STANT

347th TAC FTR WG

347 TFW DOW

INSTRUCTOR HANDOUT

NEW INFORMATION PAMPHLET #24

Revised
Jun 80

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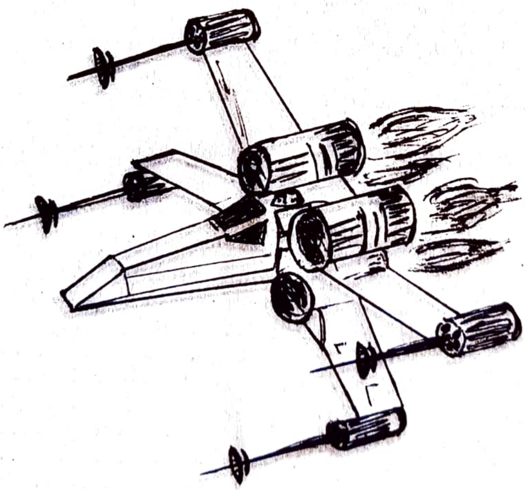
FIGURES



347TFW/DOW
Moody AFB, GA 31601

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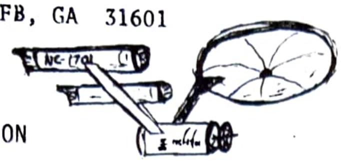

INTRODUCTION

"A long time ago in a galaxy far, far away..." begins the popular movie STAR WARS. Throughout the film Luke Skywalker and R2D2 heroically beam around with their proverbial hair on fire (errrr, dome on fire, for Artoo) duelling the dark forces ruling the Empire— with light sabers and laser equipped "X-Wing Fighters". In BATTLESTAR GALACTICA Starbuck and Apollo dogfight with the Cylon forces and blast them from existence with laser armed "Vipers". Even Kirk and Spock of STAR TREK had the phaser and photon torpedo equipped starship "Enterprise".

PAVE SPIKE is not (REPEAT NOT) a Star Trek type, "I wish you were dead" weapon system. But PAVE SPIKE is a result of technology that has developed over the last 40 years.

Laser Guided Bombs (LGBs) "...gained fame during Operation Linebacker I in the spring of 1972. For example, on 13 May 1972 the Thanh Hoa railroad bridge was attacked by 11 F-4 Phantoms with 20 laser-guided bombs--and destroyed. The magnitude of this feat becomes apparent only when one realizes that between 1965 and 1968 about 600 fighter bomber sorties, with the loss of ten of their own, had been denied this achievement. The Paul Doumer bridge shared the fate of the Thanh Hoa bridge, only instead of laser-guided bombs, a 2,000 lb TV (electro-optical) bomb did the job."[1]

PAVE SPIKE is considered by many to be the most complicated piece of equipment attached to the F-4 (except for ARN-101 and PAVE TACK). Its integration with onboard aircraft systems provides capabilities, which we have not seen in past laser designators, that aid in target acquisition as well as improved accuracy in long range weapon delivery. The pod is both a laser designator and range finder and integrates with the Inertial Navigation System (INS) and Weapon Release Computer Set (WRCS) to aid in target acquisition, tracking, and weapons delivery. System operation is demanding and both crew members must understand the system inside and out to effectively employ it, particularly in the low altitude environment. First we will discuss laser theory, followed by the system, its switchology, and displays. Then, we will discuss each of the three operating modes of PAVE SPIKE.

REFERENCES:

This NIP cannot be considered a single source document for PAVE SPIKE/LGB. Aircrews must spend some time in individual study, including the references listed below. To do less, will result in unsatisfactory knowledge of the system.

a. FWS Text, Laser Guided Weapons Delivery, Part Two (S)

b. TAB 76-4 (S) and TAB 78-2 (S)

c. TO 1F-4E-34-1-1

d. TO 1F-4E-34-1-2

e. TO 1F-4E-34-1-1-1 (C)

f. TO 1F-4E-1

g. AIRCREW'S MANUAL for PAVE SPIKE AN/ASQ-153 (V), 15 May 79, by Westinghouse Defense and Electronic Systems Center.

h. USAF Fighter Weapons Review, Spring 1977 edition, "PAVE SPIKE", page 78.

i. AFM 3-1, Vol 5 (S)

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[1]Samuel W., Lt Col, "The Smart Bomb", USAF Fighter Weapons Review, Winter 78.

j. TACM 3-1 (S)

k. TACM 51-50 Vol I and Vol V

l. MAFBR 51-1 for local training program

m. TAC ATTACK, May 1978, "Laser Systems and Hazards", page 24

n. USAF Fighter Weapons Review, Winter 1978 edition, "The Smart Bomb", page 4, (edit. Article addresses history of smart bomb development).

o. 347TFW/DOW NIP #25, "Laser Guided Bombs".

p. USAF Fighter Weapons Review, Summer 1978 edition, "Getting There is Half the Fun", page 1.

SECTION I

DEFINITION OF TERMS

1. ACCEPTANCE: Terminology used by WSO to alert AC of PAVE SPIKE Laser Range Acceptance. Also serves as "cleared to pickle" call for PAVE SPIKE self-delivery.

2. AN/AVQ-23 A/B: The laser designator pod associated with PAVE SPIKE.

3. ASQ-153 (V): The PAVE SPIKE system.

4. BLANKING: Terminology sometimes used by WSO when aircraft stores, wing tanks, etc., enter the PAVE SPIKE field of view and threaten ability to track/lase the target.

5. BORESIGHTING: Aligning the television presentation to the aircraft gunsight using boresight knobs. In addition, PAVE SPIKE can be coarse boresighted to the aircraft nine o'clock position.

6. BUNT: Terminology sometimes used by WSO during certain PAVE SPIKE attacks to command AC to bunt aircraft (altitude permitting) in order to allow continued tracking/lasing of the target. This will prevent loss of the target from the TV FOV due to exceeding pod aft gimbal limits. See also "EASE OFF" (below).

7. CAPTURE: Terminology used by WSO when target has been identified and is being tracked in the TV FOV after one of the various methods of acquisition.

8. EASE OFF: Terminology used by WSO to indicate that PAVE SPIKE pod is approaching a gimbal limit during target designation. Directive comment to AC to start bunt portion of designator turn.

9. FIELD OF VIEW: PAVE SPIKE has Wide Field of View (WFOV) or Narrow Field of View (NFOV).

10. GBU: Guided Bomb Unit. Built from mating a conventional bomb warhead with a KMU (KIT Munition Unit) which includes a CCG (Computer Control Group) and an AFG (Airfoil Group).

11. LGB: Laser Guided Bomb.

12. LOS: Line of Sight.

13. LTDSS: Laser Target Designator Scoring System. Suitcase-sized system which detects laser energy.

14. NULL: Neutral position of radar control handle where no slew commands are directed.

15. OVERRIDE: Terminology may be used by WSO when utilizing PAVE SPIKE Reject Override (REJOVRD) button to force laser range acceptance.

16. PAVEWAY I: First generation LGB.

17. PAVEWAY II: Later modified LGB with a coded laser capability and modified fins.

18. PEP WEAPON: Product of the Production Engineering Program (PEP).

19. REFERENCE HEADING: Terminology used by the flight leader to alert wingman of desired heading.

20. SPIKE TOSS: PAVE SPIKE WRCS automatic delivery wherein the delivery aircraft flies up to delivery altitude, rolls in, and tosses the bomb from altitude. Laser ranging is provided to the Weapons Release Computer System (WRCS).

21. SRI: Slant Range Indicator.

22. TAFSWAT: TACTICAL ANALYSIS FOR SYSTEMS, WEAPONS, AND TRAINING.

23. TDS: Target Designator Set.

24. TEARING: Jagged video (Abnormal TV).

25. TGW: Terminal Guided weapons such as LGB's, Maverick, GBU-15, etc.

26. TRACKING: Terminology used by AC to inform WSO of target in the gunsight, or approaching nine o'clock sight.

27. VENETIAN BLINDING: Alternating lines of dark and light on TV presentation (Abnormal TV).

28. VIDEO: Television display.

29. VTR: Video Tape Recorder.

* * *

Based on new intelligence findings, the Pentagon now suspects the Russians have jumped ahead by developing laser "death ray" weapons for battlefield use. American officials say they will need several more years of testing before the U.S. is ready to build such weapons.

U.S. News & World Report
Aug 13, 1979 - Page 16

* * *

SECTION II

LASER THEORY (U)

1-1. (U) INTRODUCTION. The word "laser" is an acronym for light amplification by stimulated emission of radiation. Fortunately, a basic understanding of laser operation and beam properties can be gained without a complete knowledge of quantum mechanic theory. Before delving briefly into the world of the electron, a look at the big picture may be helpful.

a. The laser is just one of the many types of electronmagnetic wave generators in the world today. Other man-made wave generators include flames, electric lamps, neon and fluroescent lights, and radio and TV stations. Natural wave generators include the sun, lighting, and fireflies. Although these wave generators may appear very different, they all use the same fundamental forces of electricity and magnetism.

b. Science has established the fact that radio, infrared, light, ultraviolet, X rays, gamma rays, and cosmic rays all belong to one immense family. These electromagnetic waves differ from each other in frequency and wavelength. The wavelengths of interest with lasers range from the near infrared through visible light to the near ultraviolet band. All this radiation, although it varies widely in wavelength and frequency, travels at the speed of light and has a common origin: it all originates in moving electric charges. In lasers, the electric charge we are concerned with is the electron.

c. The electron is the ultimate indivisible unit of negative electric charge. Most electrons exist "in captivity" in atoms and appear as the satellites of a dominant central nucleus which is positively charged. In the simplest of atoms, hydrogen, the nucleus is patrolled by one electron. This electron, moving at nearly the speed of light, travels around the nucleus in a random pattern. In contrast to its capricious motion, the electron possesses an amount of energy, the value of which is strictly fixed by the laws governing the atom and can be exactly calculated. The amount of energy an orbiting electron may possess is determined by the domain or shell in which it is constrained to move. Each electron has a limited number of orbits or shells where it may exist and the transition between these shells or energy levels is at the heart of laser action.

d. Quantum mechanics, the branch of science dealing with atomic and subatomic particles, describes the smallest indivisible quantity of radiant energy as the photon. Electromagnetic energy may be thought of as a stream of energy packets or photons. The amount of energy possessed by one photon U is determined by the wave frequency V and Planck's constant h; thus, U = hV. If a stream of photons of the same energy can be generated, a train of waves at a frequency corresponding to the photon energy is generated. To amplify waves, the concentration of more photons of the same energy is required. Lasers provide a method for the amplification of electromagnetic energy in this manner.

1-2. (U) EXPLANATION. Laser action is based on the transition of electrons between orbits or shells within atoms. Atoms may be visualized as a central core of positive charge that is surrounded by a number of electrons (Figure 1). (In this figure only one electron is shown for simplicity.) These electrons revolve around the nucleus in a limited number of possible orbits. In nature, atoms tend to keep electrons at the lowest energy level or ground state unless acted upon by outside forces, such as collisions with incoming photons.

a. There are three ways in which an atom may interact with a photon.

(1) If an unexcited or ground state (Figure 1-A) atom is struck by a photon with energy equal to the difference in energy levels between allowable orbit shells, the photon is probably absorbed into the atoms orbital systems. This will knock an electron out to a higher energy shell (Figure 1-B). It must be noted that only photons of exactly the energy difference between two allowable orbits will cause this. All other photons will pass through with no effect.

(2) If nothing further happens to the atom, it will sooner or later spontaneously emit this stored energy, and the electron will return to its ground state orbit (Figure 1-C).

(3) However, if a photon of proper energy strikes an excited atom, it will stimulate the atom to emit its stored photon along with the impinging photon. In this case, the two photons of exactly the same energy level, frequency, phase, and direction are emitted (Figure 1-D).

b. When some materials are exposed to light of a given wavelength they are observed to re-emit light of a longer wavelength (lower energy). This phenomenon is known as fluorescence. The electron transition that occurs during fluorescence is schematically shown in Figure 2. Some fluorescent materials possess metastable states which allow energy to be stored at intermediate energy levels before being radiated, so that energy at an intermediate level is built up. The process of moving electrons from the ground state to a fluorescent state is known as "pumping up" a sample. This is the basis for stimulated emission.

