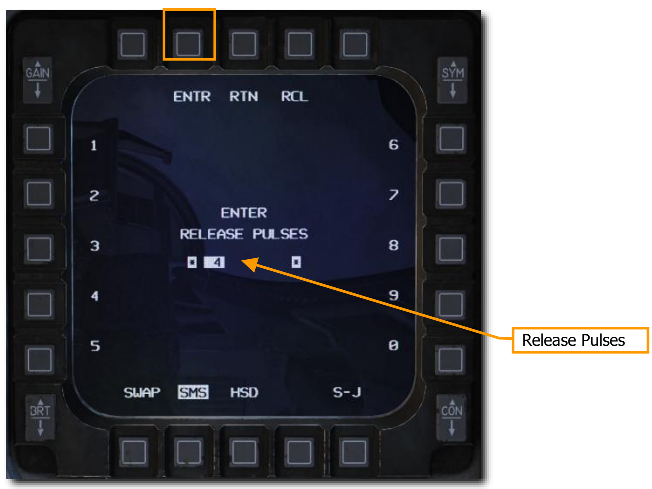


7. Set the number of release pulses if more than one bomb is to be released. (OSB 10)

This sets the number of release pulses sent to the weapons stations when the Weapon Release button is pressed. For example, a setting of 1 releases only one bomb or pair of bombs at a time while a setting of 4 releases four bombs or pairs of bombs at a time. This is commonly known as a 'ripple release'.



Type in the desired number of release pulses using the OSBs on the left and right of the display and select ENTR. You may correct numbers entered in error by selecting RCL or return to the A-G SMS page without making changes by selecting RTN.



Unguided Bombs CCIP Attack

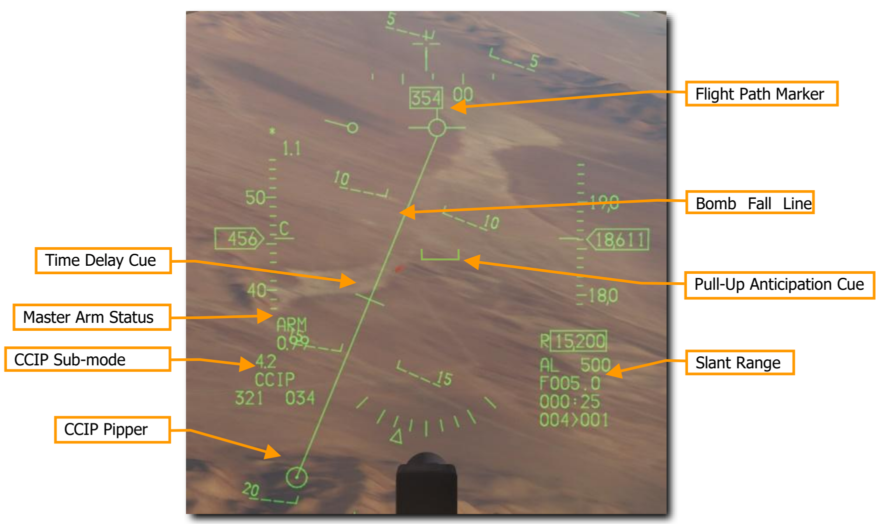
The Continuously Computed Impact Point (CCIP) mode is a computed visual delivery mode with manual weapon release. This mode allows a high degree of flexibility since the point on the ground at which the weapon will impact is continuously indicated by a CCIP Pipper on the HUD. No target designation is required. Place the thing on the thing and drop the bomb.

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Set Laser Arm Switch to Arm if laser ranging updates are desired
4. Select Bombs and desired options on SMS MFD
5. Fly the Pipper onto the target
6. Depress the Weapons Release button **[RAlt]+[Space]** to expend weapons

1. Verify CCIP symbology is displayed in the HUD.

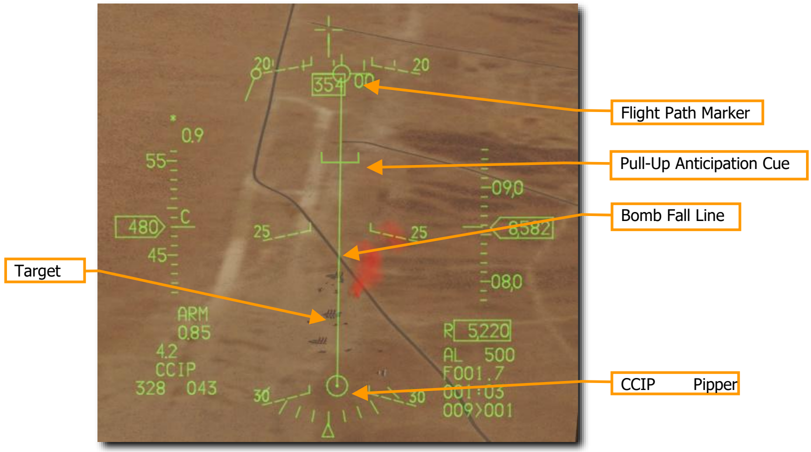
If the CCIP impact point does not lay within the HUD field of view, the Time Delay Cue (TDC) is shown as a short, horizonal line on the Bomb Fall Line. The CCIP Pipper is outside the HUD field of view when this is displayed. A second, 'post-designate CCIP' technique may be used in this situation but that will be covered in the next section.



2. Maneuver your aircraft to position the CCIP Pipper on target.

When the TDC is no longer displayed on the Bomb Fall Line, the pipper is in the HUD field of view. That will be the impact point if the bombs are released immediately.

One technique is to place the FPM ahead of the target and the pipper just short of the target. Fly the Bomb Fall Line over the target and allow the pipper to track straight up the line. This will happen naturally as slant range decreases.

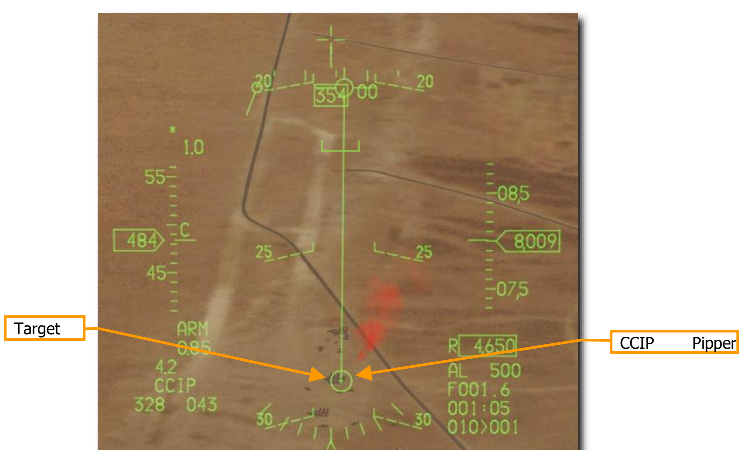


Monitor the Pull-Up Anticipation Cue to ensure it does not go above the Flight Path Marker. The Pull-Up Anticipation Cue (PUAC) provides a visual representation of the altitude required for the bomb fuze to arm or altitude to initiate a pull-up to avoid impacting the ground, whichever is more immediate. It moves up toward the Flight Path Marker (FPM) as the aircraft loses altitude. Releasing a bomb with the FPM below the PUAC will not give the bomb time to arm and result in a dud.

Laser ranging may be performed to improve the computed release solution if a targeting pod is installed. (See Laser Ranging & Target Designation in the AAQ-33 Advanced Targeting Pod chapter for more information.)

3. **Press the Weapon Release button to release the bombs when the CCIP pipper is over the target.**

   The pipper will be at the center of the 'stick' if more than one bomb is released in a ripple delivery. Hold the Weapons Release button long enough to ensure all weapons come off. The FPM flashes after weapons are released.



Pull up immediately and take evasive action to avoid flying into bomb fragments and to avoid enemy fire.

Unguided Bombs CCIP Attack (Post-Designate)

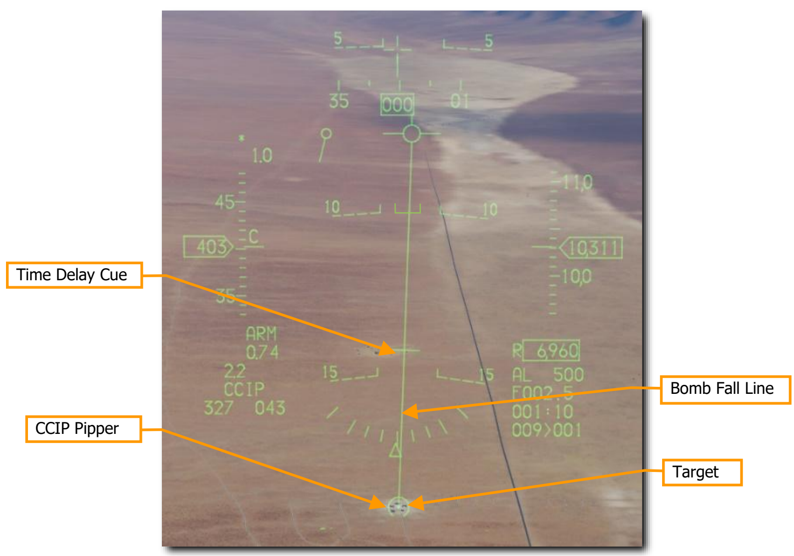
An additional option for CCIP bombs delivery is available for situations where the target cannot be within the HUD field of view at release. This can sometimes happen on attacks from a shallow dive angle or high altitude.

The steps to enter CCIP mode are the same as described above. The difference is in when you press and hold the Weapons Release button.

1. **Maneuver your aircraft to position the CCIP Pipper on target.**

   When the Time Delay Cue is displayed on the Bomb Fall Line, the pipper is not in the HUD field of view, however you will still place the pipper over the intended target.

   You will designate that location as the target by pressing and holding the Weapons Release button. The fire control computer will do the rest.

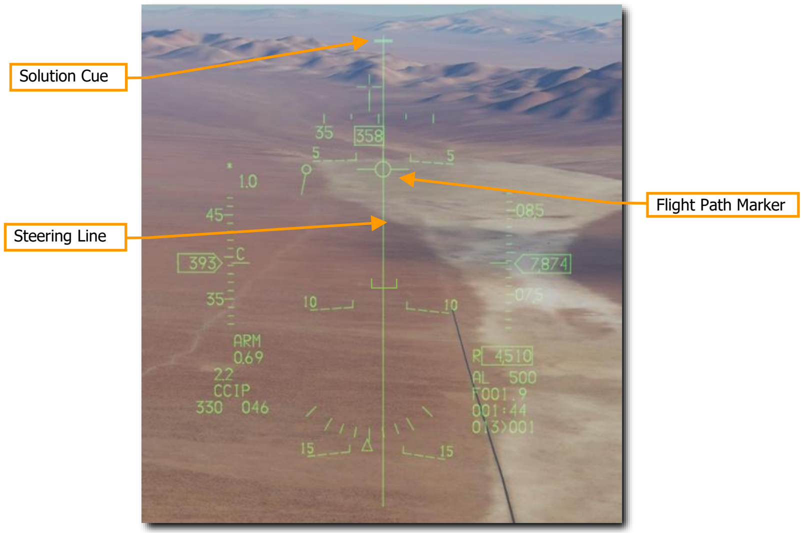


   Laser ranging may be performed to improve the computed release solution if a targeting pod is installed. (See Laser Ranging & Target Designation in the AAQ-33 Advanced Targeting Pod chapter for more information.)

2. **Press and HOLD the Weapons Release button.**

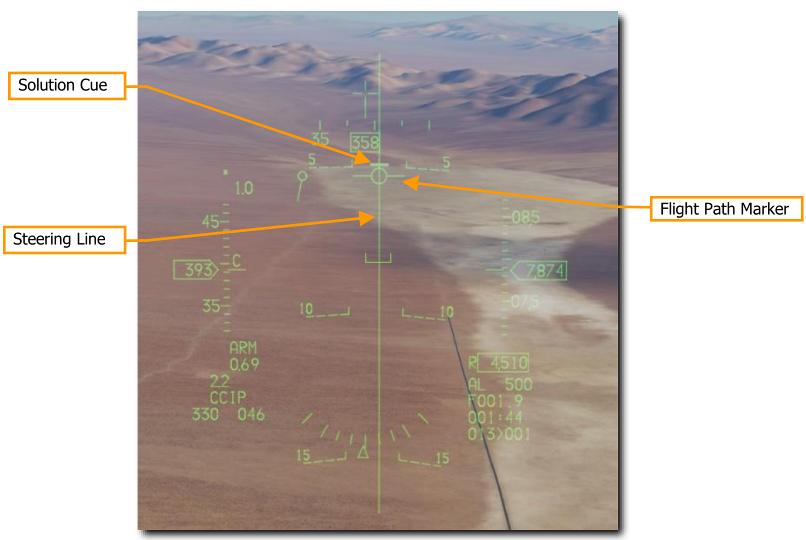
   The HUD symbology displayed is identical to that used for a CCRP delivery. Keep the Flight Path Marker aligned with the Steering Line. This will align your aircraft with the target even though the target will be out of sight.

   A Solution Cue is displayed at the top of the Steering Line. It will fall down the line as the range decreases and the weapon is about to be released.



3. Keep the Weapons Release button held until after the Solution Cue passes the Flight Path Marker.

Keep flying the Flight Path Marker over the Steering Line as the Sulution Cue continues to track downward. The bombs are released when the Steering Cue passes the Flight Path Marker.



Hold the Weapons Release button long enough to ensure all weapons come off. The FPM flashes after weapons are released. Pull up immediately and take evasive action to avoid flying into bomb fragments and to avoid enemy fire.

Unguided Bombs CCRP Attack

The Continuously Computed Release Point (CCRP) mode provides computed, automatic release of bombs. This can be done from a dive, but also from wings-level or a nose-high attitude.

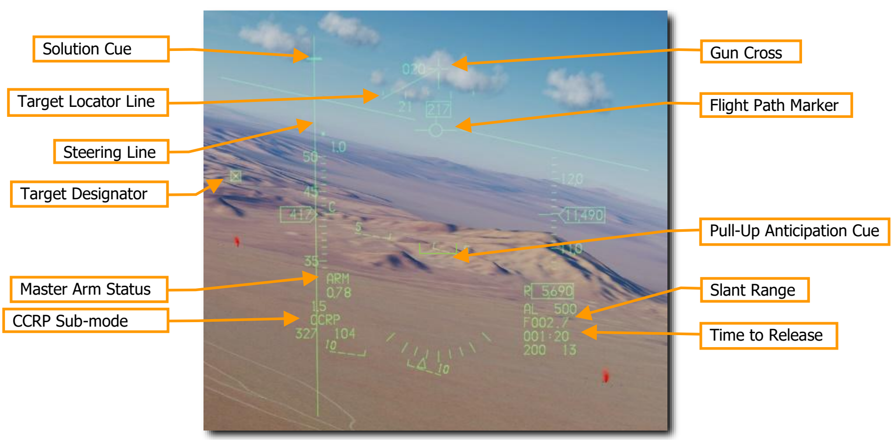
This mode requires a target designation point from which to build the bombing solution. Command steering is provided to the appropriate weapon release point and the weapon will release automatically at the proper time such that the weapons hit the target.

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Set Laser Arm Switch to Arm if laser ranging updates are desired
4. Select Bombs and desired options on SMS MFD
5. Set desired steerpoint number or designate target with TGP
6. Center FPM on Steering Line
7. Depress and hold Weapons Release button **[RAlt]+[Space]** to expend weapons at computed point

1. Verify CCRP symbology is displayed in the HUD.

The fire control system provides a Steering Line (SL) to provide steering to the designated target. By placing the Flight Path Marker (FPM) on the SL and holding down the Weapon Release Button, the weapon will release at the proper time and account for wind.



A Solution Cue is displayed at the top of the SL. It will fall down the line as the range decreases and the weapons are about to be released.

When the Target Designator (TD) is outside the HUD field on view as shown above, a Target Locator Line (TLL) extends from the Gun Cross pointing directly at the target. The relative angle is displayed next to the Gun Cross showing the number of degrees in tens between the cross and the target.

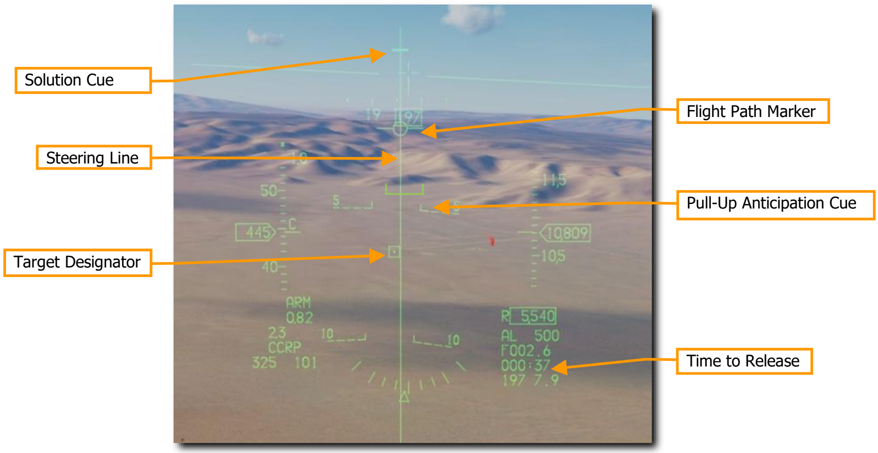
2. Designate the desired target.

To calculate a bombing solution in CCRP mode, a target first must be designated. This can be done by:

- Selecting a Steerpoint that was placed at the target location

- Designating a target with the Targeting Pod (if installed)

Updates to the target location may be made by slewing the TD Box in the HUD or slewing the TGP crosshairs onto a new position with the RDR CURSOR/ENABLE switch.



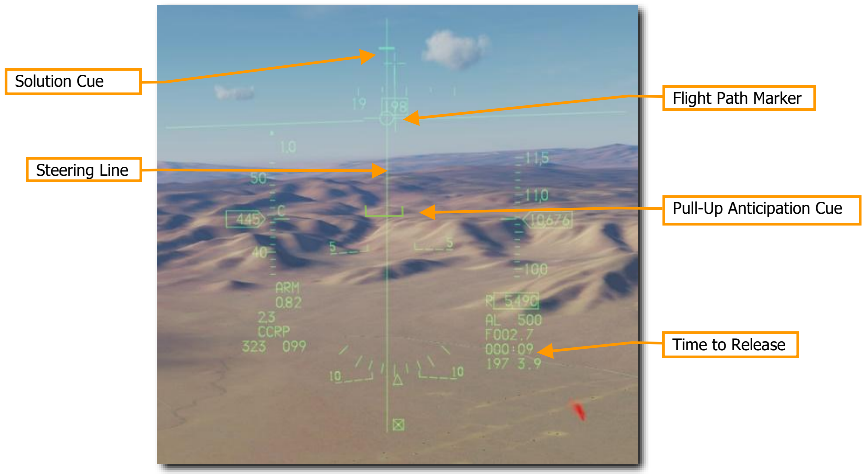
Monitor the Pull-Up Anticipation Cue to ensure it does not go above the Flight Path Marker. The Pull-Up Anticipation Cue (PUAC) provides a visual representation of the altitude required for the bomb fuze to arm or altitude to initiate a pull-up to avoid impacting the ground, whichever is more immediate. It moves up toward the Flight Path Marker (FPM) as the aircraft loses altitude. Releasing a bomb with the FPM below the PUAC will not give the bomb time to arm and result in a dud.

Laser ranging may be performed to improve the computed release solution if a targeting pod is installed. (See Laser Ranging & Target Designation in the AAQ-33 Advanced Targeting Pod chapter for more information.)

3. **Press and HOLD the Weapon Release button.**

Keep the Flight Path Marker aligned with the Steering Line. This will align your aircraft with the target even though the target will be out of sight.

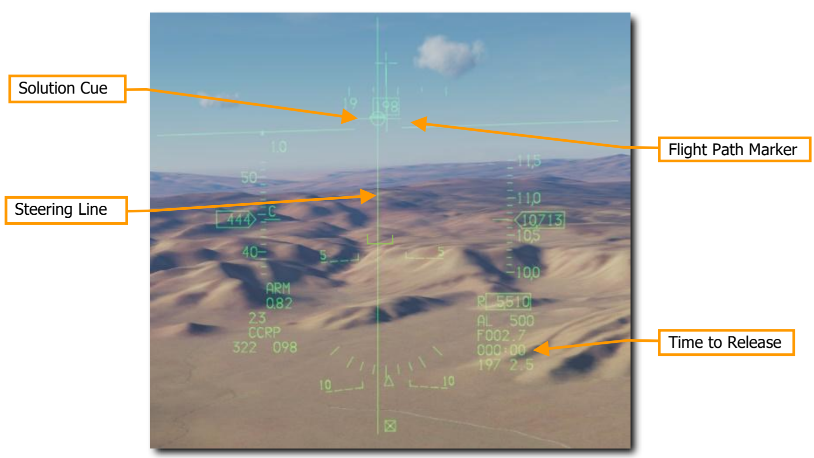
Time to release counts down at the lower right of the HUD.



When the Solution Cue begins to move down the Steering Line, about 10 seconds prior to release, press and hold the Weapon Release button. This provides the fire control computer consent to release the weapons.

4. Keep the Weapons Release button held until after the Solution Cue passes the Flight Path Marker.

Keep flying the Flight Path Marker over the Steering Line as the Sulution Cue continues to track downward. The bombs are released when the Steering Cue passes the Flight Path Marker.



Hold the Weapons Release button long enough to ensure all weapons come off. The FPM flashes after weapons are released.

LASER-GUIDED BOMBS

The development of laser guided weapons has dramatically improved the accuracy of weapon guidance and delivery. With the assistance of build-up guidance kits, general GP bombs are turned into laser-guided bombs (LGBs). The kits consist of a computer- control group (CCG), guidance canards attached to the front of the warhead to provide steering commands, and a wing assembly attached to the aft end to provide lift. LGBs are maneuverable, free-fall weapons requiring no electronic interconnect to the aircraft. They have an internal semi-active guidance system that detects laser energy and guides the weapon to a target illuminated by an external laser source. The designator can be in the delivery aircraft, another aircraft, or a ground source.

All LGB weapons have a Computer Control Group (CCG), a warhead (bomb body with fuze), and an airfoil group. The computer section transmits directional command signals to the appropriate pair of canards. The guidance canards are attached to each quadrant of the control unit to change the flight path of the weapon. The canard deflections are always full scale (referred to as "bang, bang" guidance).

The LGB flight path is divided into three phases: ballistic, transition, and terminal guidance. During the ballistic phase, the weapon continues via the unguided trajectory established by the flight path of the delivery aircraft at the moment of release. In the ballistic phase, the delivery attitude takes on additional importance since maneuverability of the LGB is related to the weapon velocity during terminal guidance. Therefore, airspeed lost during the ballistic phase equates to a proportional loss of maneuverability. The transition phase begins at acquisition. During the transition phase, the weapon attempts to align its velocity vector with the line-of-sight vector to the target. During terminal guidance, the LGB attempts to keep its velocity vector aligned with the instantaneous line-of-sight. At the instant alignment occurs, the reflected laser energy centers on the detector and commands the canards to a trail position, which causes the weapon to fly ballistically with gravity biasing towards the target.

GBU-10 Paveway II. This Guided Bomb Unit (GBU) weighs 2,562 lbs. and is basically a laser-guided version of the Mk-84 unguided bomb with a general-purpose warhead. The laser detector on the nose of the seeker detects the reflected energy of the designating laser at the set laser code. Once dropped, the wing-like airfoil surfaces at the rear of the bomb extend and are used to maneuver the bomb to the laser designation point. Rather than smooth and constant input of course-corrections to reach the target, the bomb uses a series of discreet input corrections and this is often referred to as "bang-bang" guidance mode.

GBU-10 can only be hung from a MAU-12 ejector rack on stations 3, 4, 6, and 7.

Suitable targets for the GBU-10 are large and/or hardened targets that require an accurate and powerful strike. Such targets often include bridges, bunkers, and hardened command posts.

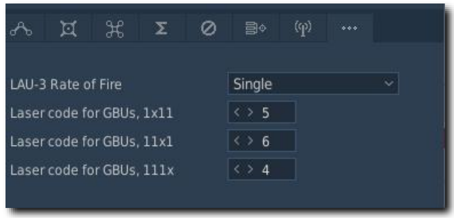
GBU-12 Paveway II. This GBU is the laser-guided version of the Mk-82 unguided, general purpose bomb. The GBU-12 guides using the same principles as the GBU-10, the only difference being the bomb the LGB is based on.

The GBU-12 can be mounted singly on a MAU-12 ejector rack at stations 3, 4, 6, and 7. Only two may be loaded on a TER when wing external fuel tanks are installed due to clearance constraints. This is commonly referred to as a 'slant load'.

Terminal Laser Guidance Codes

The seeker head on each laser guided bomb is set to track only a specific laser pulse rate frequency (PRF) code. These are manually set by the weapons load crew during ground operations and may not be set from the cockpit during flight.

To replicate this, the laser code may be set using the mission editor. In this example, the laser code on each bomb seeker head is 1564.



An additional method to set the bomb seeker laser code is included on the in-game kneeboard. You may access this using keyboard command **[RShift]+[K]**, then use the **[** and **]** (bracket) keys to access the page. Use the keyboard commands listed to the right of each digit to change the laser code.

Bomb seeker laser codes can only be changed using this method on the ground prior to engine start and with the STA POWER switch on the right console OFF.

The laser designator on the targeting pod must be set to match the code on the bomb. (See LASR DED Page for more information.)

A-G SMS Page

The A-G SMS display and procedures for setting up an attack with guided or unguided bombs are identical. See the Bombs A-G SMS Page section for procedures.

Laser Guided Bomb CCRP Attack

The Continuously Computed Release Point (CCRP) mode provides computed, automatic release of bombs. This can be done from a dive, but also from wings-level or a nose-high attitude. The laser guided bomb attack is identical to unguided bombs with the addition of laser designation with the Targeting Pod (TGP)

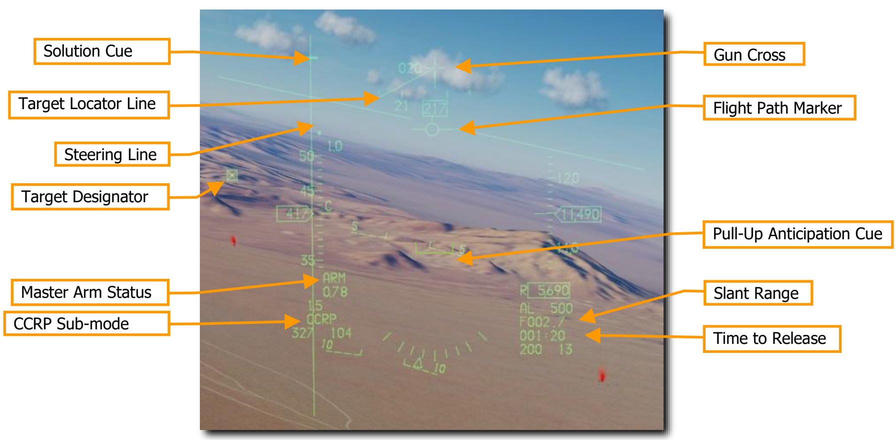
This mode requires a target designation point from which to build the bombing solution. Command steering is provided to the appropriate weapon release point and the weapon will release automatically at the proper time such that the weapons hit the target.

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Set Laser Arm Switch to Arm
4. Select Bombs and desired options on SMS MFD
5. Set desired steerpoint number or designate target with TGP
6. Center FPM on Steering Line
7. Depress and hold Weapons Release button **[RAlt]+[Space]** to release at the computed point
8. Lase target at least 8-12 seconds prior to impact

1. Verify CCRP symbology is displayed in the HUD.

The fire control system provides a Steering Line (SL) to provide steering to the designated target. By placing the Flight Path Marker (FPM) on the SL and holding down the Weapon Release Button, the weapon will release at the proper time and account for wind.



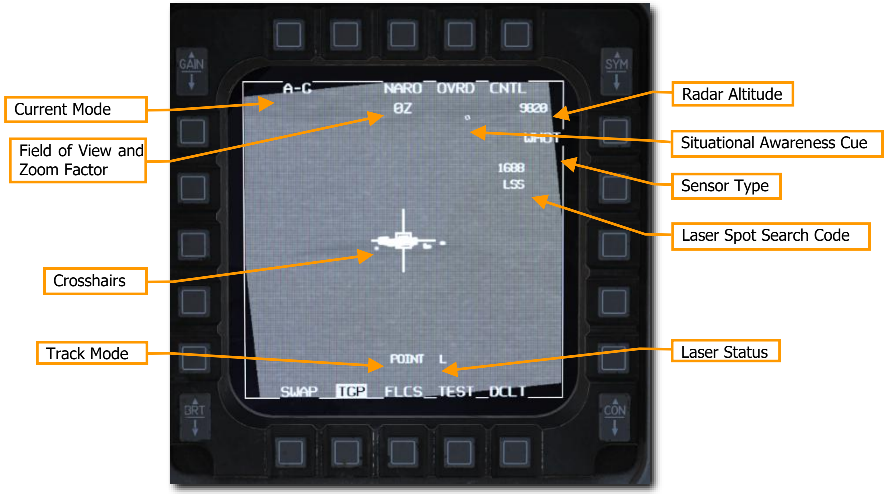
A Solution Cue is displayed at the top of the SL. It will fall down the line as the range decreases and the weapons are about to be released.

When the Target Designator (TD) is outside the HUD field on view as shown above, a Target Locator Line (TLL) extends from the Gun Cross pointing directly at the target. The relative angle is displayed next to the Gun Cross showing the number of degrees in tens between the cross and the target.

2. Verify TGP is configured for target search and laser fire.

Select A-G mode on the TGP to configure it for target acquisition and weapon guidance. The line of sight will slave to the selected steerpoint when CCRP delivery mode is selected.

The TGP display may be made the sensor of interest (SOI) by positioning the Display Management Switch (DMS) Down. The current SOI can be identified by the box surrounding the display.



The TGP crosshairs may then be slewed to a new position using the RDR CURSOR/ENABLE switch. Slewing the Target Designator with the HUD as SOI will also slew the TGP crosshairs.

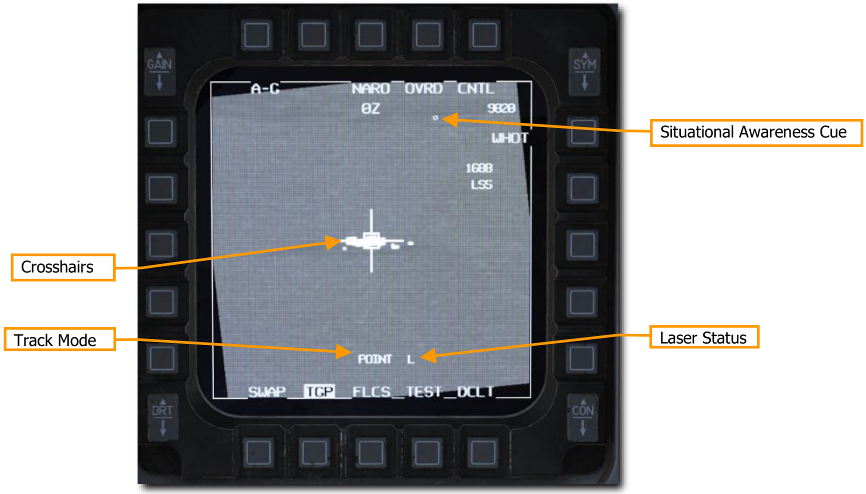
3. Locate and designate the desired target.

To calculate a bombing solution in CCRP mode, a target first must be designated. This can be done in two ways:

- **Select a Steerpoint that was placed at the target location.** The Target Designator box on the HUD will be placed at the steerpoint. The TGP will slave to that location when CCRP mode is selected.
- **Locate a target with the Targeting Pod.** With the TGP SOI, position the TMS Aft to undesignate. The TGP will return to the boresight position near the center of the HUD. Fly or slew the TGP line of sight to the desired target location. TMS Forward to designate. The Target Designator box on the HUD will be placed at that location.

Updates to the target location may be made by slewing the TD Box in the HUD or slewing the TGP crosshairs onto a new position with the RDR CURSOR/ENABLE switch. The Targeting Pod line of sight is used to calculate the bombing solution regardless of the track mode used.

Command an area track with TMS Forward to stabilize the crosshairs over the target. A Point Track may also be commanded using TMS Forward to aid in targeting if desired.



Laser ranging may be performed to improve the computed release solution if a targeting pod is installed. (See Laser Ranging & Target Designation in the AAQ-33 Advanced Targeting Pod chapter for more information.)

The laser designator may be fired with any sensor type selected and from any track mode. The Laser status is displayed as an L near the bottom of the display when the Laser Arm switch is set to arm.

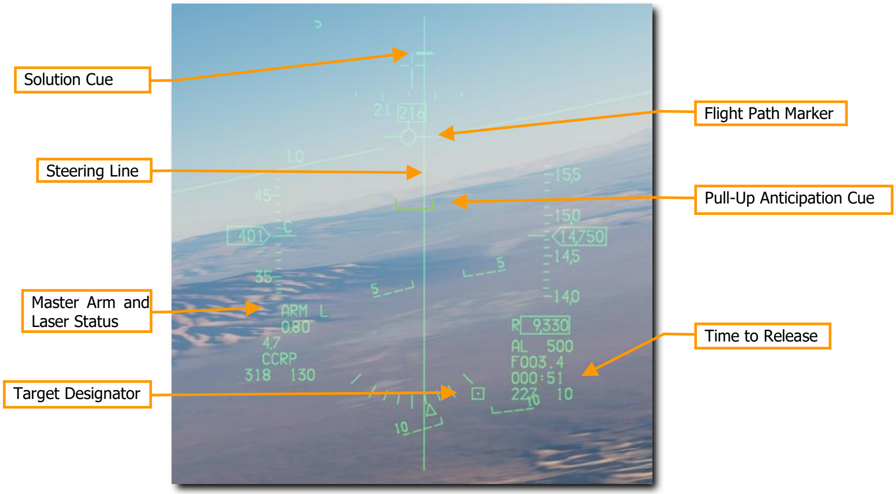
The laser is fired by squeezing the trigger to the first detent. The L flashes when the laser designator is firing.