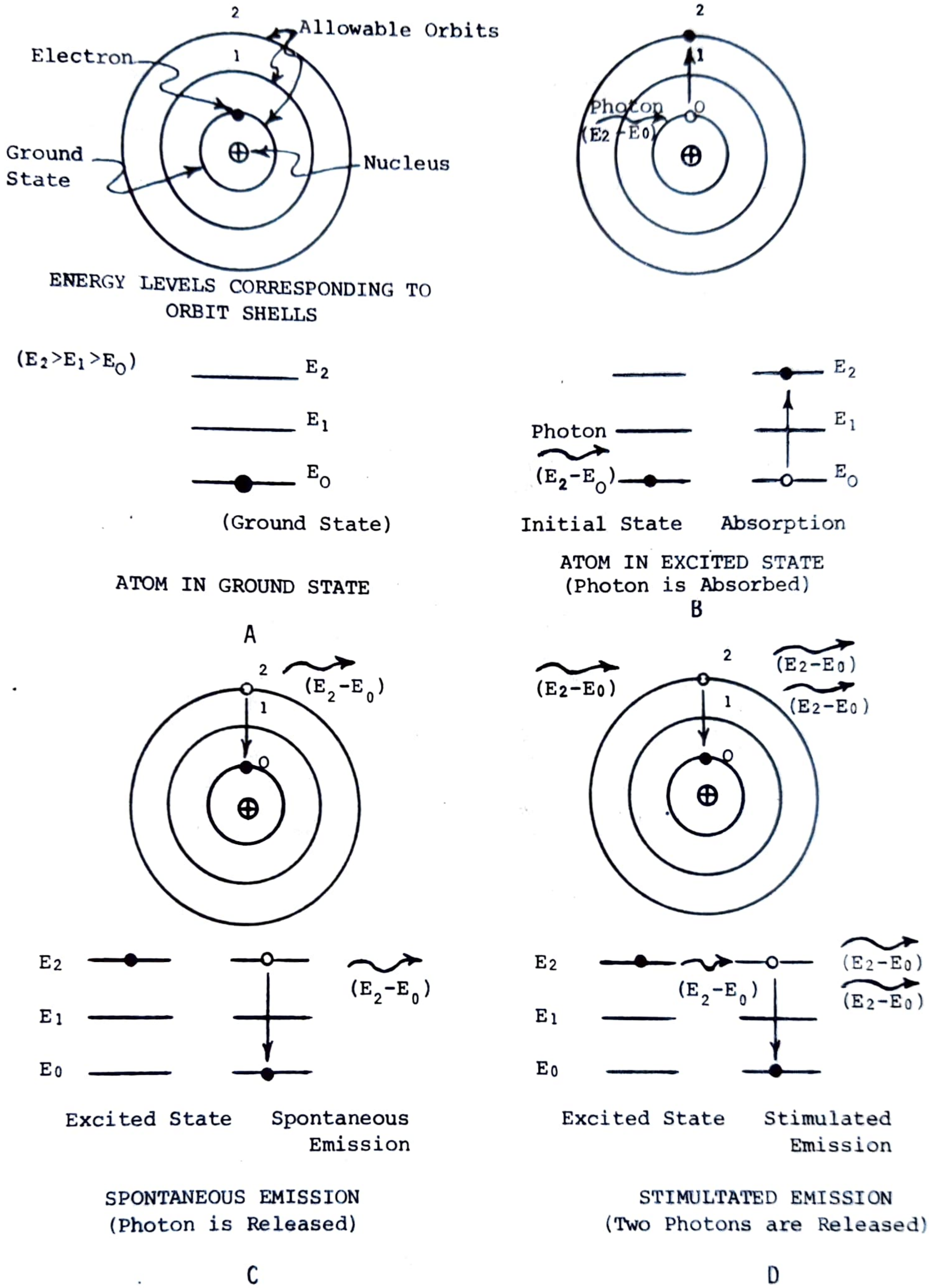
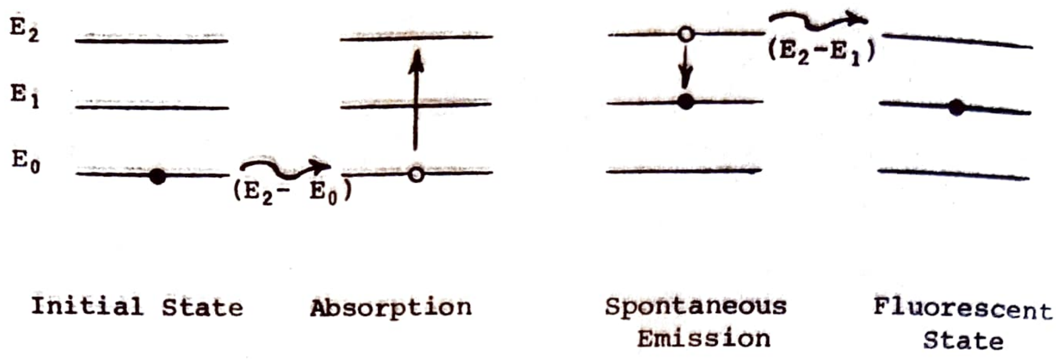


Figure 1. Electron Orbits and Energy Transitions



NOTE: The Photon (E_2-E_1) is lower energy (longer wavelength) than Photon (E_2-E_0).

Figure 2. Transition from Ground State to Fluorescent State.

c. Stimulated emission may be thought of as the reverse process of absorption. In this case an induced downward transition occurs in which a photon liberates a new photon rather than being absorbed. (Figure 3). Amplification occurs in a material when stimulated emission overrides absorption, and this can occur only when there are more atoms in the fluorescent state than the ground state. When this occurs a population inversion is said to exist. In this case there is a higher probability that each impinging photon will liberate a new photon rather than be absorbed. This does not ordinarily occur in materials in their natural state because the atoms tend to exist in their ground state.

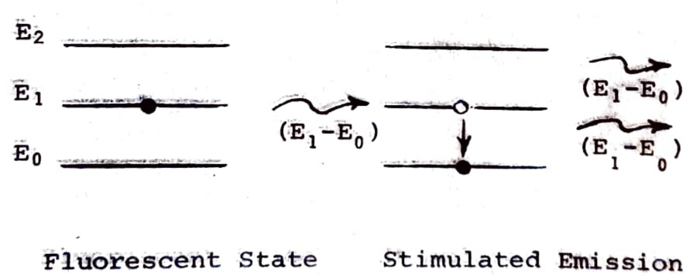


Figure 3. Amplification of Light Energy (Photons) by Stimulated Emission From Fluorescent State.

d. The above discussion has paved the way for an understanding of laser action. The goal of lasers, as the acronym implies, is to amplify light energy by the process of stimulated emission. To accomplish this, a material must be brought to a highly fluorescent state and then be allowed to discharge toward its ground state with the accompanying release of energy.

e. In solid-state lasers an active laser material is imbedded in a suitable host. In the PAVE SPIKE system neodymium is contained in a yttrium aluminum garnet (YAG) rod. An active material is one which will exist in the fluorescent state long enough for laser action to occur. Solid-state lasers use optical sources to supply photons to pump the active material electrons out of the ground state into the fluorescent state. PAVE SPIKE uses a xenon strobe lamp to supply photons to the laser rod. Of course, since the strobe lamp is an incandescent light source, it supplies photons of many energy levels. Only those photons with the energy state necessary to cause fluorescence of the active material are of interest and the rest are wasted as heat energy. The PAVE SPIKE laser consists of a neodymium doped YAG rod wrapped in a helical xenon strobe lamp.

f. The building of laser action is shown schematically in Figure 4.

(1) The laser rod with its imbedded active material is shown with a 100 percent reflective mirror on the left and a partially reflecting mirror on the right. A strobe lamp may be used to pump up the sample into a highly fluorescent state so that a population inversion exists.

(2) Some the atoms will spontaneously emit photons and return to the ground state. These transitions will occur in random directions.

(3) When a photon is emitted parallel to the rod, it has a greater probability of stimulating emission since it will travel through more of the pumped up sample. Since each photon that strikes an excited atom stimulates the release of another photon of exactly the same energy level and continues through the sample itself, a chain reaction is started.

(4) The mirrors build up the quantity of photons through reflection and the laser beam emerges through the partially reflective mirror at one end. Each lap the photons take between mirrors knocks out new photons and the action cascades to produce an intense flash of light. Because feedback occurs only along the axis of the rod, the output is radiated only in one direction as a narrow beam of low divergence.

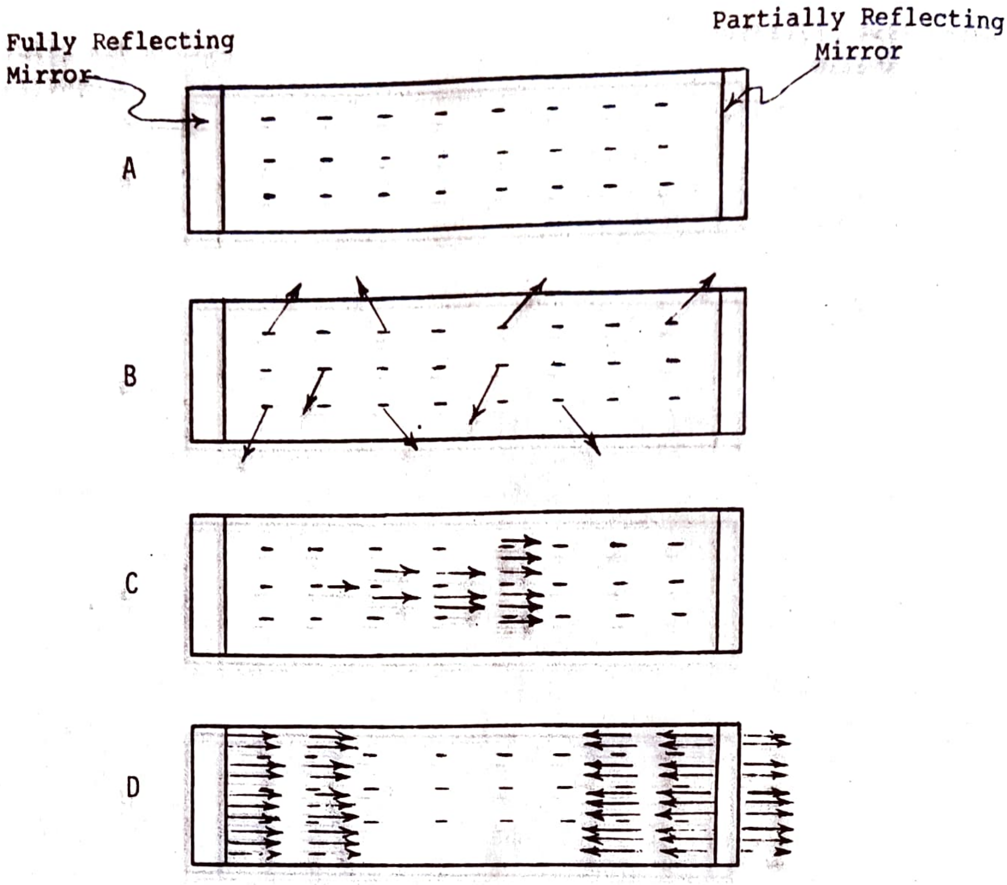


Figure 4. Buildup of Laser Action.

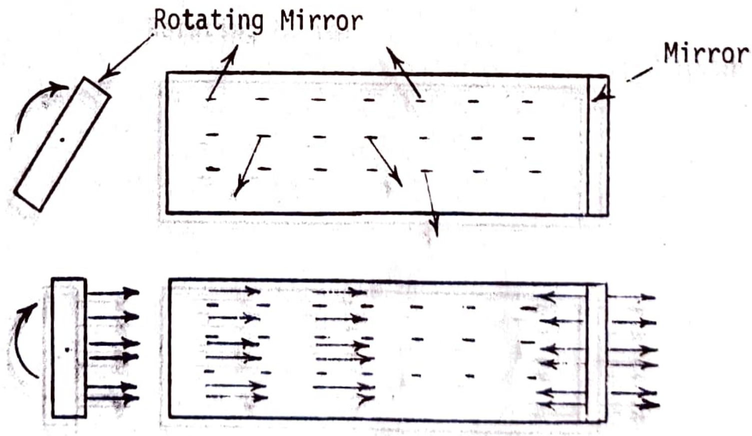


Figure 5. Q-switching Technique

g. Current tactical lasers generate a pulsed, rather than continuous, laser beam. These short, high intensity flashes can be much brighter that a continuous beam from the same power source. A technique known as Q-switching is used to produce the pulsed energy in our tactical lasers. This is achieved by allowing the fluorescence to occur, but delaying the application of feedback from the axial mirrors. Figure 5 shows schematically one method which may be used to accomplish this by the use of a rotating mirror. In this case, the sample is pumped up continuously but reinforcement along the laser axis occurs only when the mirror surfaces are parallel. In PAVE SPIKE, the rotating mirror is not used, but an electro-optic cell (pockels cell) is inserted in front of one of the mirrors. This cell acts much like the shutter in a camera, allowing the passage of photons only when stimulated by an external voltage. The rate at which the voltage is applied to the pockels cell determines the laser pulse rate.

h. Review of laser action:

(1) An active material which may exist in a metastable fluorescent state and which releases energy in the wave length desired is selected.

(2) The active material is pumped up into a fluorescent state by another light source. When more atoms of the sample are existing in the fluorescent state than the ground state (population inversion) amplification can occur.

(3) In a Q-switched laser the sample is pumped up, but reinforcement along the axis of the sample is prevented by preventing feedback between the end mirrors. When feedback is allowed to occur a very short, intense flash of laser energy is generated along the sample axis by the process of stimulated emission.

1-3. (U) CHARACTERISTICS. As a result of the special way laser energy is produced, the following characteristics are exhibited:

a. Divergence. Conventional light sources radiate uniformly in all directions. Since laser beams are generated only along the sample axis and the direction of each photon is the same as the one that stimulated emmission, the beam has very small divergence.

b. Coherence. Obeying the laws of quantum mechanics, each photon generated from a laser has exactly the same wavelength (monochromatic), direction, and phase as the stimulating photon. This means that the energy waves generated are exactly in step with each other.

c. Energy Output. Laser output is measured in energy units of the joule. One joule is equal to a watt-second. Since this is a large unit, laser output may be expressed in millijoules (10^{-3} joule).

1-4. (U) BEHAVIOR. Despite the unique properties of laser energy, it behaves similar to white light when it impinges on an object. Reflectivity patterns depend upon the type of target designated and fall into three general categories.

a. A laser beam striking a perfect reflector bounces off, unchanged, reflected at the same angle that it struck. This is known as specular reflectivity (Figure 6). No tactical targets fall exactly in this category, but water and polished metal are close.

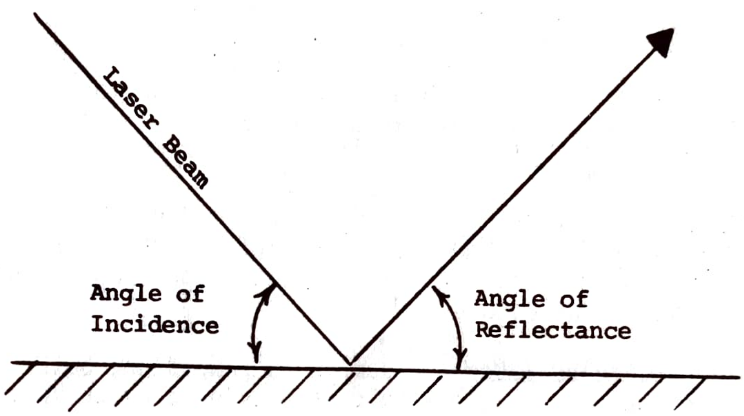


Figure 6. Perfect Reflector.

b. Targets such as flat concrete or metal surfaces are known as diffuse reflectors. The primary difference between specular and diffuse reflection is that the specularly reflected energy is highly directional and can be "seen" only in the path of the beam, while the diffusely reflected energy is scattered and (though of lower intensity) can be seen from essentially anywhere in front of the reflecting surface. Intensity of diffusely reflected energy is maximum in the direction perpendicular to the surface but is scattered in all directions. An ideal diffuse target follows a lambertian distribution of reflected energy as show in Figure 7. This energy theoretically drops to zero at a 90° angle to the laser beam, and is tactically usable up to 75 to 80° from the beam. Targets such as runways are very close to this distribution and little energy will be reflected at 90° to the beam.

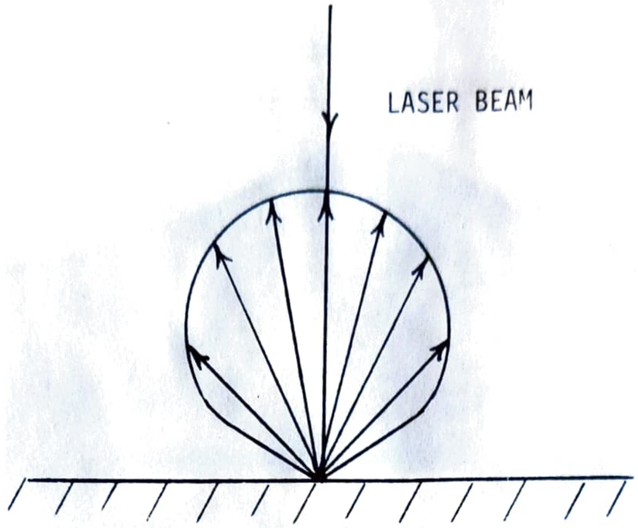


Figure 7. Diffuse Reflector.

c. Tactical targets usually present surfaces which provide a combination of specular and diffuse reflections. Their rough surface reflects energy in all directions and an unrestricted line of sight (LOS) to the point being lased is all that is required to see the reflected energy.


PAVE
SPIKE
AN/ASQ-153

SECTION III - A

PAVE SPIKE SYSTEM

1. PAVE SPIKE GENERAL DISCRIPTION:

a. The PAVE SPIKE system provides the F-4E aircraft with the capability to laser designate targets for accomplishing terminal guidance of laser weapons. The PAVE SPIKE components are contained in a pod 144 inches long, 10 inches in diameter, and weighing 422 pounds. The pod, which is carried in the left forward missile well (Station 4), provides a clean configuration that does not significantly impair aircraft performance (Drag Index = 1.3). The pod is suspended on a standard electronic countermeasure (ECM) adapter. The lower hemisphere of the aircraft is observed for target tracking (to within limitations of fuselage and stores masking, and aft gimbal limit) by using a gimbaled optical system controlled from the cockpit with the target presentation provided to the operator via closed circuit TV. The pod elevation gimbal limits are +15° to -160°, and the pod head roll limits are +110° to -160°. The resultant tracking coverage is 15° above the aircraft nose, 20° above the right wing, and 70° above the left wing. See Figure 8.

b. The AN/AVQ-23A/B pod is divided into the following subsystems.

(1) Television subsystem.

(2) Laser subsystem.

(3) Optical subsystem.

(4) Stabilization and Beam Pointing subsystem.

(5) Interface Electronics subsystem.

(6) Low Voltage Power Supply and Pod Control subsystem.

(7) Environmental Control subsystem.

c. These subsystems above are integrated with the following aircraft systems:

(1) Weapons Release Computer Set AN/ASQ-91 (WRCS).

(2) Inertial Navigation Set AN/ASN-63 (INS).

(3) Navigation Computer AN/ASN-46A.

(4) Optical Sight AN/ASG-26.

(5) Attitude Director Indicator (ADI).

(6) Radar Set AN/APQ-120(V).

d. Pod Structure: (See Figure 9).

(1) The nose of the pod has a glass dome which is protected by a visor when the pod is stowed and rolled upward, under the aircraft surface. The visor protects the dome during supersonic flight and flight through rain. The visor contains a heater to minimize icing in the window area. The nose compartment is pressurized with nitrogen and contains a heat exchanger to control humidity and temperature. A plunger-type indicator provides preflight inspection of the nitrogen pressure available.

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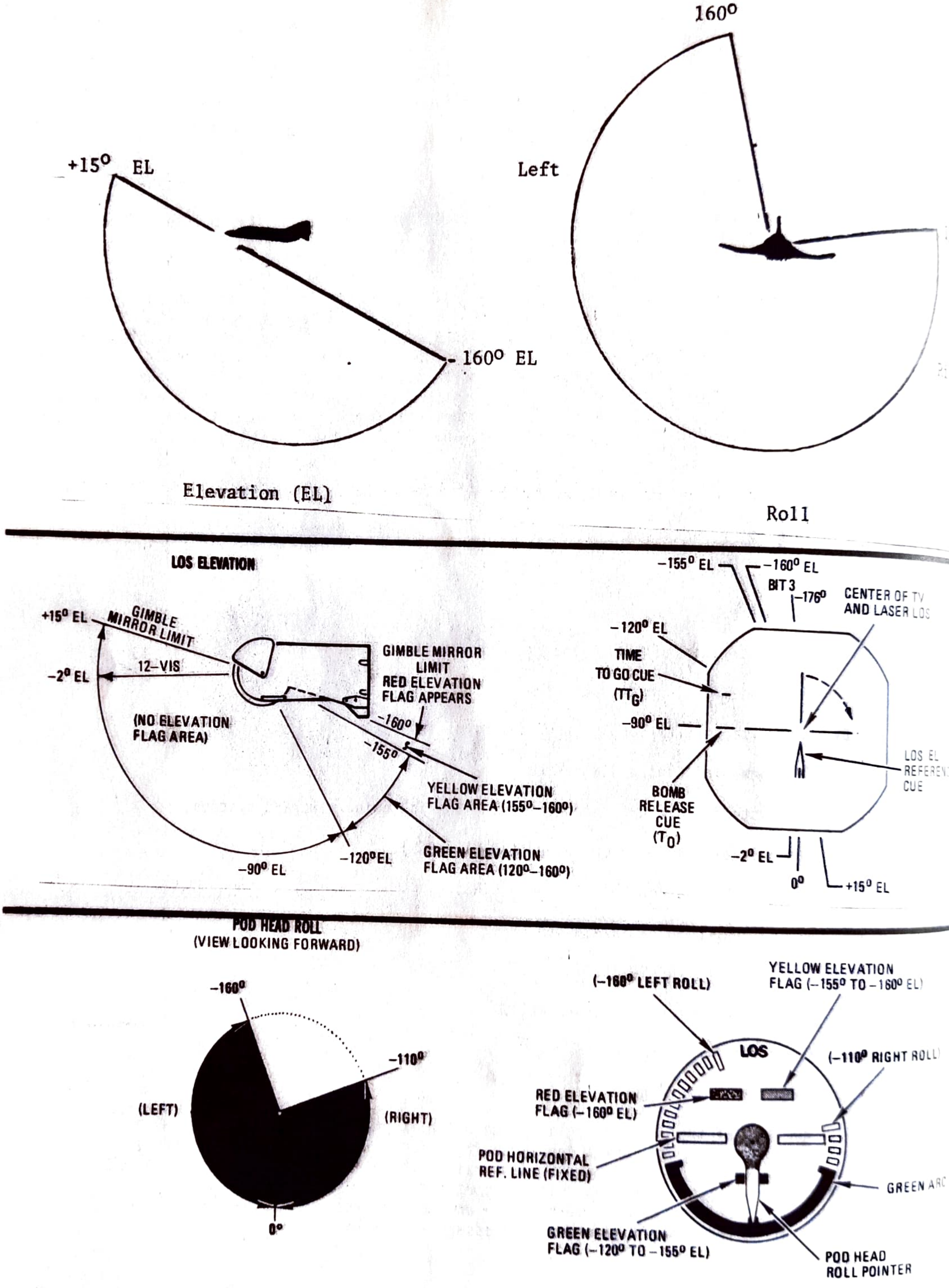


Figure 8, Pod Gimbal Limits

Note

WHEN GREEN ELEVATION FLAG IS UP, POD HEAD ROLL POINTER MUST BE IN GREEN ARC.

(2) The nose section is connected to and rolls with the sensor assembly. The sensor assembly is covered by an inner shell. The inner shell is mounted on bearings within the outer shell and driven by a roll drive motor. The outer shell supports the forward mounting lug.

(3) The middle section contains the umbilical plugs, the aft mounting lug, and access doors to the electrical and cooling connections. The aft outer shell covers the laser power supply and the electronics assembly, and can be removed with the pod mounted on the aircraft. A surface heat exchanger is attached to the aft outside surface of the shell. An end cap provides access to the phase change material (PCM) status indicator (an environmental sensor), elapsed time meter, laser pulse counter, and various hydraulic connectors. An overheat condition in the pod is monitored and sent to the OVHT light on the target designator panel.

2. DESCRIPTION OF SUBSYSTEMS:

a. Television Subsystem. The TV subsystem consists of a TV camera and a camera electronics unit. Both units are mounted on the sensor assembly. This subsystem provides high-quality video information over a wide range of light levels. The video output is held relatively constant by automatic light control (ALC) and automatic gain control circuits in the camera and camera electronics unit. Other features include gamma and aperture correction circuits. FOV switching (wide angle and narrow angle) via the optics assembly, and fail-safe circuits that protect the camera tube in the event of sweep failure. The TV camera is synchronized to produce a standard 525-line frame by the outputs of the self-contained sync generator. The television camera is derotated by the stabilization and beam pointing subsystem to offset the picture rotation caused by movement of the elevation gimbal mirror. The TV picture is always displayed with the top of the picture indicating the most forward point in the FOV relative to the direction of flight of the aircraft. If the derotation circuits become inoperative (e.g., INS OUT mode of operation), the picture on the display will undergo considerable rotation as the elevation mirror moves throughout its range. In the track mode, the dot/line time-to-release cursors displayed on the left side of the TV picture indicate the status of the laser as described under the laser subsystem. In the acquisition modes, the T_0 and TTG indexes are not present.

b. Laser Subsystem:

(1) The laser subsystem includes a laser transmitter, laser receiver, and the laser coder control unit. The use of the laser coder control unit, laser radiated power, pulse width, and pulse repetition frequency (prf) are presented in TO 1F-4E-34-1-1-1. The system provides a means of pinpointing a target for laser-guided ordnance, using coherent laser radiation. The narrow radiation beam width and spectral purity enable the laser designator to illuminate the target with high-intensity invisible radiation. Laser guided weapons "home" on the point of reflected laser radiation.

(2) The laser transmitter produces a narrow beam of pulsed laser energy. The pulses are used to measure slant range. The laser pulses are produced in the transmitter by a xenon flashlamp which serves as the pump source for the laser rod.

(3) The laser receiver detects each laser pulse reflected from the target and sends an amplified signal to the range circuits in the laser control electronics. The range circuits provide accurate range to the last target detected in the range window. The range window is set to accept only targets within the range of interest (refer to TO 1F-4E-34-1-1-1). This laser derived slant range is compared with a computed slant range derived from aircraft system inputs. The laser range is rejected if it appears invalid. The WSO can override this rejection by momentarily depressing the REJOVRD button.

(4) The operating status of the laser system is indicated on the TV display. See Section III B: Controls, Indicators, Displays, Symbology.