4. Execute a CCRP bombing delivery.

Weapons delivery for laser guided bombs is identical to unguided bomb CCRP delivery.

Keep the Flight Path Marker aligned with the Steering Line. This will align your aircraft with the target even though the target will be out of sight.

The Steering Cue will fall down the Steering Line as the range decreases and the weapon is about to be released. Time to release counts down at the lower right of the HUD.

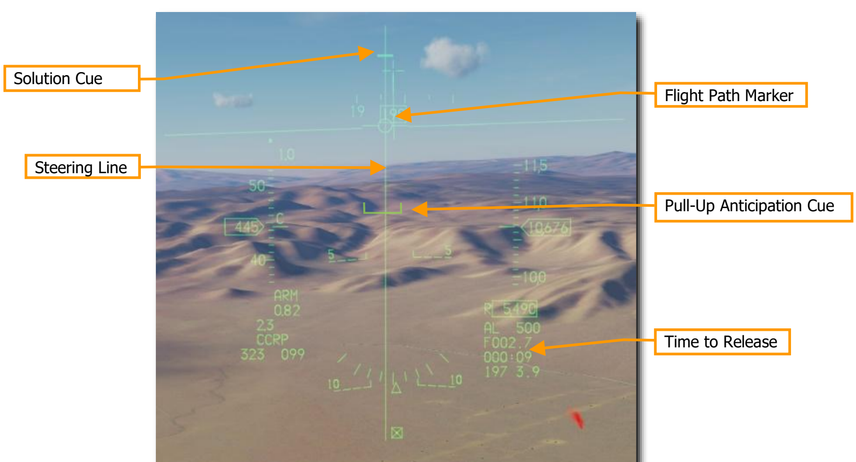


Monitor the Pull-Up Anticipation Cue to ensure it does not go above the Flight Path Marker. The Pull-Up Anticipation Cue (PUAC) provides a visual representation of the altitude required for the bomb fuze to arm or altitude to initiate a pull-up to avoid impacting the ground, whichever is more immediate. It moves up toward the Flight Path Marker (FPM) as the aircraft loses altitude. Releasing a bomb with the FPM below the PUAC will not give the bomb time to arm and result in a dud.

5. Press and HOLD the Weapon Release button.

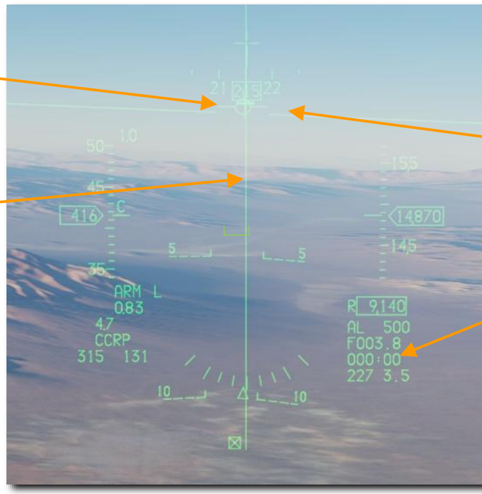
When the Solution Cue begins to move down the Steering Line, about 10 seconds prior to release, press and hold the Weapon Release button. This provides the fire control computer consent to release the weapon.

Keep the Flight Path Marker aligned with the Steering Line. This will align your aircraft with the target even though the target will be out of sight.



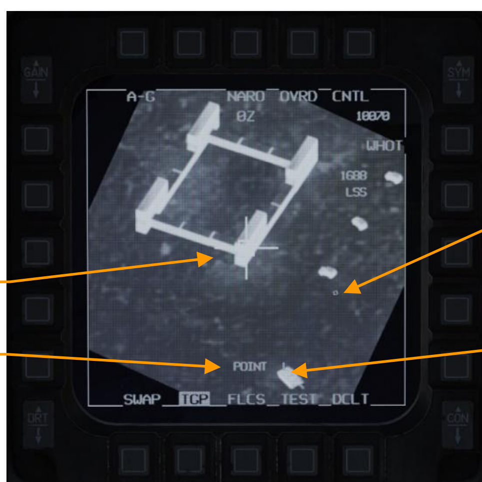
6. Keep the Weapons Release button held until after the Solution Cue passes the Flight Path Marker.

Keep flying the Flight Path Marker over the Steering Line as the Sulution Cue continues to track downward. The bombs are released when the Steering Cue passes the Flight Path Marker.



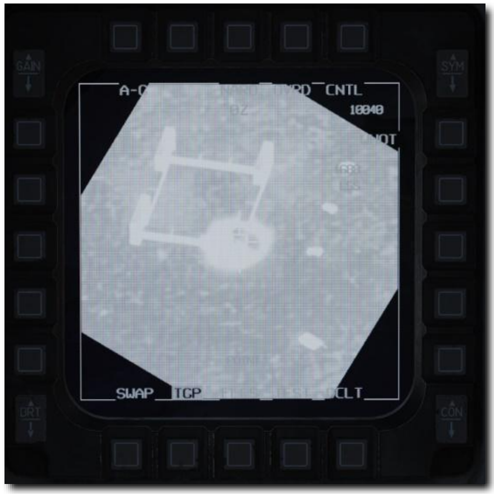
Hold the Weapons Release button long enough to ensure all weapons come off. The FPM flashes after weapons are released.

Execute a 30-45 degree check turn to the left or right to avoid overflight of the target and possible TGP gimbal roll. Continue to track the target in the TGP and update the crosshair aimpoint if necessary.



7. Lase the target with the TGP.

Squeeze the Trigger to lase the target no later than 8-12 seconds prior to impact. The L flashes when the laser designator is firing. At impact, the screen will wash out from the IR energy of the explosion.

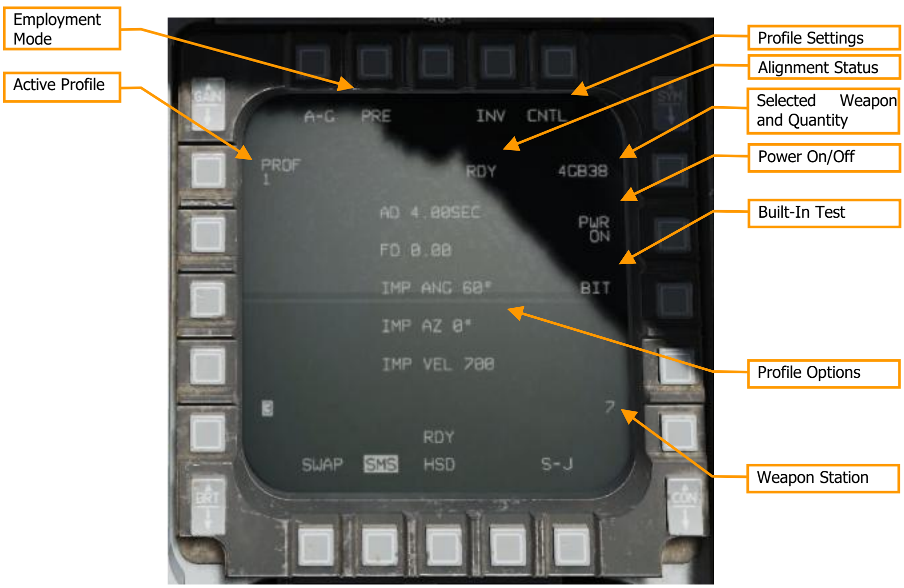


Switch to a wide field of view for an assessment and documentation of target damage. Set up for a re-attack if necessary or exit the area.

JOINT DIRECT ATTACK MUNITIONS (JDAM)

JDAM is an inertial and GPS guidance kit that can be attached to the Mk-82 or Mk-84 general-purpose bombs. When released, the aircraft downloads the target coordinates to the JDAM. The JDAM then guides to those coordinates. The weapon is completely fire-and-forget but cannot be steered or re-targeted post-launch.

JDAM SMS Format



Employment Mode. Toggles between pre-planned (PRE) and visual (VIS) employment modes. (See Employment in Pre-planned Mode and Employment in Visual Mode.)

Active Profile. Cycles between four different employment profiles. (See SMS Control Page for more information.)

Profile Settings. Press this OSB to open the Control page, where you can modify the active profile. (See SMS Control Page for more information.)

Alignment Status. When the weapon is first powered on, will display "A10" (unstable alignment). During the alignment process, it will count down, and then display "RDY" when alignment is complete.

Selected Weapon and Quantity. Displays the weapon quantity and "GB38" or "GB31".

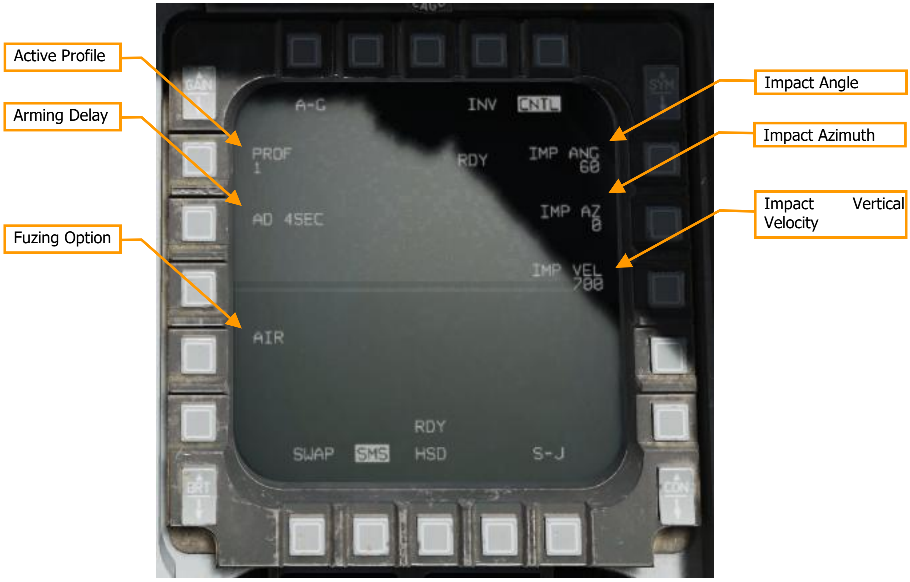
Power On/Off. Press to toggle power to all JDAM stations.

Built-In Test. Runs built-in tests. (N/I)

Profile Options. Displays the parameters of the selected profile. (See SMS Control Page for more information.)

Weapon Station. The selected weapon station for the next release is displayed in reverse video.

SMS Control Page



Active Profile. Cycles between four different profiles to edit.

Arming Delay. Selects the delay between weapon release and arming. Options are 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, 10, 14, 21, and 25 seconds.

Fuzing Option. Sets the fuzing option:

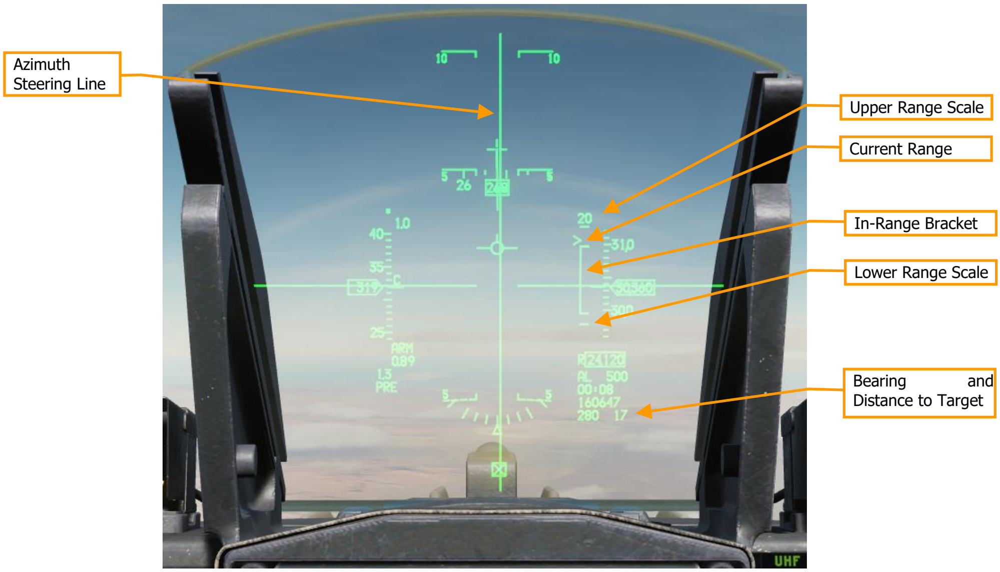
- AIR: Weapon will air-burst above the target. This reduces the penetrative effect of the bomb but improves its area effect.
- GND: Weapon will explode on impact. Selecting GND will reveal an additional option labeled FD (fuzing delay). Selectable fuzing delays are 0 (instant), 5, 15, 25, 45, 60, 90, 180, and 240 milliseconds. Adding a fuzing delay allows the weapon to penetrate the target prior to exploding.
- GND DLY: Weapon will impact target inert, and then explode after an extended period. Selecting GND DLY will reveal an additional option labeled FD (fuzing delay). Selectable fuzing delays are 0.25, 0.5, 0.75, 1, 4, 8, 12, 16, 20, and 24 hours after impact.

Impact Angle. Sets the angle that the bomb will attempt to impact the target at (e.g., 60°). A higher impact angle should be used if tall structures surround the target.

Impact Azimuth. Sets the heading that the bomb will attempt to fly to the target during the terminal phase. A value of "0" means no specific heading; use a value of "360" if you want the bomb to impact the target from the south flying north.

Impact Vertical Velocity. Sets the vertical velocity the bomb will attempt to achieve when impacting the target, in feet per second. A higher vertical velocity creates more effective penetration.

JDAM HUD Symbology



Azimuth Steering Line. Center the Flight Path Marker over this line to fly the fastest course to the launch acceptability region (LAR).

Upper Range Scale. Indicates the top range of the dynamic launch zone (DLZ) in nautical miles.

Current Range. The caret indicates the aircraft's current range to the target. If the caret is within the in-range bracket, the weapon can reach the target if released.

In-Range Bracket. Indicates the range where the weapon can reach the target.

Lower Range Scale. Indicates zero range.

Bearing and Distance to Target. Indicates the bearing (degrees) and distance (nautical miles) the current SPI, which is the location the bomb will fly to after release.

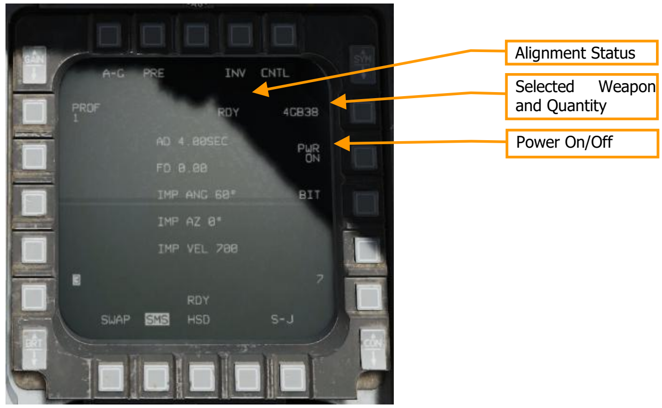
Employment in Pre-Planned (PRE) Mode

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Select JDAM and power on
4. Set desired options on SMS format
5. Set desired steerpoint or designate target
6. Center FPM on Steering Line and fly in range
7. Depress and hold Weapons Release button **[RAlt]+[Space]** to release at the computed point

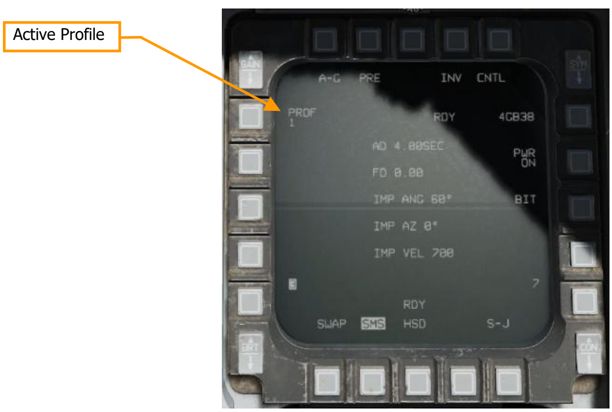
1. Select JDAM and power on.

Set the master mode to A-G, and on the SMS format, use OSB 6 to select GBU-38 (GB38) or GBU-31 (GB31) as the active weapon. Press OSB 7 (PWR OFF) to power on the weapon and begin the alignment process. Alignment will take a few minutes.



2. Set desired options on SMS format.

On the SMS format, select and configure the profile you want to use.



3. Set desired steerpoint or designate target

The weapon will guide to the current sensor point of interest (SPI) when released. If no cursor has been added, or Cursor Zero (CZ) has been pressed, the SPI will be the selected steerpoint. Designating a target (e.g., using the targeting pod) will shift the SPI to that location.

4. Center FPM on Steering Line and fly in range

Steer to place the azimuth steering line (ASL) over the flight path marker. Fly until the range caret is within the in-range bracket.

5. Depress and hold Weapons Release button

You must hold the Weapons Release button continuously until the weapon releases. During this process, target coordinates and profile data is downloaded to the JDAM kit. If this process is interrupted by releasing the Weapons Release button before the download finishes, the weapon will become a hung store and will be unusable.

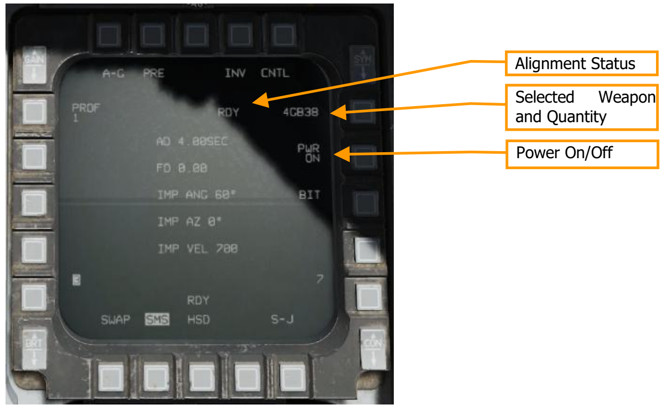
Employment in Visual (VIS) Mode

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Select JDAM and power on
4. Set VIS mode and desired options on SMS format
5. Use HUD and TDC to designate target
6. Center FPM on Steering Line and fly in range
7. Depress and hold Weapons Release button **[RAlt]+[Space]** to release at the computed point

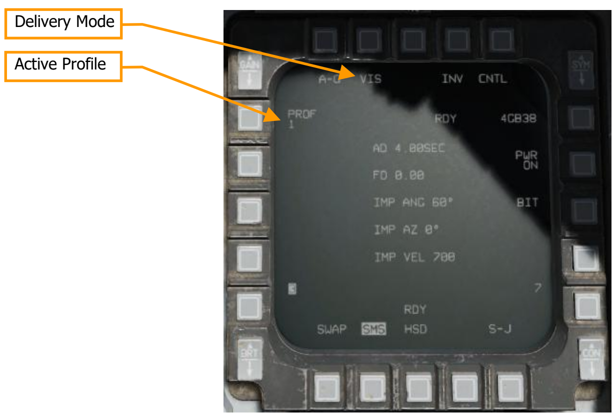
1. Select JDAM and power on.

Set the master mode to A-G, and on the SMS format, use OSB 6 to select GBU-38 (GB38) or GBU-31 (GB31) as the active weapon. Press OSB 7 (PWR OFF) to power on the weapon and begin the alignment process. Alignment will take a few minutes.



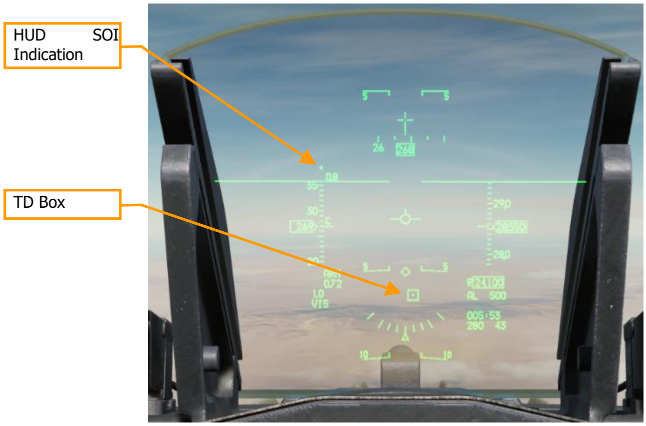
2. Set VIS mode and desired options on SMS format.

On the SMS format, select and configure the profile you want to use. Press OSB 2 to change the delivery mode to VIS.



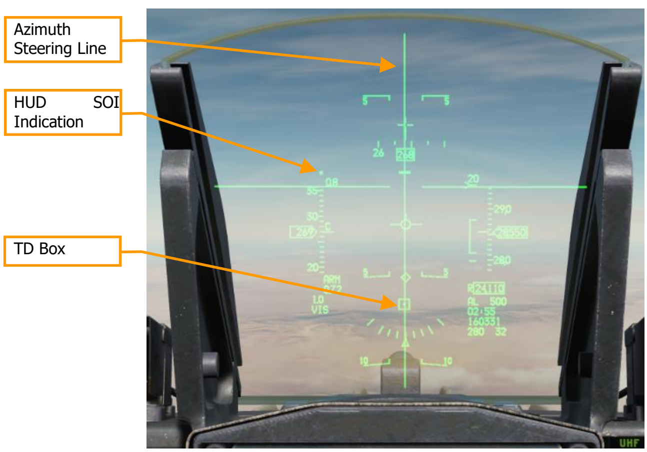
3. Use HUD and TDC to designate target

Upon enabling VIS mode, a target-designator (TD) box will appear on the HUD, and the HUD will become SOI. Use the TDC to slew the TD box over the target, then press TMS Forward to designate.



4. **Center FPM on Steering Line and fly in range**

Steer to place the azimuth steering line (ASL) over the flight path marker. Fly until the range caret is within the in-range bracket. You can continue to adjust the position of the TD box using the TDC.



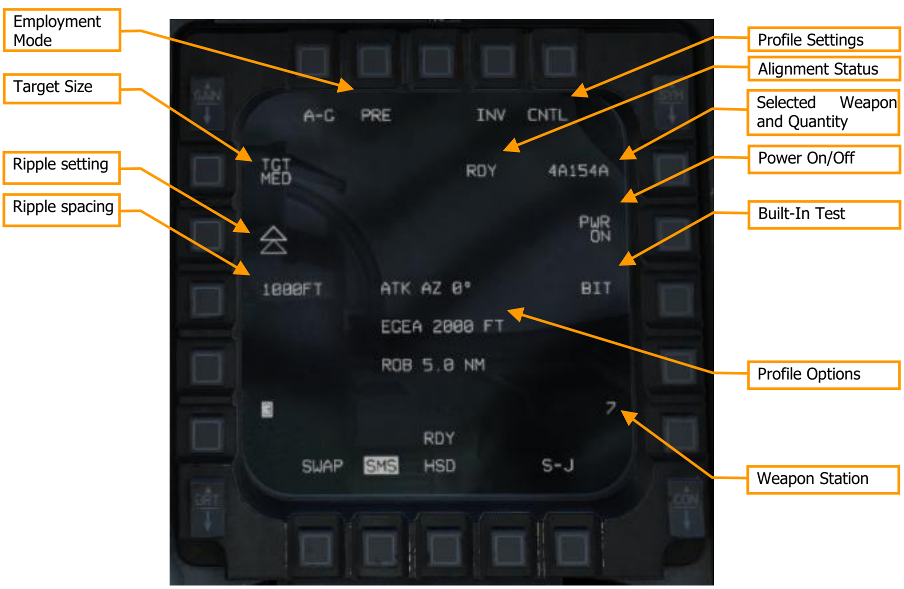
5. **Depress and hold Weapons Release button**

You must hold the Weapons Release button continuously until the weapon releases. During this process, target coordinates and profile data is downloaded to the JDAM kit. If this process is interrupted by releasing the Weapons Release button before the download finishes, the weapon will become a hung store and will be unusable.

AGM-154 JOINT STANDOFF WEAPON (JSOW)

JSOW is an inertially-aided glide bomb capable of striking targets up to 70 NM away, depending on the altitude and speed of launch. When released, the aircraft downloads the target coordinates to the JSOW. The JSOW then guides to those coordinates. The weapon is completely fire-and-forget. The AGM-154A variant has BLU-97/B warheads and cannot be re-targeted after launch.

JSOW SMS Format



Employment Mode. Toggles between pre-planned (PRE) and visual (VIS) employment modes. (See Employment in Pre-planned Mode and Employment in Visual Mode.)

Target Size. Not yet implemented.

Profile Settings. Press this OSB to open the Control page, where you can modify the active profile (not implemented).

Alignment Status. When the weapon is first powered on, will display "A10" (unstable alignment). During the alignment process, it will count down, and then display "RDY" when alignment is complete.

Selected Weapon and Quantity. Displays the weapon quantity and "A154A".

Power On/Off. Press to toggle power to all JSOW stations.

Built-In Test. Runs built-in tests. (N/I)

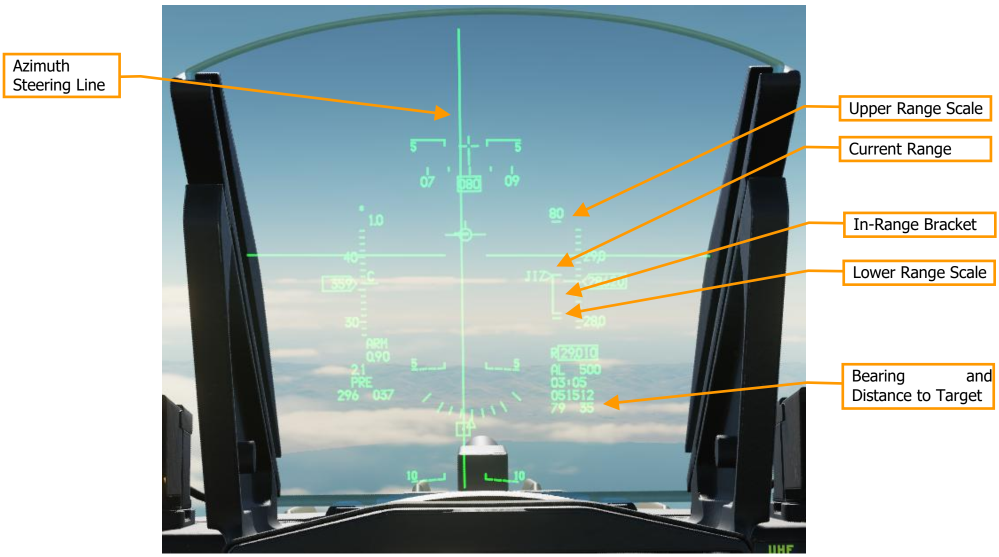
Profile Settings. Displays the parameters of the selected profile. (N/I)

Weapon Station. The selected weapon station for the next release is displayed in reverse video.

Ripple setting. Toggle between single release and pairs release with longitudinal or lateral separation.

Ripple spacing: Press to enter the distance in feet between the two bombs at height of function. Not displayed if the single release mode is selected.

JSOW HUD Symbology



Upper Range Scale. Indicates the top range of the dynamic launch zone (DLZ) in nautical miles.

Current Range. The caret indicates the aircraft's current range to the target. If the caret is within the in-range bracket, the weapon can reach the target if released.

In-Range Bracket. Indicates the range where the weapon can reach the target.

Lower Range Scale. Indicates zero range.

Bearing and Distance to Target. Indicates the bearing (degrees) and distance (nautical miles) the current SPI, which is the location the bomb will fly to after release.

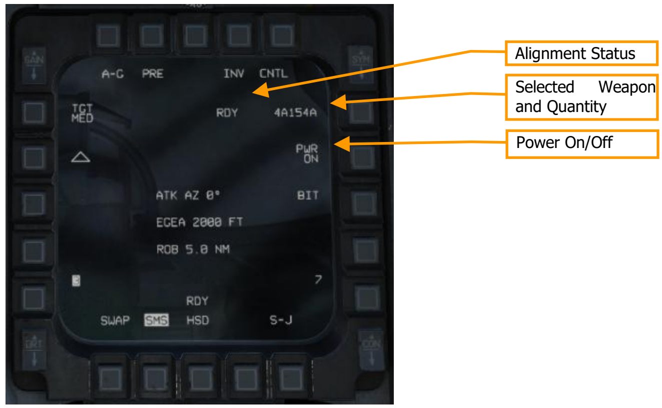
Employment in Pre-Planned (PRE) Mode

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Select JSOW and power on
4. Set desired options on SMS format
5. Set desired steerpoint or designate target
6. Center FPM on Steering Line and fly in range
7. Depress and hold Weapons Release button **[RAlt]+[Space]** to release at the computed point

1. **Select JSOW and power on.**

   Set the master mode to A-G, and on the SMS format, use OSB 6 to select AGM-154A (A154A) as the active weapon. Press OSB 7 (PWR OFF) to power on the weapon and begin the alignment process. Alignment will take a few minutes.



2. **Set desired options on SMS format.**

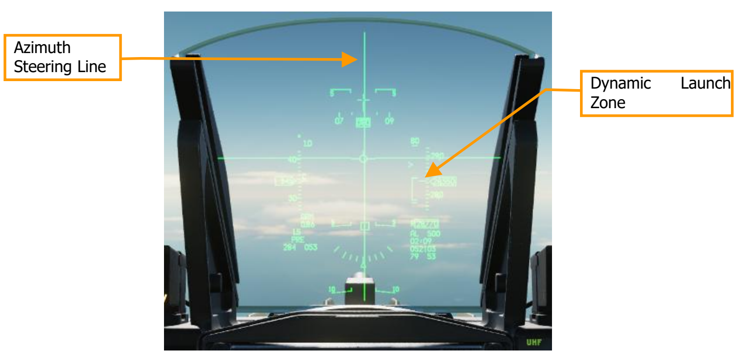
   On the SMS format, configure the weapon as desired.

3. **Set desired steerpoint or designate target**

   The weapon will guide to the current sensor point of interest (SPI) when released. If no cursor has been added, or Cursor Zero (CZ) has been pressed, the SPI will be the selected steerpoint. Designating a target (e.g., using the targeting pod) will shift the SPI to that location.

4. **Center FPM on Steering Line and fly in range**

   Steer to place the azimuth steering line (ASL) over the flight path marker. Fly until the range caret is within the in-range bracket.



5. **Depress and hold Weapons Release button**

   You must hold the Weapons Release button continuously until the weapon releases. During this process, target coordinates and profile data is downloaded to the JSOW. If this process is interrupted by releasing the Weapons Release button before the download finishes, the weapon will become a hung store and will be unusable.

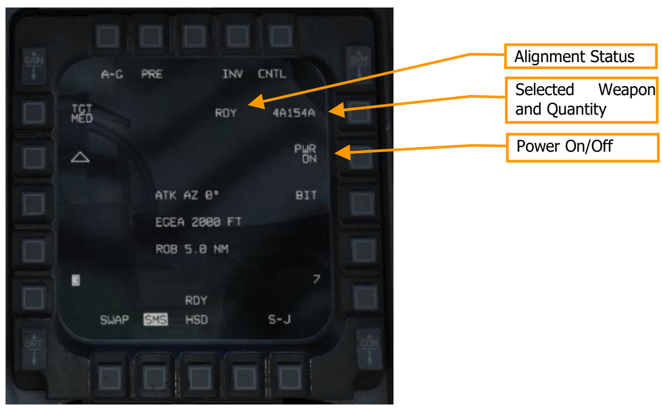
Employment in Visual (VIS) Mode

Summary

1. Select A-G Master Mode [2]
2. Set Master Arm Switch to Arm
3. Select JSOW and power on
4. Set VIS mode and desired options on SMS format
5. Use HUD and TDC to designate target
6. Center FPM on Steering Line and fly in range
7. Depress and hold Weapons Release button [RAlt]+[Space] to release at the computed point

1. Select JSOW and power on.

Set the master mode to A-G, and on the SMS format, use OSB 6 to select AGM-154A (A154A) as the active weapon. Press OSB 7 (PWR OFF) to power on the weapon and begin the alignment process. Alignment will take a few minutes.

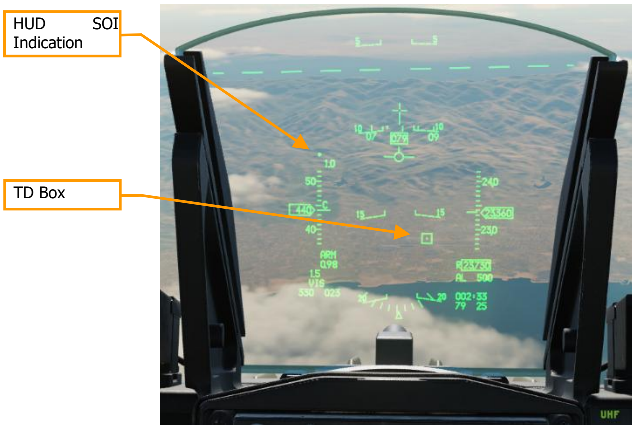


2. Set VIS mode and desired options on SMS format.

On the SMS format, select and configure the options you want to use. Press OSB 2 to change the delivery mode to VIS.

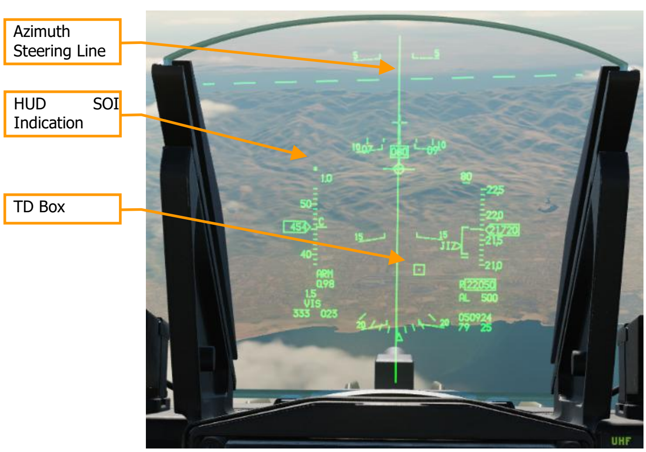
3. Use HUD and TDC to designate target

Upon enabling VIS mode, a target-designator (TD) box will appear on the HUD, and the HUD will become SOI. Use the TDC to slew the TD box over the target, then press TMS Forward to designate.



4. Center FPM on Steering Line and fly in range

Steer to place the azimuth steering line (ASL) over the flight path marker. Fly until the range caret is within the in-range bracket (labeled "JIZ"). You can continue to adjust the position of the TD box using the TDC.



5. Depress and hold Weapons Release button

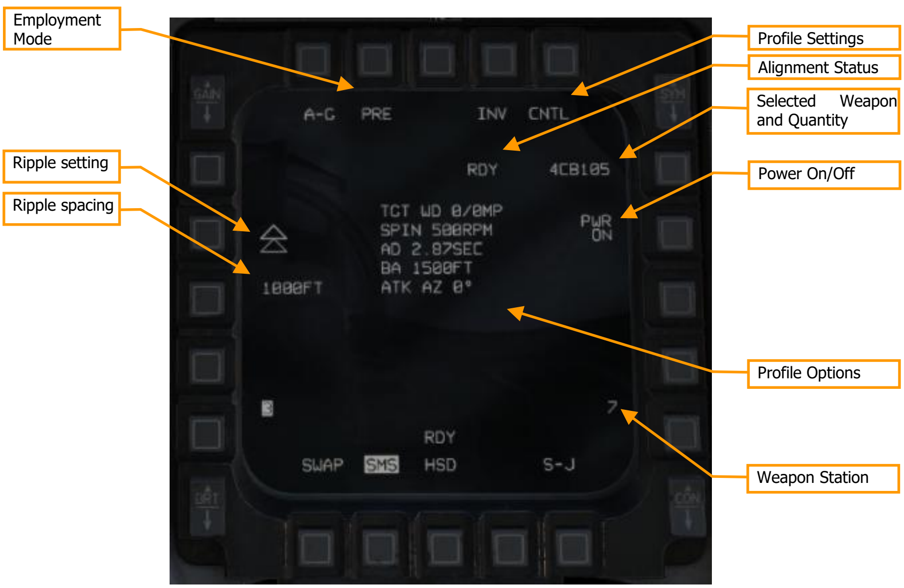
You must hold the Weapons Release button continuously until the weapon releases. During this process, target coordinates and profile data is downloaded to the JSOW. If this process is interrupted by releasing the Weapons Release button before the download finishes, the weapon will become a hung store and will be unusable.

WIND-CORRECTED MUNITIONS DISPENSERS (WCMD)

Wind-Corrected Munitions Dispensers (WCMD, pronounced "wick-mid") are tail kits that can be equipped to a CBU-87 CEM or CBU-97 SFW, giving the precision guidance capability. WCMD includes an onboard INS and can be programmed with the winds aloft to improve accuracy.

When the CBU-87 is equipped with WCMD, it is called the CBU-103. A CBU-97 with WCMD is called a CBU-105.

WCMD SMS Format



Employment Mode. Toggles between pre-planned (PRE) and visual (VIS) employment modes. (See Employment in Pre-planned Mode and Employment in Visual Mode.)

Profile Settings. Press this OSB to open the Control page, where you can modify the active profile. (See WCMD CNTRL Page).

Alignment Status. When the weapon is first powered on, will display "A10" (unstable alignment). During the alignment process, it will count down, and then display "RDY" when alignment is complete.

Selected Weapon and Quantity. Displays the weapon quantity and "CB103" or "CB105".

Power On/Off. Press to toggle power to all WCMD stations.

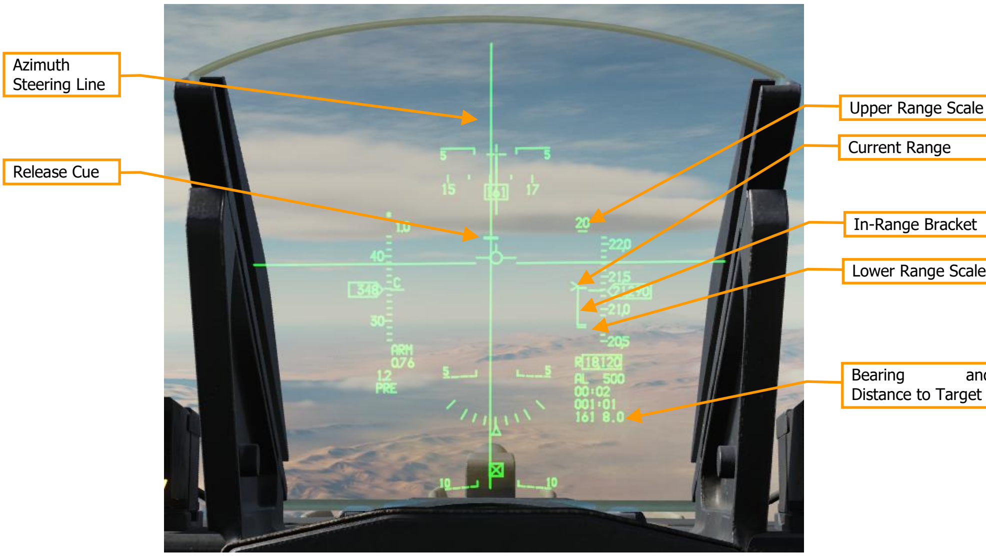
Profile Settings. Displays the parameters of the selected profile.

Weapon Station. The selected weapon station for the next release is displayed in reverse video.

Ripple setting. Toggle between single release and pairs release with longitudinal or lateral separation.

Ripple spacing: Press to enter the distance in feet between the two bombs at height of function. Not displayed if the single release mode is selected.

WCMD HUD Symbology



Upper Range Scale. Indicates the top range of the dynamic launch zone (DLZ) in nautical miles.

Current Range. The caret indicates the aircraft's current range to the target. If the caret is within the in-range bracket, the weapon can reach the target if released.

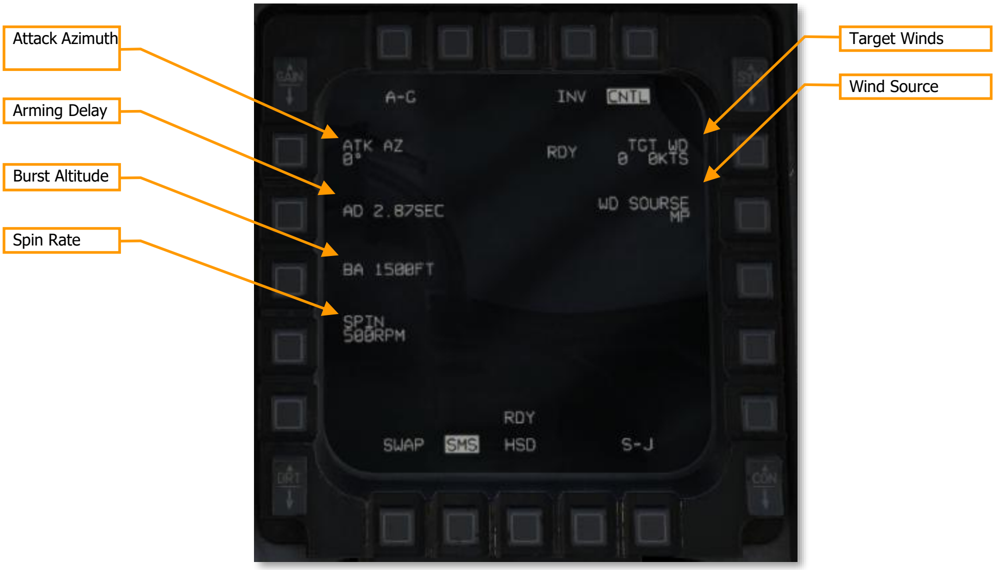
In-Range Bracket. Indicates the range where the weapon can reach the target.

Lower Range Scale. Indicates zero range.

Bearing and Distance to Target. Indicates the bearing (degrees) and distance (nautical miles) the current SPI, which is the location the bomb will fly to after release.

WCMD CNTL Page

The CNTL page lets you configure the WCMD engagement profile and other options.



Attack Azimuth. Sets the attack direction that the bombs will attempt to achieve. A setting of "0" means that the bombs will use the most direct attack direction ("360" means attack heading north). (Not implemented.)

Arming Delay. Sets the delay after release before the weapon arms. (Not implemented.)

Burst Altitude. Sets the height of function, which is the altitude (MSL) when the submunitions will be released. Higher burst altitudes create a wider dispersal.

Spin Rate. The bomb will begin rotating at this RPM value prior to submunitions release (CBU-103 only). Higher spin rates create a wider dispersal.

Target Winds. Manual winds aloft entry. Not implemented.

Wind Source. Toggles wind data from mission planning (MP), pilot-entered (PI), and avionics system (SY). Currently only MP is available.

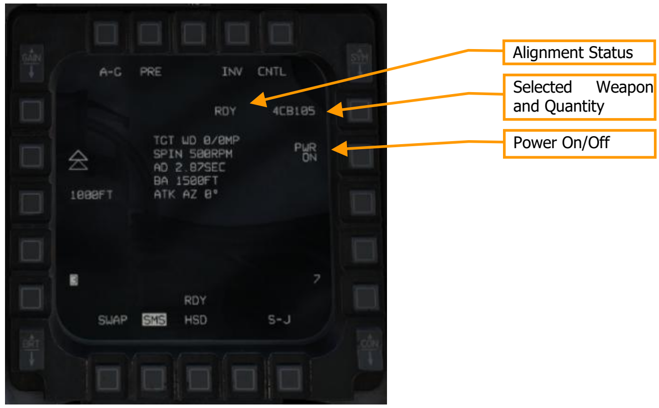
Employment in Pre-Planned (PRE) Mode

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Select WCMD and power on
4. Set desired options on SMS format
5. Set desired steerpoint or designate target
6. Center FPM on Steering Line and fly in range
7. Depress and hold Weapons Release button **[RAlt]+[Space]** to release at the computed point

1. Select WCMD and power on.

Set the master mode to A-G, and on the SMS format, use OSB 6 to select WCMD (CB103 or CB105) as the active weapon. Press OSB 7 (PWR OFF) to power on the weapon and begin the alignment process. Alignment will take a few minutes.



2. **Set desired options on SMS format.**

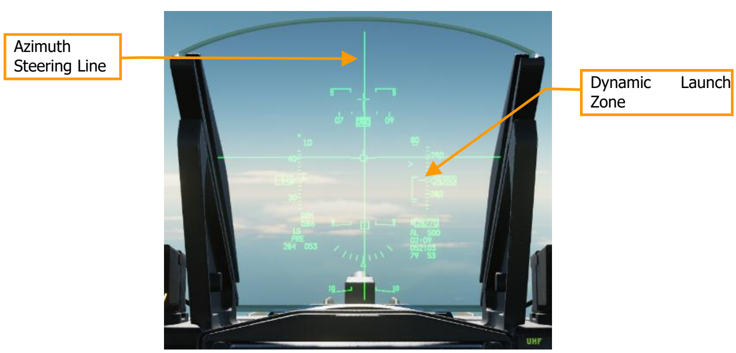
On the SMS format, configure the weapon as desired.

3. **Set desired steerpoint or designate target**

The weapon will guide to the current sensor point of interest (SPI) when released. If no cursor has been added, or Cursor Zero (CZ) has been pressed, the SPI will be the selected steerpoint. Designating a target (e.g., using the targeting pod) will shift the SPI to that location.

4. **Center FPM on Steering Line and fly in range**

Steer to place the azimuth steering line (ASL) over the flight path marker. Fly until the range caret is within the in-range bracket.



5. **Depress and hold Weapons Release button**

You must hold the Weapons Release button continuously until the weapon releases. During this process, target coordinates and profile data is downloaded to the WCMD. If this process is interrupted by releasing the Weapons Release button before the download finishes, the weapon will become a hung store and will be unusable.

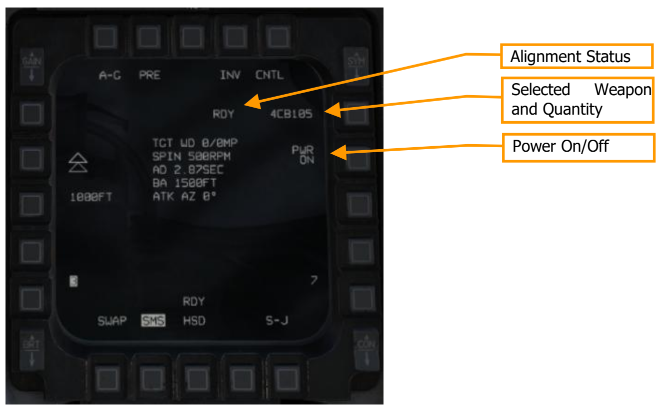
Employment in Visual (VIS) Mode

Summary

1. Select A-G Master Mode **[2]**
2. Set Master Arm Switch to Arm
3. Select WCMD and power on
4. Set VIS mode and desired options on SMS format
5. Use HUD and TDC to designate target
6. Center FPM on Steering Line and fly in range
7. Depress and hold Weapons Release button **[RAlt]+[Space]** to release at the computed point

1. **Select WCMD and power on.**

   Set the master mode to A-G, and on the SMS format, use OSB 6 to select WCMD (CB103 and CB105) as the active weapon. Press OSB 7 (PWR OFF) to power on the weapon and begin the alignment process. Alignment will take a few minutes.

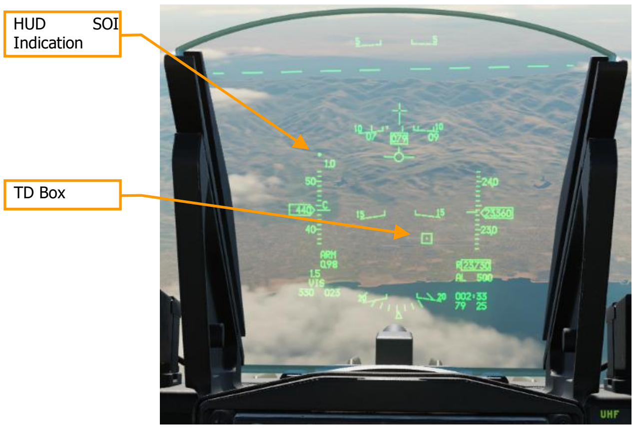


2. **Set VIS mode and desired options on SMS format.**

   On the SMS format, select and configure the options you want to use. Press OSB 2 to change the delivery mode to VIS.

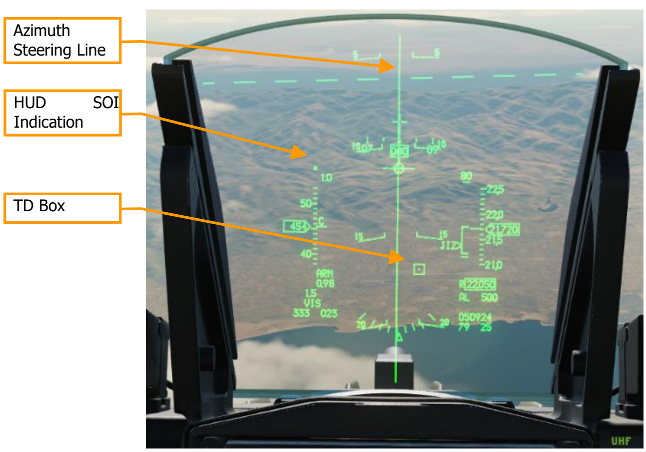
3. Use HUD and TDC to designate target

Upon enabling VIS mode, a target-designator (TD) box will appear on the HUD, and the HUD will become SOI. Use the TDC to slew the TD box over the target, then press TMS Forward to designate.



4. Center FPM on Steering Line and fly in range

Steer to place the azimuth steering line (ASL) over the flight path marker. Fly until the range caret is within the in-range bracket. You can continue to adjust the position of the TD box using the TDC.



5. Depress and hold Weapons Release button

You must hold the Weapons Release button continuously until the weapon releases. During this process, target coordinates and profile data is downloaded to the WCMD. If this process is interrupted by releasing the Weapons Release button before the download finishes, the weapon will become a hung store and will be unusable.

AGM-88 HARM

The AGM-88C High-speed Anti-Radiation Missile (HARM) is a supersonic, passive radar-guided air-to-ground missile intended to strike air defense radar sites and vehicles. The missile has an onboard radar receiver that homes in on radar energy emitted by ground-based radars, making it fire-and-forget. The pilot can designate targets using the missile's onboard radar receiver or using the HARM Targeting System (HTS) external sensor pod. The HARM may be loaded on stations 3, 4, 6, or 7, but is typically only employed from stations 3 and 7.

The HARM can be targeted using one of three modes: position known (POS), HARM-as-sensor (HAS), or datalink (DL). Currently, DL is not implemented in DCS.

Communication with the HARM missile is managed by the aircraft launcher interface computer (ALIC) within the LAU-118 missile launcher. The ALIC provides HARM sensor video to the SMS and allows the SMS to hand off threat types to the AGM-88. After launch, the AGM-88 will home on threat radars matching the handed-off threat type.

Preparation

Prior to departure, set up your HARM threat tables as necessary. The threats you expect to fire against must be present on the selected threat table for the AGM-88 to detect them. Most of the time, you will be able to use one of the default threat tables:

WPN	TBL1 (*MODERN SAM SYSTEMS*)	WPN	TBL2 (*AAA & SHORAD*)	WPN	TBL3 (*OLDER SAM SYSTEMS*)
10	SA-10 "FLAP LID"	19	SA-19 "HOT SHOT"	3	SA-3 "LOW BLOW"
BB	SA-10 "BIG BIRD"	15	SA-15 "SCRUM HALF"	S	P-19 "FLAT FACE"
CS	SA-10 "CLAM SHELL"	8	SA-8 "LAND ROLL"	6	SA-6 "STRAIGHT FLUSH"
11	SA-11 "FIRE DOME"	A	ZSU-23-4 "GUN DISH"	2	SA-2 "FAN SONG"
SD	SA-11 "SNOW DRIFT"	DE	PPRU-M1 "DOG EAR"	13	SA-13 "SNAP SHOT"

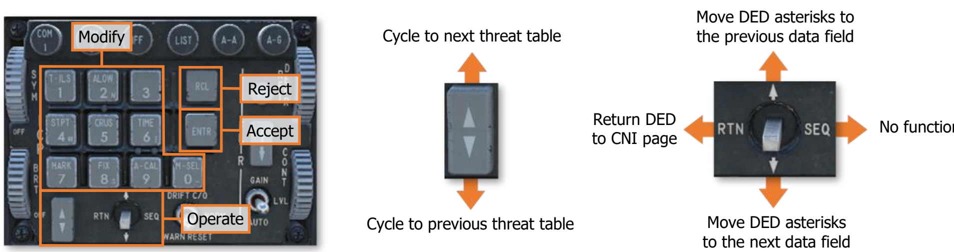
If any expected threats do not appear on these tables, you will need to edit one or more of the tables. It may be wise to consolidate the expected threats to one table to improve the efficiency of employing HARM missiles during the mission.

The HARM DED page is used to edit the default HARM threat tables.

HARM DED Page

The HARM DED page is accessed by pressing **0/M-SEL** on the ICP keypad when the MISC DED page is displayed on the DED, or by pressing **UFC** (OSB 5) on the MFD Weapon (WPN) format, when "AG88" is the current SMS profile. This page is used to configure the HARM threat tables to better tailor the AGM-88 scans to the radar signals that are anticipated to be encountered during the mission.

(See Appendix B for a complete list of all threat radar ALIC codes.)



1. **HARM Threat Table.** Displays the HARM threat table that corresponds with the displayed threat ALIC codes. The ICP Increment/Decrement rocker may be used to cycle to a different threat table.

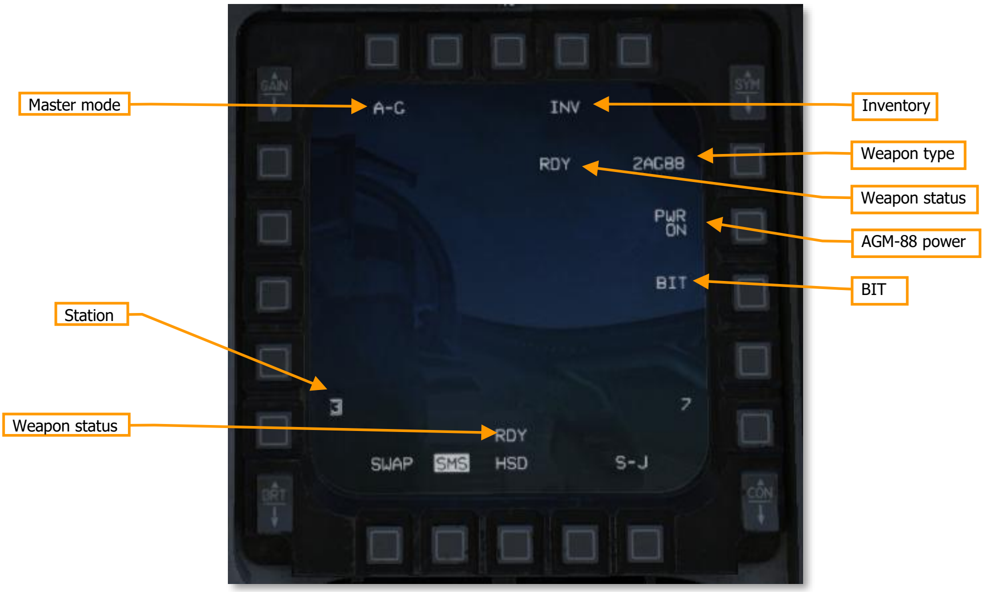
2. **Table Threat Number.** Displays five threat entries that may accept an ALIC code for the displayed threat table.

3. **Threat ALIC Code.** Displays the ALIC code representing a specific threat radar type that is loaded into the corresponding threat entry. May be modified using the ICP keypad.

4. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

SMS Format

Prior to employing HARMs, press the A-G button on the ICP to select air-to-ground master mode. Ensure that the SMS and WPN formats are visible on an MFD. From the SMS format, power on the HARMs:



Master mode: Toggles between A-G and STRF (gun strafe) air-to-ground modes.

Inventory: Pressing this OSB displays the Inventory page.

Weapon type: Displays "AG88" for AGM-88 HARM, and the number of missiles loaded.

Weapon status: Displays "RDY" when the AGM-88 is ready for launch.

AGM-88 power: Displays "PWR ON" or "PWR OFF". Pressing commands spin-up or spin-down to all loaded AGM-88 missiles.

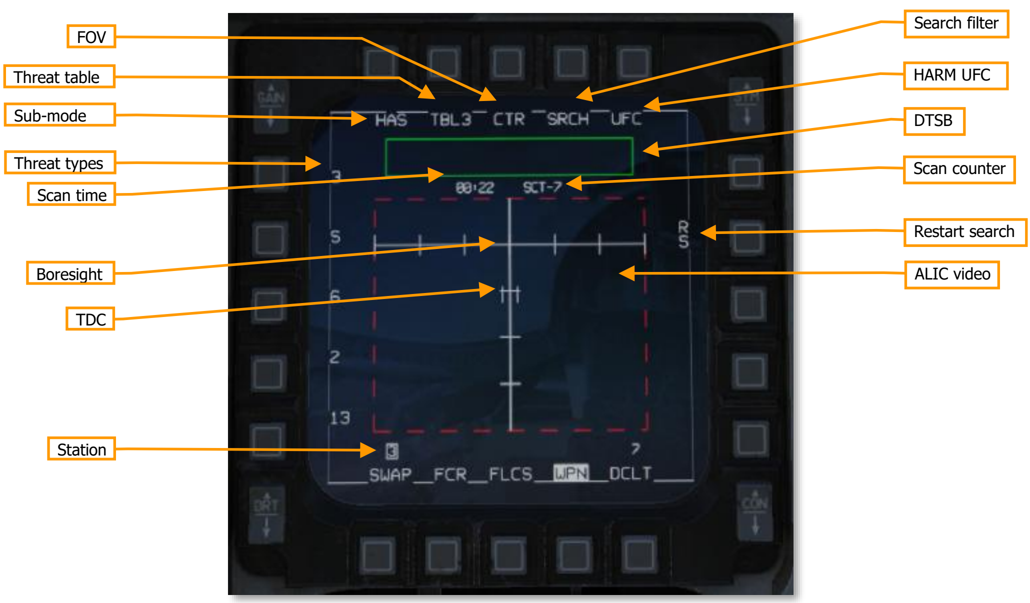
BIT: Commands execution of a built-in test. The status of each station will be updated following completion of the BIT.

Station: Displays the stations on which HARMs are loaded. The station selected for launch is boxed. Above the station number is a character indicating the missile degrade state for that station: "D" for degraded or "F" for failed. No character above the station number indicates a functioning missile.

WPN Format

The AGM-88 HARM can be targeted using its onboard sensor in one of three modes: position known (POS), HARM-as-sensor (HAS), or datalink (DL). (Currently DL is not supported in DCS.) Each mode has its own WPN format.

HAS Mode



Sub-mode: Displays "HAS" in HARM-as-Sensor sub-mode.

Threat table: Displays the current threat table (TBL1, TBL2, or TBL3). Pressing cycles through the three tables. Pressing TMS Left when the WPN page is SOI also cycles through threat tables.

FOV: Displays the missile field of view: "CTR" for center, "LT" for left, "RT" for right, and "WIDE" for wide. Pressing cycles through FOV settings. The FOV setting controls which portion of the missile's forward hemisphere it searches. Pressing the Expand/FOV button on the SSC also cycles FOV settings.

Search filter: Pressing this OSB allows the pilot to toggle on and off threats within the current threat table. Reducing the number of threats that the ALIC is searching for reduces the time for each scan cycle.

HARM UFC: Pressing this OSB displays the HARM page on the DED, where threat tables can be modified.

DTSB: The detected target status box lists detected threat types. When a new threat is detected, its type (e.g., "2" for SA-2) is added to the DTSB.

Scan counter: This counter increments after each successive scan made by the AGM-88.

Restart search: Pressing this OSB cancels the current scan cycle and begins a new one.

ALIC video: Detected threats are displayed in this area. Only threats from the active threat table are displayed. ALIC video is ground stabilized and referenced to missile boresight line. Threats displayed as characters representing their type (e.g., "2" for SA-2). If the threat is active (radiating), the letter "A" follows the threat type. If the threat is tracking (guiding an in-flight missile), the letter "T" follows the threat type. If the threat is not radiating (memory threat), or multiple threats of the same time are co-located, no "A" or "T" is shown.

Pressing TMS Forward commands designation of the threat under the TDC. The ALIC video display will switch to a non-ground-stabilized display of the targeted threat, with crosshairs indicating missile boresight.

Station: Shows which stations have AGM-88s loaded. The station selected for next launch is boxed. A "D" or "F" is displayed over the station number to indicate a degraded or failed missile.

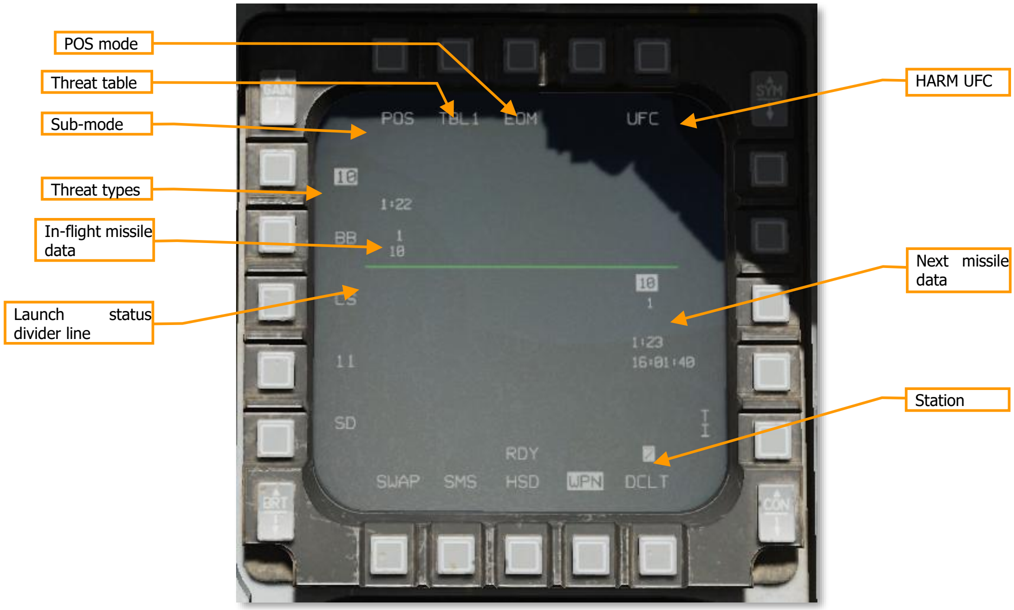
TDC: The target designator cursor is slewed over a target the pilot wishes to designate, using the RDR CURSOR/ENABLE switch on the throttle grip. Pressing TMS Forward commands designation of the threat under the TDC, and hands off the threat type to the AGM-88.

Boresight: Indicates the missile boresight axis.

Scan time: Shows worst-case scan time. The ALIC will repeatedly scan for threats according to the chosen parameters. Reducing the number of threats to be scanned using the SRCH OSB, or reducing the FOV, will reduce the scan time and therefore decrease the amount of time before a threat is detected.

Threat types: The five threat types for the current threat table (TBL1, TBL2, or TBL3) are shown along the left side. If a threat is designated, its type is highlighted. The adjacent OSBs have no function in the HAS sub-mode.

POS Mode



Sub-mode: Displays "POS" in Position Known sub-mode.

Threat table: Displays the current threat table (TBL1, TBL2, or TBL3). Pressing cycles through the three tables. Pressing TMS Left when the WPN page is SOI also cycles through threat tables.

HARM UFC: Pressing this OSB displays the HARM page on the DED, where threat tables can be modified.

POS mode: Selects the attack profile to use: EOM (equations of motion), PB (pre-briefed), or RUK (range unknown).

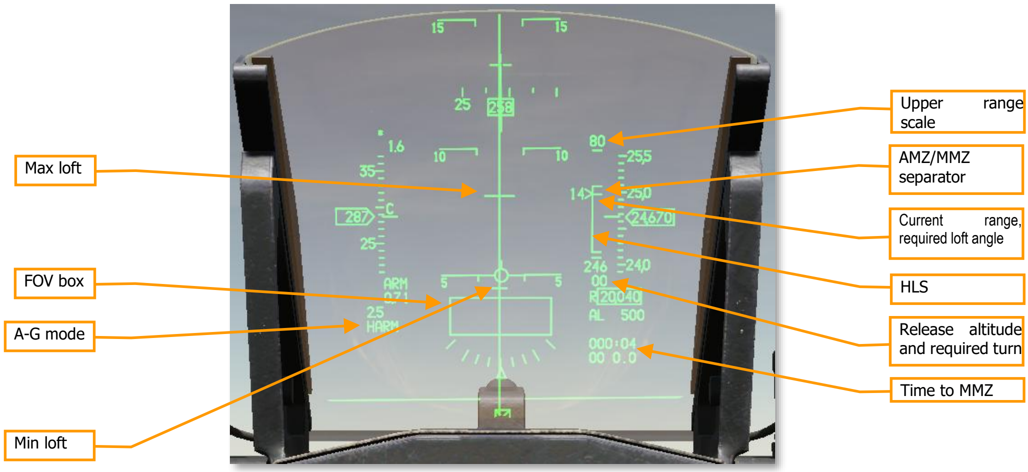
Threat types: Lists the threats in the current table. Pressing the OSB adjacent to a threat hands off that threat type to the ALIC.

Next missile data: Information about the next missile to be launched. Not displayed if all missiles have been launched. Line 1 is the threat type to be handed off to the missile. Line 2 is the steerpoint to be handed off to the missile. Line 3 is the predicted time until impact, and line 4 is the predicted impact time, if the missile were launched now. Only lines 1 and 2 are shown for RUK attacks.

In-flight missile data: Information about the in-flight missile. If multiple missiles are in-flight, multiple datablocks will be shown along this row. Line 1 is the predicted time until impact. Line 2 is the steerpoint that was handed off to the missile, and line 3 is the threat type that was handed off to the missile. Only lines 2 and 3 are shown for RUK attacks.

Launch status divider line (LSDL): Divides in-flight missile information from next missile information.

HUD Symbology



On the right side is the HARM Launch Scale (HLS), which indicates the range potential of the missile to reach the current target. The target is assumed to be at the selected steerpoint. The SMS estimates both the aircraft maneuver zone (AMZ), and the missile maneuver zone (MMZ). The AMZ is the zone where the missile can reach the target if the launching aircraft lofts or turns towards the target first. The MMZ is the zone where the missile can reach the target by doing entirely its own maneuvering.