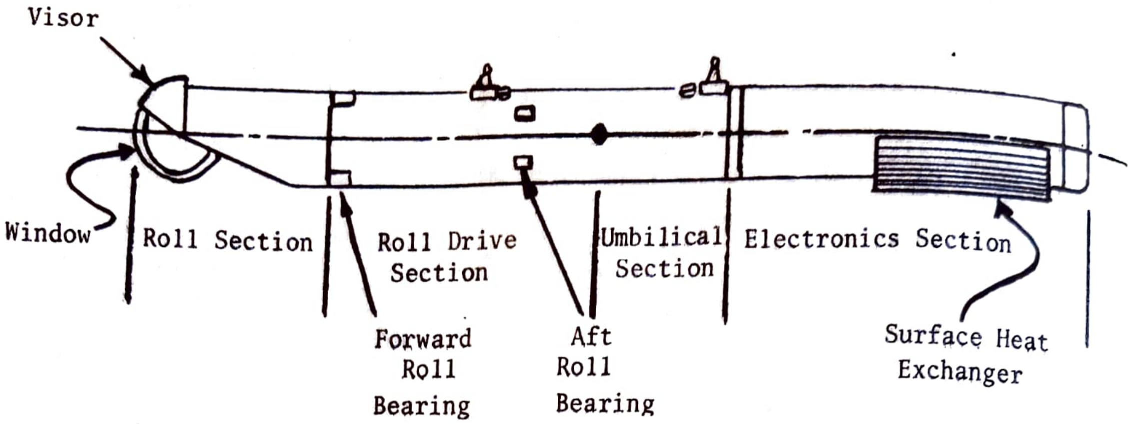


Figure 9, Pod Structure

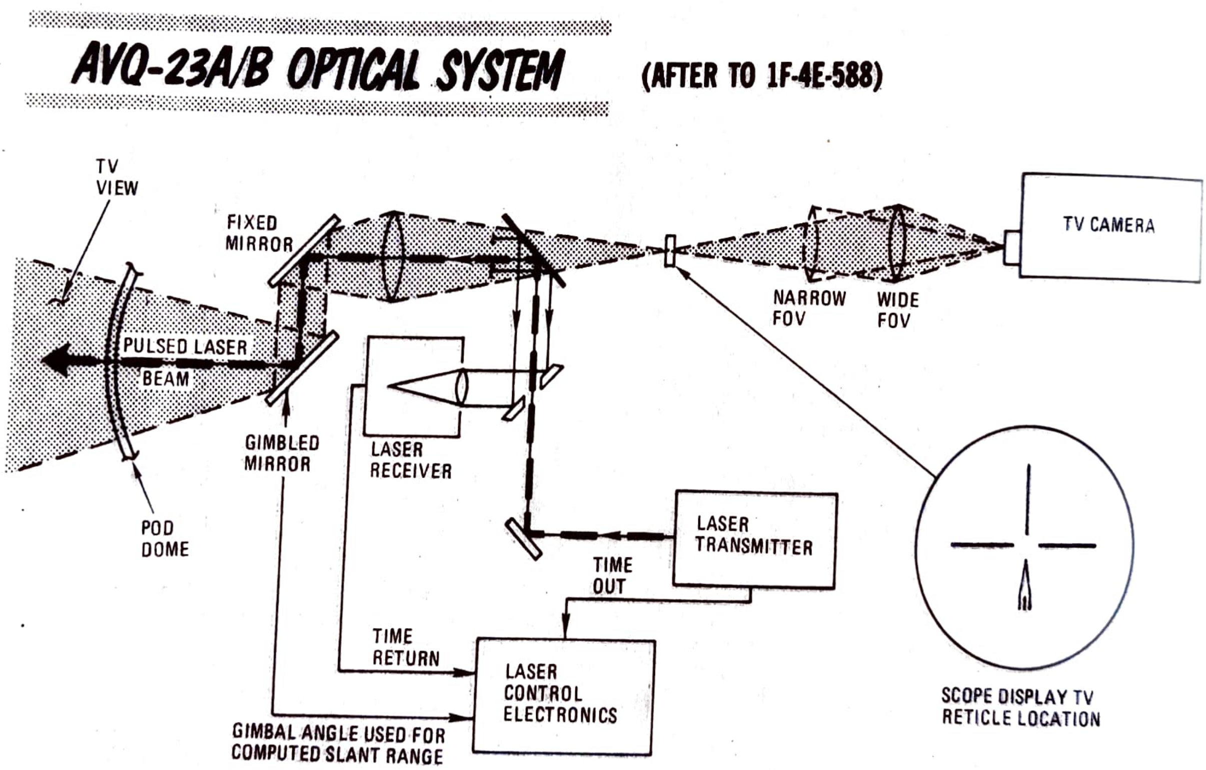


Figure 10, Optical Subsystem

(5) Laser transmitter cooling is accomplished by circulating a coolant (fluro-carbon mixture) through cavities around the flashlamp and laser rod. The heat generated by the laser transmitter is passed to a heat exchanger in the pod nose section. A flow switch in the coolant line protects the transmitter if the coolant is not flowing.

c. Optical Subsystem: The optical subsystem consists of a composite optics assembly, pod dome, folding mirror, and gimbaled mirror (Figure 10). The composite optics assembly includes lens assemblies, dichroic beam splitter, filter wheel, narrow FOV and wide FOV relay optics, fiducial marks (tracking gate), and laser/TV boresight adjustments. The TV LOS and laser LOS are boresighted together and pointed via the gyrostabilized gimbaled mirror. The TV and laser boresight alignments are accomplished in the maintenance shop. For boresighting the laser and TV together, the laser transmitter lens in the composite optics assembly is adjustable in two perpendicular axes. After the pod is mounted to the aircraft, the TV LOS is boresighted parallel with the aircraft datum line by electrical adjustments on the target designator set control. Other characteristics of the optical subsystem include the following:

(1) A glass dome protected by a mechanical visor when in the stowed position.

(2) Gimbaled mirror azimuth coverage of $\pm 15^{\circ}$ (extended by pod roll control loop) and elevation coverage of $+15^{\circ}$ to -160°.

(3) Filter wheel position controlled ALC circuits in TV subsystem (the filter wheel is driven to maximum density when the pod is turned off).

(4) Composite optics assembly pressurized with dry nitrogen to protect optical surface.

d.. Stabilization and Beam Pointing Subsystem. The stabilization and beam pointing subsystem includes the two-axis gimbal, roll drive assembly, servo electronics, and part of the electronics interface unit. Inputs to the stabilization and beam pointing subsystem are provided by the INS, the WRCS, and the antenna control handle. All pointing commands are provided via the electronics interface unit. The two-axis gimbal and roll drive assembly constitute a three-axis gimbal arrangement. The stabilization function is provided by the inner rate loops associated with the azimuth and elevation axes on the two-axis gimbal. These axes are gyrostabilized. Azimuth coverage by the two-axis gimbal is limited to $\pm 15^{\circ}$; however, coarse pointing is provided by the roll drive assembly (outer axis roll loop) to extend the coverage. The pod roll gimbal coverage is from $+110^{\circ}$ to -160° (Figure 8). Azimuth and elevation range commands (track mode), azimuth and elevation position error commands (acquisition modes), and roll error commands from the electronics interface unit are applied to the servo electronics unit. The derotation loop senses the position of the elevation gimbal, and the derotation circuits in the servo electronics unit apply drive to the motor in the derotation drive assembly. This causes the TV camera to be physically rotated in the proper direction to offset the picture rotation caused by movement of the elevation gimbal. Synchros are associated with the two-axis gimbal, roll drive assembly, and derotation drive assembly. These synchros provide position signals to the control circuits. The pointing direction is positioned via the stabilization and beam pointing subsystem by the hand control, optical sight, radar set or WRCS, depending on the mode of operation.

e. Interface Electronics Subsystem: The units in this functional group include the electronics interface unit, the pod control unit, and the low-voltage power supply. The electronics interface unit provides the required interface functions between the pod-mounted equipment and the aircraft subsystems. The pod control unit provides the necessary isolation between pod input signals and their destinations within the pod. This minimizes the possibility of noise or transients causing unwanted switching or triggering of logic circuits in the pod. The low-voltage power supply generates all regulated direct current voltages required by the units within the pod.

f. Pod Environmental Control Subsystem:

(1) During a normal mission, the pod is subjected to extreme cold when the aircraft is flying at high altitude, but at low altitude for an attack, the pod skin temperature rises rapidly (approximately 180°F). The function of the pod environmental control subsystem is to enable the pod to operate under these temperature extremes. Pod environmental control is accomplished by the following:

(a) An integral cold plate assembly containing the primary coolant (Coolanol 20) and phase change material (PCM) for heat storage during high-speed dashes.

(b) A surface heat exchanger on the aft section of the pod exterior skin for dissipation of heat (via Coolanol 20) to outside air.

(c) A dry nitrogen, pressurized nose compartment and nose heat exchanger for humidity and temperature control of the optics and sensors.

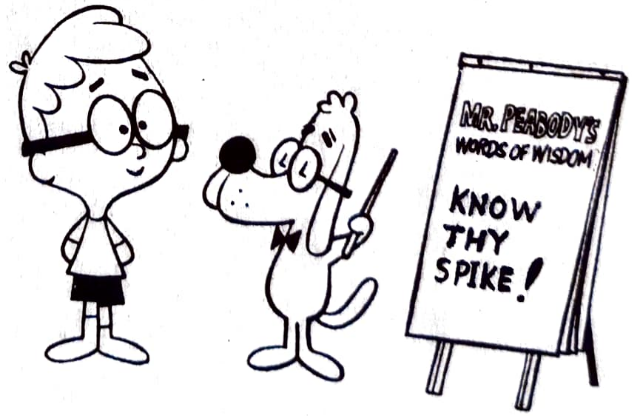
(d) A laser cooling loop which contains a flurocarbon mixture, FC-104. The FC-104 dissipates the heat generated by the laser transmitter in the nose heat exchanger.

(e) A visor heater to minimize icing in the visor/dome area.

(f) Accessories and controls for maintaining the temperature within the design limits.

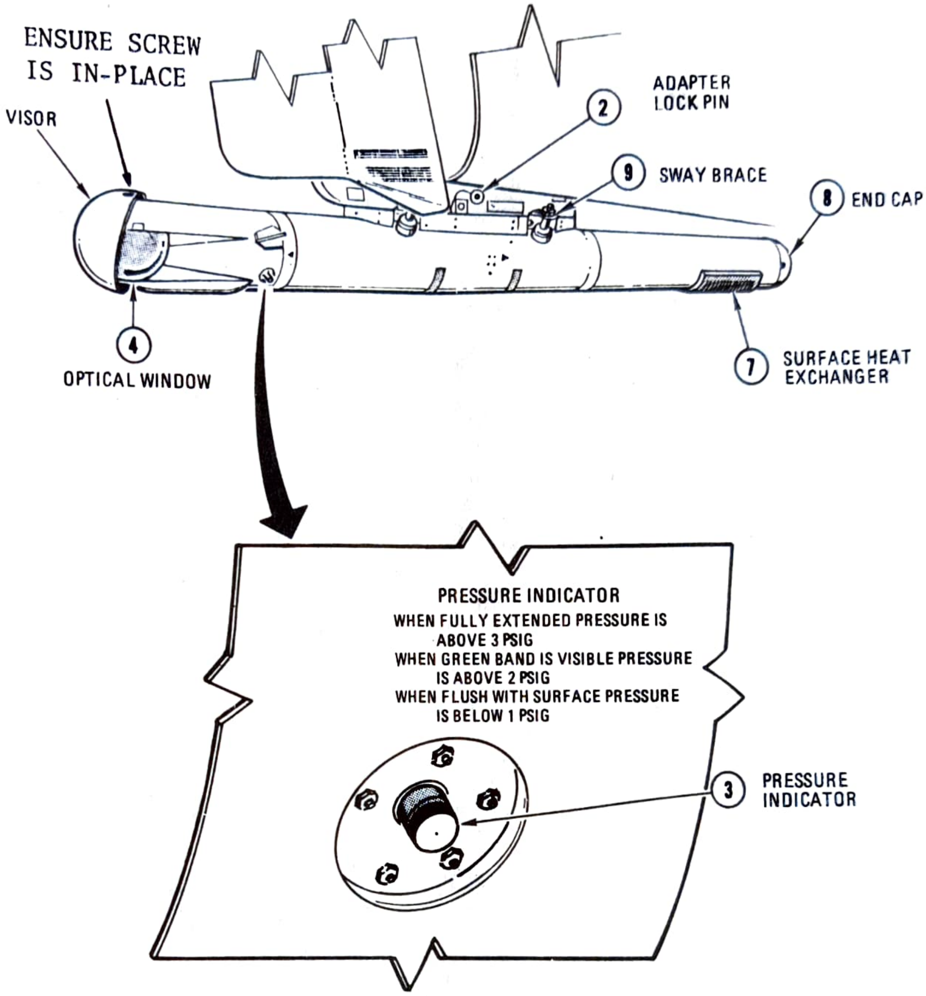
(2) The electronic units in the aft pod section are mounted on the integral cold plate assembly. Heat generated by these units is transferred to the Coolanol 20. The Coolanol 20 is pumped through the nose heat exchanger where laser transmitter heat dissipated in the FC-104 is transferred to the Coolanol. The heat in the Coolanol is then dissipated in the outside air or in the PCM in the cold plate.

3. PAVE SPIKE POD PREFLIGHT (See Figure 11):



EXTERIOR INSPECTION

AN/AVQ-23 TARGET DESIGNATOR POD



1. Boarding steps - RETRACTED

CAUTION

Do not use retractable boarding steps. Damage to the pod can result.

2. Missile well adapters look pin - INSTALLED

Note

The lock pin may be safetywired and remains installed in flight.