FOV box: Indicates the end-game field-of-view of the HARM. The FOV box flashes when the aircraft is within the missile maneuver zone, target handoff is completed, and the missile is ready to be fired.

HLS: The HARM launch scale (HLS) staple represents the combined AMZ and MMZ; in other words, the ranges at which the missile can reach the target with or without aircraft maneuvering. The horizontal dash within the staple indicates the top of the MMZ range and the bottom of the AMZ range. The bottom of the staple indicates minimum launch distance. The pickle button is only hot when the staple is within the MMZ.

The HLS and all associated symbology are inhibited in HAS mode.

Current range, required loft angle: The position of the caret along the staple represents the current aircraft range to target along the HLS range scale. If the caret is above the AMZ/MMZ separator, the aircraft must first maneuver before the missile can reach the target. The number adjacent to the caret is the required loft angle to place the aircraft within the MMZ. The loft angle is prefixed by an "A" when the aircraft is within the MMZ. The caret is inhibited when in PB mode and more than 10° off-bearing.

Upper range scale: Will be either 40 or 80 NM, whichever is sufficient to cover the distance to the target.

Zero range: The bottom end of the HLS is a target distance of zero.

Min loft, optimal loft, max loft: The horizontal ticks along the azimuth steering line (ASL) indicate the minimum and maximum loft required for the missile to reach the target. Maximum loft is the larger tick and represents the loft angle that will give the missile maximum range. Minimum loft is the smaller tick and represents the range where the missile would have to do a max-g pulldown to reach the target. In PB mode, optimal loft is also shown as a pair of whiskers along the ASL. Optimal loft represents the loft angle that gives the missile the maximum energy available at impact.

Loft cues are inhibited in HAS and POS/RUK modes.

Release altitude: The top number of this datablock is the predicted release altitude assuming the aircraft makes a 4-g loft to the optimal loft altitude (or the maximum loft altitude if not within the MMZ).

Required turn: The bottom number of this datablock is the required turn to place the aircraft within the MMZ (e.g., "L03" if a 3° left turn is required). Shows "00" if the aircraft is on-bearing but not yet within the MMZ range. Once the aircraft is within the MMZ, this field shows the aircraft required turn to face the target (e.g., "L90" if the aircraft nose is 90° right of the target).

This datablock is not displayed in HAS and POS/RUK modes.

Time to MMZ: Displays the estimated time until the aircraft reaches the MMZ. Displays "0:00" when the aircraft is inside the MMZ. Not displayed in HAS or POS/RUK modes.

Bearing and distance to target: The bearing and distance (in nautical miles) from the aircraft's present position to the target. Not displayed in HAS mode.

Employment using HARM-as-Sensor (HAS) Mode

Summary

1. Select A-G Master Mode **[2]**.
2. Set MASTER ARM switch to ARM.
3. Select AG88 on SMS page (OSB6).
4. Select HAS sub-mode on the WPN page (OSB1).
5. Make the WPN page SOI.
6. Select the desired threat table on the WPN page (OSB2).
7. Wait until your threat appears in the ALIC video display on the WPN page.
8. Move the WPN cursor over the threat and designate with TMS Forward **[RCtrl]+[Up]**.
9. Fire the missile using the Weapon Release button **[RAlt]+[Space]**.

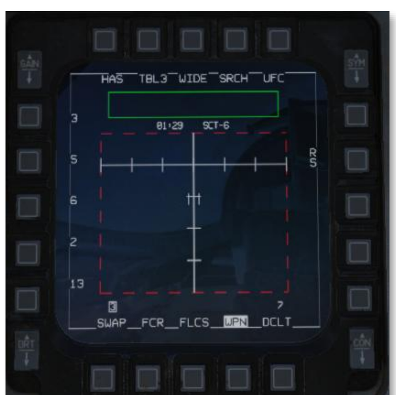
HARM-as-sensor (HAS) mode is a target-of-opportunity employment mode using the HARM's onboard radar receiver. The HARM detects air defense radar signals and transmits that information to the aircraft. The pilot can then select a radar to attack and launch a HARM against it. With this mode, distance to the target is not known, only bearing, so the HARM does not loft, which decreases its effective range.

In HAS mode, the HARM repeatedly scans for threats that match the current active threat table. The HARM begins with a full scan of its FOV, once for each of the selected threat types. If any targets are found, a detailed scan is performed to determine the target coordinates. The HARM then steps to the next threat type. In all, this results in a worst-case scan cycle time of 90 seconds.

The ALIC is in HAS operational mode when the master mode is A-G, AG88 is the selected weapon on the SMS MFD format, and "HAS" is displayed as the active sub-mode on the WPN page.

1. **Select HAS mode and make WPN page SOI.**

   Press OSB 1 if necessary to change to HAS sub-mode. Ensure that the WPN page is SOI; if not, press DMS Aft-Short to change SOI to the WPN page.



2. **Select the appropriate threat table.**

   Press OSB 2 or TMS Left until the desired threat table is selected.

3. **Reduce the scan time by selecting only the threats you wish to scan for (optional).**

   If you want to reduce scan time, press SRCH (OSB 4), then leave highlighted only the threats you are interested in searching for.

Press HAS (OSB 1) to return to the HAS page.

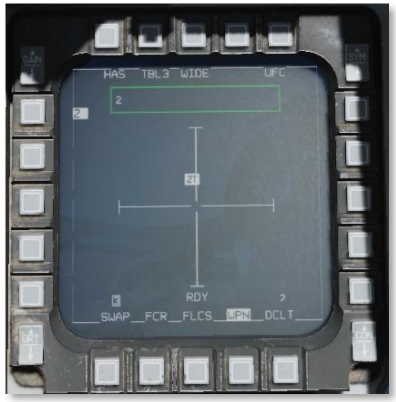
4. **Select an FOV (optional).**

   You can further reduce scan time by using the Expand/FOV button (or OSB 3) to cycle through FOV options until you find an appropriate FOV.

5. **Locate and designate your target.**

   Point your aircraft (and the missile seeker) in the direction of your expected threat. As each scan cycle completes, detected threats will be shown in the ALIC video area and placed into the DTSB.

Slew the cursor over the detected threat, then press TMS Forward to designate it. The HAS display will change to indicate the designated threat.



Note that you can designate and fire against any threat that appears on the HAS display, but many radar operators will cycle their radars on and off or track different targets. This will result in the HARM being unable to continue tracking the target, and the missile will become ineffective.

To increase probability of kill, you may wish to wait until the threat radar is guiding a missile at you ("T" appears next to threat type on HAS display) before firing, since a radar operator is less likely to cease tracking you while guiding a missile. However, this strategy comes with its own obvious risks!

6. Fire the missile.

Verify the proper threat is highlighted, "RDY" is displayed in the SMS and WPN pages, and the FOV box in the HUD is flashing, then press and hold the pickle button to fire the missile.

Employment using Position Known (POS) Mode

Summary

1. Select A-G Master Mode **[2]**.
2. Set MASTER ARM switch to ARM.
3. Select AG88 on SMS page (OSB6).
4. Select POS sub-mode on the WPN page (OSB1).
5. Select the attack profile on the WPN page (OSB3).
6. Select the desired threat table and threat on the WPN page (OSB2).
7. Select the target steerpoint.
8. Fly to the AMZ, follow the loft and turn cues, and wait until the FOV box on the HUD is flashing.
9. Fire the missile using the Weapon Release button **[RAlt]+[Space]**.

Position Known (POS) mode is a pre-planned employment mode that relies on a steerpoint being placed at or near the target radar. The radar type will be downloaded to the ALIC, and the HARM will fly towards the target steerpoint until the radar is detected, at which point it will home on the radar signal.

In POS mode, the pilot selects one of three attack profiles: Equations of Motion (EOM), Pre-Briefed (PB), or Range Unknown (RUK). Each of these profiles makes different assumptions about the aircraft maneuver zone (AMZ) and missile maneuver zone (MMZ). The AMZ is the zone where the missile can reach the target, assuming the aircraft maneuvers to a required bearing and loft angle first. The MMZ is the zone where the missile can reach the target without requiring the aircraft to turn or loft.

Equations of Motion (EOM) mode is the most effective profile for off-boresight launches but requires the most accurate target steerpoint data. To launch with EOM selected, the pilot must first fly to the AMZ, then loft and launch once within the MMZ. EOM is useful when attacking threats that require high-angle off-boresight (HOB) defensive tactics.

Pre-Briefed (PB) mode is the most effective profile at longer ranges but requires an on-bearing attack. To launch with PB selected, the pilot must first turn the aircraft to point at the target, then fly to the AMZ, then loft and launch once within the MMZ. PB is most effective at longer ranges but requires the aircraft to fly directly at the target.

Range Unknown (RUK) mode is the most versatile profile when working with degraded target data. To launch with RUK selected, the pilot must fly the aircraft into the MMZ, where the missile can make all required maneuvering to reach the target. RUK is much more tolerant of inaccurate target steerpoints, or when fighting threats where only bearing information is available.

1. **Select POS sub-mode on the WPN page.**

   Press OSB 1 if necessary to change to POS sub-mode. You will see the launch status divider line (LSDL) and next-launch information below the LSDL.

2. **Select the attack profile.**

   On the WPN page, press OSB 3 until the desired attack profile is shown.

3. **Select the threat table and threat.**

   On the WPN page. press OSB 2 until the desired threat table is shown, and then press the OSB adjacent to the threat you wish to attack from the list on the left side. This will hand off the threat to the ALIC.

4. **Select the target steerpoint.**

   Activate the steerpoint co-located with the threat you are attacking.

5. **Fly to the AMZ, follow the required turn and loft cues, and wait until the FOV box on the HUD is flashing.**

   The attack profile you will fly is dependent on whether you have selected EOM, PB, or RUK.

EOM Attacks

In EOM mode, you can launch from any relative bearing, as long as you follow the cues to the MMZ. First fly towards the target until the HLS range caret indicates that you are within the AMZ. If a required turn is indicated on the datablock below the HLS, turn as indicated until it reads “00”. (You do not necessarily need to be facing the target, as long as there is no required turn.) Then, pull up until the VVI is between the minimum and maximum loft cues on the ASL. When the FOV box is flashing, you can launch.

PB Attacks

In PB mode, you must be within 10° of bearing to the target. Once your aircraft is pointed towards the target, fly towards the target until within the AMZ. You will see the minimum, optimal, and maximum loft cues on the ASL. Pitch the aircraft to place the VVI between the minimum and maximum loft cues. When the FOV box is flashing, you can launch.

RUK Attacks

In RUK mode, you must fly the aircraft all the way to the MMZ. Follow the azimuth steering line (ASL) on the HUD towards the target until the FOV box on the HUD is flashing. Once it is flashing, you are within the MMZ and the weapon release button will be hot. For RUK attacks, the HARM will loft, but the loft angle will be limited to the maximum the missile can achieve while keeping the threat within its field of view.

Because range information is degraded or unavailable for RUK attacks, no time-until-intercept or time-to-impact data is shown on the WPN page, and loft information is suppressed on the HUD.

AGM-65 MAVERICK

The AGM-65 Maverick is an optically guided air-to-ground missile intended for the close air support (CAS) mission. It uses an onboard electro-optical (E/O) or infrared imager that tracks the target, giving it "fire and forget" capability. The pilot locks the target using the image from the onboard seeker head and fires the missile. The missile tracks to the target using the image from its seeker head.

The AGM-65 was developed by Hughes Missile Systems Division in 1966 and entered service in 1972.

Operation

The AGM-65 must be warmed up before it can be used. During the warm-up period, onboard image-stabilizing gyroscopes spin up to operating speed. The missile's video can be used before the gyroscopes have spun up, but the image will not be ground stabilized.

Missile video will become available on the WPN page once the gyroscopes are spun up. If you wish to shorten the warm-up period, pressing the Uncage button while the WPN page is SOI will activate missile video once the gyroscopes have reached 90% of operating speed.

The pilot can locate and designate targets using the Fire Control Radar (FCR) or Head-Up Display (HUD), using the AGM-65's own seeker head, or the pilot can handoff targets designated from the AAQ-33 Advanced Targeting Pod.

When handing off targets from the targeting pod (TGP), the missile boresight correlator (MBC) compares the image from the targeting pod with the image from the missile seeker head and slews the missile seeker head until the images match. The MBC is only active when in A/G mode with an AGM-65 selected, and the TGP is sensor of interest (SOI).

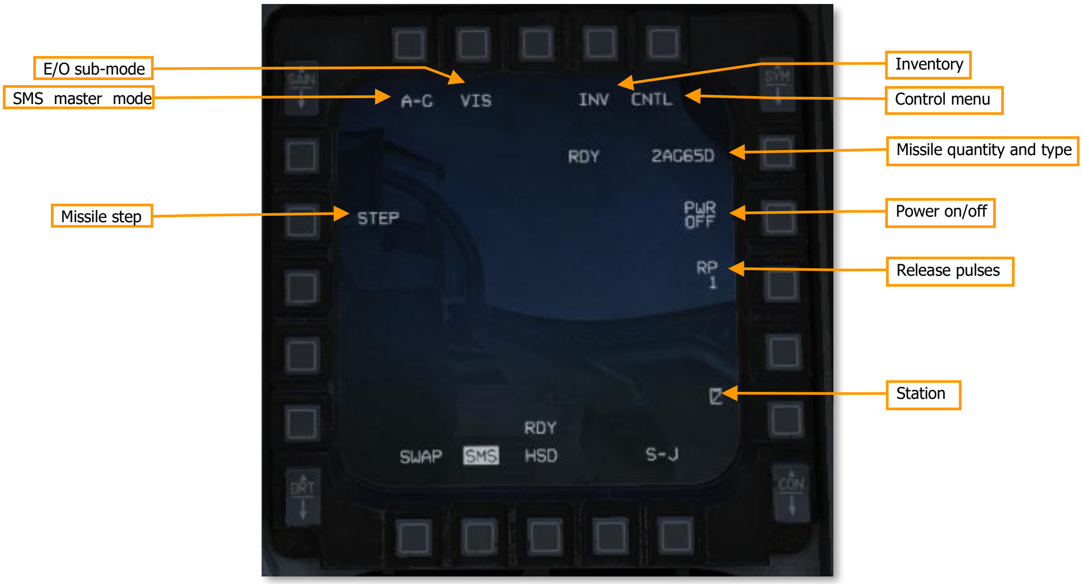
When the Maverick is fired, its onboard imager continues to track the target until the target grows to fill about 75% of the seeker head field of view (FOV). At this point, to continue to impact, the Maverick uses forced correlation.

The AGM-65 has a ground-configurable fuzing delay and a ground-selectable LAND/SHIP selector that changes the tracking algorithm to be more suitable for vehicles or ships.

Limitations

Standby time	1 hour
Video time	30 minutes
Seeker gimbal limits	
AGM-65D	±42° horizontally ±30-54° vertically

A-G SMS Page



SMS master mode: Toggles between A-G and STRF (gun strafe) master modes.

E/O sub-mode: Cycles between PRE, VIS, or BORE E/O sub-modes. You can also toggle sub-modes by depressing the RDR CURSOR/ENABLE switch on the throttle grip. (See Employment sections below for more information.)

Inventory page: Press to show the Inventory page.

Control page: Press to show the Control page.

Missile quantity and type: Cycles between different types of loaded AGM-65s.

Auto power toggle: Toggles on or off the auto-power feature (See Automatic Power-On below for more information.)

Release pulses: Controls the number of missiles released per press of the weapon release button. Only available for AGM-65D and -65G.

Stations: Shows the stations loaded with AGM-65s. The next station to fire is highlighted.

Missile step: Cycles the next station to fire between loaded stations.

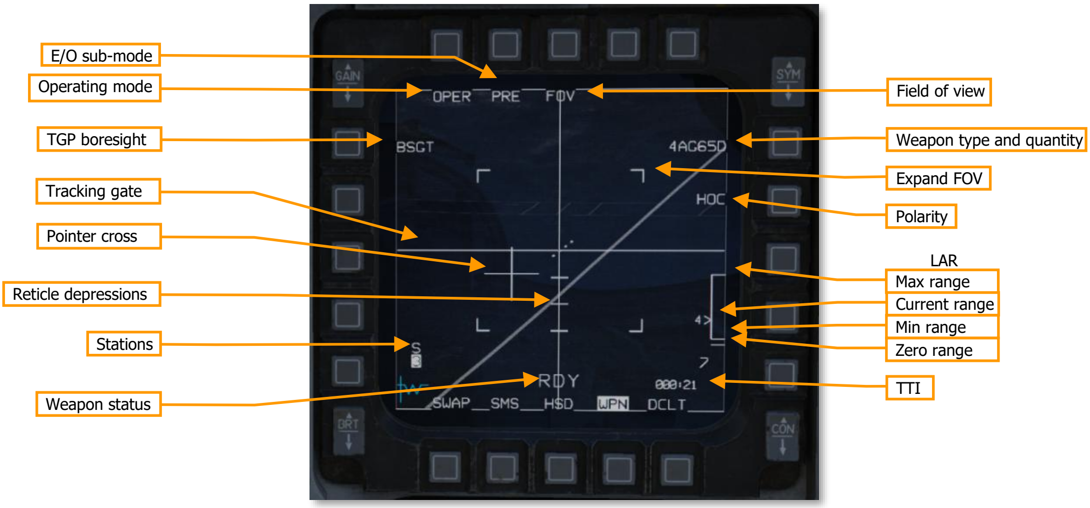
A-G SMS CNTL Page

Auto power toggle: Turns on or off the auto power-on feature.

Auto power steerpoint: Sets the steerpoint where the Maverick will automatically turn on.

Auto power direction: Sets the general direction the airplane must be going when it crosses that steerpoint to automatically power on the Mavericks. Cycles between north/east/south/west.

WPN Page



Operating mode: Cycles between STBY (standby) and OPER (operating) modes.

E/O sub-mode: Cycles between PRE, VIS, or BORE E/O sub-modes. You can also toggle sub-modes by depressing the RDR CURSOR/ENABLE switch on the throttle grip. (See Employment sections below for more information.)

TGP boresight: Press to mark this Maverick station as boresighted to the targeting pod. This should be done after confirming that the targeting pod and Maverick seeker head are pointing at the same target. (See Missile Boresighting more information.)

Tracking gate: Indicates the missile track target. The crosshairs will expand to indicate the boundaries of the target being tracked.

Pointer cross: Indicates the seeker head direction relative to boresight (center of the screen). The AGM-65D seeker head is capable of ±42° horizontally, and +30–54° vertically.

The pointer cross will flash when any of the following launch criteria are not met.

- Seeker head must be within 10° horizontally and vertically of boresight.
- Target image must be large enough to maintain continuous track.

Reticle depressions: Indicates 5°, 10°, and 15° of reticle depression.

Stations: Shows the stations loaded with AGM-65s. The next station to fire is highlighted. Above the station number will be a character indicating the status of the Missile Boresight Correlator:

- S: Slave (MBC has not been commanded to slew missile)
- 1: Slew 1 (MBC is slewing to match missile LOS to TGP LOS)
- 2: Slew 2 (MBC is slewing to match missile video to TGP video)
- T: Track (MBC has commanded missile to track)
- C: Complete (MBC has finished correlating)
- I: Impossible (MBC was unable to complete handoff)

Weapon status: One of the following.

- REL: Release signal being transmitted to weapon.
- RDY: Weapon is armed and ready for release.
- MAL: Weapon cannot be released due to malfunction.
- SIM: Weapon is unarmed and will not be released, but release symbology is being displayed.
- (blank): MASTER ARM is in OFF position.

Field of view: Toggles between wide and narrow FOV. You can also toggle FOV using the Expand/FOV button on the Side Stick Controller (SSC) when the WPN format is SOI, or using the Un-cage function on the MANRNG/UNCAGE knob regardless of SOI.

Weapon type: Cycles between the different types of loaded AGM-65s. Shows the quantity and type of AGM-65 loaded and active.

Expand FOV: Outlines the boundaries of the expanded field of view.

Polarity: Toggles between hot-on-cold (HOC) and cold-on-hot (COH) polarity. You can also press TMS Right to toggle between polarities. The AGM-65G and -H additionally have an AREA mode for forced correlation mode. (See Force Correlate below for more information.)

LAR: The launch acceptable region for the next missile, showing the acceptable launch range and current range adjacent to the caret. Accurate range data is only available if the SPI is in proximity to the missile LOS.

Time to impact (TTI): The time until the next missile impacts its target, if launched now.

Preparation

The AGM-65 has a duty cycle of one hour in standby, and 30 minutes when active. After powering the AGM-65s, the missiles will begin their 3-minute warm-up period. Once three minutes has passed, the missiles are in standby mode and ready for employment. In standby mode, the missiles have one hour of available duty time. Once a missile's video is activated, it has 30 minutes of available duty time. When a missile's duty time has expired, it must be powered off for two hours.

Automatic Power-On

The SMS can be configured to automatically power on the Mavericks when crossing a configured steerpoint, so that the pilot does not need to remember to power them on at least three minutes prior to employment.

Summary

1. On the SMS format, select Mavericks.
2. Display the Control page.
3. Choose the steerpoint.
4. Choose the direction and enable auto power-on.

1. On the SMS format, select Mavericks.

On the SMS format, press OSB 6 until AG65 is shown as the active weapon.

2. Display the Control page.

Press the CNTL (OSB 5) to display the Control page.

3. **Choose the steerpoint.**

   Press OSB 19, labeled STPT *X*.

   Using the OSBs, enter the steerpoint number, then press the OSB labeled ENTR. The Mavericks will be powered on upon crossing this steerpoint. You can press RCL to undo an errant digit, or RTN to return to the Control page without changing the steerpoint number.

4. **Choose the direction and enable auto power-on.**

   Press OSB 20 (NORTH OF) to cycle between different direction options. The Maverick will not be powered on until the aircraft crosses the configured steerpoint traveling in generally this direction.

   Press AUTO PWR (OSB 7) to turn on the automatic power-on feature.

You can leave the Control page by pressing the CNTL (OSB 5) again.

Missile Boresighting

Missile boresighting should be done prior to employing Mavericks using TGP handoff. It can be done either on the ground or in the air while enroute.

Summary

1. Power on the Mavericks and TGP.
2. Set GND JETT switch to ENABLE, MASTER ARM switch to MASTER ARM or SIMULATE, A-G master mode [2], and TGP to A-G mode.
3. On the SMS format, select AG65 and set E/O sub-mode to PRE or VIS.
4. On the TGP format, slew the seeker head to the boresight target.
5. On the WPN format, slew the seeker head to the same target and designate.
6. Press the BSGT button (OSB 20).
7. Repeat steps 4–6 for each station.
8. Power off the Mavericks and reset all switches.

1. Power on the Mavericks and TGP.

Place the TGP format on one MFD, and the SMS format on another.

If the Mavericks are not already powered on: On the SMS format, press the PWR OFF (OSB 7) to power on the Mavericks.

If the TGP is not already powered on: Set the RIGHT HDPT power switch to on, on the SENSOR panel.

2. Set GND JETT ENABLE ON, MASTER ARM SIM, A-G master mode, and A/G TGP mode.

If on the ground, set GND JETT ENABLE to ON. Press the A-G button on the ICP to switch to air-to-ground master mode. Set the MASTER ARM switch to SIM.

If the TGP is not already in air-to-ground mode, then on the TGP format, press the OSB labeled STBY, then the OSB labeled A-G to put the targeting pod in A/G mode.

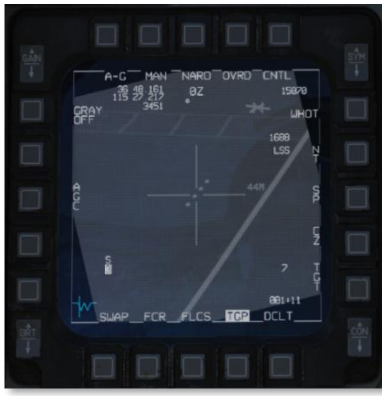
3. On the SMS format, select AG65 and set E/O sub-mode to PRE or VIS.

On the SMS format, press OSB 2 until PRE or VIS is shown as the Maverick sub-mode. (You can also depress the RDR CURSOR/ENABLE switch on the throttle grip to cycle between delivery modes.) Use PRE if your boresight target is co-located with a steerpoint; use VIS if you are visually locating your boresight target. Confirm that AGM-65 PRE or VIS symbology is shown on the HUD. Choosing a target further away will reduce parallax errors.

Change the MFD displaying the SMS format to the WPN format. On the WPN format, verify that NOT TIMED OUT is no longer displayed, indicating the missiles have completed their three-minute warm-up. The WPN page should begin displaying video from the missile seeker head.

4. **On the TGP format, slew the seeker head to the boresight target.**

Use DMS Aft-Short to move SOI to the TGP. Using the RDR CURSOR/ENABLE switch, slew the TGP pointing cross over the boresight target.



5. **On the WPN format, slew the seeker head to the same target and designate.**

Press DMS Aft-Short until SOI moves to the WPN format. Use the RDR CURSOR/ENABLE switch to slew the Maverick tracking gate over that same boresight target, then press TMS Forward to designate. Verify that the tracking gate closes, and the correct target is being tracked.

6. **Press the BSGT button (OSB 20).**

Press OSB 20, labeled BSGT, to boresight the missiles.

Press TMS Aft to break missile track, then verify the missile LOS follows the TGP LOS.

7. **Repeat steps 4–6 for each station.**

Press the Missile Step button to move to the next pylon. Repeat this procedure for each pylon loaded with AGM-65s.

8. Power off the Mavericks and reset all switches.

When you are finished boresighting your missiles, go back to the SMS format and press the OSB labeled PWR ON. This will prevent your Mavericks from running through their duty time before you enter the combat area.

Be sure to reset the positions of the MASTER ARM and GND JETT ENABLE switches, as well as the master mode.

Employment using PRE mode

The PRE (pre-planned) delivery mode allows you to lock targets in the vicinity of a sensor point of interest (SPI), such as a steerpoint. PRE uses CCRP-style HUD symbology, and the Maverick seeker head will be slaved to the SPI.

Summary

1. On the WPN format, set E/O sub-mode to PRE. Make sure WPN page is SOI.
2. Slew the tracking gate over the target and designate **[RCtrl]+[Up]**.
3. Fire the missile **[RAlt]+[Space]**.

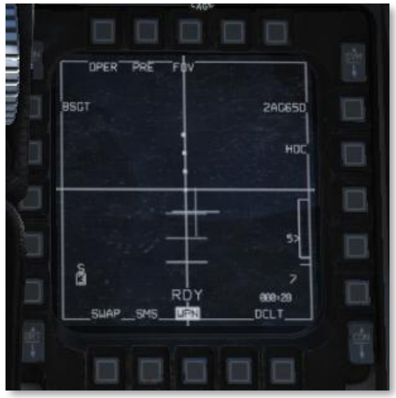
1. On the WPN format, set E/O sub-mode to PRE. Make sure WPN page is SOI.

On the WPN format, set the delivery mode to PRE by depressing the RDR CURSOR/ENABLE switch or OSB 2. The Maverick seeker head will be slaved to the SPI (typically the selected steerpoint). Confirm that seeker head video is available.

Press DMS Aft-Short until the WPN page is SOI.

2. Slew the tracking gate over the target and designate.

Use the RDR CURSOR/ENABLE switch to slew the tracking gate over the target, then press TMS Forward to designate. The tracking gate will close on the target. Confirm that the missile is tracking the correct target, the pointer cross is not flashing, and that the target is in range.



3. **Fire the missile.**

   Fire the missile with the Weapon Release button.

Employment using VIS mode

The VIS (visual) delivery mode allows you to lock targets that you can see in front of you, by using the HUD to slew a TD box onto the target. VIS uses DTOS-style sighting. VIS mode is unavailable if the Mavericks are loaded onto an LAU-88/A rack.

Summary

1. On the WPN format, set E/O sub-mode to VIS.
2. On the HUD, slew the TD box over the target and designate **[RCtrl]+[Up]** twice.
3. On the WPN format, slew the tracking gate over the target and designate **[RCtrl]+[Up]**.
4. Fire the missile **[RAlt]+[Space]**.

1. On the WPN format, set E/O sub-mode to PRE.

On the WPN format, set the delivery mode to VIS by depressing the RDR CURSOR/ENABLE switch or OSB 2. SOI will move to the HUD, and a TD box will appear initially caged to the flight path marker (FPM). Confirm that seeker head video is available on the WPN page.

2. On the HUD, slew the TD box over the target and designate.

Slew the TD Box using the RDR CURSOR/ENABLE switch on the throttle grip. Press TMS Forward to ground-stabilize the TD Box.

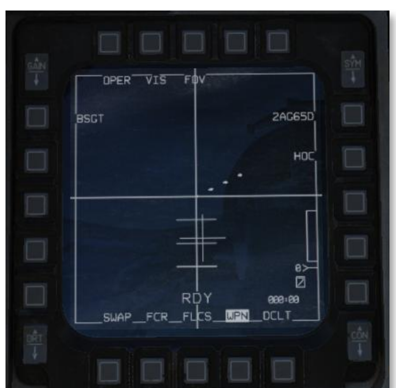
Refine the TD Box location as necessary using the RDR CURSOR/ENABLE switch on the throttle grip. Press TMS Forward to designate the location and the SOI will move to the WPN format.

If necessary, reject the designation by setting HUD as SOI using DMS Forward, and then TMS Aft-Short.

3. **On the WPN format, slew the tracking gate over the target and designate.**

   Use TMS Left or OSB 7 to change video polarity, if desired.

   Use the RDR CURSOR/ENABLE switch to place the target within the crosshairs on the WPN format, then press TMS Forward to track the target. The crosshairs will close on the target. Confirm that the missile is tracking the correct target, the pointer cross is not flashing, and that the target is in range.



4. **Fire the missile.**

   Fire the missile with the Weapon Release button.

Employment using BORE mode

BORE (boresight) delivery mode is intended for quick reactive or target-of-opportunity shots. Missiles can be launched against any target in BORE mode without having to change the SPI. In BORE mode, the Maverick seeker head is slaved to the pointer cross on the HUD.

Summary

1. On the WPN format, set E/O sub-mode to BORE.
2. On the HUD, fly the boresight cross over the target and designate **[RCtrl]+[Up]**.
3. Fire the missile **[RAlt]+[Space]**.

1. On the WPN format, set E/O sub-mode to BORE.

On the WPN format, set the delivery mode to BORE by depressing the RDR CURSOR/ENABLE switch or OSB 2. SOI will move to the WPN format. Confirm that seeker head video is available. SOI will move to the WPN page and missile seeker head position will be displayed on the HUD as a cross. Seeker head position will initially be boresight.

2. On the HUD, fly the boresight cross over the target and designate.

Fly the pointer cross near your target, then use the RDR CURSOR/ENABLE switch to slew the pointer cross over the target. Reference both the HUD and the WPN format to correctly place the pointer cross, then press TMS Forward to designate.

Confirm that the missile is tracking the correct target, the pointer cross is not flashing, and that the target is in range.

3. **Fire the missile.**

Fire the missile with the Weapon Release button.

Employment using TGP handoff

The TGP can hand-off targets to the AGM-65, which will attempt to track the TGP target. To improve the likelihood of a successful handoff, perform the steps listed in Missile Boresighting above, prior to entering the target area.

You should have the TGP format active on one MFD and the WPN format active on the other.

Summary

1. On the WPN format, set the delivery mode to PRE or VIS by depressing the RDR CURSOR/ENABLE switch **[Enter]** or OSB2. Confirm that seeker head video is available.
2. Using the DMS switch, move SOI to the TGP format **[RAlt]+[.]**.
3. Using the RDR CURSOR/ENABLE switch, slew to the target. For a moving target, use TMS Forward **[RCtrl]+[Up]** to switch to POINT track. (See the AAQ-33 Advanced Targeting Pod chapter for more information.)

While the TGP is slewed, the Missile Boresight Correlator (MBC) will command the seeker head to match slew and automatically attempt a track. During the attempt, HANDOFF IN PROGRESS will be displayed on the WPN format. The amount of time to complete correlation is reduced if the missile boresight procedure was completed prior to weapon employment.

If handoff succeeds, a "C" (correlated) will be displayed over the active pylon number. There is no need to switch SOI away from the TGP format. Confirm that the missile is tracking the correct target, the pointer cross is not flashing, and that the target is in range, then press the weapon release button to fire.

If the handoff cannot succeed, "I" (impossible) is displayed above the pylon number instead.

Ripple Fire

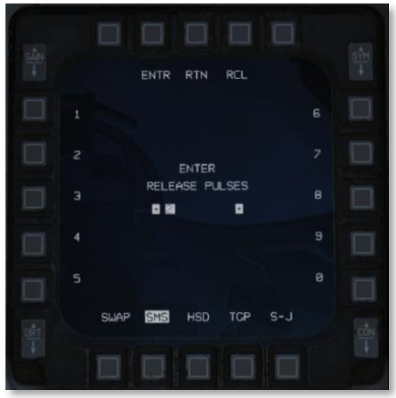
Up to two Mavericks can be queued with separate targets for a ripple fire (a.k.a. "quick-draw") attack. When more than one Maverick is tracking a target, two 10-mr LOS circles will appear on the HUD, labeled "1" and "2". The AGM-65s must be loaded on LAU-117 pylons for ripple fire to be available.

Summary

1. On the SMS MFD format, set RP to 2 (optional).
2. Using one of the delivery modes above, designate a target for the first Maverick **[RCtrl]+[Up]**.
3. Press the Missile Step button **[S]** to step to the next missile.
4. Designate a target **[RCtrl]+[Up]** for the second Maverick.
5. Fire both missiles.

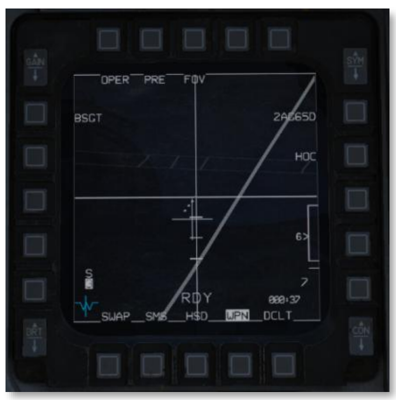
1. On the SMS format, set RP to 2 (optional).

Optionally, set the release pulses to two. To do this, from the SMS page, press OSB 8 (labeled RP). Use the MFD to set the releases pulses to 2, then press ENTR (OSB 2).



2. **Using one of the delivery modes above, designate a target for the first Maverick.**

   Using one of the delivery modes above, locate and designate a target for the first Maverick. Confirm that the missile is tracking the correct target. Do not fire the missile.

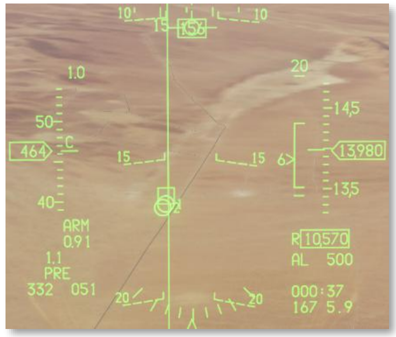


3. **Step to the next missile.**

   Press the Missile Step button to step to the next missile.

4. **Designate a target for the second Maverick.**

   Using the same procedure, locate and designate a target for the second missile. Confirm that the missile is tracking the correct target, the pointer cross is not flashing, and that the target is in range. On the HUD, LOS circles labeled "1" and "2" will indicate missile LOS and the order the missiles will fire in.



5. **Fire both missiles.**

If you set releases pulses to two, press and hold the Weapon Release button until both missiles have come off the rail. If not, press and hold the Weapon Release button once for each missile (twice total).

Force Correlate

The AGM-65G and -H models can be launched in force-correlate mode. This mode does not use the normal centroid tracking algorithm suitable for targeting vehicles, instead using an image-correlation algorithm suitable for tracking elements within a picture. Force-correlate mode is useful when launching Mavericks against static targets such as buildings and structures, when it is desired that the Maverick impact a specific part of that structure. Instead of tracking the target centroid, the Maverick will strive to impact the exact part of the image that was targeted (e.g., the base of an antenna).

Summary

1. Using one of the delivery modes above, locate a target.
2. Set the polarity mode to AREA.
3. Designate the image feature you wish to target **[RCtrl]+[Up]**.
4. Fire the missile. **[RAlt]+[Space]**

1. **Using one of the delivery modes above, locate a target.**

   Select either PRE, VIS, or BORE mode and locate your target.

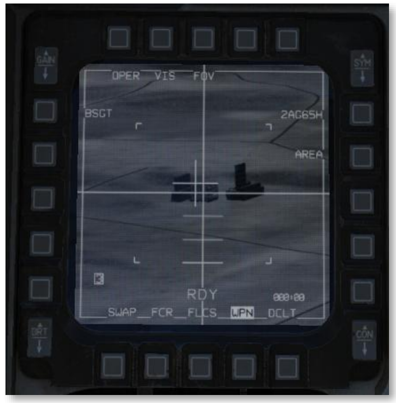
2. **Set the polarity mode to AREA.**

   Press OSB 7, or (if the WPN page is SOI) press TMS Right to cycle between polarity modes until AREA is shown next to OSB 7.

3. **Designate the image feature you wish to target.**

   Press DMS Aft-Short until the WPN page is SOI.

   Using the RDR CURSOR/ENABLE switch, slew the targeting gate to the image feature you wish to target, then press TMS forward to designate it. Confirm that the missile is tracking the correct portion of the image, the pointer cross is not flashing, and the target is in range.



4. Fire the missile.

Fire the missile with the weapon release button.

DEFENSIVE SYSTEMS

USAF Photo
by MSgt Cecilio Ricardo

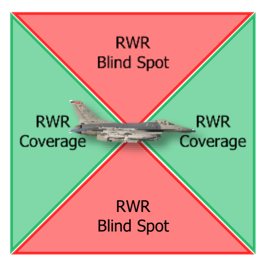
RADAR WARNING RECEIVER

The F-16C is equipped with the AN/ALR-56M Advanced Radar Warning Receiver system. The ALR-56M includes an array of passive radar receiver antennas mounted to the exterior of the airframe, internal signal processors, a threat warning azimuth indicator, and associated cockpit control panels.

AN/ALR-56M Advanced RWR Antenna Locations

When radar signals are detected by the external receiver antennas, the signal characteristics are analyzed and processed by the ALR-56M electronics to determine the specific type of radar that has been detected, what mode the radar is currently operating within, and its relative bearing from the aircraft. When these characteristics have been processed, a corresponding symbol is displayed on the Threat Warning Azimuth Indicator and corresponding audio feedback is provided to the pilot's helmet.

Antenna coverage of the ALR-56M is 360° in azimuth but only ±45° in elevation. As a result, the F-16C cannot detect radar signals that are directly above or below the fuselage centerline. This should be considered when performing defensive maneuvers at high pitch or roll attitudes, which could result in placing hostile radars into an RWR blind spot. When this occurs, radar lock and missile launch warnings will be lost.



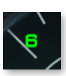
When employing the CMDS in Semi-automatic or Automatic modes, this will also cause the ECM pod to cease emitting, which may increase the aircraft's vulnerability to attack for the duration the hostile radar signals are within the RWR blind spot.

It is important to note that the RWR only detects the presence of radar signals; it does not indicate when a threat radar can see the ownship aircraft, nor does it indicate whether a threat radar is actually tracking the ownship aircraft or another aircraft along the same general bearing. Prudence should be taken when analyzing the information the RWR is providing, and weighing that with the other sensors on board your aircraft to produce an accurate assessment of the tactical situation.

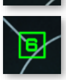
Threat Warning Azimuth Indicator

The Threat Warning Azimuth Indicator is a circular-shaped display mounted in the upper left portion of the Instrument Panel, with a brightness knob in the top left corner of the display that brightens or dims the display itself. The Azimuth Indicator is an azimuth-only top-down display with the center of the display representing the aircraft, and radar threat symbols displayed 360° in azimuth around it. If a threat symbol is displayed at the top of the display, the associated radar is directly in front of the aircraft. If the threat symbol is displayed at the bottom of the display, the associated radar is directly behind the aircraft.

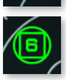
The nature of the threat is indicated by the type of symbol, and the relative lethality of the threat is indicated by the distance from the center of the display at which the threat symbols are positioned. Radar symbols that represent more lethal threats to the aircraft are shown closer to the center of the display. As a threat radar progresses from a search/acquisition mode, to target tracking, and then to missile guidance, the symbol will be incrementally moved toward the center of the display to symbolize its increasing lethality against the aircraft.



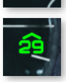
Radar in Search/Acquisition mode. The detected radar is operating in a search or target acquisition mode, with the symbol positioned along the outside of the display.



Radar in Tracking mode. The detected radar is operating in a target tracking mode, with the symbol positioned just outside the solid white circle and enhanced by a box.



Radar in Missile Guidance mode. The detected radar is operating in a missile guidance mode, with the symbol positioned inside the solid white circle and further enhanced by a flashing circle.



Airborne Radar. Detected radars that correspond with airborne platforms, such as a fighter or other aircraft, are enhanced with a chevron over the symbol.

Highest Priority Radar Threat. The radar threat that is determined to be the highest priority threat is enhanced by a diamond. The highest priority threat is continuously evaluated, which may cause the diamond to be reassigned to a different threat based on detected radar activity and relative lethality.

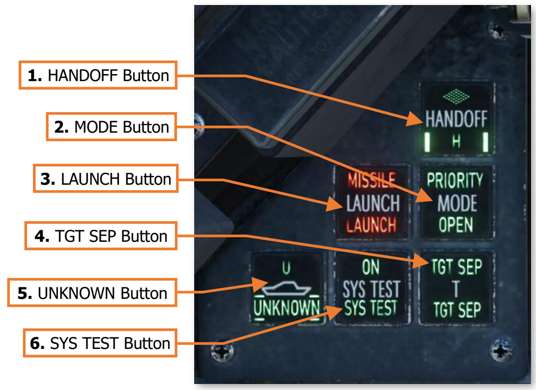
When performing defensive maneuvers, the symbols that are closer to the center of the display (especially those that are actively engaging the aircraft) should take priority consideration over those along the outer area.

A complete list of all RWR symbols and their corresponding threat systems can be found in Appendix B.

When a new threat is detected, an audio tone will be played over the THREAT audio channel, which can be adjusted on the AUDIO 1 control panel. Additionally, distinctive audio tones are played to indicate to the pilot when a radar is detected in track or missile guidance modes.

Threat Warning Prime Control Panel

The Threat Warning Prime control panel is mounted to the left of the Azimuth Indicator and includes several buttons for controlling the Azimuth Indicator display as well as several indicator lights.



1. **HANDOFF Button.** Not implemented.
2. **MODE Button.** Toggles the Azimuth Display between OPEN and PRIORITY modes.
   - **OPEN.** "OPEN" is displayed on the lower portion of the button and the 16 highest priority radar threats are displayed on the Threat Warning Azimuth Indicator.
   - **PRIORITY.** "PRIORITY" is displayed on the upper portion of the button and the 5 highest priority radar threats are displayed on the Threat Warning Azimuth Indicator.
3. **LAUNCH Button.** When a threat radar is detected to be in missile guidance mode, "MISSILE LAUNCH" flashes on the button.
4. **TGT SEP Button.** When pressed, "TGT SEP" is illuminated in the upper portion of the button and any threat symbols that are overlaid on top of each other are separated radially outward to aid in reading their symbol labels. Target separation is enabled for 5 seconds following the press of the TGT SEP button, after which all threat symbols will return to their original positions on the Azimuth Indicator.
5. **UNKNOWN Button.** Enables/disables the ALR-56M UNKNOWN mode. When enabled, "U" is illuminated in the upper portion of the button and any radars that cannot be identified by the ALR-56M will be displayed on the Azimuth Indicator with a "U" symbol. When disabled, any such radar signals that are detected by the ALR-56M are not displayed on the Azimuth Indicator, but the "U" in the upper portion of the button will flash to indicate the presence of unknown radar signals.
6. **SYS TEST Button.** When pressed and held for 1 second, "ON" is illuminated in the upper portion of the button while a system self-test is performed. All button lights on the Threat Warning Prime and Auxiliary control panels will illuminate, the Azimuth Indicator will display a series of diagnostic status messages and symbols, and a series of audio alert tones will be heard.

   When the self-test is complete, "ON" in the upper portion of the button will extinguish, all button lights on the Threat Warning Prime and Auxiliary control panels will extinguish as necessary, and the Azimuth Indicator will return to normal operation.

   The self-test may be manually aborted by pressing the SYS TEST button a second time.

Threat Warning Auxiliary Control Panel

The THREAT WARNING AUX control panel is mounted to the left of the CMDS control panel on the Left Auxiliary Console. The panel includes buttons for powering and controlling the operation of the ALR-56M.

1. **SEARCH Button.** Enables/disables the ALR-56M Search mode. When enabled, "S" is illuminated in the upper portion of the button and any radar signals that are determined to be early warning, surveillance, or non-lethal target acquisition radars by the ALR-56M will be displayed on the Azimuth Indicator. When disabled, any such radar signals that are detected by the ALR-56M are not displayed on the Azimuth Indicator, but the "S" in the upper portion of the button will flash to indicate the presence of such radar signals.

   When Search Mode is enabled, an "S" symbol will be displayed within the center of the Azimuth Indicator. If Search mode is enabled at the same as Low Altitude mode, the "S" symbol will alternate, or "mipple", with the Low Altitude "L" symbol.

2. **ACT/PWR Button.** When the ALR-56M is powered, "POWER" will illuminate in the lower portion of the button. If the ALR-56M detects any radar signals operating in a target tracking or missile guidance mode, "ACTIVITY" will illuminate in the upper portion of the button.

3. **ALTITUDE Button.** Toggles the ALR-56M between High Altitude and Low Altitude modes.

   - **High Altitude Mode.** "ALT" is illuminated on the lower portion of the button. Long-range, high-altitude air defense systems and fighter aircraft are prioritized as higher threats over short-range, low-altitude air defense systems. This mode may be appropriate for fighter sweeps, CAP patrols, or precision air strikes that are normally performed at high altitudes.

   - **Low Altitude Mode.** "LOW" is illuminated in the upper portion of the button in addition to "ALT". Short-range, low-altitude air defense systems and fighter aircraft are prioritized as higher threats over long-range, high-altitude air defense systems. This mode may be appropriate for low-level strikes, interdiction, or close air support operations that are normally performed at low altitudes.

   When Low Altitude mode is enabled, an "L" symbol will be displayed within the center of the Azimuth Indicator. If Low Altitude mode is enabled at the same as Search mode, the "L" symbol will alternate, or "mipple", with the Search "S" symbol.

4. **POWER Button.** Enables/disables power to the ALR-56M radar warning receiver. When the ALR-56M is powered, "SYSTEM POWER" will illuminate on the button.

5. **DIM knob.** Rotating the knob clockwise increases the brightness intensity of the indicator lights on the panel as well as those on the Threat Warning Prime control panel.

COUNTERMEASURES DISPENSING SET

The F-16C is equipped with the AN/ALE-47 Airborne Countermeasures Dispensing Set (CMDS) for protection against radar-guided and infrared-guided threats. The ALE-47 includes four expendable countermeasure dispensers mounted to the exterior of the airframe, internal processors, and a control panel within the cockpit. The cockpit-mounted CMDS control panel allows the pilot to review expendable countermeasure quantities, configure CMDS modes of operation, and manage individual countermeasure programs.

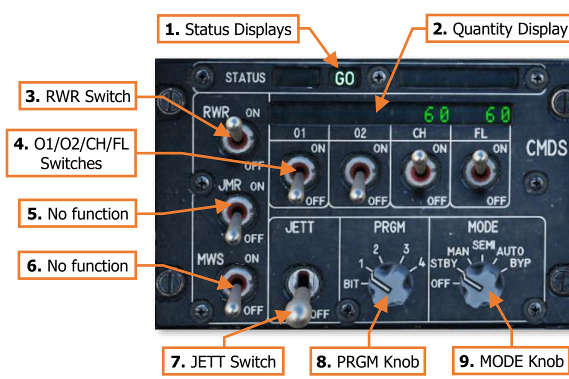
AN/ALE-47 Airborne Countermeasures Dispenser Locations

The main interfaces with the CMDS are through the CMDS Control Panel and the CMDS DED pages. The primary controls for countermeasure employment are on the Side Stick Controller (SSC).

CMDS Control Panel

The CMDS control panel is located on the Left Auxiliary Console and powers the ALE-47 countermeasure dispensers and configures the CMDS Manual programs and modes of operation.

1. **Status Displays.** Indicates the status of the countermeasures dispensing set.
    - **NO GO.** The CMDS is powered but has malfunctioned and cannot dispense countermeasures.
    - **GO.** The CMDS is powered and ready to dispense countermeasures.
    - **DISPENSE RDY.** The CMDS is ready to dispense countermeasures in reaction to a threat but requires consent from the pilot when CMDS MODE knob is set to SEMI. This will be accompanied by a "Counter" voice message, if enabled on the CMDS BINGO DED page.



2. **Quantity Display.** Displays the remaining quantity of each countermeasure type on board the aircraft. System failure messages are also displayed in these display fields when applicable.

   If a countermeasure type is at or below the respective Bingo quantity set on the CMDS BINGO DED page, "LO" will displayed adjacent to the corresponding countermeasure type. This will be accompanied by a "Low" voice message, if enabled on the CMDS BINGO DED page.

3. **RWR Switch.** Enables the CMDS to use threat indications detected by the ALR-56M Radar Warning Receiver to determine appropriate countermeasure programs when CMDS MODE is set to SEMI or AUTO.

4. **O1/O2/CH/FL Switches.** Enables the dispensing of the respective countermeasure type. When set to the ON position, the quantity of the corresponding countermeasure type will be displayed on the Quantity Display above the switch.

   - **O1.** No function.
   - **O2.** No function.
   - **CH.** Chaff cartridges are enabled for dispensing.
   - **FL.** Flare cartridges are enabled for dispensing.

5. **JMR Switch.** No function.

6. **MWS Switch.** No function.

7. **JETT Switch.** When moved to the forward position, all expendable countermeasures on board the aircraft will be dispensed simultaneously, regardless of the position of the CMDS MODE knob.

8. **PRGM Knob.** Selects the CMDS program to be manually dispensed using CMS Forward on the SSC when the CMDS Mode is in Manual, Semi-automatic, or Automatic.

   - **BIT.** Initiates a BIT of the CMDS. (N/I)
   - **1.** Selects Manual Program 1.
   - **2.** Selects Manual Program 2.
   - **3.** Selects Manual Program 3.
   - **4.** Selects Manual Program 4.

9. **MODE Knob.** Selects the operating mode of the CMDS.

   - **OFF.** The CMDS is not powered and dispensing is not possible, except for jettison using the JETT switch. ECM pod emissions are disabled.
   - **STBY.** The CMDS is powered but dispensing is not enabled, except for jettison using the JETT switch. Changes to the CMDS settings and programs may be made using the CMDS DED pages while in this mode. ECM pod emissions are disabled.
   - **MAN.** The CMDS is powered and only Manual programs may be dispensed. ECM pod emissions are enabled and disabled manually by the pilot.
     - CMS Aft will activate ECM pod noise jamming signals if ECM XMIT switch is in position 3.
     - CMS Right will deactivate ECM pod noise jamming signals.
     - Manual Programs 1-4 may be dispensed based on the position of the PRGM knob.
     - Manual Programs 5 and 6 may be dispensed.

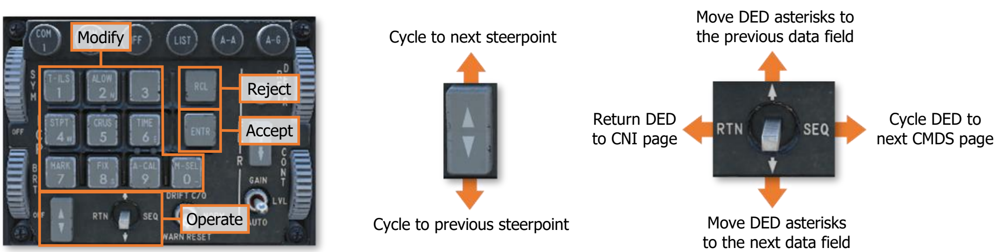
- **SEMI.** The CMDS is powered and determines the appropriate Automatic program to be dispensed based on the threat; and will dispense a single Automatic program if consent is provided by the pilot. ECM pod emissions require pilot consent but will only occur when the aircraft is actively being engaged by a hostile radar threat.
    - CMDS selects the appropriate Automatic Program against the current radar threat. The pilot is prompted by DISPENSE RDY Status Display on the CMDS panel and a "Counter" voice message to dispense a Manual program or provide consent to dispense a single Automatic program.
    - Once an Automatic or Manual program has completed, the pilot will be prompted again to dispense a Manual program or provide consent to dispense a single Automatic program.
    - CMS Aft will dispense a single Automatic Program and will enable the ECM pod to emit deception jamming signals any time the aircraft is locked by a hostile radar threat if ECM XMIT switch is in position 1 or 2.
    - Automatic programs will not be dispensed if the chaff is in LO status.
    - CMS Right will disable the ECM pod from emitting.
    - Manual Programs 1-4 may be dispensed based on the position of the PRGM knob.
    - Manual Programs 5 and 6 may be dispensed.
- **AUTO.** The CMDS is powered and determines the appropriate Automatic program to be dispensed based on the threat; and will repetitively dispense the selected Automatic program if consent is provided by the pilot. ECM pod emissions *do not* require pilot consent and will occur any time the aircraft is actively being engaged by a hostile radar threat.
    - CMDS selects the appropriate Automatic Program against the current radar threat. If consent has already been given to dispense Automatic programs, the selected Automatic program will be repetitively dispensed any time the aircraft is locked by a hostile radar threat, until the aircraft is no longer locked by a hostile radar threat or the chaff reaches the Bingo quantity set on the CMDS BINGO DED page.
    - CMS Right will revoke consent for dispensing Automatic programs and will interrupt any Automatic or Manual programs that are currently in progress.
    - CMS Aft will grant consent for dispensing Automatic programs.

      NOTE: Consent is granted as the default state each time the CMDS MODE knob is moved into the AUTO position.
    - If the ECM power switch is set to OPR, the ECM pod will emit deception jamming signals any time the aircraft is locked by a hostile radar threat if ECM XMIT switch is in position 1 or 2.
    - Automatic programs will not be dispensed if the chaff is in LO status.
    - Manual Programs 1-4 may be dispensed based on the position of the PRGM knob.
    - Manual Programs 5 and 6 may be dispensed.
- **BYP.** Bypass mode may be used if the other CMDS modes have malfunctioned in any way. When CMS Forward is pressed, one chaff cartridge and one flare cartridge will be dispensed. Manual Programs 1 through 6 will be unavailable, as well as any other CMS functions. If the ECM pod is currently emitting in deception jamming mode, it will continue to emit until the current threat is no longer present, after which it will be placed in a standby state.

CMDS BINGO DED Page

The Countermeasures Dispensing Set DED page is accessed by pressing **7/MARK** button on the ICP keypad when the LIST DED page is displayed on the DED. This page allows the pilot to edit the "BINGO" quantity values for each expendable countermeasure type and toggle voice message alerts regarding countermeasure dispensing.

NOTE: Prior to making any changes on the CMDS BINGO DED page, the CMDS MODE knob must be set to the STBY position on the CMDS control panel to prevent erroneous data entry into the CMDS settings.

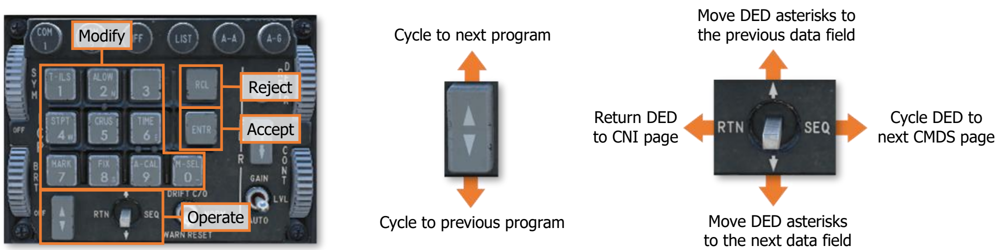


1. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to enter a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.
2. **Chaff Bingo Quantity.** Displays the chaff "LO" threshold. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. Valid entries range from 0 to 99.
3. **Flare Bingo Quantity.** Displays the flare "LO" threshold. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. Valid entries range from 0 to 99.
4. **Other 1/Other 2 Bingo Quantities.** No function.
5. **Selected Steerpoint.** Displays the selected steerpoint. The ICP Increment/Decrement rocker may be used to cycle to a different steerpoint.
6. **Feedback Voice Message.** When set to ON, a "Chaff flare" voice message will be played when an Automatic or Manual program begins dispensing, regardless of whether the program includes either countermeasure type. May be toggled by placing the DED asterisks over the data field and pressing any ICP keypad button 1-9.
7. **Request Countermeasures Voice Message.** When set to ON, a "Counter" voice message will be played when the CMDS MODE is set to SEMI and pilot consent is requested to dispense an Automatic program. May be toggled by placing the DED asterisks over the data field and pressing any ICP keypad button 1-9.
8. **Bingo Voice Message.** When set to ON, a "Low" voice message will be played when a countermeasure type has reached its Bingo threshold, and an "Out" voice message will be played when depleted. May be toggled by placing the DED asterisks over the data field and pressing any ICP keypad button 1-9.

CMDS CHAFF & FLARE DED Pages

The CMDS Chaff and Flare DED pages are accessed by pressing **7/MARK** button on the ICP keypad when the LIST DED page is displayed, and then momentarily setting the ICP DCS switch to the SEQ position. These pages allow the pilot to modify the dispensing sequence of chaff and/or flares when Manual programs are employed.

NOTE: Prior to making any changes on the CMDS CHAFF and FLARE DED pages, the CMDS MODE knob must be set to the STBY position on the CMDS control panel to prevent erroneous data entry into the CMDS settings.



1. **Burst Quantity.** Number of cartridges dispensed within each salvo. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. Valid entries range from 0 to 99.

2. **Burst Interval.** Time interval between cartridges dispensed within a salvo. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. Valid entries range from 0.020 to 10.000, in 0.001 increments.

3. **Salvo Quantity.** Number of salvos within the program. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. Valid entries range from 0 to 99.

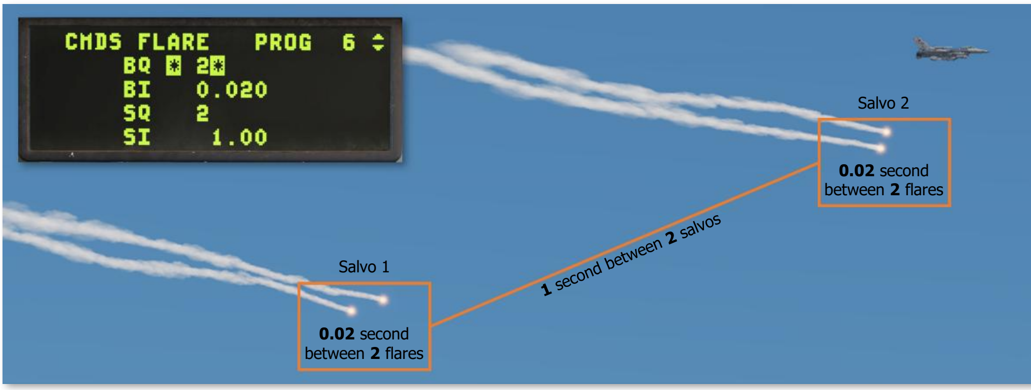
4. **Salvo Interval.** Time interval between each salvo within the program. May be modified by placing the DED asterisks over the data field, inputting a value using the ICP keypad, and pressing ENTR. Valid entries range from 0.50 to 150.00 in 0.01 increments.

5. **Manual Program Number.** Displays the Manual program that is being edited. The ICP Increment/Decrement rocker may be used to cycle to a different Manual program.

   - **Manual Program 1-4.** Dispensed by pressing CMS Forward when the CMDS Mode is in Manual, Semi-automatic, or Automatic, based on the position of the CMDS PRGM knob.
   - **Manual Program 5.** Dispensed by pressing the CHAFF/FLARE Dispense button, located on the left cockpit wall above the throttle, when the CMDS Mode is in Manual, Semi-automatic, or Automatic.
   - **Manual Program 6.** Dispensed by pressing CMS Left when the CMDS Mode is in Manual, Semi-automatic, or Automatic.

6. **DED Asterisks.** If a data field on the DED is bracketed by these symbols, the ICP keypad may be used to input a different value, or the 0/M-SEL button may be used to enable it in some cases. A data field that has been modified but has not been accepted will be highlighted. When the modified data is accepted (ICP ENTR button) or rejected (ICP RCL button) the data field will be returned to normal, de-highlighted text.

Setting the Burst Quantity or Salvo Quantity to 0 on the CMDS CHAFF or CMDS FLARE DED pages will prevent the respective countermeasure type from being dispensed within the displayed Manual program. In the example below, the BQ value on the CMDS CHAFF DED page has been set to 0 for Manual program 6, and the values on the CMDS FLARE DED page are configured as shown on the inset image of the DED.

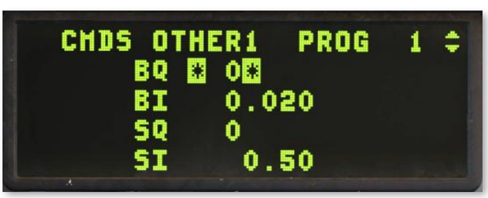


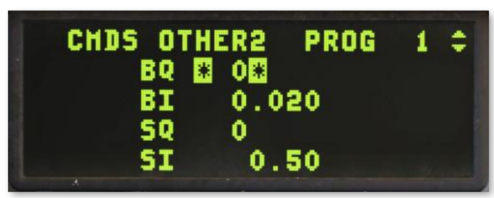
Countermeasure Program Quantities & Intervals

In this example, Manual program 6 is dispensed by pressing CMS Left on the SSC, resulting in only flares being dispensed in accordance with the settings shown above.

CMDS OTHER1 & OTHER2 DED Pages

The CMDS OTHER1 and OTHER2 DED pages have no function. Chaff and flares are the only expendable countermeasures utilized by the F-16C variant that is simulated by DCS: F-16C Viper.





Momentarily setting the ICP DCS switch to the SEQ position will cycle through these pages back to the CMDS BINGO DED page.

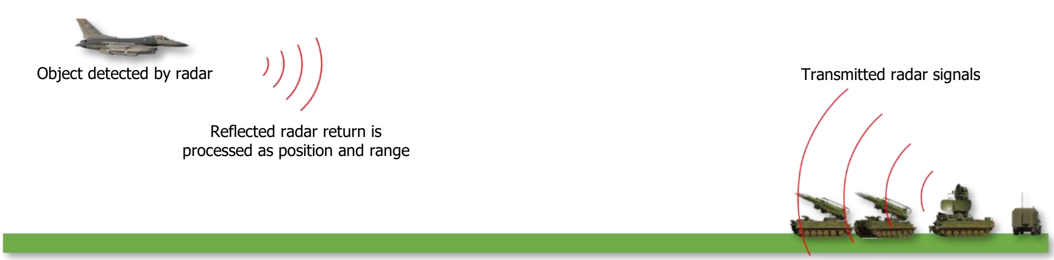
ELECTRONIC COUNTERMEASURES

Electronic countermeasures (or ECM) pods can be carried to provide an additional layer of protection against radar threats such as surface-to-air missile (SAM) batteries. Depending on the sophistication and range of the radar system that is attempting to acquire and track the aircraft, ECM pods can be used to deny, degrade or delay an attack so that the pilot can escape the engagement envelope of the threat system, evade incoming weapons, or gain additional time to execute their mission before being forced to take evasive maneuvers.

The F-16C can be equipped with either the AN/ALQ-131 or AN/ALQ-184 electronic countermeasures pods.

Radar Jamming

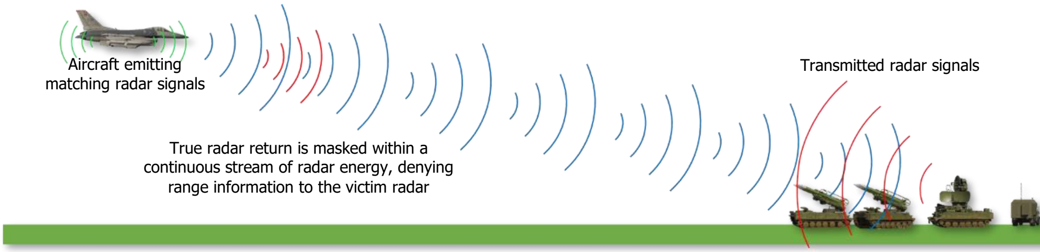
A radar system relies on its ability to receive reflections of its own radio signals off an object, and that these reflections (called "radar returns") are strong enough to be processed among other noise and clutter within the electromagnetic environment. Radar jamming is a type of electronic attack that intentionally radiates radio signals back to a radar system in order to confuse or degrade the radar's ability to calculate range and position using its own radar signals. By matching the victim radar's signal characteristics, a radar jammer can effectively send false information into the victim radar. This can be done using "noise jamming" or "deception jamming".



Radar Detection

Noise Jamming

Noise jamming is accomplished by saturating a victim radar with radio signals that match the frequencies transmitted by its own radar antenna. This is primarily performed to deny ranging data by interfering with the radar's ability to accurately measure the elapsed time between transmissions and reflected radar energy.

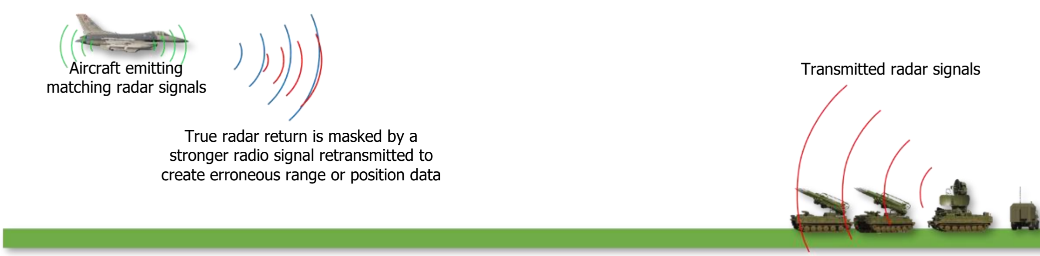


Noise Jamming

Unfortunately, since noise jamming relies upon the continuous transmission of high-power radio signals, often across multiple frequencies (known as "barrage jamming"), it can also highlight the presence of the aircraft to hostile radar systems before the aircraft itself would have been detected.

Deception Jamming

Deception jamming is accomplished by analyzing a radar signal, and then retransmitting a signal that precisely matches the signal characteristics in order to generate false targeting information. In contrast to noise jamming, deception jamming can either produce false target returns or introduce errors into automatic target tracking techniques within certain radar systems.