3. Pressure indicator - EXTENDED
4. Optical window - CLEAR; NO NICKS
5. Nose section - NO DAMAGE; SECURE & ROTATES FREELY, DETENT
6. Dome heater wire cable - NO DAMAGE
7. Surface heat exchanger - NO DAMAGED FINS
8. End cap - SECURE
9. Swaybraces - TIGHTENED; POD SECURE

Figure 11, PAVE SPIKE Pod Preflight

EO TARGET DESIGNATOR SYSTEM

(AFTER TO 1F-4E-588)
IN SELECTED AIRCRAFT FROM BLOCK 31 THROUGH BLOCK 48

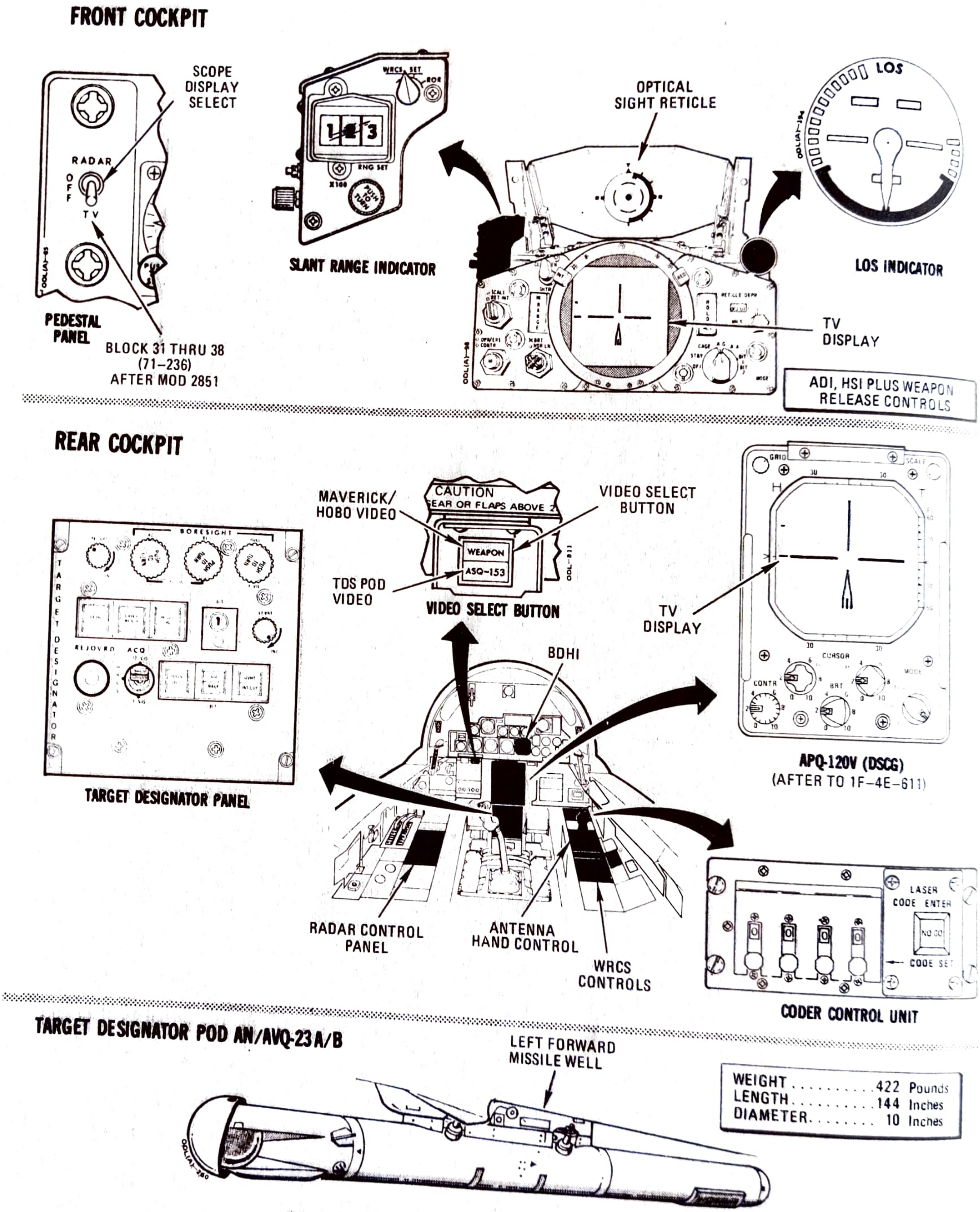


Figure 12, System Controls and Indicators

SECTION III - B

CONTROLS, INDICATORS, DISPLAYS, SYMBOLOGY

1. CONTROLS AND INDICATORS: (See Figure 12, previous page.)

a. DSCG Scope Mode Knob. The DSCG scope mode knob must be in the TV position to obtain EO or PAVE SPIKE pod video. With the radar power knob (Radar Control Panel) in STBY, only the EO weapon or PAVE SPIKE pod TV display is available (i.e., no radar display unless you select OPERATE on the radar power knob and select RDR on the DSCG scope mode knob). The RDR position is selected when the WRCS is used with the radar to perform a ROAP type of WRCS acquisition. With 1) the radar power knob in OPR, 2) the radar mode switch in MAP, 3) the radar display switch MAP PPI, and 4) the DSCG scope mode knob in RDR then radar ground mapping is available (standard switches, right!).

b. FCP Scope Display Select Switch (Pedestal Panel). The scope display select switch provides the pilot with a scope display selection: OFF, RADAR or TV independent of WSO selection. For example: with the radar power knob in OPR position, the pilot may receive the EO weapon or PAVE SPIKE TV display (depending on WSO selection on the video select button), if the pilot has TV selected, while the WSO receives a radar display with RDR selected on the DSCG scope mode knob.

c. Video Select Button (RCP). The video select button is located above the WSO's left knee and adjacent to the air-to-air button. The video select button has two positions that illuminate when selected: WEAPON on the upper half of the button and ASQ-153 on the lower half. The WEAPON position selects the TV display produced by the EO weapon aboard (such as Maverick) and selected. The ASQ-153 position selects the TV display produced by AVQ-23 target designator pod when the PAVE SPIKE system is operating. The pilot receives the TV display selected by the WSO on the video select button, providing the pilot has selected TV on the scope display select switch. The video select button also gives PAVE SPIKE use of antenna control.

d. PAVE SPIKE Control Panel (TDS Control). This panel contains the primary switches necessary to operate the PAVE SPIKE system. The panel is located in the rear cockpit below the DSCG scope and just forward of the control stick. See Figure 13.

(1) POWER-ON Button (and Light). When this two-position switch is depressed and released, 28- and 115-volt aircraft power is applied to the target designator system and the POWER ON light and the STOW Light (if pod head was stowed when power was applied) illuminate. When pressed and released to turn the system off, the POWER ON light remains on (if the pod was in the unstowed position) until the pod head is stowed, the filter wheel is in maximum density position, and the visor is closed. Power is then disconnected, and all indicator lights turn off. If the pod was stowed when the power button was positioned to off, the power is removed from the system immediately.

(2) STOW Button. This switch alternately stows and unstows the pod head. The pod head is stowed when the STOW button is illuminated. When the Stow Button is pressed and released, the pod unstows, the STOW light extinguishes, and the head rolls to the position selected by the Acquisition Switch on the PAVE SPIKE Control Panel. The next time the Stow Button is pressed and released the pod head stow sequence begins. The stow sequence includes: rolling the pod head to the stow position, positioning the filter wheel to maximum density, and positioning the visor over the optical window. The stow sequence requires approximately 5 seconds. Note that the pod head remains in the stow position (160^{0} on the LOS pointer) only while the POWER ON button is illuminated. When the POWER ON light is off, the pod head is free to rotate; but the visor and filter wheel remain stowed.

(3) LASER READY Button. This switch must be depressed and lit before the laser can be fired. The switch serves as a laser safety interlock, the LASER READY light remains off (after button depressed ON) until the fire interlocks are satisfied: nose

TARGET DESIGNATOR PANEL

(AFTER TO 1F-4E-588)

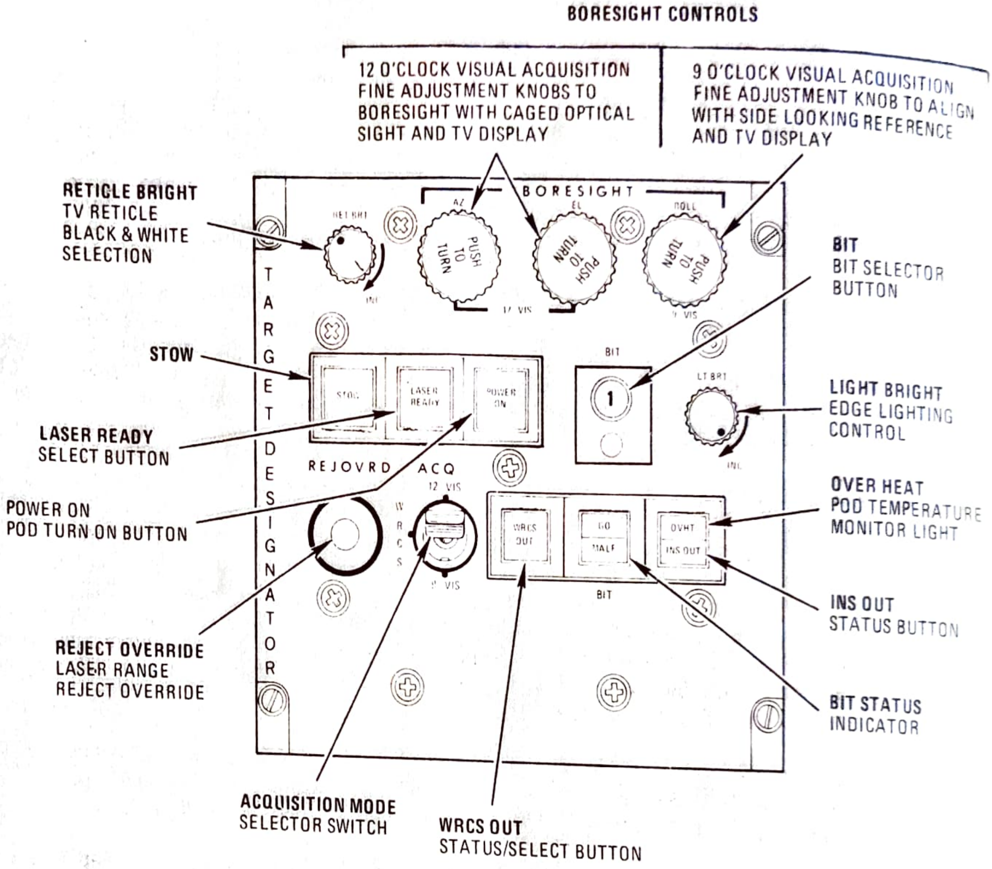


Figure 13, PAVE SPIKE Control Panel

gear UP and all laser pod systems functioning. In the maintenance shop, the nose gear interlock can be bypassed with test equipment. Depressing the illuminated LASER READY button turns off the light and disables laser fire.

(4) Acquisition (ACQ) Switch. This is a three-position switch that selects one of the following acquisition modes and positions the pod line-of-sight (LOS) to the selected position. (Assuming not in the Memory Mode.)

(a) 12-VIS. The 12-VIS (12 o'clock visual) acquisition mode slaves the pod LOS to 0^{o} azimuth, -2^{o} elevation, and 0^{o} roll (i.e., RBL). Acquisition is accomplished by using the caged gunsight pipper. When the PAVE SPIKE is integrated with the WRCS the pipper is automatically caged until after PAVE SPIKE track is achieved. After track, the pipper accepts the preset depression (sight is not drift stabilized). If WRCS is not integrated; the gunsight must be manually caged and uncaged if the pipper is to be used as a cueing reference.

(b) 9-VIS. The 9-VIS (9 o'clock visual) acquisition mode slaves the pod LOS to 90^{o} left azimuth, 0^{o} elevation, and 90^{o} roll (coincident to boresight position of the side-looking sight [if mounted]). Grease pencil reference marks on the canopy are used in lieu of a side-looking sight.

(c) WRCS. The WRCS acquisition mode slaves the pod LOS to the intersection of the WRCS cursors if the WRCS OUT light is off (i.e., WRCS is in [integrated]). If the WRCS OUT light is on (i.e., WRCS is not integrated), the 12-VIS mode is automatically selected provided that the Acquisition switch is in the WRCS position. Types of WRCS acquisition modes include Visual IP (VIP), Visual Offset Aim Point (VOAP), and Radar Offset Aim Point (ROAP).

(5) WRCS OUT Button:

(a) This switch controls and indicates the integration of the WRCS and the target designator system. When depressed, the indicator is illuminated WRCS OUT, and the WRCS and target designator system are not integrated. Automatic weapon release by the WRCS is not available for the target designator system when WRCS OUT is indicated. (An automatic release mode is still available by using the range indicator and the PAVE SPIKE-derived slant range.) Acquisition modes with WRCS OUT illuminated are limited to 12-VIS and 9-VIS.

NOTE: The WRCS out light will illuminate, and the WRCS will be deintegrated from the PAVE SPIKE regardless of the WRCS Out switch position if Target Find/LORAN Lay position or the Direct position is not selected in the front cockpit or if the Target Find Hold switch is in the HOLD position in the rear cockpit.

When pressed and released again, the indicator light turns off, and the system is again integrated with the WRCS. WRCS acquisition and track modes are now available. In the track mode, the WRCS automatic weapon release function is available, and if a gimbal limit is reached, the system switches to the WRCS memory mode.

(b) A malfunction in the WRCS or the INS illuminates the WRCS OUT light, automatically deselects the WRCS, and selects the 12-VIS acquisition mode.

(c) In the WRCS OUT mode (light on), the PAVE SPIKE system may be operated in the 12-VIS or 9-VIS acquisition modes only.