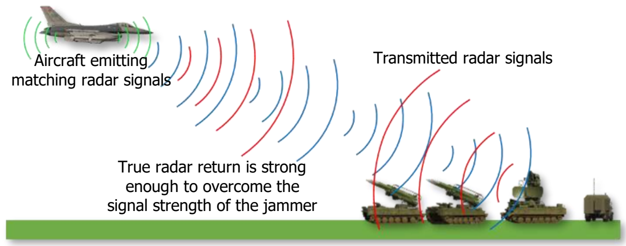
Deception Jamming

The advantage of deception jamming is that the jammer itself can be employed intermittently to avoid highlighting the position or presence of the aircraft until necessary. However, depending on the specific radar system, the effectiveness of these jamming techniques may vary.

Burnthrough

"Burnthrough" may occur when the radar return of the aircraft is strong enough that it exceeds the power of the jammer's radio signal when received by the victim radar.

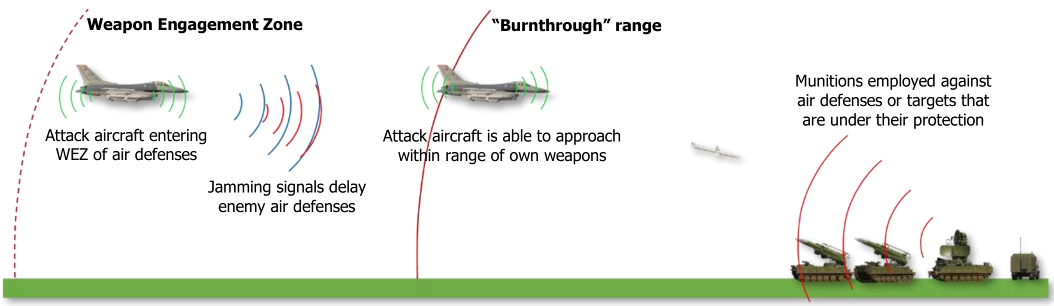
Burnthrough commonly occurs when the aircraft is at closer ranges to the victim radar, which will produce a stronger radar return. As such, the range at which burnthrough occurs will vary between different types of radar systems.



Radar "Burnthrough" of Jamming Signals

Application of Electronic Countermeasures

Although ECM does not provide a guarantee against enemy air defenses, when properly employed during a mission ECM can provide additional time to determine the best way to counter enemy air defenses, or allow an attack aircraft to sufficiently reduce their range to target in order to employ their own weapons.

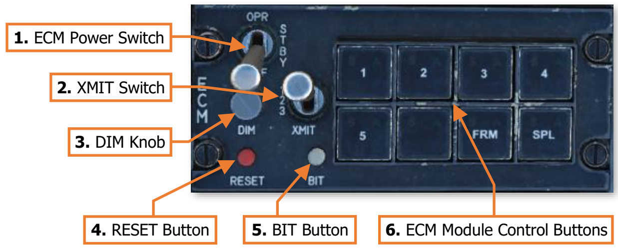


Electronic Countermeasures Against Enemy Air Defenses

ECM Control Panel

The ECM control panel is located on the Left Console and controls the operation of the ALQ-131 or ALQ-184 ECM pod (if installed).

NOTE: Each ECM pod available to the DCS: F-16C Viper functions identically within DCS World. The selection of a specific pod may provide other benefits such as different weight and drag impacts, emulating the inventory of a specific country's military, or simulating a specific conflict or time period.



1. **ECM Power Switch.** Controls the ECM pod operation.
    - **OPR.** ECM pod is powered and operating. Threat signals are processed, and the pod's transmitters operate in accordance with the settings on this panel and the Hands-On Controls.

      NOTE: If the pod has not completed the warm-up prior to moving the switch from STBY to OPR, the pod will not emit jamming signals until the warm-up is complete.
    - **STBY.** ECM pod is powered and begins warm-up (approximately 3 minutes) but will not process threat signals or emit jamming signals.
    - **OFF.** ECM pod is not powered.
2. **XMIT Switch.** Determines the operational mode of the ECM pod.
    - **1 – Deception jamming mode (Avionics Priority).** The ECM pod will reactively emit jamming signals if the ECM system determines the aircraft is being actively tracked or engaged by a threat radar system. The FCR will continue to operate, however the FCR detection and lock ranges will be reduced.

      The CMDS MODE knob must be set to SEMI or AUTO to enable ECM emissions when set to this mode.
    - **2 – Deception jamming mode (ECM Priority).** The ECM pod will reactively emit jamming signals if the ECM system determines the aircraft is being actively tracked or engaged by a threat radar system. The FCR will be placed in a standby state, unless the current weapon profile is AIM-120, in which case the ECM pod will operate in Avionics Priority mode.

      The CMDS MODE knob must be set to SEMI or AUTO to enable ECM emissions when set to this mode.
    - **3 – Noise jamming mode (ECM Priority).** The ECM pod will continuously transmit jamming signals in a preemptive manner. The FCR will be placed in a standby state.

      CAUTION: Continuously broadcasting jamming signals in position 3 will increase the likelihood your aircraft's presence will be detected by hostile aircraft or air defense units.

      The CMDS MODE knob must be set to MAN to enable ECM emissions when set to this mode.
3. **DIM Knob.** Controls the brightness of the ECM panel indicator lights on the module control buttons.
4. **RESET Button.** No function.
5. **BIT Button.** Performs a Built-In Test of the ECM pod. (N/I)
6. **Manual Band Control Buttons.** Selectively enables emissions from individual modules within the ECM pod. Each button is latched in that the buttons are pressed down and held in place to enable that module; or pressed down and popped out to disable that module.
    - **1.** Enables/disables Band 1 module.

- **2.** Enables/disables Band 2 module.
- **3.** Enables/disables Band 3 module.
- **4.** Enables/disables Band 4 module.
- **5.** Enables/disables Band 5 module.
- **(Blank).** Enables/disables an un-marked module for growth within the system.
- **FRM.** No function.
- **SPL.** No function.

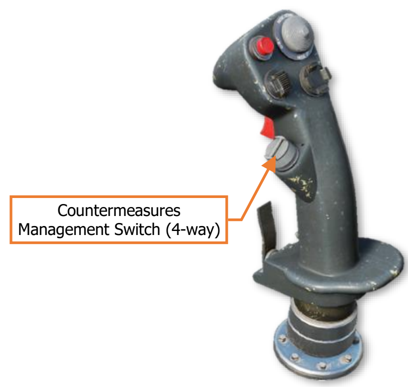
Four status lights on each button provide an indication as to the operational state of the ECM modules.

- **S.** Standby. The ECM module is powered but not enabled for transmission.
- **A.** Active. The ECM module is powered and enabled for transmission.
- **F.** Failed. The ECM module has malfunctioned or failed.
- **T.** Transmitting. The ECM module is powered and is currently transmitting.

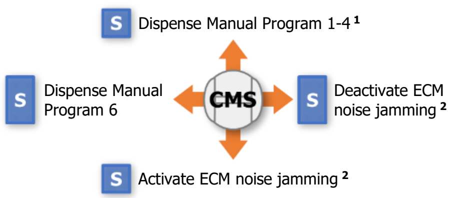
NOTE: The Manual Band Control Buttons in the DCS: F-16C Viper function identically within DCS World. The selection of different ECM modules will not produce different effects on a given threat system.

HANDS-ON CONTROLS

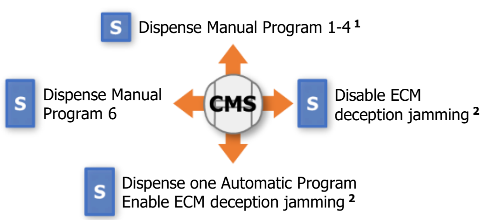
The Countermeasures Management Switch (CMS) on the Side Stick Controller (SSC) is the pilot's primary control over the F-16C's defensive systems. The CMS is a 4-way switch which controls the deployment of countermeasures and operation of the ECM pod (if installed).



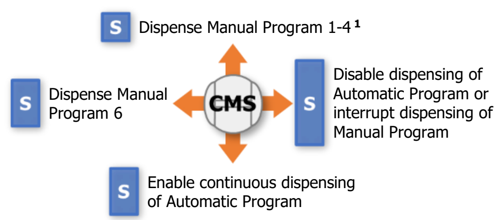
CMDS MODE – MAN. The following CMS actions are performed when the CMDS Mode is set to Manual.



CMDS MODE – SEMI. The following CMS actions are performed when the CMDS Mode is set to Semi-automatic.



CMDS MODE – AUTO. The following CMS actions are performed when the CMDS Mode is set to Automatic.



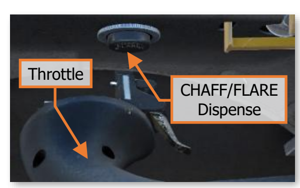
S Short press (<0.5 sec)

1. CMS Forward will dispense the Manual Program selected by the CMDS PRGM knob, unless another Manual or Automatic program is already in progress.
2. XMIT Switch on ECM Panel must be set to positions 1 or 2 to enable Deception jamming in Semi-automatic CMDS mode, or position 3 to activate Noise jamming in Manual CMDS mode.

CHAFF/FLARE Dispense Button

The CHAFF/FLARE Dispense button is located on the left cockpit wall outboard and above the throttle, and immediately aft of the canopy locking lever.

The button is used to dispense Manual Program 5 when the CMDS Mode is set to Manual, Semi-automatic, or Automatic. This button operates independently of the CMS functions on the Side Stick Controller (SSC).



APPENDICES

APPENDIX A – ABBREVIATED CHECKLISTS

Procedures

Navigation

Radio Communications

Datalink Communications

Combat Employment

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Procedures

Abbreviated checklists for performing start-up, INS alignment, taxi, takeoff, landing, shutdown, and aerial refueling procedures.

Before Engine Start

1	MAIN PWR switch – **BATT**.
2	Verify light: • ACFT BATT **FLCS RLY** – **On**.
3	FLCS PWR TEST switch – **TEST** and hold.
4	Verify lights: • **FLCS PMG**, ACFT BATT **TO FLCS**, and FLCS PWR **A**, **B**, **C**, **D** – **On**. • ACFT BATT FLCS RLY – **Off**.
5	FLCS PWR TEST switch – Release.
6	MAIN PWR switch – **MAIN PWR**.
7	Verify lights: • **ENGINE** and **HYD/OIL PRESS** warning lights – **On**. • **ELEC SYS** and SEC caution lights – **On**. • ACFT BATT **FLCS RLY** – **On**. • EPU GEN and EPU PMG – **Off**.
8	Communications – Established with ground crew and ATC as required for engine start.
9	Canopy – As desired.
10	Chocks – In place.
11	Ground crew – Clear of intake and other danger areas.

Engine Start

1	JFS switch – **START 2**.
2	SEC caution light – Off.
3	Throttle – Advance to IDLE.
4	ENGINE warning light – Off (approximately 60% RPM).
5	Verify lights: • **SEAT NOT ARMED** caution light – On. • Three green WHEELS down lights – On.
6	JFS switch – Confirm OFF; manually set to OFF if necessary.
7	HYD/OIL PRESS warning light – Off.
8	FUEL FLOW – 700-1700 PPH.

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9	Engine OIL pressure – 15 PSI (minimum).
10	Engine NOZ POS – above 94%.
11	Engine RPM – 62%-80%.
12	Engine FTIT – 650° C or less.
13	HYD PRESS A & B – 2850-3250 PSI.

After Engine Start

1	TEST panel – Check.
2	AVIONICS POWER panel – Set MMC, ST STA, MFD, UFC, GPS.
3	INS – Align. (See Normal INS Alignment or Stored Heading INS Alignment on the following page)
4	AVIONICS POWER panel – Set DL, MIDS LVT.
5	SNSR PWR panel – Set.
6	HUD – As desired.
7	C & I knob – UFC.
8	Secondary (SEC) engine control mode – Check.
9	Flight controls – Cycle to ensure maximum deflection of flight control surfaces.
10	FLCS BIT – Initiate and monitor.
11	ECM panel – As required.
12	SPD BRK switch – Cycle to extended position and then retract.
13	WHEELS down lights – Three green.
14	Standby Attitude Indicator – Uncage and set.
15	FUEL QTY SEL knob – Check and set.
16	EPU FUEL quantity – 95-102%.
17	Avionics, MFD's, and VHF radio – Configure as required.
18	DBU – Check (after FLCS BIT is complete).
19	TRIM – Check.
20	MPO – Check.
21	Operate controls – Verify all surfaces respond normally and no FLCS lights illuminate.
22	Air refueling system (if required) – Check.
23	EPU GEN and EPU PMG – Confirm Off.
24	EPU – Check.

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Normal INS Alignment

1	INS Knob – **ALIGN NORM**.
2	ICP Keypad – Input **2** for N (North) or **8** for S (South).
3	ICP **Keypad** – Input Latitude in DD°MM.M' format, which is input as DDMMM in a continuous string of five numbers.
4	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.
5	ICP DCS Switch – **Down** to move DED Asterisks around LNG data field.
6	ICP Keypad – Input **6** for E (East) or **4** for W (West).
7	ICP **Keypad** – Input Longitude in DDD°MM.M' format, which is input as DDDMMM in a continuous string of six numbers, to include a leading zero if necessary.
8	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.
9	ICP DCS Switch – **Down** to move DED Asterisks around SALT data field.
10	ICP **Keypad** – Input Altitude in feet.
11	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.

When "RDY" flashes on the INS DED page and "ALIGN" flashes in the HUD, the alignment is complete.

12	INS Knob – NAV.

Stored Heading INS Alignment

1	INS Knob – **ALIGN STOR HDG**.

When "RDY" flashes on the INS DED page and "ALIGN" flashes in the HUD, the alignment is complete.

2	INS Knob – NAV.

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Before Taxi

1	Canopy – Close and lock.
2	Backup UHF radio – Set and check as required.
3	Altimeter and altitude indications – Set and check.
4	Exterior lights – As required.
5	INS knob – NAV.
6	Chocks – Remove.

Taxi

1	Throttle – Advance.
2	Brakes and NWS – Check.
3	Heading – Check.
4	Flight instruments – Check for proper operation.

Before Takeoff

1	ALT FLAPS switch – Verify NORM.
2	Trim – Check.
3	ENG CONT switch – Verify PRI (guard down).
4	Speedbrakes – Verify closed.
5	Canopy – Verify closed and locked.
6	IFF – Set and check. (N/I)
7	External fuel tanks – Verify feeding.
8	FUEL QTY SEL knob – NORM.
9	STORES CONFIG switch – As required.
10	OXYGEN SUPPLY lever – PBG (if high-G maneuvers are expected immediately following takeoff).
11	PROBE HEAT switch – PROBE HEAT (if required).
12	Ejection safety lever – Down (Armed).
13	Flight controls – Cycle.
14	Engine OIL pressure – 15-65 PSI.
15	Warning and caution lights – Verify no unexpected conditions.
16	Targeting pod – STBY mode (if installed).

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Takeoff

1	Brakes – Hold.
2	Parking Brake – Verify disengaged.
3	Throttle – 90% RPM. Check for normal engine indications:
4	HYD/OIL PRESS warning light – Off.
5	OIL pressure – 25-65 PSI
6	FTIT – 935° C or less
7	HYD PRESS A & B – 2850-3250 PSI

TAKEOFF SPEED BASED ON AIRCRAFT GROSS WEIGHT

GROSS WEIGHT (GWT)	20,000 lbs.	24,000 lbs.	28,000 lbs.	32,000 lbs.	36,000 lbs.	40,000 lbs.	44,000 lbs.
TAKEOFF SPEED (KCAS)	128 kts	142 kts	156 kts	168 kts	178 kts	188 kts	198 kts

8	LG Handle – UP; after a positive rate of climb is established. **NOTE:** Ensure landing gear is fully retracted with the gear doors closed before exceeding 300 KCAS.

Descent/Before Landing

1	Fuel – Check quantity/transfer/balance.
2	Landing Light – On.
3	Altimeter – Set and check.
4	Attitude References – Check.
5	ANTI ICE switch – As required.
6	Targeting pod – STBY mode (if installed).

After Landing

1	PROBE HEAT switch – Verify OFF.
2	ECM Power switch – OFF.
3	Speedbrakes – Close.
4	Ejection Safety Lever – Safe (Up).
5	IFF MASTER knob – STBY.
6	LANDING/TAXI Light switch – As required.
7	MASTER ARM and LASER ARM switches – OFF.

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Engine Shutdown

1	C & I knob – BACKUP.
2	HUD SYM knob – Minimize.
3	SNSR PWR panel – Set.
4	AVIONICS POWER panel – Set.
5	Throttle – OFF. **NOTE:** Wait at least 10 seconds after INS knob has been moved to OFF before shutting down the engine.
6	JFS RUN light – Confirm off.
7	EPU GEN and EPU PMG – Confirm Off.
8	MAIN PWR switch – OFF. **NOTE:** Delay placing MAIN PWR switch to OFF until after engine rpm decreases through 20 percent.
9	OXYGEN SUPPLY lever – OFF.
10	OXYGEN Diluter lever – 100%.
11	Canopy – Open.

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Pre-Refueling Checklist

1	MASTER ARM switch – OFF.
2	LASER ARM switch – OFF.
3	CMDS MODE knob – STBY.
4	Emitters – Off or Standby. **NOTE:** Emitters should be disabled prior to reaching the Pre-contact position.
5	AIR REFUEL switch – OPEN. (3-5 minutes prior to refueling if equipped with external fuel tanks)
6	AR Status Light – Verify **RDY**.
7	HOT MIC/CIPHER switch – HOT MIC.
8	Exterior Lights – As required. For night refueling set: • POSITION WING/TAIL switch – DIM. • POSITION FLASH/STEADY switch – STEADY. • ANTI-COLL knob – OFF.

Post-Refueling Checklist

1	AIR REFUEL switch – CLOSE.
2	HOT MIC/CIPHER switch – OFF.
3	Fuel quantity – Check. Verify proper transfer and balance.
4	AR Status Lights – All off.
5	Exterior Lights – As required.
6	Emitters – As required.
7	MASTER ARM – As required.
8	LASER ARM – As required.
9	CMDS MODE knob – As required.

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Navigation

Abbreviated checklists for performing navigation, editing steerpoints and offset aimpoints within the navigation database, storing markpoints, tuning navigation aids (TACAN or ILS), performing in-flight INS alignments, and performing position fixes and altitude calibrations to maintain INS accuracy.

Selecting a Steerpoint

To select a steerpoint using the Upfront Controls, perform the following:

1	ICP **Increment/Decrement** Rocker – Select the steerpoint number. *or* ICP Keypad – Press **4/STPT** to display the STPT DED page.
2	ICP **Keypad** – Input the steerpoint number.
3	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

To select a steerpoint using the Hands-On Controls, perform the following:

1	DMS Left or DMS Right – Press as necessary to display the HSD format on either MFD.
2	DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HSD MFD format.
3	RDR CURSOR/ENABLE Switch – Slew the HSD cursor to the symbol of the steerpoint that is intended to be used for navigation.
4	TMS Up-Short – Press to select the steerpoint symbol.

Editing a Steerpoint

1	ICP **LIST** Button – Press.
2	ICP Keypad – Press **1/T-ILS** to display the DEST UTM DED page.
3	ICP DCS Switch – **SEQ** to cycle to the DEST DIR DED page (P2>).
4	ICP **Keypad** – Input the steerpoint number. *or* ICP **Increment/Decrement** Rocker – Select the steerpoint number.
5	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.
6	ICP DCS Switch – **Down** to move DED asterisks around LAT data field.
7	ICP Keypad – Input **2** for North or **8** for South.
8	ICP **Keypad** – Input latitude in DD°MM.MMM’ format, which is input as DDMMMMM in a continuous string of seven numbers.
9	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
10	ICP DCS Switch – **Down** to move DED asterisks around LON data field.
11	ICP Keypad – Input **6** for East or **4** for West.

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12	ICP **Keypad** – Input longitude in DDD°MM.MMM' format, which is input as DDDMMMMM in a continuous string of eight numbers, to include a leading zero if necessary.
13	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
14	ICP DCS Switch – **Down** to move DED asterisks around ELEV data field.
15	ICP **Keypad** – Input the elevation in feet.
16	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
17	**(Optional)** ICP DCS Switch – **Down** to move DED asterisks around TOS data field.
18	ICP **Keypad** – Input the desired time in a 24-hour HH:MM:SS format, which is input as HHMMSS in a continuous string of six numbers.
19	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

Modifying an Offset Aimpoint

1	ICP **LIST** Button – Press.
2	ICP Keypad – Press **1/T-ILS** to display the DEST UTM DED page.
3	ICP DCS Switch – **SEQ** to cycle to the DEST DIR DED page (P2>).
4	ICP **Keypad** – Input the steerpoint number. *or* ICP **Increment/Decrement** Rocker – Select the steerpoint number.
5	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.
6	ICP DCS Switch – **SEQ** to cycle to the DEST OA1 page (P3>) or the DEST OA2 page (P4>).
7	ICP DCS Switch – **Down** to move DED asterisks around RNG data field.
8	ICP **Keypad** – Input the offset aimpoint range from the steerpoint in feet.
9	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
10	ICP DCS Switch – **Down** to move DED asterisks around BRG data field.
11	ICP **Keypad** – Input the offset aimpoint true bearing from the steerpoint in DD.D° or DDD.D° format, which is input as either DDD or DDDD in a continuous string of numbers.
12	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
13	ICP DCS Switch – **Down** to move DED asterisks around ELEV data field.
14	ICP **Keypad** – Input the offset aimpoint elevation in feet.
15	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

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Converting MGRS to Latitude/Longitude (Steerpoints 21-25 only)

1	ICP **LIST** Button – Press.
2	ICP Keypad – Press **1/T-ILS** to display the DEST UTM DED page.
3	ICP **Keypad** – Input the steerpoint number. *or* ICP **Increment/Decrement** Rocker – Select the steerpoint number.
4	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.
5	ICP DCS Switch – **Down** to move DED asterisks around GRID data field.
6	ICP **Keypad** – Input the 2-digit grid zone.
7	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
8	ICP **Increment/Decrement** rocker – Select the letter of the grid zone designator.
9	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
10	ICP DCS Switch – **Down** to move DED asterisks around SQUARE data field.
11	ICP **Increment/Decrement** rocker – Select the first letter of the square as necessary.
12	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
13	ICP **Increment/Decrement** rocker – Select the second letter of the square as necessary.
14	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
15	ICP DCS Switch – **Down** to move DED asterisks around EAST/NORTH data field.
16	ICP **Keypad** – Input the 10-digit easting and northing as a continuous string.
17	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
18	ICP DCS Switch – **Down** to move DED asterisks around ELEV data field.
19	ICP **Keypad** – Input the elevation in feet.
20	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
21	ICP DCS Switch – **Down** to move DED asterisks around CNVRT data field.
22	ICP Keypad – Press **ENTR** to initiate the conversion to Latitude/Longitude format. When the conversion is complete, the DED asterisks will be placed around the steerpoint data field automatically.

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Storing a Markpoint using HUD

1	ICP Keypad – Press **7/MARK**.
2	ICP DCS Switch – **SEQ** to select HUD in the sensor option data field.
3	RDR CURSOR/ENABLE switch (Throttle) – Slew the Mark Cue to the desired location within the HUD.
4	TMS Forward-Short (Stick) – Press to ground stabilize the Mark Cue.
5	**(Optional)** RDR CURSOR/ENABLE switch (Throttle) – Adjust the Mark Cue, as necessary.
6	TMS Forward-Short (Stick) – Press to designate the location as a markpoint. *or* TMS Aft-Short (Stick) – Press to cage the Mark Cue to the HUD FPM without designating a markpoint.

Storing a Markpoint using HMCS

1	ICP Keypad – Press **7/MARK**.
2	ICP DCS Switch – **SEQ** to select HUD in the sensor option data field.
3	TMS Forward-Long (Stick) – Press to select the HMCS as SOI.
4	Place the HMCS Aiming Cross over the desired location by head movement.
5	TMS Forward-Short (Stick) – Press to ground stabilize the Mark Cue.
6	**(Optional)** RDR CURSOR/ENABLE switch (Throttle) – Adjust the Mark Cue, as necessary.
7	TMS Forward-Short (Stick) – Press to designate the location as a markpoint. *or* TMS Aft-Short (Stick) – Press to cage the Mark Cue to the HMCS Aiming Cross without designating a markpoint.

Storing a Markpoint using FCR

1	DMS Aft-Short – Press as necessary to select the FCR as SOI on the applicable MFD.
2	RDR CURSOR/ENABLE switch (Throttle) – Slew the FCR crosshairs to the desired location.
3	TMS Forward-Short (Stick) – Press to switch the FCR to Fixed Target Track (FTT).
4	ICP Keypad – Press **7/MARK**. **NOTE:** If the FCR is already in FTT when the MARK DED page is displayed, the sensor option is automatically set to "FCR" and step 5 is not required.
5	ICP DCS Switch – **SEQ** to select FCR in the sensor option data field, if necessary.
6	TMS Forward-Short (Stick) – Press to designate the FTT location as a markpoint. *or* TMS Aft-Short (Stick) – Press to reject Fixed Target Track (FTT) without designating the markpoint.

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Storing a Markpoint using TGP

1	DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.
2	RDR CURSOR/ENABLE switch (Throttle) – Slew the TGP line-of-sight crosshairs to the desired location.
3	TMS Forward-Short (Stick) – Press and release to switch the TGP to POINT track. *or* TMS Right-Short (Stick) – Press to switch the TGP to AREA track.
4	ICP Keypad – Press **7/MARK**. **NOTE:** If the TGP is already in POINT track when the MARK DED page is displayed, the sensor option is automatically set to "TGP" and step 5 is not required.
5	ICP DCS Switch – **SEQ** to select TGP in the sensor option data field, if necessary.
6	**(Optional)** LASER ARM Switch (MISC panel) – Set to **LASER ARM** position, if necessary.
7	**(Optional)** Trigger (Stick) – Pull and hold to gain accurate range data.
8	TMS Forward-Short (Stick) – Press to designate the TGP location as a markpoint.
9	Trigger (Stick) – Release.

Storing a Markpoint using OFLY

1	ICP Keypad – Press **7/MARK**.
2	ICP DCS Switch – **SEQ** to select OFLY in the sensor option data field.
3	Maneuver the aircraft as necessary to ensure the flight path will take it over the intended location.
4	TMS Forward-Short (Stick) – Press to designate the location as a markpoint as the aircraft passes overhead the intended location.

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Tuning a TACAN Station

1	ICP Keypad – Press **1/T-ILS**.
2	ICP DCS Switch – **SEQ** to select the desired TACAN mode of operation, as necessary.
3	ICP DCS Switch – **Down** to move DED asterisks around CHAN data field.
4	ICP **Keypad** – Input the TACAN channel (1-126), which is input with no leading zeros.
5	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
6	ICP Keypad – Press **0/M-SEL** as necessary to toggle the band between X and Y.
7	ICP Keypad – Press **ENTR** to accept the selected TACAN band or **RCL** to reject it. Verify the BCN data field displays the correct 3-character identifier for the TACAN station that is intended to be used for navigation.
8	**(A/A TR mode only)** ICP DCS Switch – **RTN** to display the CNI page as desired to view the distance measurement to the paired TACAN receiver.
9	**EHSI Instrument Mode** Selector Button – Press as necessary to select TCN mode.
10	EHSI Course Set/Brightness Knob – Rotate as necessary to set the desired course to/from the selected TACAN station.

Tuning an ILS Localizer

1	ILS Knob (AUDIO 2 control panel) – Rotate clockwise out of the OFF position as necessary.
2	ICP Keypad – Press **1/T-ILS**. Verify the ILS status data field displays ILS ON.
3	ICP DCS Switch – **Down** to move DED asterisks around FRQ data field.
4	ICP **Keypad** – Input the localizer frequency, which is input as a continuous string of five numbers with no leading zeros.
5	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
6	ICP DCS Switch – **Down** to move DED asterisks around CRS data field.
7	ICP **Keypad** – Input the approach course, which is input as degrees magnetic with no leading zeros.
8	ICP Keypad – Press **ENTR** to accept the selected TACAN band or **RCL** to reject it.
9	**EHSI Instrument Mode** Selector Button – Press as necessary to select NAV/PLS or TCN/PLS mode.
10	EHSI Course Set/Brightness Knob – Rotate as necessary to set the desired course to/from the selected TACAN station.

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Performing an In-flight INS Alignment (with GPS-aiding)

1	Establish level flight at a constant heading, altitude, and airspeed using backup instruments; or remain stationary on the ground.
2	INS Knob – **IN FLT ALIGN.**
3	**(Optional)** ICP DCS Switch – **SEQ** to display the INS page and monitor the alignment status.

When "ALIGN" is replaced by "NAV" in the HUD, the alignment is complete.

4	INS Knob – NAV.

Performing an In-flight INS Alignment (without GPS-aiding)

1	Establish level flight at a constant heading, altitude, and airspeed using backup instruments; or remain stationary on the ground.
2	INS Knob – **IN FLT ALIGN.**
3	ICP **Keypad** – Input the current magnetic heading of the aircraft, without leading zeros.
4	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it and input different data.
5	ICP DCS Switch – **SEQ** to display the INS page and monitor the alignment status.
6	ICP DCS Switch – **RTN** when the alignment state reaches 75.
7	ICP Keypad – Press **8/FIX**. Perform a position fix using the FCR or TGP to attain position/velocity data.

When "MAN" is replaced by "NAV" in the HUD, the alignment is complete.

8	INS Knob – NAV.

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Performing a Position Fix using HUD

1	ICP Keypad – Press **8/FIX**.
2	ICP DCS Switch – **SEQ** to select HUD in the sensor option data field.
3	DMS Forward-Short – Press to select the HUD as SOI.
4	RDR CURSOR/ENABLE switch (Throttle) – Slew the Diamond symbol to the correct location.
5	ICP Keypad – **ENTR** to accept the position delta and update the INS position.

Performing a Position Fix using FCR

1	ICP Keypad – Press **8/FIX**.
2	ICP DCS Switch – **SEQ** to select FCR in the sensor option data field.
3	DMS Aft-Short – Press as necessary to select the FCR as SOI on the applicable MFD.
4	RDR CURSOR/ENABLE switch (Throttle) – Slew the FCR crosshairs to the correct location.
5	TMS Forward-Short (Stick) – Press to switch the FCR to Fixed Target Track (FTT).
6	ICP Keypad – **ENTR** to accept the position delta and update the INS position.

Performing a Position Fix using TGP

1	ICP Keypad – Press **8/FIX**.
2	ICP DCS Switch – **SEQ** to select TGP in the sensor option data field.
3	DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.
4	RDR CURSOR/ENABLE switch (Throttle) – Slew the TGP line-of-sight crosshairs to the correct location.
5	TMS Right-Short (Stick) – Press to switch the TGP to AREA track.
6	**(Optional)** LASER ARM Switch (MISC panel) – Set to **LASER ARM** position, if necessary.
7	**(Optional)** Trigger (Stick) – Pull and hold to gain accurate range data.
8	ICP Keypad – **ENTR** to accept the position delta and update the INS position.
9	Trigger (Stick) – Release.

Performing a Position Fix using OFLY

1	ICP Keypad – Press **8/FIX**.
2	ICP DCS Switch – **SEQ** to select OFLY in the sensor option data field.
3	Maneuver the aircraft as necessary to ensure the flight path will take it over steerpoint location.
4	TMS Forward-Short (Stick) – Press to freeze the position delta when overhead the steerpoint location.
5	**(Optional)** TMS Aft-Short (Stick) – Press to reject the frozen position delta, if necessary.
6	ICP Keypad – **ENTR** to accept the position delta and update the INS position.

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Performing an Altitude Calibration using RALT

1	ICP Keypad – Press **9/A-CAL**.
2	ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.
3	ICP DCS Switch – **SEQ** to select the type of update to be performed (ALT, BOTH, or POS).
4	ICP Keypad – Press any button **1-9** to select RALT in the sensor option data field.
5	Maneuver the aircraft as necessary to ensure the flight path will take it over the steerpoint location.
6	TMS Forward-Short (Stick) – Press to freeze the altitude/position delta(s) when overhead the location.
7	**(Optional)** TMS Aft-Short (Stick) – Press to reject the frozen altitude/position delta(s), return to step 5, and attempt another overflight if necessary.
8	ICP Keypad – **ENTR** to accept the altitude/position delta(s) and update the INS-only altitude/position.

Performing an Altitude Calibration using FCR

1	ICP Keypad – Press **9/A-CAL**.
2	ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.
3	ICP DCS Switch – **SEQ** to select the type of update to be performed (ALT, BOTH, or POS).
4	ICP Keypad – Press any button **1-9** to select FCR in the sensor option data field.
5	DMS Aft-Short – Press as necessary to select the FCR as SOI on the applicable MFD.
6	RDR CURSOR/ENABLE switch (Throttle) – Slew the FCR crosshairs to the correct location (10 NM limit).
7	TMS Forward-Short (Stick) – Press to switch the FCR to Fixed Target Track (FTT).
8	**(Optional)** TMS Aft-Short (Stick) – Press to reject Fixed Target Track, return to step 6, and adjust the FCR crosshairs if necessary.
9	ICP Keypad – **ENTR** to accept the altitude/position delta(s) and update the INS-only altitude/position.

Performing an Altitude Calibration using HUD

1	ICP Keypad – Press **9/A-CAL**.
2	ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.
3	ICP DCS Switch – **SEQ** to select the type of update to be performed (ALT, BOTH, or POS).
4	ICP Keypad – Press any button **1-9** to select HUD in the sensor option data field.
5	DMS Forward-Short – Press to select the HUD as SOI.
6	RDR CURSOR/ENABLE switch (Throttle) – Slew the Diamond symbol to the correct location.
7	TMS Forward-Short (Stick) – Press to freeze the altitude/position delta(s).
8	**(Optional)** TMS Aft-Short (Stick) – Press to reject the frozen altitude/position delta(s), return to step 6, and adjust the Diamond symbol if necessary.
9	ICP Keypad – **ENTR** to accept the altitude/position delta(s) and update the INS-only altitude/position.