NOTE: If the acquisition mode switch is in WRCS with the WRCS OUT (light on), the pod goes to the 12-VIS acquisition mode. If gimbal bump is encountered in the track mode, the system reverts to the acquisition mode selected by the acquisition switch.

WRCS OUT Light Indications Summarized:

Light Illuminated = WRCS OUT = WRCS not integrated.

Light Not illuminated = WRCS IN = WRCS is integrated.

(6) OVHT/INS OUT Indicator and Control: This is a push-on, push-off switch/indicator which isolates the PAVE SPIKE functions from INS inputs. During normal operation, the switch is raised (not depressed and both halves of the indicator are not illuminated. In this case, the target designator system is fully integrated with the INS and can be integrated with the WRCS (WRCS OUT not illuminated). All operating modes are available when integrated with the WRCS and INS. If the INS fails, the OVHT/INS OUT switch can be depressed, the INS OUT portion of the indicator illuminates, and the pod is operated independently of the INS. The operator must use the hand control to compensate for all LOS pointing corrections (track mode). Track is further complicated by the loss of derotation of the video display. The WRCS integrated mode is automatically switched out if INS OUT is selected. The OVHT section of the switch serves only as an indicator. When OVHT illuminates, the pod temperture is too high, and the pod should be turned off until the cause is known and corrected.

(7) Boresight Controls: This is a group of three push-to-turn controls which accomplish the following:

(a) AZ establishes pod-to-aircraft azimuth boresight adjustment (used with system in 12-VIS mode) $\pm 2.5^{o}$.

(b) EL establishes pod-to-aircraft elevation boresight adjustment (used with system in 12-VIS mode) $\pm 2.5^{o}$.

(c) ROLL establishes pod roll reference to aircraft nadir (referenced to INS platform) $\pm 2.5^{o}$. Do not use this knob during 12-VIS boresight.

These knobs provide fine adjustment of the TV LOS when operating in the 12-VIS and 9-VIS acquisition modes. To reiterate, use the AZ and EL knobs for 12-VIS boresight. Roll may be used to aid in 9-VIS boresight, but is not recommended. DO NOT use AZ and EL knobs for a 9-VIS boresight. If you do, you will destroy your 12-VIS boresight.

(8) REJOVRD Button: This momentary push-button switch is used only in the track mode and when the laser is firing. If the laser range is invalid (the dot part of the laser status symbol flashes at 2 Hz as viewed on display), the laser range is rejected by the pod, and computed range is used instead. Laser range can be accepted by pressing the REJOVRD switch. In BIT 3, the laser transmitter is fired by pressing this switch.

(9) BIT Switch: The normal operating position of this switch is BIT 1 (i.e., one (1) showing in the window). This is a push button-operated, five-position (BIT Ø to BIT 4) switch. Each time the pushbutton is pressed, the switch advances one step. When BIT position 4 is reached, the next time the pushbutton is pressed, the switch rotates to position Ø. The BITS are described in Section III C.

(10) GO/MALF Indicator: This indicator is used in conjunction with the BIT switch. In BIT 0, both sections illuminate. When in BIT 1, GO is inhibited at all times. MALF illuminates in BIT positions 1 through 4 when a circuit failure occurs in the selected position.

(11) RET BRT Control: This control adjusts the contrast of the TV reticle from black (fully CCW) to white (fully CW).

(12) LT BRT Control: This control adjusts edge lighting of the pod control panel. Clockwise rotation increases light intensity. The LT BRT knob is not functional in BIT Ø.

e. Slant Range Indicator (SRI): See Figure 14. The SRI is located on the left side of the FCP above the glare shield and is functional when the pod is turned on. The indicator provides a three-digit readout of the slant range (X100 feet) to designated target.

(1) Test Control. When pressed, this control energizes all seven segments of each digit of the three-digit X100 display. The display then indicates 888. If any part of an 8 is missing, the readout unit is defective and must be replaced.

(2) BRT Control. This control adjusts the intensity of the readout.

(3) RNG SET Control. This is a push-to-turn control that is used to preset and store in the range indicator the desired release range for automatic weapon delivery in the release on range (ROR) mode.

(4) Mode Switch. This three-position switch is used for automatic weapons delivery as described below.

(a) WRCS. In this position, the weapon release computer set generates a release signal when the weapons delivery problem is solved if the WPN REL switch is turned to the Target Find/LORAN Lay position. This position is effective only when the target designation system is in the track mode and integrated with the WRCS (WRCS out light not illuminated). WRCS must be selected for WRCS (SPIKE) Toss or WRCS Loft.

(b) SET. When the mode switch is in this position, the RNG SET control can be used to preset the desired weapon release range-to-target when the automatic ROR mode is selected for weapon release. Clockwise rotation of RNG SET increases the readout on the three-digit range display. Any time SET is selected, the preset range is displayed.

(c) ROR. In this position, the range indicator generates a weapon release signal when the range to target is equal to or less than the range preset by the RNG SET control if the WPN REL switch is turned to the target find/LORAN lay position and the pickle button is depressed. A release signal is generated in the track mode only.

(5) X100 Display. The three seven-segment units in this direct readout display indicate the range to target (X100) in feet or, for the ROR mode, indicate the preset range for weapon release (mode switch at SET).

f. Azimuth-Elevation Indicator (LOS): See Figure 15. This indicator provides the pilot with a display of the pod LOS position relative to the aircraft obscuration limits. The relative pod LOS is affected by both the target position relative to the aircraft and the attitude of the aircraft; consequently, the pilot must consider both of these parameters when interpreting the information displayed.

(1) Dial Pointer (Head Roll): The pointer rotates in step with and in the direction of pod roll. The pointer is pointing straight down when the pod LOS is dead ahead with zero pod roll. The pointer position provides the pilot with pod roll data and, in conjunction with three flags, indicates the degree of obscurity that can occur unless the aircraft is maneuvered toward a more favorable position with respect to the target. When pod gimbal angle is no greater than 120° aft, no flags show. The flag area is blank, and those flight limitations imposed on the pilot to avoid obscurity in the pod LOS are the basic pod roll and positive gimbal angle limits. (This is recognized by the broken-line area of the dial.)

(2) Flag Indications.

(a) Green flag. The LOS will remain unobscured as long as the pointer is within the solid green area of the dial (70° right and 60° left). Pod gimbal is between -120° and -155°.

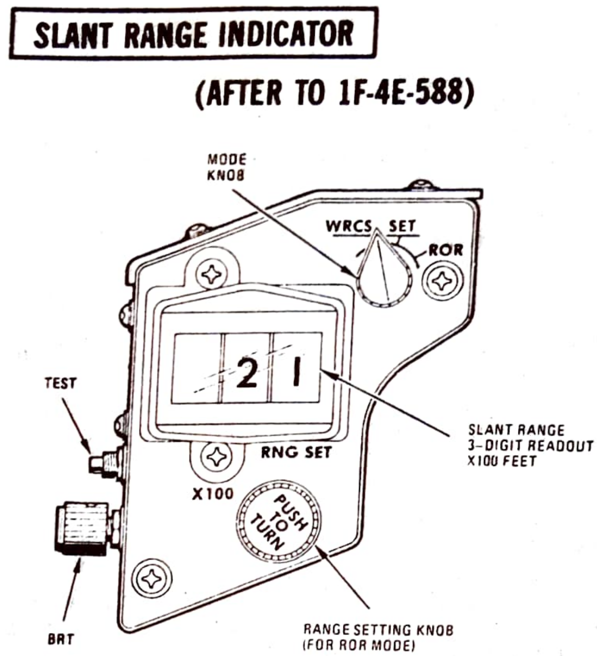


Figure 14, Slant Range Indicator (SRI)

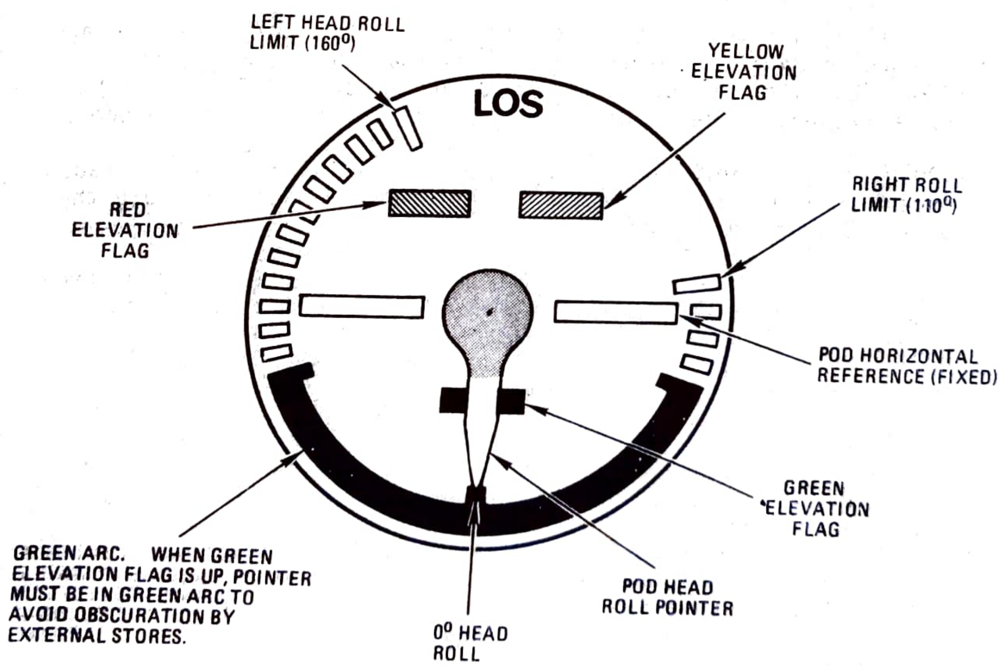


Figure 15, Azimuth-Elevation (LOS) Indicator

(b) Yellow flag. This flag warns that the elevation limit is 5° from present position. (Gimbal angle is -155°.)

(c) Red flag. This flag indicates that the gimbal limit of -160° has been reached, and the LOS is more than 50 percent obscured. Loss of track occurs when the limit is reached. The system enters memory mode if WRCS is integrated (WRCS OUT light not illuminated). Aircraft must be maneuvered to a more favorable position with respect to the target before the WSO can reacquire the target and resume track. If WRCS OUT is illuminated, the system returns to the selected acquisition mode.

g. Antenna Hand Control: See Figure 16. The radar hand control is used to track the target and fire the laser. The magnitude of the corrective rate commands generated by the hand control is proportional to the amount of displacement of the control from the centered position. Forward and aft movement changes the elevation angle of pod FOV, and left/right changes the pod azimuth angle (track mode only).

(1) FOV Button (same as APX interrogate button). This alternates between WFOV and NFOV each time the switch is pressed. When the target designator system, is unstowed, WFOV is automatically selected until the FOV switch is pressed.

(2) Trigger Switch. This switch has three positions: fully released, pressed to the first detent, and pressed to the second detent. The functions are as follows:

(a) First detent (half action). When the switch is in this position, it selects between track and acquisition modes. Any time the system is unstowed, it is in the acquisition mode. When the trigger switch is pressed to the first detent (half action) and released, the system switches from acquisition to track. The next time the switch is pressed to half action and released, the system switches to the acquisition mode selected on the set control. Half action thus alternately switches between acquisition and track modes.

(b) Second detent (full action). This position of the trigger switch fires the laser if all interlocks are closed. If the system was in acquisition and the trigger switch is pressed to full action and released, the system is switched to track, and the laser fires. When the switch is pressed to full action and released a second time, the laser stops firing, but track mode is maintained. To place the system in the selected acquisition mode, the trigger switch must be pressed to half action and released. Any time the system is in an acquisition mode, the laser will not fire.

h. Coder Control Unit (CCU): See Figure 17.

(1) The code is set in the panel with four numbers, each of which is adjusted with a pushbutton-operated switch. Each time the pushbutton is depressed, the affected number increases in value by one. When the PAVE SPIKE is initially turned on, the code set in the panel is inserted into the laser control unit. Any subsequent code changes must be set on the code panel, and the enter button depressed and released. If the code set on the control panel is not within the capability of the code PC board installed in the pod, the insert button will light and indicate NO GO. With no code board installed in the pod, the insert button will indicate NO GO any time power is on, and the laser will be uncoded.

(2) To enter code accomplish the following:

(a) CCU-PRESET DESIRED CODE (1688 for non-coded use).

(b) Laser code enter button - PRESS AND RELEASE.

(c) NO GO light illuminates for ½ second then remains OFF.

ANTENNA HAND CONTROL

(AFTER TO 1F-4E-588)

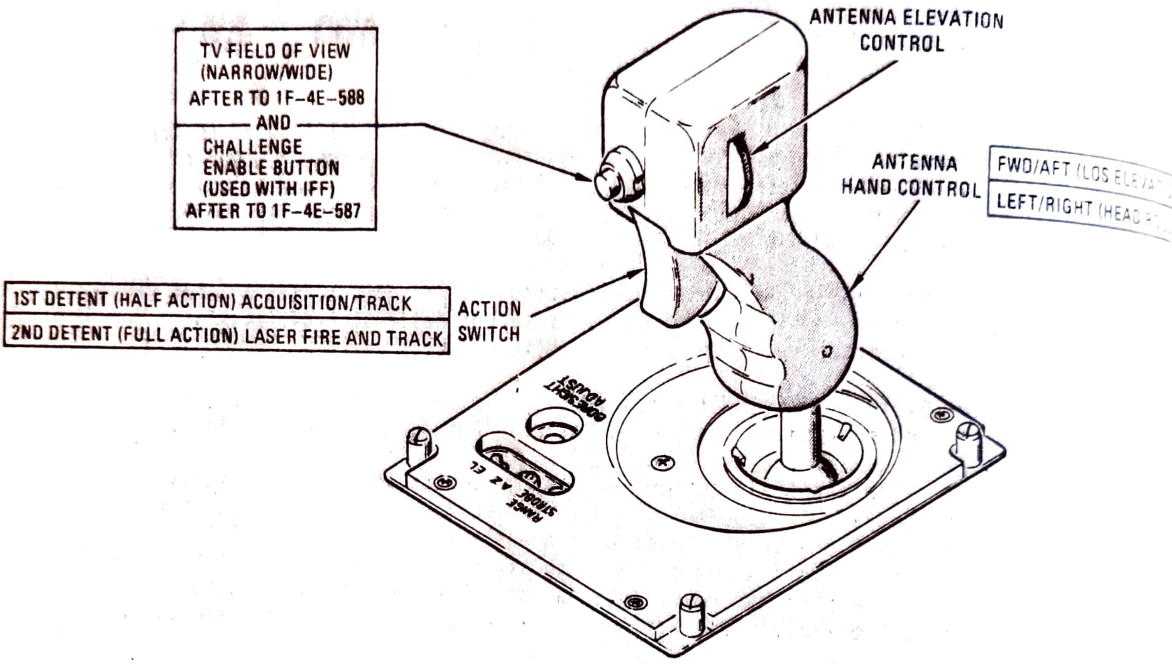


Figure 16, Antenna Hand Control

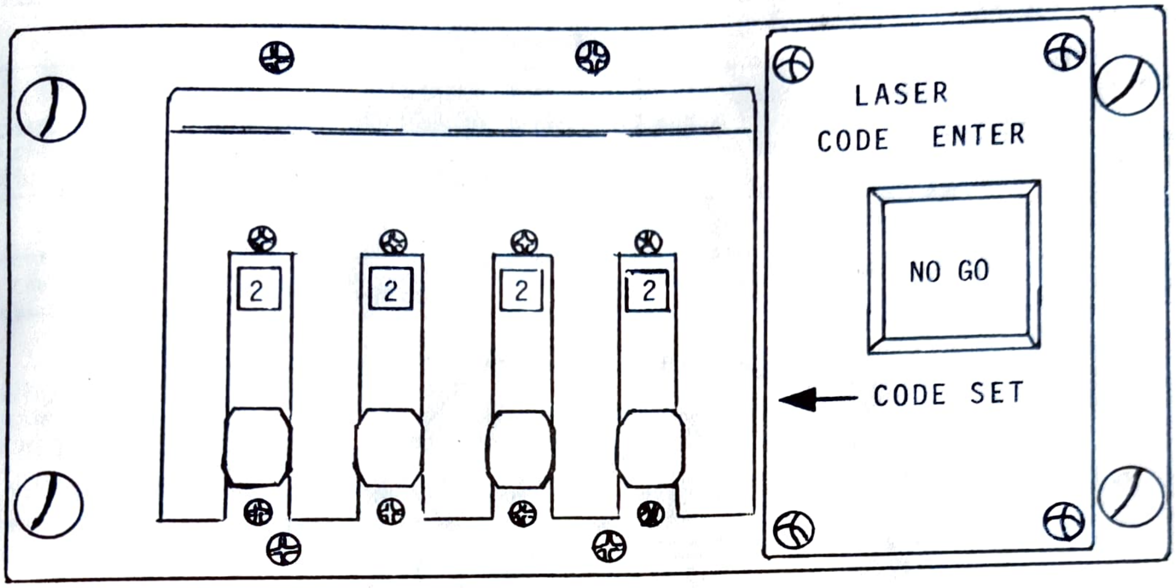


Figure 17, Coder Control Unit

INDICATION		STATUS
TIME TO GO CUE (TT_G)	RELEASE CUE (T_0)	ACQUISITION/TRACK MODE SELECTED AND LASER OPERATING STATUS.
REMOVED	REMOVED	ACQUISITION OR MEMORY MODE SELECTED.
STEADY	STEADY	LASER FIRED, LASER RANGE ACCEPTANCE.
2Hz FLASHING	STEADY	LASER FIRED LASER RANGE NOT ACCEPTED
5Hz FLASHING	STEADY	ATTEMPTED LASER FIRE, NO OR LOW LASER ENERGY.
5Hz FLASHING	5Hz FLASHING	TRACK MODE SELECTED, NO LASER FIRE ATTEMPT.

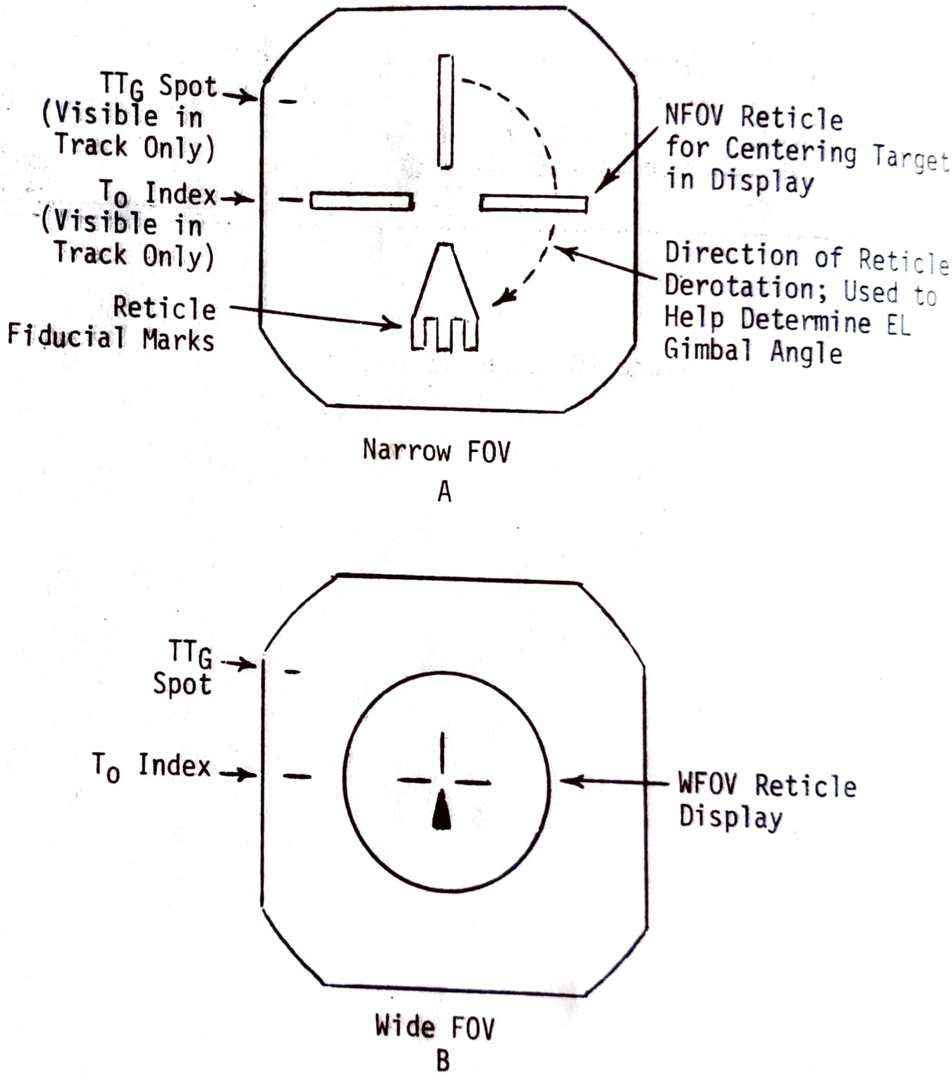


Figure 18, TV Displays and Symbology

i. TV Display and Symbology: See Figure 18.

(1) Reticle (Narrow FOV [NFOV]). In NFOV the scene and reticle are magnified considerably. The reticle consists of three bars and a resolution wedge. The functions of the reticle consists of three bars and a resolution wedge. The functions of the reticle are as follows:

(a) The projected center of the reticle is the center of the pod LOS. This is the reference for target tracking and the boresight position of the laser. The gap in the center of the reticle closely approximates the area on the target covered by the laser spot.

(b) The reticle is oriented so that the wedge is at the bottom of the display and is vertical when the elevation angle is 0^o. The entire reticle rotates clockwise as the elevation angle is depressed. At -90^o pod LOS elevation depression the wedge has rotated clockwise to the left side of the display (9 o'clock).

(2) Reticle (Wide FOV [WFOV]). WFOV covers a much greater area in the televised scene. The circle appears around the center of the display when WFOV is selected. If the target is in the circle, it will appear on the display when NFOV is selected.

(3) Time-To-Go (TTG) Spot, Time Zero (T_0) Index Line. These symbols (1) indicate the time-to-go for weapons release, (2) provide an indication of laser status, and (3) continuously indicate mode of operation. When the track mode is entered, these symbols are displayed in the left side of the scene. The functions of these symbols are as follows:

(a) When integrated with the WRCS and a WRCS delivery mode is selected, the TTG spot appears initially above the T_0 line and moves downward toward the T_0 index line as the aircraft range to target decreases. The automatic weapon delivery signal is generated when the spot reaches the line. In this mode, the TTG spot position indicates the time for weapon release. The point in the delivery maneuver where the TTG spot intersects the T_0 line is controlled by the drag coefficient set on the WRCS control panel. If the WRCS is not used for the weapon release solution and the drag coefficient is not adjusted for the release conditions, the TTG spot does not accurately depict the time for weapon release. If the system is not integrated with the WRCS, the TTG spot remains stationary just above the T_0 index line.

(b) The TTG dot and T_0 line also provide an indication of laser status as follows:

1. Dot and Line removed (not displayed) - The system is not in a track mode. The system is either in an acquisition mode or memory mode.

2. Dot and Line both steady - Laser fire and laser range acceptance is normal. This is the normal display after you fire a good laser (full-action on the antenna hand control).

3. Dot flashing at 2 Hz; Line steady - Laser ranging not accepted/valid. Laser has fired.

4. Dot flashing at 5 Hz; Line steady - Laser has fired but there is no laser energy or low laser energy.

5. Dot and Line both flashing at 5 Hz - System is in track mode and the laser is not firing. This should be the normal display after you take track (half-action on antenna hand control).

Not too long ago,
in a swamp
far, far away...

SECTION III - C

BIT CHECKS

1. Following is a description of the PAVE SPIKE BIT checks.

a. BIT 0 - Lamp Test: All lights on the PAVE SPIKE control panel illuminate for identification of defective lights.

b. BIT 1 - System Status Test: BIT switch must be in this position during normal operation of the system. The GO indicator is inoperative in BIT 1. The low-voltage power supply, laser triggers, servo loop, and TV sensor are continuously monitored without interfering with target designator system operation. A failure of any of the monitored parameters causes the MALF indicator to illuminate.

c. BIT 2 - Servo Dynamic Track and TV Performance: To accomplish BIT 2 the aircraft must be stationary and the system must be in 12-VIS. The test starts when BIT 2 is selected, and in about 15 seconds either MALF or GO will illuminate. This indicates the status of the servo system. TV performance is evaluated by the operator. The filter wheel is driven to maximum density, and the TV scene should dim.

d. BIT 3 - Laser Test:

WARNING

Ensure ground crew is clear of the pod while performing BIT 3.

When BIT 3 is selected, the laser systems are monitored, and the elevation gimbal is driven to the laser test position (to reflect laser energy from a black diffused surface). This is indicated by TV reticle rotation of 180°. A GO or MALF lights immediately. An immediate GO indicates the system is normal. The operator then depresses and holds the REJOVRD button to fire the laser and the GO turns off. After about 5 seconds either the MALF or GO indicator illuminates to indicate the status of the laser transmitter.

e. BIT 4 - Laser Slant Ranging: This BIT checks the laser receiver and ranging circuits. The SRI should indicate Ø21±2. A GO or MALF in 4-15 seconds indicates the status of the circuit operation.

TDS BIT FAULT ANALYSIS

Step	Problem	Additional Tests	Status
BIT 0	All indicators do not illuminate.		Mission may be flown with burned out lamps.
BIT 1	MALF light ON.	Press WRCS OUT button to light.	If MALF light goes out when WRCS OUT light illuminates, operate TDS without WRCS. If MALF light remains ON, mission should not be flown until problem is corrected.
BIT 2	MALF light ON.		Mission may be flown. TDS track mode may be severely degraded.
	TV scene does not dim.		Filter wheel malfunction. TV scene may washout in extreme high light level areas.
BIT 3	MALF light ON immediately.		No laser fire capability.
BIT 4	MALF light ON.	Check slant range indicator readout.	If a MALF appears, or if SRI does not read 021+002, ranging capability may be degraded. Perform inflight check of system operation.

NOTES

SECTION III - D

SYSTEM INTERFACE

1. The PAVE SPIKE pod is normally interfaced with the aircraft INS and WRCS. When fully integrated, all cockpit WRCS/INS indications are the same as in non-PAVE SPIKE operation, except, after PAVE SPIKE track is taken, off flags cover all distance measuring equipment (DME) windows. After track, the only range available is from the PAVE SPIKE slant range indicator. See Figures 19, 20, and 21.

a. When in the memory mode, cockpit DME and bearing readouts are coincident with the PAVE SPIKE pod LOS.