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Performing an Altitude Calibration using TGP

1	ICP Keypad – Press **9/A-CAL**.
2	ICP DCS Switch – **SEQ** to switch the ACAL DED page to MAN sub-mode, if necessary.
3	ICP DCS Switch – **SEQ** to select the type of update to be performed (ALT, BOTH, or POS).
4	ICP Keypad – Press any button **1-9** to select TGP in the sensor option data field.
5	DMS Aft-Short – Press as necessary to select the TGP as SOI on the applicable MFD.
6	RDR CURSOR/ENABLE switch (Throttle) – Slew the TGP line-of-sight crosshairs to the correct location.
7	TMS Right-Short (Stick) – Press to switch the TGP to AREA track.
8	**(Optional)** LASER ARM Switch (MISC panel) – Set to **LASER ARM** position, if necessary.
9	**(Optional)** Trigger (Stick) – Pull and hold to gain accurate range data.
10	TMS Forward-Short (Stick) – Press to freeze the altitude/position delta(s).
11	Trigger (Stick) – Release.
12	**(Optional)** TMS Aft-Short (Stick) – Press to reject AREA track, return to step 6, and adjust the TGP line-of-sight crosshairs if necessary.
13	ICP Keypad – **ENTR** to accept the altitude/position delta(s) and update the INS-only altitude/position.

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Radio Communications

Abbreviated checklists for tuning the radios to preset or manual frequencies via the UFC or backup control panel.

Tuning a Preset Frequency (Upfront Controls)

1	ICP **COM 1** Button – Press to access the UHF DED page. *or* ICP **COM 2** Button – Press to access the VHF DED page.
2	ICP **Keypad** - Input the 1- or 2-digit preset channel number (1-20).
3	ICP Keypad – Press **ENTR** to accept the channel number or **RCL** to reject it.

If the applicable radio is already tuned to a preset channel, the radio may be cycled incrementally through the 20 preset channels on the CNI DED page.

1	ICP DCS Switch – **Up/Down** to move the Increment/Decrement symbol adjacent to the UHF or VHF data field, as necessary.
2	ICP **Increment/Decrement** Rocker – Press as necessary to select the desired preset channel.

Editing a Preset Frequency (Upfront Controls)

1	ICP **COM 1** Button – Press to access the UHF DED page. *or* ICP **COM 2** Button – Press to access the VHF DED page.
2	ICP **Increment/Decrement** Rocker – Select the preset channel to be edited. (Skip to step 5) *or* ICP DCS Switch – **Up/Down** to move the DED Asterisks around the Preset Channel Number data field.
3	ICP **Keypad** - Input the 1- or 2-digit preset channel number (1-20) to be edited.
4	ICP Keypad – Press **ENTR** to accept the channel number or **RCL** to reject it.
5	ICP DCS Switch – **Up/Down** to move the DED Asterisks around the Preset Channel Frequency data field.
6	ICP **Keypad** - Input the 4- or 5-digit frequency in a continuous string without leading zeros.
7	ICP Keypad – Press **ENTR** to accept the frequency or **RCL** to reject it.

Tuning a Manual Frequency (Upfront Controls)

1	ICP **COM 1** Button – Press to access the UHF DED page. *or* ICP **COM 2** Button – Press to access the VHF DED page.
2	ICP **Keypad** - Input the 4- or 5-digit frequency in a continuous string without leading zeros.
3	ICP Keypad – Press **ENTR** to accept the frequency or **RCL** to reject it.

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Tuning a Preset frequency (UHF Backup control panel)

1	Function Knob – Set to **MAIN** or **BOTH**.
2	Mode Knob – Set to **PRESET**.
3	**CHAN** Knob – Rotate until the desired preset channel is displayed in the CHAN Display indicator.
4	**(Optional)** STATUS Button – Press to verify the frequency assigned to the selected preset channel within the FREQUENCY STATUS/DISPLAY indicator.

Tuning a Manual Frequency (UHF Backup control panel)

1	Function Knob – Set to **MAIN** or **BOTH**.
2	Mode Knob – Set to **MNL**.
3	**A-3-2** Knob – Rotate until the first digit of the desired frequency is displayed in the FREQUENCY STATUS/DISPLAY indicator.
4	**Manual Frequency** Knobs – Rotate until the remaining four digits of the desired frequency are displayed in the FREQUENCY STATUS/DISPLAY indicator.

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Datalink Communications

Abbreviated checklists for configuring datalink settings and transmitting/receiving Markpoints or SEAD targets.

Manually Synchronizing with TNDL Network

1	**(Recommended)** ICP Keypad – Press any button **1-9** to set GPS TIME to ON if intending to use GPS as the ownship's timing signal. Proceed to step 5. *or* **(Optional)** ICP Keypad – Press any button **1-9** to set GPS TIME to OFF if intending to use a manual time entry for network synchronization.
2	ICP DCS Switch – **Down** to move DED asterisks around TIME data field to input a manual time.
3	ICP **Keypad** – Input the desired manual time in HHMMSS format.
4	ICP Keypad – Press **ENTR** to accept the manual time or **RCL** to reject it. **NOTE:** The MIDS LVT chronometer will be manually updated to the manual time value when the ENTR button is pressed on the ICP to accept the TIME data field. When manually synchronizing to another TNDL participant that is transmitting the network time reference, the ENTR button must be pressed at the moment *their* onboard system time corresponds with the manual time on *your* DED. Repeat steps 3 and 4 if the MIDS LVT is unable to manually synchronize with the TNDL network.
5	ICP DCS Switch – **Down** to move DED asterisks around NTR data field.
6	**(Recommended)** ICP Keypad – Press any button **1-9** to set NTR to OFF, if necessary. *or* **(Optional)** ICP Keypad – Press any button **1-9** to set NTR to ON if intending to provide the network timing reference for the TNDL network. **NOTE:** Coordination must be performed with all other TNDL participants if your aircraft is intended to be the network timing reference.

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Editing Ownship Datalink Settings

1	ICP DCS Switch – **SEQ** to cycle to the TNDL DED page (P2>).
2	ICP DCS Switch – **Down** to move DED asterisks around first Voice Callsign data field.
3	ICP **Keypad** – Input the 2-digit Voice Callsign number for the ownship within the flight.
4	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
5	ICP **Increment/Decrement** rocker – Select the first letter of the Voice Callsign as necessary.
6	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
7	ICP **Increment/Decrement** rocker – Select the second letter of the Voice Callsign as necessary.
8	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
9	ICP DCS Switch – **Down** to move DED asterisks around the FL data field, if necessary.
10	ICP Keypad – Press any button **1-9** as necessary to set FL to YES if the ownship is the Flight Lead, or NO if the ownship is not the Flight Lead.
11	ICP DCS Switch – **Down** to move DED asterisks around the XMT data field.
12	ICP Keypad – Press any button **1-9** as necessary to cycle XMT to HI, MED, LO, or NONE.

Editing Flight/Team STN Network

1	ICP DCS Switch – **SEQ** to cycle to the TNDL STN DED page (P3>).
2	ICP DCS Switch – **Down** to move DED asterisks around the STN data field of Flight member 1.
3	ICP **Keypad** – Input the 5-digit STN of Flight member 1, or enter 00000 to zeroize the STN.
4	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
5	ICP DCS Switch – **Down** to move DED asterisks around the STN data field of the next Flight member and repeat steps 3 and 4.
6	ICP DCS Switch – **Down** to move DED asterisks around the STN data field of Team member 5.
7	ICP **Keypad** – Input the 5-digit STN of Team member 5, or enter 00000 to zeroize the STN.
8	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.
9	ICP DCS Switch – **Down** to move DED asterisks around the STN data field of the next Team member and repeat steps 7 and 8.
10	ICP DCS Switch – **Down** to move DED asterisks around the OWN # data field.
11	ICP **Keypad** – Input the number corresponding with the ownship position within the flight (1-8).
12	ICP Keypad – Press **ENTR** to accept the data or **RCL** to reject it.

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Transmitting Selected Steerpoint as a Markpoint

1	MFD format – Select **HSD**.
2	XMT (OSB 6) – Select **TNDL**, if SMDL is displayed.
3	Select the steerpoint intended for transmission as a markpoint.
4	**(If a radar is designated on HAD)** DMS Forward/Aft – Press as necessary to ensure HAD is not the Sensor-Of-Interest (SOI).
5	Verify FCR and TGP are not in an air-to-ground track mode.
6	IFF IN-Long – Press.

Transmitting FCR or TGP SPI as a Markpoint

1	MFD format – Select **HSD**.
2	XMT (OSB 6) – Select **TNDL**, if SMDL is displayed.
3	Enter FCR Fixed Target Track or Ground Moving Target Track mode. *or* Enter TGP Point Track or Area Track mode.
4	IFF IN-Long – Press.

Receiving a Markpoint

To set the markpoint as your selected steerpoint using the Upfront Controls, perform the following:

1	ICP **Increment/Decrement** Rocker – Select the steerpoint number corresponding with the received markpoint. *or* ICP Keypad – Press **4/STPT** to display the STPT DED page.
2	ICP **Keypad** – Input the steerpoint number corresponding with the received markpoint.
3	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

To set the markpoint as your selected steerpoint using the Hands-On Controls, perform the following:

1	MFD format – Select **HSD**.
2	DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HSD MFD format.
3	RDR CURSOR/ENABLE Switch – Slew the HSD cursor to the symbol of the received markpoint.
4	TMS Up-Short – Press to select the markpoint symbol.

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Transmitting a SEAD Target

1	MFD format – Select **HSD**.
2	XMT (OSB 6) – Select **TNDL**.
3	MFD format – Select **HAD**.
4	DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HAD MFD format.
5	RDR CURSOR/ENABLE Switch – Slew the HAD cursor to the symbol of the HTS-detected radar intended for transmission as a SEAD target.
6	TMS Up-Short – Press to designate the radar symbol.
7	IFF IN-Long – Press. (Throttle)

Receiving a SEAD Target

To set the SEAD target as your selected steerpoint using the Upfront Controls, perform the following:

1	ICP **Increment/Decrement** Rocker – Select the steerpoint number corresponding with the received SEAD target. *or* ICP Keypad – Press **4/STPT** to display the STPT DED page.
2	ICP **Keypad** – Input the steerpoint number corresponding with the received SEAD target.
3	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.

To set the SEAD target as your selected steerpoint using the Hands-On Controls, perform the following:

1	MFD format – Select **HSD**.
2	DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HSD MFD format.
3	RDR CURSOR/ENABLE Switch – Slew the HSD cursor to the symbol of the received SEAD target.
4	TMS Up-Short – Press to select the SEAD target symbol.

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Configuring a TDOA Sub-team

1	ICP DCS Switch – **SEQ** to cycle to the TNDL STN DED page (P3>).
2	ICP DCS Switch – **Up/Down** as necessary to place the DED asterisks adjacent to the STN of the corresponding Flight/Team member.
3	ICP Keypad – Press any button **1-9** to add or remove the Flight/Team member from the TDOA sub-team. (i.e., "T" indicates TDOA sub-team.)
4	Repeat steps 2 and 3 as necessary.

TDOA Ranging a SEAD Target (Master)

1	MFD format – Select **HAD**.
2	DMS Aft-Short – Press as necessary to assign the Sensor-Of-Interest (SOI) to the HAD MFD format.
3	RDR CURSOR/ENABLE Switch – Slew the HAD cursor to the symbol of the HTS-detected radar intended for TDOA ranging.
4	TMS Up-Short – Press to designate the radar symbol as the SEAD target.
5	TMS Left-Long – Press to initiate TDOA ranging of the designated SEAD target.
6	**(Optional)** TMS Aft-Short – Press to terminate TDOA ranging and drop target designation. *or* **(Optional)** TMS Aft-Long – Press to terminate TDOA ranging without dropping target designation.

TDOA Ranging a SEAD Target (Slave)

To support TDOA ranging of an HTS-detected radar designated by another Flight/Team member, perform the following:

1	MFD format – Select **HAD**.
2	TDOA Availability (OSB 18) – Select **TM** to accept TDOA messages from TDOA sub-team only. *or* TDOA Availability (OSB 18) – Select **AL** to accept TDOA messages from any Flight/Team members.
3	If necessary, maneuver the aircraft in the direction of the TDOA steering displayed in the center of the HUD until the designated TDOA target is within the field-of-regard of the HTS pod.
4	TMS **(Optional)** Maneuver the aircraft to gain separation from other Flight/Team members that are supporting TDOA ranging. This will increase the measured time-difference-of-arrival between the other Flight/Team members and accelerate the TDOA ranging process.

To terminate support of TDOA ranging, perform the following:

1	TDOA Availability (OSB 18) – Select **NO** to reject TDOA messages from all Flight/Team members.

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Combat Employment

Abbreviated checklist for performing pre-combat checks.

Performing Pre-Combat Checks

Fuel	**1.**	Total fuel quantity – Check.
	2.	FUEL QTY SEL knob – Check balance between tanks.
	3.	ENGINE FEED knob – Set to NORM.
	4.	TANK INERTING switch – Set to TANK INERTING.
Emitters	**5.**	TACAN – Set A/A T/R settings or configure as necessary.
	6.	FCR – Set mode and scan volume.
	7.	RF switch – Set as required.
	8.	RWR – Configure as necessary.
	9.	ECM control panel – Configure as necessary.
	10.	IFF – Set modes & codes; configure as necessary. (N/I)
	11.	EXT LIGHTING control panel – Set MASTER knob to OFF (or as appropriate).
Navigation	**12.**	ICP STPT/DEST pages – Verify steerpoint data.
	13.	NAV page – Verify SYS ACCUR and GPS ACCUR are HIGH.
	14.	FIX/A-CAL pages – Perform updates as necessary.
Chaff/Flares	**15.**	CMDS settings – Configure as necessary on CMDS control panel and CMDS DED page.
	16.	CMDS MODE knob – Set to MAN, SEMI, or AUTO as required.
	17.	CMS switch – Press to Aft position to confirm consent in SEMI/AUTO modes; or press to Right position to revoke consent in SEMI/AUTO modes.
Employment	**18.**	SMS – Check weapon profiles and settings in each master mode (A-A, A-G, MSL, DGFT)
	19.	MASTER ARM switch – Set as required.
	20.	LASER ARM switch – Set as required.
	21.	HUD control panel – Configure as desired; confirm correct symbology and indications are displayed.
	22.	AUDIO 1 & AUDIO 2 control panels - Set volume levels as desired.
	23.	SOI – Confirm or set as desired.

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Designating the IP using Direct Overflight

1	ICP **Increment/Decrement** Rocker – Select the VIP steerpoint number. *or* ICP Keypad – Press **4/STPT** to display the STPT DED page.
2	ICP **Keypad** – Input the VIP steerpoint number.
3	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.
4	ICP **A-G** Button – Press to enter A-G master mode.
5	MFD format – Select **SMS**.
6	SMS OSB 6 – Select **weapon**, as desired.
7	SMS OSB 2 – Select pre-planned weapon delivery sub-mode, as desired.
8	DMS Forward – Press to set SOI to HUD, if necessary.
9	Visually acquire the physical landmark that corresponds with the Initial Point (IP) location.
10	Maneuver the aircraft as necessary for a direct overflight of the IP location.
11	TMS Forward-Short – Press when directly over the landmark at the IP location.

Designating the RP using Direct Overflight

1	ICP **Increment/Decrement** Rocker – Select the VRP steerpoint number. *or* ICP Keypad – Press **4/STPT** to display the STPT DED page.
2	ICP **Keypad** – Input the VRP steerpoint number.
3	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.
4	ICP **A-G** Button – Press to enter A-G master mode.
5	MFD format – Select **SMS**.
6	SMS OSB 6 – Select **weapon**, as desired.
7	SMS OSB 2 – Select pre-planned weapon delivery sub-mode, as desired.
8	DMS Forward – Press to set SOI to HUD, if necessary.
9	Visually acquire the physical landmark that corresponds with the Reference Point (RP) location.
10	Maneuver the aircraft as necessary for a direct overflight of the RP location.
11	TMS Forward-Short – Press when directly over the landmark at the RP location

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Aligning the RP using VRP Cursor Slew

1	ICP **Increment/Decrement** Rocker – Select the VRP steerpoint number. *or* ICP Keypad – Press **4/STPT** to display the STPT DED page.
2	ICP **Keypad** – Input the VRP steerpoint number.
3	ICP Keypad – Press **ENTR** to accept the steerpoint number or **RCL** to reject it.
4	ICP **A-G** Button – Press to enter A-G master mode.
5	MFD format – Select **SMS**.
6	SMS OSB 6 – Select **weapon**, as desired.
7	SMS OSB 2 – Select pre-planned weapon delivery sub-mode, as desired.
8	DMS Forward – Press to set SOI to HUD, if necessary.
9	**(Optional)** TMS Right – Press as necessary to sequence the sighting point rotary to Reference Point (RP).
10	Visually acquire the physical landmark that corresponds with the RP location.
11	RDR CURSOR/ENABLE Switch – Slew the VRP cursor as necessary to align the Diamond symbol over the RP location.
12	TMS Right – Press to sequence the sighting point rotary to TGT, if necessary.

APPENDIX B – ALIC CODES & RWR SYMBOLS

The Aircraft Launcher Interface Computer (ALIC) codes listed under the "ID" column in the Air Defense and Naval Radar Systems tables can be used on the HARM DED page or HTS DED page to program custom threat tables for the AGM-88 HARM or HARM Targeting System radar signal scans.

The threat radar codes under the "RWR" column correspond with how the threat radar will appear on the ALR-56M Threat Warning Azimuth Indicator, the MFD HARM Attack Display (HAD) format, or the MFD Weapon (WPN) format when the AGM-88 weapon profile is selected.

Air defense radar systems are further identified by their type. The table below lists the definition of each "Type" abbreviation to identify the radar's function within their respective air defense units.

TYPE	DESCRIPTION	TYPE	DESCRIPTION
CWAR	Continuous-Wave Acquisition Radar	**STR**	Search and Tracking Radar
EWR	Early Warning Radar	**TAR**	Target Acquisition Radar
FCR	Fire Control Radar	**TI**	Target Illumination
RR	Ranging Radar	**TTR**	Target Tracking Radar
SR	Surveillance Radar		

Air Defense Radar Systems

ID	RWR	NATO SYSTEM	SYSTEM	RADAR DESIGNATION	TYPE
-				1L13 "BOX SPRING"	SR / EWR
-				5G66 "TALL RACK"	SR / EWR
122	S	SA-2 / SA-3 / SA-5	S-75 / S-125 / S-200	P-19 "FLAT FACE B"	SR / TAR
126	2	SA-2 "GUIDLELINE"	S-75	SNR-75 "FAN SONG"	TTR
	2	SA-2 "GUIDLELINE"	S-75	RD-75 Amazonka	RR
123	3	SA-3 "GOA"	S-125	SNR-125 "LOW BLOW"	TTR
129	5	SA-5 "GAMMON"	S-200	5N62 "SQUARE PAIR"	TTR / TI
108	6	SA-6 "GAINFUL"	2K12 Kub	1S91 "STRAIGHT FLUSH"	TAR / TI
117	8	SA-8 "GECKO"	9K33 Osa	"LAND ROLL"	TAR / TTR
130	TS	SA-5 / SA-10	S-200 / S-300	ST-68U "TIN SHIELD"	TAR
104	BB	SA-10 "GRUMBLE"	S-300PS	64N6E "BIG BIRD"	TAR
103	CS	SA-10 "GRUMBLE"	S-300PS	5N66M "CLAM SHELL"	TAR
110	10	SA-10 "GRUMBLE"	S-300PS	30N6E "FLAP LID"	TTR
107	SD	SA-11 "GADFLY"	9K37M Buk-M1	9S18M1 "SNOW DRIFT"	TAR
115	11	SA-11 "GADFLY"	9K37M Buk-M1	9S35 "FIRE DOME"	TTR
109	DE		PPRU-M1	9S80M1 "DOG EAR"	TAR
118	13	SA-13 "GOPHER"	9K35 Strela-10M3	9S86 "SNAP SHOT"	RR
119	15	SA-15 "GAUNTLET"	9K331 Tor-M1	"SCRUM HALF"	TAR / TTR

132	15	SA-15 "GAUNTLET"	9K332 Tor-M2	"SCRUM HALF"	TAR / TTR
120	19	SA-19 "GRISON"	2S6M Tunguska	1RL144 "HOT SHOT"	TAR / TTR
134	22	SA-22 "GREYHOUND"	96K6 Pantsir-S1	2RL80 / 1RS2-1 "TRICK SHOT"	TAR / TTR
131	FC		S-60 / KS-19	SON-9 "FIRE CAN"	FCR
121	A		ZSU-23-4 Shilka	RPK-2 "GUN DISH"	FCR
128	HQ	CSA-7 / HQ-7B	Hóng Qí-7	HQ-7 ACU	TAR
127	7	CSA-7 / HQ-7B	Hóng Qí-7	Type 345	TTR
-				AN/FPS-117 "SEEK IGLOO"	SR / EWR
203	HK	MIM-23B I-Hawk		AN/MPQ-50	TAR
204	HK	MIM-23B I-Hawk		AN/MPQ-46	TTR
206	HK	MIM-23B I-Hawk		AN/MPQ-55	CWAR
202	P	MIM-104C Patriot PAC-2		AN/MPQ-53	STR
209	NS	NASAMS 2		AN/MPQ-64F1 Sentinel	STR
135	IT	IRIS-T SLM		TRML-4D	STR
208	A	M163 Vulcan ADS		AN/VPS-2	RR
	CR	LPWS C-RAM		AN/TPQ-36	FCR
124	RP	Rapier FSA		DN 181 Blindfire	TTR
125	RT	Rapier FSA		Rapier PU	SR
205	RO	Roland TÜR		MPDR-3002S	SR
201	RO	Marder Roland		MPDR-16 / DOMINO-30	TAR / TTR
207	A	Flakpanzer Gepard		MPDR-12 / Albis	TAR / FCR

Naval Radar Systems

ID	RWR	SHIP CLASS	TYPE	DESIGNATION
301	SW	Kuznetsov class	Heavy Aircraft Cruiser	Project 1143.5 (Admiral Kuznetsov)
320	SW	Kuznetsov class	Heavy Aircraft Cruiser	Project 1143.5 [2017 SC revision]
313	HN	Kirov class	Guided Missile Cruiser	Project 1144.2 (Piotr Velikiy)
303	T2	Slava class	Guided Missile Cruiser	Project 1164 (Moskva)
319	TP	Neutrashimy class	Guided Missile Frigate	Project 11540 (Neutrashimy)
309	TP	Krivak II class	Frigate / Guard Ship	Project 1135M (Rezky)
306	HP	Grisha class	Anti-Submarine Corvette	Project 1124.4 (Grisha)
312	PS	Tarantul III class	Missile Corvette	Project 1241.1 (Molniya)
414	T2	Vasiliy Bykov class	Patrol Ship	Project 22160
415	15	Vasiliy Bykov class	Patrol Ship	Project 22160 with Tor M2KM
321	SC	Ropucha I class	Large Landing Ship	Project 775
410	HN	Luyang II class	Guided Missile Destroyer	Type 052C (PLAN)

409	MR	Luyang I class	Guided Missile Destroyer	Type 052B (PLAN)
411	MR	Jiangkai II class	Guided Missile Frigate	Type 054A (PLAN)
408	PS	Yuzhao class	Amphibious Transport Dock	Type 071 (PLAN)
403	SS	Nimitz class	Aircraft Carrier	CVN-71 (USS Theodore Roosevelt)
404	SS	Nimitz class	Aircraft Carrier	CVN-72 (USS Abraham Lincoln)
405	SS	Nimitz class	Aircraft Carrier	CVN-73 (USS George Washington)
406	SS	Nimitz class	Aircraft Carrier	CVN-74 (USS John C. Stennis)
413	SS	Nimitz class	Aircraft Carrier	CVN-75 (USS Harry S. Truman)
	FR	Forrestal class	Aircraft Carrier	CV-59 (USS Forrestal)
407	40	Tarawa class	Amphibious Assault Ship	LHA-1 (USS Tarawa)
315	AE	Ticonderoga class	Guided Missile Cruiser	CG (USS)
412	AE	Arleigh Burke class	Guided Missile Destroyer	DDG (USS)
401	49	Oliver Hazard Perry class	Guided Missile Frigate	FFG (USS)
	IV	Invincible class	Light Aircraft Carrier	R05 (HMS)
	TP	Leander class	Frigate	F12, F57, F72 (HMS)
	TP	Condell class	Frigate	PFG-06, PFG-07 (CNS)
416	LC	La Combattante IIa class	Fast Attack Craft	FAC La Combattante IIa

Airborne Radar Systems

RWR	AIRCRAFT	RWR	AIRCRAFT	RWR	AIRCRAFT
19	MiG-19	JF	JF-17	F4	F-4
21	MiG-21	29	J-11	F5	F-5
23	MiG-23	50	KJ-2000	14	F-14
24	Su-24			15	F-15
25	MiG-25	F1	Mirage F1	16	F-16
29	MiG-29	M2	Mirage 2000	18	F/A-18
29	Su-27	F2	Tornado GR4	E2	E-2
29	Su-33	U	Tornado IDS	E3	E-3
30	Su-30	37	AJS37		
31	MiG-31				
34	Su-34				
50	A-50				

Other Threat Symbols

RWR	TYPE	THREATS
	Missile radar seeker detected	Active radar-homing missiles (ARH)

APPENDIX C – HAD / WPN THREAT TABLES

The threat radar codes under the "HAD" column correspond with how the threat radar will appear on the MFD HARM Attack Display (HAD) format if the corresponding threat class is enabled within the HTS scan cycles.

The HAD Manual threat Class is programmable via the HTS DED page and can include up to eight threat radar types. This can be used to better tailor the HTS scan cycles to the radar signals that are anticipated to be encountered during the mission.

HARM Attack Display (HAD) Threat Classes

HAD	THRT CLASS 1	HAD	THRT CLASS 2	HAD	THRT CLASS 3
TS	SA-5 "TIN SHIELD"	S	P-19 "FLAT FACE B"	DE	PPRU-M1 "DOG EAR"
BB	SA-10 "BIG BIRD"	2	SA-2 "FAN SONG"	19	SA-19 "HOT SHOT"
CS	SA-10 "CLAM SHELL"	3	SA-3 "LOW BLOW"	FC	SON-9 "FIRE CAN"
10	SA-10 "FLAP LID"	5	SA-5 "SQUARE PAIR"	A	ZSU-23-4 "GUN DISH"
SD	SA-11 "SNOW DRIFT"	6	SA-6 "STRAIGHT FLUSH"		
11	SA-11 "FIRE DOME"	8	SA-8 "LAND ROLL"		
15	SA-15 "SCRUM HALF"	13	SA-13 "SNAP SHOT"		
HQ	HQ-7 ACU				
7	HQ-7 Type 345				

HAD	THRT CLASS 4	HAD	THRT CLASS 5	HAD	THRT CLASS 6
		SW	Kuznetsov-class	P	MIM-104C Patriot PAC-2
		HN	Kirov/Luyang II-class	NS	NASAMS 2 "Sentinel"
		T2	Slava-class	IT	IRIS-T TRML-4D
		HP	Neutrashimy/Grisha-class		
		TP	Krivak II-class		
		MR	Luyang I/Jiangkai-class		
		PS	Tarantul III/Yuzhao-class		
		SC	Ropucha I-class		
		T2	Vasily Bykov-class		
		15	Vasily Bykov-class		

HAD	THRT CLASS 7	HAD	THRT CLASS 8	HAD	THRT CLASS 9
HK	MIM-23B I-Hawk	A	M163 Vulcan ADS		
RO	Roland TÜR	A	Flakpanzer Gepard		
RO	Marder Roland				
RP	Rapier FSA "Blindfire"				
RT	Rapier FSA				

HAD	THRT CLASS 10	HAD	THRT CLASS 11	HAD	THRT MANUAL CLASS
SS	Nimitz-class				
AE	AN/SPY-1 "Aegis"				
49	Oliver Hazard Perry-class				
40	Tarawa-class				

The emitter codes under the "WPN" column correspond with how the threat radar will appear on the MFD Weapon (WPN) format when the corresponding threat table is selected.

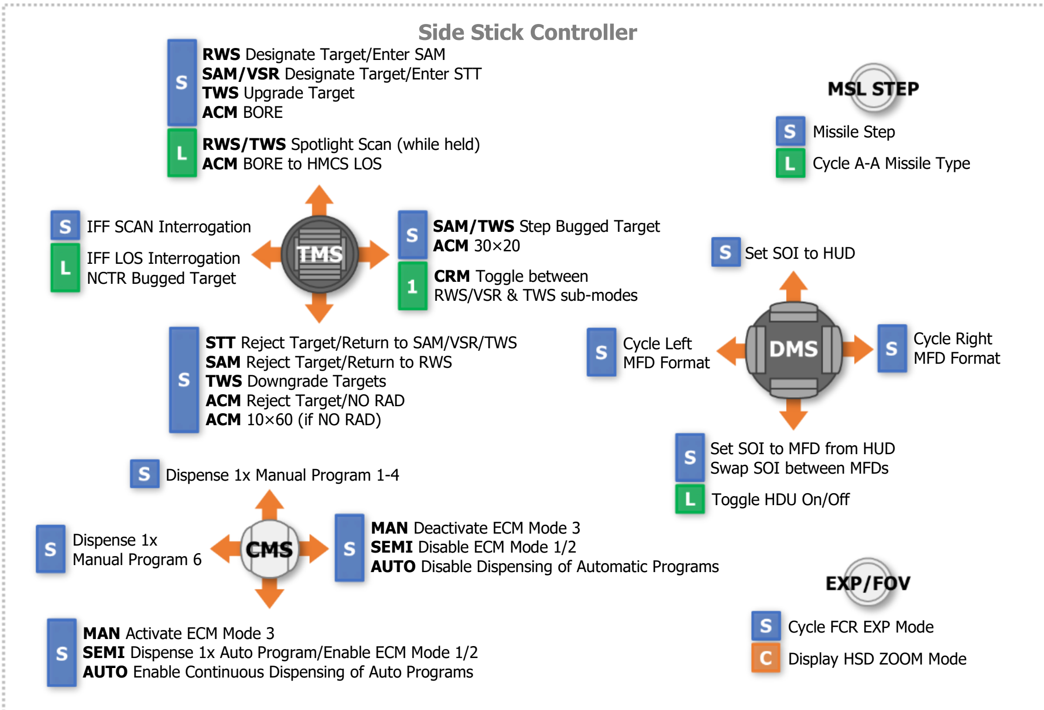
Each HARM threat table can be modified using the HARM DED page. This can be used to better tailor the AGM-88 scans to the radar signals that are anticipated to be encountered during the mission.

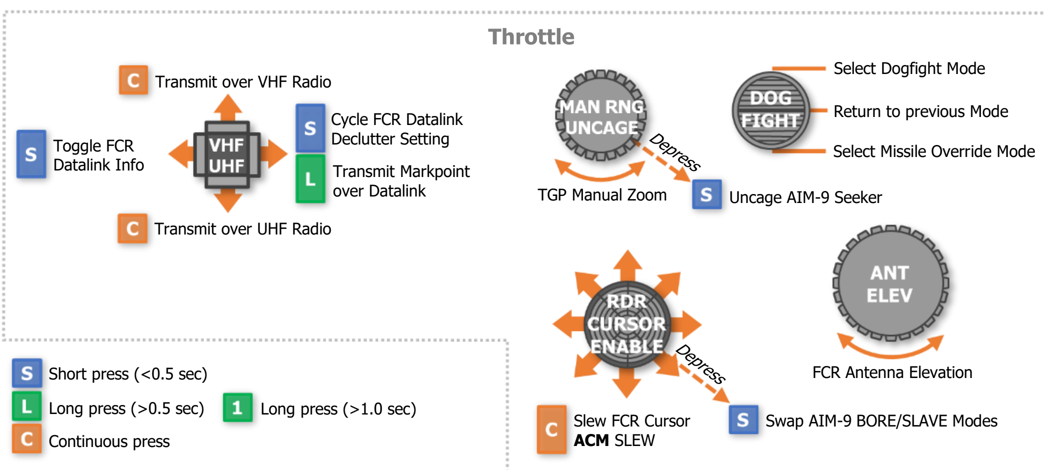
AGM-88 Weapon (WPN) Threat Tables

WPN	TBL1 (*MODERN SAM SYSTEMS*)	WPN	TBL2 (*AAA & SHORAD*)	WPN	TBL3 (*OLDER SAM SYSTEMS*)
10	SA-10 "FLAP LID"	19	SA-19 "HOT SHOT"	3	SA-3 "LOW BLOW"
BB	SA-10 "BIG BIRD"	15	SA-15 "SCRUM HALF"	S	P-19 "FLAT FACE"
CS	SA-10 "CLAM SHELL"	8	SA-8 "LAND ROLL"	6	SA-6 "STRAIGHT FLUSH"
11	SA-11 "FIRE DOME"	A	ZSU-23-4 "GUN DISH"	2	SA-2 "FAN SONG"
SD	SA-11 "SNOW DRIFT"	DE	PPRU-M1 "DOG EAR"	13	SA-13 "SNAP SHOT"

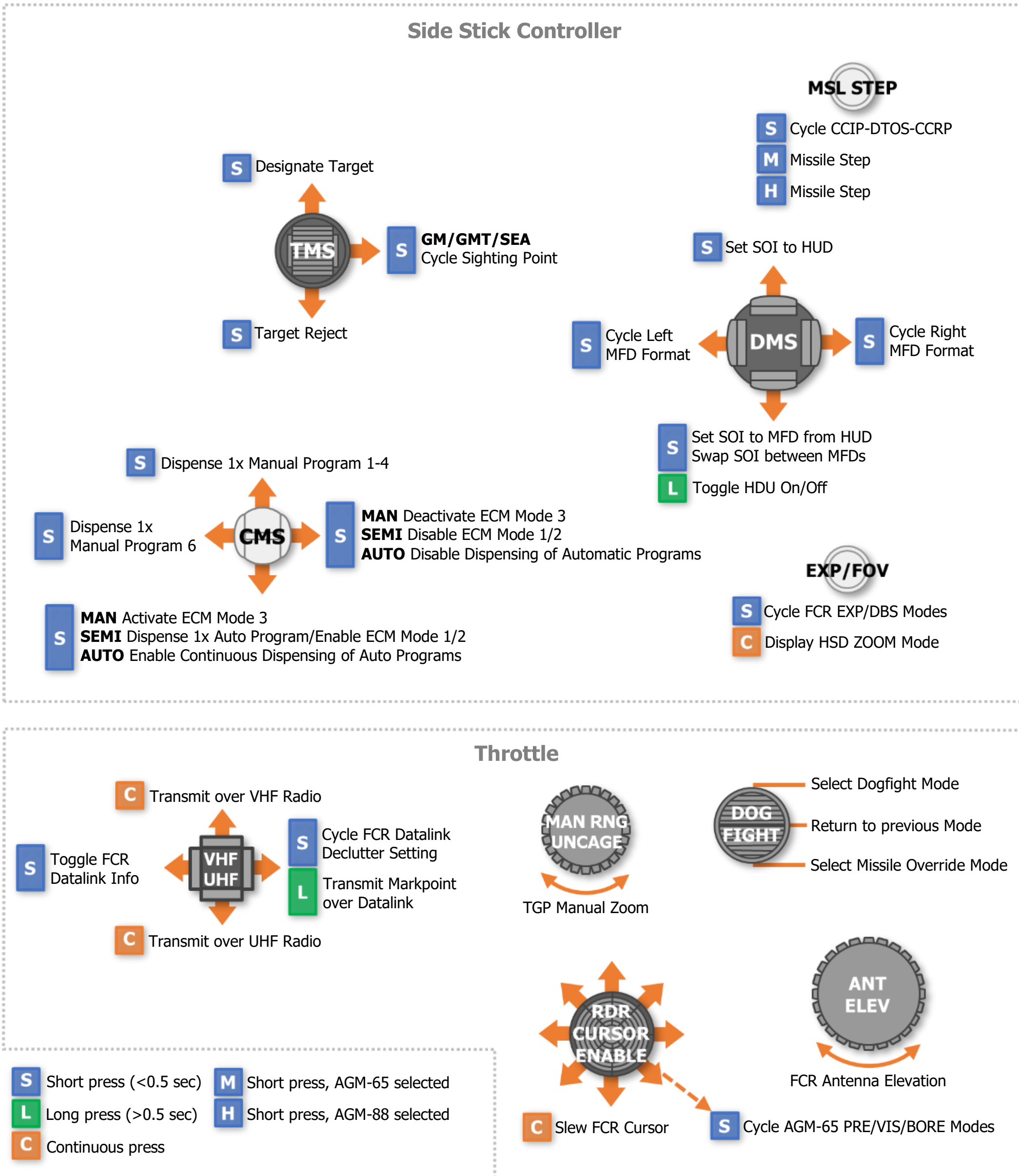
APPENDIX D – HOTAS QUICK REFERENCES

A-A, MSL, DGFT Master Modes / SOI set to FCR

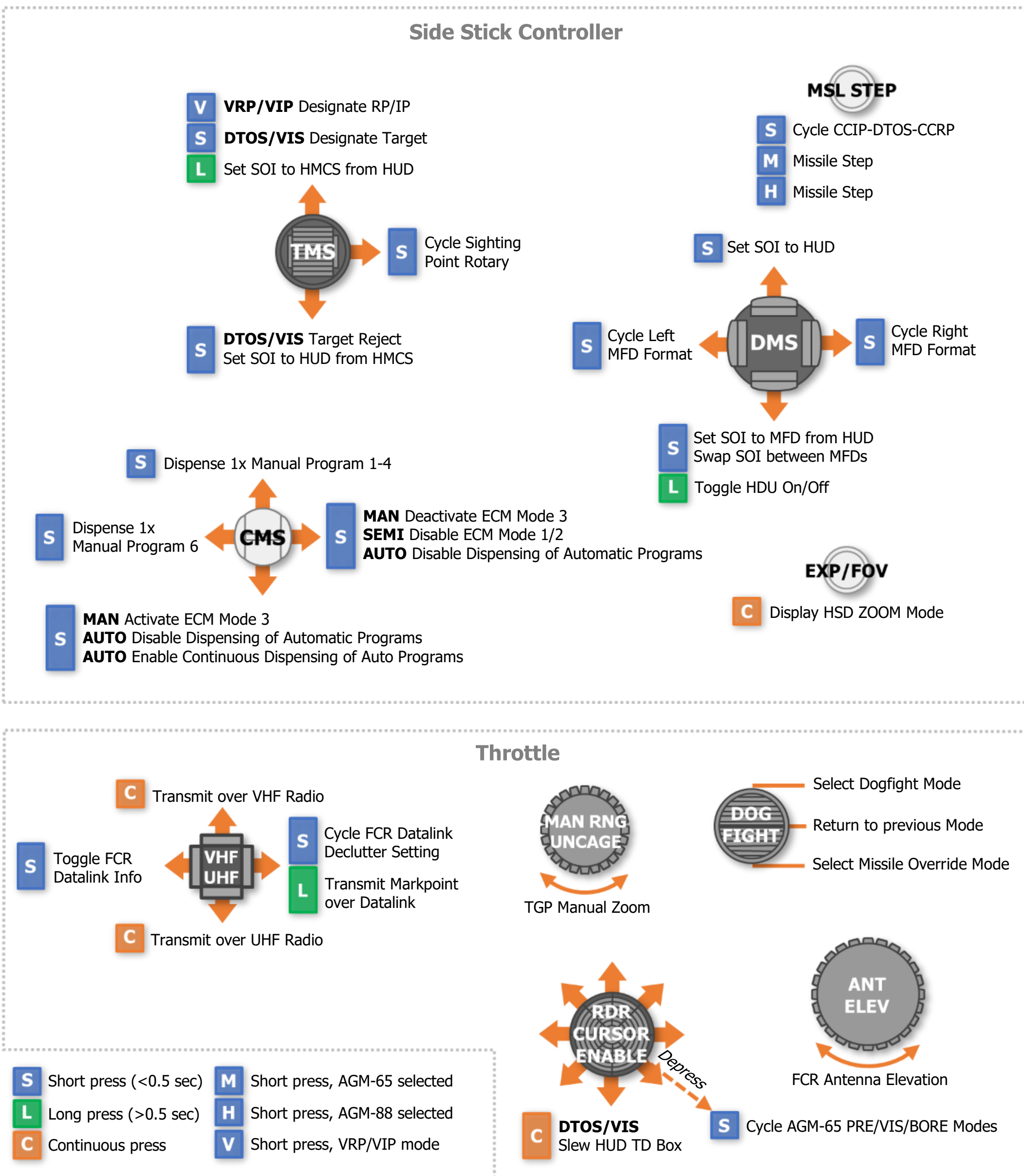




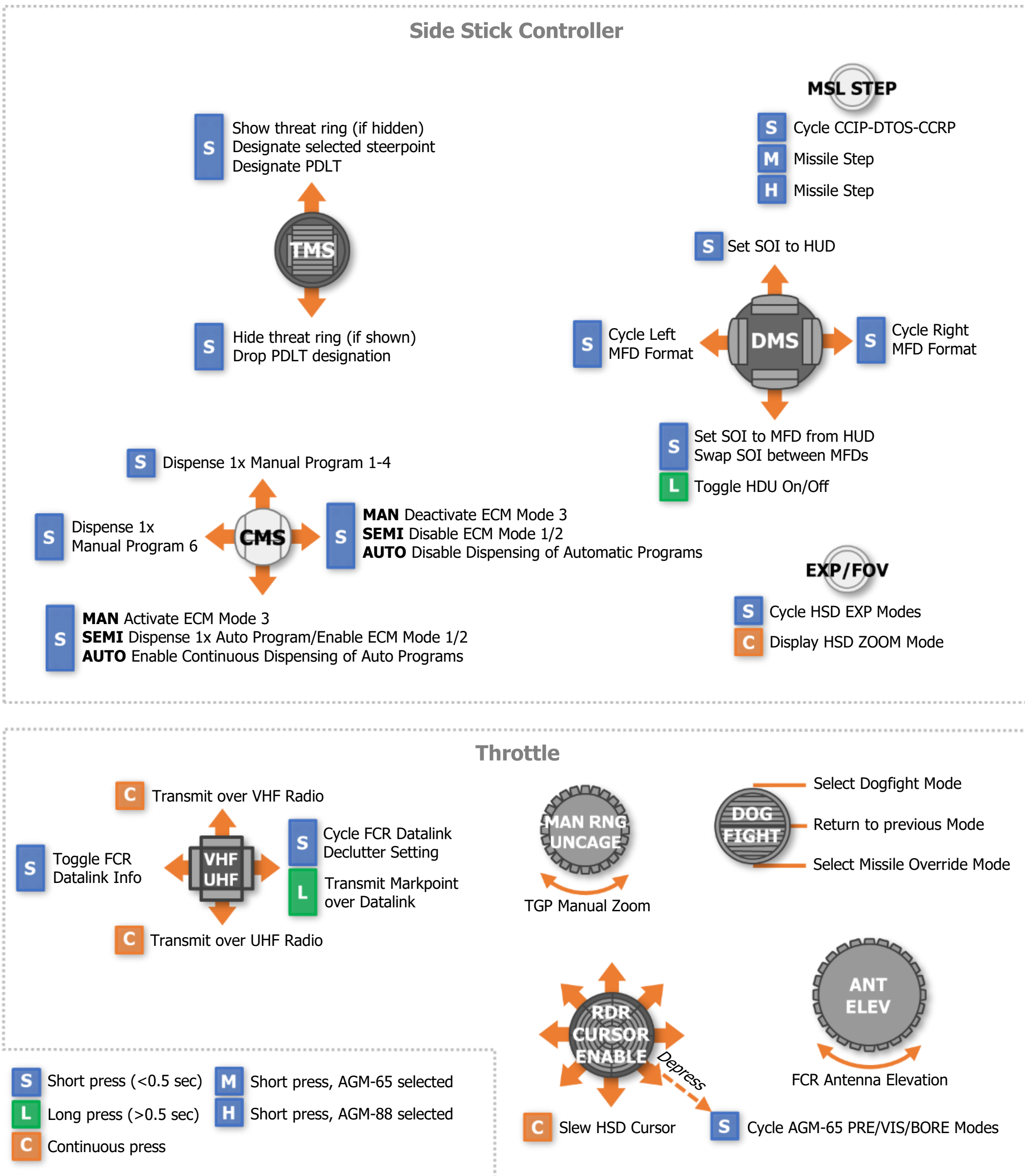
A-G Master Mode / SOI set to FCR



A-G Master Mode / SOI set to HUD

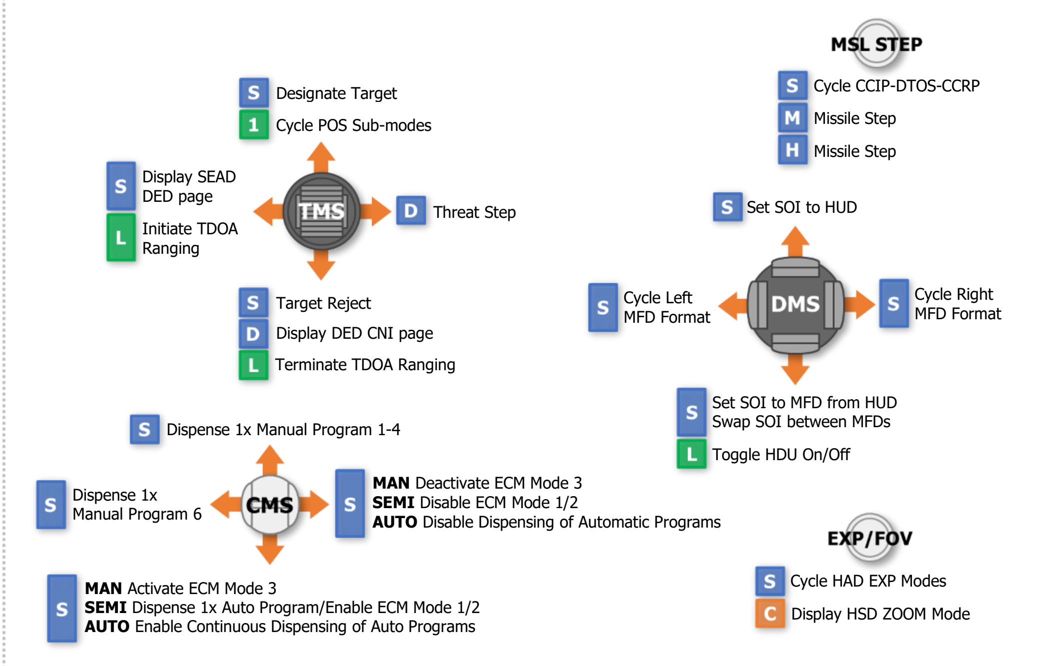


A-G Master Mode / SOI set to HSD

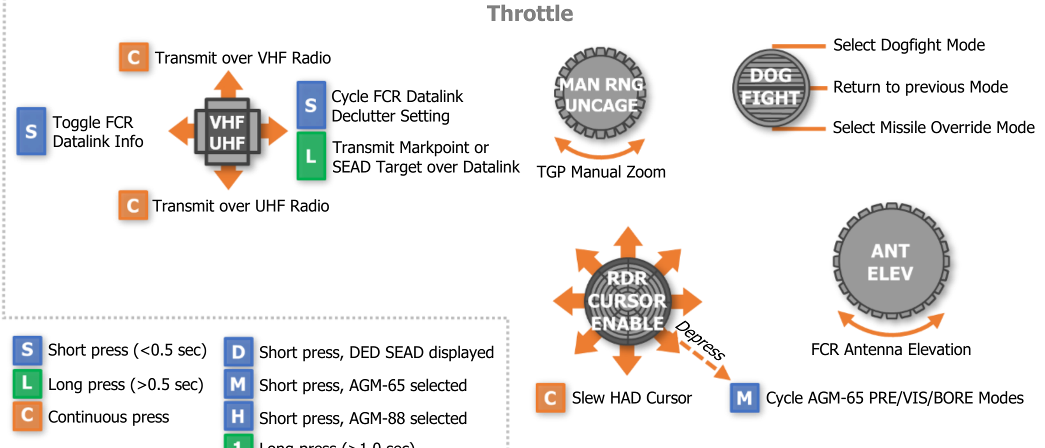


A-G Master Mode / SOI set to HAD

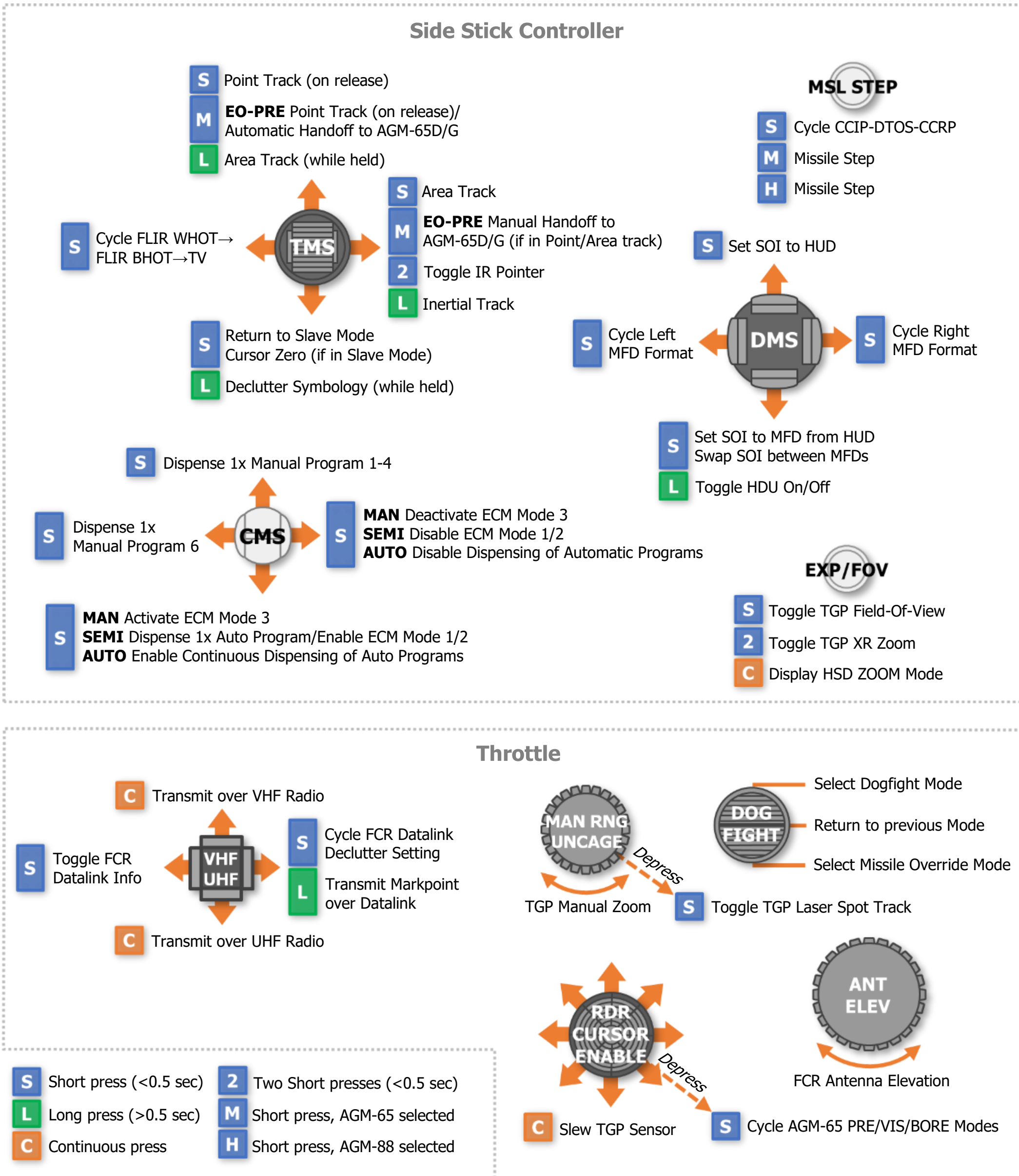
Side Stick Controller



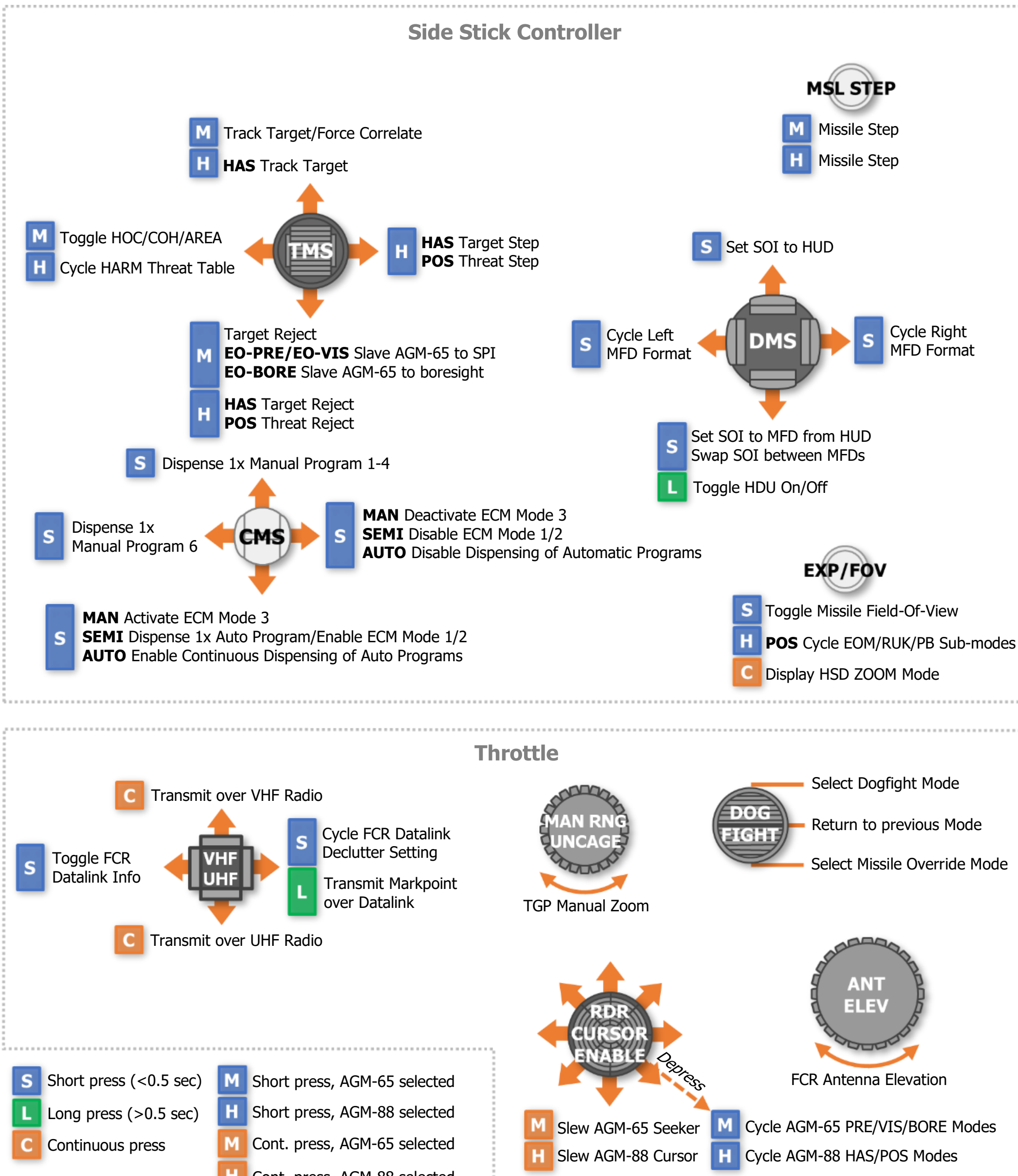
Throttle



A-G Master Mode / SOI set to TGP



A-G Master Mode / SOI set to WPN



APPENDIX E – GLOSSARY OF TERMS

Definitions of acronyms, abbreviations, labels, and terms.

A-A, A/A	Air-to-Air
AAA	Anti-Aircraft Artillery
A-CAL	Altitude Calibration
ACM	1. Air Combat Mode; 2. Air Combat Maneuvers
ADI	Attitude Director Indicator
A-G	Air-to-Ground
AGC	Automatic Gain Control
AGL	Above Ground Level
AGM	Air-to-Ground Missile
AGR	Air-to-Ground Ranging
AIFF	Advanced Identification-Friend-or-Foe
AIM	Air Intercept Missile
ALIC	Aircraft Launcher Interface Computer
ALOW	Altitude Low
ALT	1. Altitude; 2. Alternate
AMRAAM	Advanced Medium Range Air-to-Air Missile
AOA	1. Angle-Of-Attack; 2. Angle-Of-Arrival
AR	Aerial Refuel
ATC	Air Traffic Control
ATDT	Air Target Data Table
ATP	Advanced Targeting Pod
ATT	Attitude
AUTO	Automatic
AWACS	Airborne Warning And Control System
AZ	Azimuth
BFM	Basic Fighter Maneuvers
BHOT	Black Hot

BI	Burst Interval
BIT	Built-In Test
BNGO	Bingo
BORE	Boresight
BQ	Burst Quantity
BT	Black Track
BULL	Bullseye
BUP	Backup
BVR	Beyond Visual Range
BYP	Bypass
C2	Command and Control
CARA	Combined Altitude Radar Altimeter
CBU	Cluster Bomb Unit
CCD	Charge-Coupled Device
CCIP	Continuously Computed Impact Point
CCRP	Continuously Computed Release Point
CEN	Centered
CH	Chaff
CMBT	Combat
CMDS	Countermeasures Dispenser Set
CMS	Countermeasures Management Switch
CNI	Communications/Navigation/IFF
CNTL	Control
COM1	Communications radio 1; the ARC-164 UHF-AM radio
COM2	Communications radio 2; the ARC-222 VHF-AM/FM radio
CORR	Correction
CPL	Coupled
CRM	Combined Radar Modes
CRUS	Cruise

CTR	Center
CZ	Cursor Zero
DBS	Doppler Beam Sharpening
DEC	Decrement
DECL	Decoupled
DED	Data Entry Display
DEFOG	De-Fog
DEP	Depressed
DEPR	Depression
DEST	Destination
DLNK, DL	Datalink
DLZ	Dynamic Launch Zone
DMS	Display Management Switch
DRNG	Delta Range
DTC	Data Transfer Cartridge
DTE	Data Transfer Equipment
DTOS	1. Dive/Toss; 2. Delta Time-Over-Steerpoint
DTT	Dual Target Track
DTU	Data Transfer Unit
ECM	Electronic Countermeasures
ECS	Environmental Control System
EDR	Endurance
EEGS	Enhanced Envelope Gun Sight
EHSI	Electronic Horizontal Situation Indicator
E-J	Emergency Jettison
ELEV, EL	Elevation
ENG	Engine
ENTR	Enter
EO	Electro-Optical

EOM	Equations Of Motion
ETA	Estimated Time of Arrival
ETE	Estimated Time Enroute
EOM	Equations Of Motion
EPU	Emergency Power Unit
EXP	Expand
FC	Fighter Channel
FCR	Fire Control Radar
FDBK	Feedback
FEBA	Forward Edge of the Battle Area
FL	Flight Lead
FLCC	Flight Control Computer
FLCS	Flight Control System
FLIR	Forward Looking Infrared
FLOT	Forward Line of Own Troops
FLT	Flight
FOV	Field-Of-View
FPM	Flight Path Marker
FRND	Friend
FTT	Fixed Target Track
FT	Feet (unit of measurement)
FZ	Freeze
G	G-force (unit of measurement)
GBU	Glide Bomb Unit
GM	Ground Mapping
GMT	Ground Moving Target
GPS	Global Positioning System
GRD	GUARD
GS, G/S	1. Ground Speed; 2. Glideslope

HAD	HARM Attack Display
HARM	High-speed Anti-Radiation Missile
HAS	HARM As Sensor
HDG	Heading
HMCS	Helmet-Mounted Cueing System
HOTAS	Hands-On Throttle and Stick System
HOB	High-angle Off-Boresight
HSD	Horizontal Situation Display
HSI	Horizontal Situation Indicator
HTS	HARM Targeting System
HUD	Head-Up Display
HYD	Hydraulic
IAS	Indicated Airspeed
IBIT	Initiated Built-In-Test
ICP	Integrated Control Panel
ICS	Inter-Communication System
IDENT	Identification
IFF	Identification Friend or Foe
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IN	Inches (unit of measurement)
INC	Increment
INFLT	In-Flight
INR	Inertial
INS	Inertial Navigation System
INSM	Inertial Navigation System Memory
INTG	Interrogate
INV	Inventory
IR	Infrared

IP	Initial Point
JDAM	Joint Direct Attack Munition
JETT	Jettison
JFS	Jet Fuel Starter
JHMCS	Joint Helmet-Mounted Cueing System
JSOW	Joint Stand-Off Weapon
KM	Kilometer (unit of measurement)
LADD	Low Altitude Drogue Delivery
LAR	Launch Acceptability Region
LASR	Laser
LAT	Latitude
Lat/Long	Latitude/Longitude
LB	Pound (unit of measurement)
LGB	Laser-Guided Bomb
LO	Low
LONG	Longitude
LRFD	Laser Rangefinder/Designator
LSS	Laser Spot Search
LST	Laser Spot Tracker
LVT	Low Volume Terminal
MAGV	Magnetic Variation
MAN	Manual
MC	Mission Channel
MFD	Multi-Function Display
MGC	Manual Gain Control
MGRS	Military Grid Reference System
MIDS	Multifunction Information Distribution System
MISC	Miscellaneous
MKPT	Markpoint

MMC	Modular Mission Computer
M-SEL	Mode Select
MSG	Message
MSL	1. Missile; 2. Mean Sea Level
MT	Multi-Target tracking mode
NAV	Navigation
N/I	Not Implemented
NM	Nautical Mile (unit of measurement)
NORM	Normal
NTR	Network Time Reference
NWS	Nose Wheel Steering
NVG	Night Vision Goggles
OAP, OA1, OA2	Offset Aimpoint, Offset Aimpoint 1, Offset Aimpoint 2
OFP	Operational Flight Program
OPR	Operation
OSB	Option Select Button
OVRD	Override
PB	Pre-Briefed
PFLD	Pilot Fault List Display
PDLT	Primary Datalink Track
PGM	Precision Guided Munition
PIP	Picture-In-Picture
POS	Position
PPLI	Precise Participant Location Identification
PRE	Pre-planned
PRF	Pulse Repetition Frequency
PRGM, PROG	Program
PSI	Pounds per Square Inch (unit of measurement)
PTR	Pointer

PTT	Push-To-Talk
PUP	Pull-Up Point
PWR	Power
QTY	Quantity
RCL	Recall
RCS	Radar Cross Section
RDY	Ready
REC	Receive
REQCTR	Request Countermeasures
RNG	Range
ROE	Rules-Of-Engagement
RP	Reference Point
RTN	Return
RUK	Range Unknown
RWR	Radar Warning Receiver
RWS	Range While Scan
SAI	1. Standby Attitude Indicator; 2. Situational Awareness Indicator
SAM	1. Surface-to-Air Missile, 2. Situation Awareness Mode
SCT	Scan Cycle Time
SEAD	Suppression of Enemy Air Defenses
SEMI	Semi-automatic
SEQ	Sequence
SI	Salvo Interval
S-J	Selective Jettison
SMDL	Secure Modem Datalink
SMS	Stores Management Set
SNSR	Sensor
SOI	Sensor-Of-Interest
SP	Snowplow

SPI	System-Point-of-Interest
SQ	Salvo Quantity
SQL	Squelch
SSC	Side Stick Controller
STBY	Standby
STF	System Track File
STN	Source Track Number
STOR	Store
STP, STPT	Steerpoint
STR	Steer
ST STA	Stores Stations
STT	Single Target Track
SURV	Surveillance
SYM	Symbology
SYNC	Synchronization
TACAN, TCN	Tactical Air Navigation
TAS	True Airspeed
TBL	Table
TD-M	TDOA Master
TDMA	Time Division Multiple Access
TDOA	Time-Difference-Of-Arrival
TD-S	TDOA Slave
TER	1. Tertiary; 2. Triple Ejector Rack
TGP	Targeting Pod
TGT	Target
TGTS	Targets
THRT	Threat
T-ILS	TACAN/Instrument Landing System
TISL	Target Identification Set, Laser

TLA	Target Locator Angle
TLE	Target Location Error
TLL	Target Locator Line
TMS	Target Management Switch
TNDL	Tactical Net Datalink
TOF	1. Time Of Flight; 2. Time Of Fall
TOI	Target-Of-Interest
TOT	Time Over Target
T/R	Transmit/Receive
TRNG	Training
TWS	Track While Scan
UFC	Upfront Controls
UHF	Ultra High Frequency
UTM	Universal Transverse Mercator
VAH	Velocity/Altitude/Heading
VHF	Very High Frequency
VIP	Visual Initial Point
VIS	Visual
VMC	Visual Meteorological Conditions
VRP	Visual Reference Point
VV	Vertical Velocity
VVI	Vertical Velocity Indicator
WCMD	Wind-Corrected Munition Dispenser
WEZ	Weapon Engagement Zone
WHOT	White Hot
WPN	Weapon
WVR	Within Visual Range
XMT, XMIT	Transmit
XR	Extended Range

APPENDIX F – FORMULAS

Use these calculation and conversion formulas for pre-mission planning or while in flight. Desired resultants are bolded.

Speed/Time/Distance Calculations

Ground Speed Required (knots) = (Distance ÷ Minutes) × 60

Time of Flight (mins) = (Distance ÷ Ground Speed) × 60

Fuel/Endurance Calculations

Bingo Fuel (lbs) = (Time of Flight ÷ 60) × Fuel LB/HR

Objective Time (mins) = ([Total Fuel − Bingo Fuel] ÷ Fuel LB/HR) × 60

Fuel/Range Calculations

Specific Range Factor (SFR) = Ground Speed ÷ Fuel LB/HR

Flight Range (NM) = Specific Range Factor × Total Fuel

Fuel Required (lbs) = Distance ÷ Specific Range Factor

Distance Conversion

Nautical Miles (NM) to **feet (ft)** = [NM] x 6,076

Feet (ft) to **Nautical Miles (NM)** = [ft] ÷ 6,076

Nautical Miles (NM) to **Kilometers (Km)** = [NM] × 1.85

Kilometers (Km) to **Nautical Miles (NM)** = [Km] ÷ 1.85

Altitude/Elevation Conversion

Feet (ft) to **Meters (m)** = [ft] ÷ 3.281

Meters (m) to **Feet (ft)** = [m] × 3.281

Latitude/Longitude Conversion

DDD-MM-SS.SS to **DDD-MM.MMM**

SS.SS ÷ 60 = .MMM

DDD-MM.MMM to **DDD-MM-SS.SS**

.MMM × 60 = SS.SS

Good hunting!

The Eagle Dynamics SA team

USAF Photo
by SSgt Deana Heitzman