(1) The memory mode can be achieved by encountering a gimbal limit or depressing target insert on the cursor control when in track or depressing target insert when the WRCS acquire position is selected on the target designator set control.

(2) When memory operation is achieved through use of the target insert button, any offset values set in the WRCS control panel will be applied to the PAVE SPIKE LOS and the DME and bearing readings.

b. In addition to the normal WRCS indications, the attitude director indicator (ADI) horizontal bar will provide the same weapon release time information to the aircraft commander that is provided by the TTG dot on the video display. The bar moves up the ADI, and when the bar reaches the center of the ADI, the WRCS release solution occurs.

c. To achieve angular motion coordinate transformation, the interface electronics subsystem uses aircraft roll, pitch, and heading angles: and PAVE SPIKE pod azimuth and elevation gimbal angles and pod nose roll angle. Input output interface signals are as follows:

(1) From the INS--aircraft velocity, altitude, and attitude.

(2) From the WRCS--range, offset, time-to-release, and target altitude.

(3) From the electronics interface unit--target altitude (WRCS out operation).

(4) From the hand control--angular velocity commands.

(5) From the electro-optical head--gimbal angles.

(6) From the laser control electronics--laser, or computed slant range (as applicable).

(7) From the set control--mode and control commands, boresight information, and BIT checks.

(8) To azimuth, elevation, and nose roll servos--computer error signals.

(9) To azimuth and elevation gimbal servos--angular rate adding commands.

(10) To the LOS indicator--elevation gimbal position and pod head roll angle.

(11) To the range indicator--filtered slant range.

(12) To the WRCS--filtered slant range, laser-derived altitude (when applicable),

(13) To the ADI, TV, and optical sight--scaled time-to-release signal from WRCS.

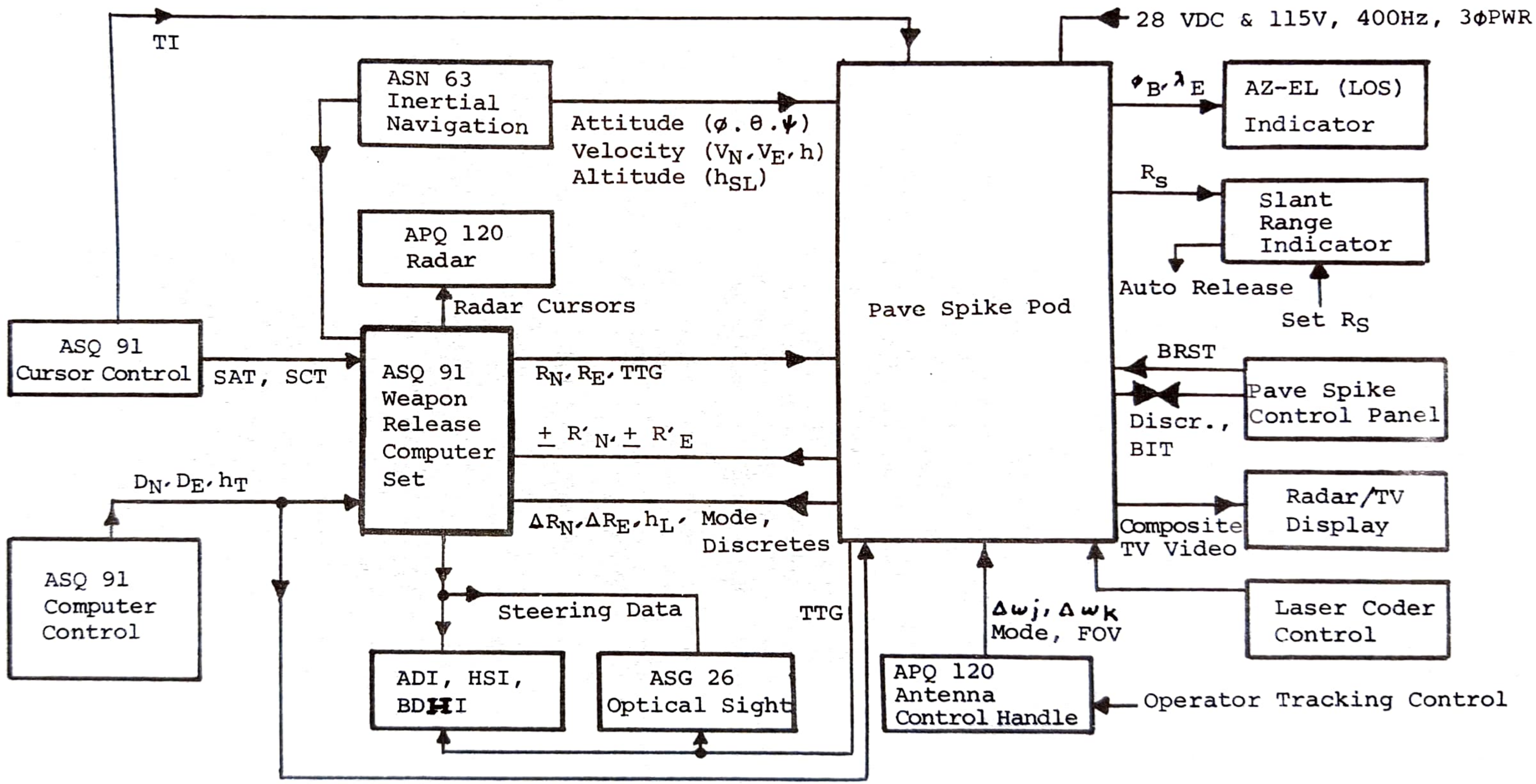


Figure 19, PAVE SPIKE F-4E Interface

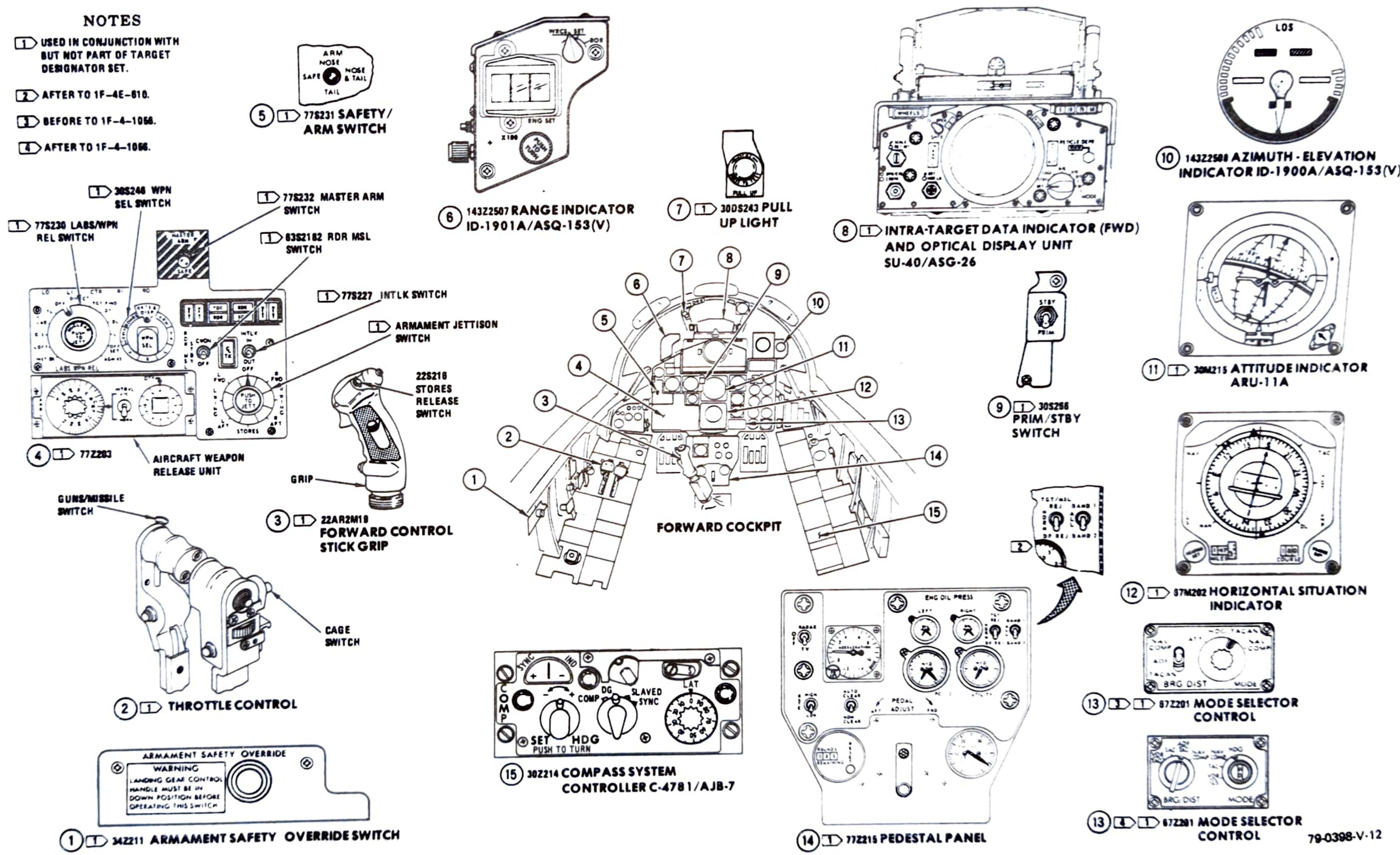


Figure 20, Front Cockpit Associated Equipment

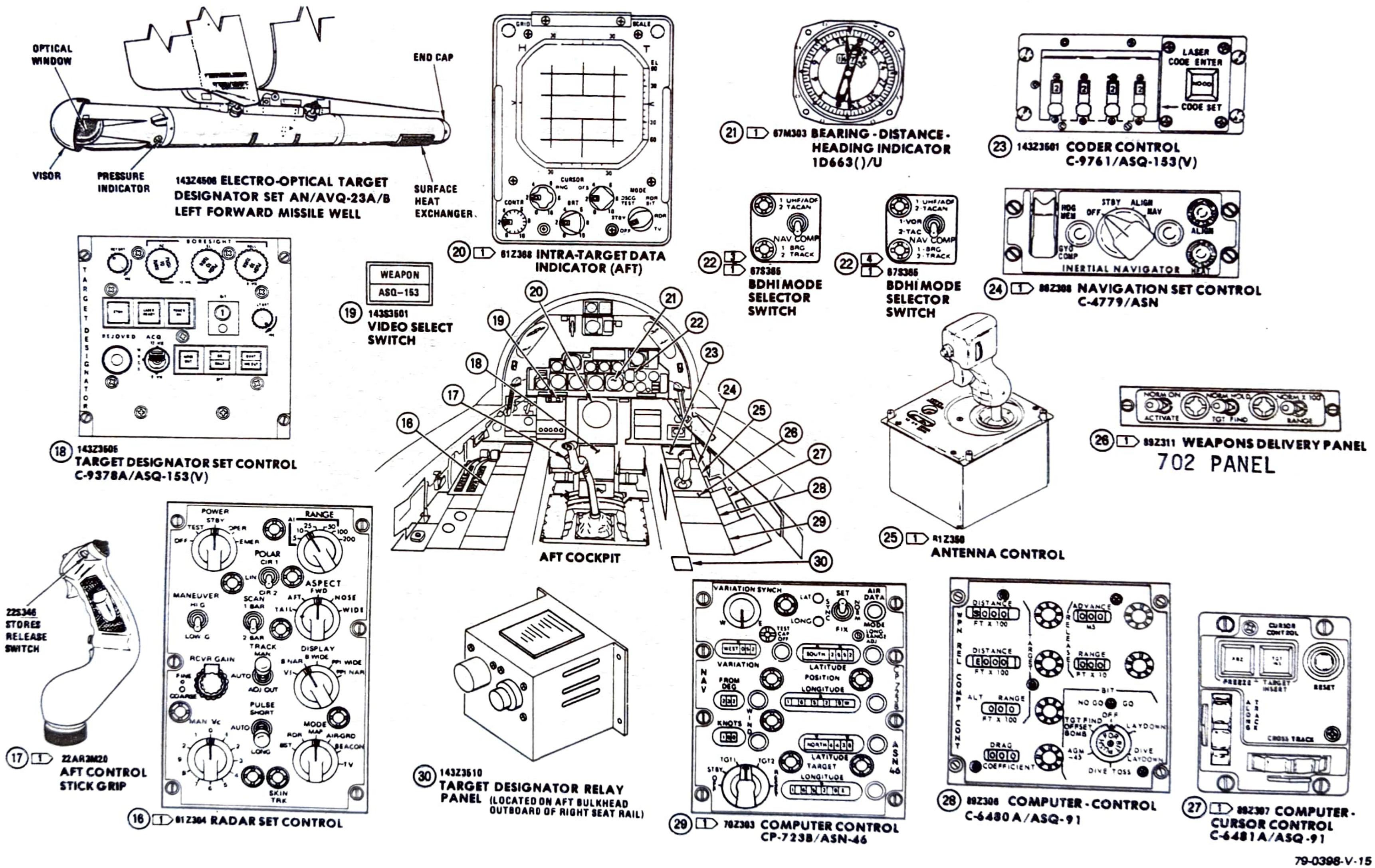


Figure 21, Rear Cockpit Associated Equipment

2. In the track mode, the roll tabs provide steering information to the target. The position of the roll tabs, with respect to the fixed index tabs, indicates the angle between the ground track and course to the target. In the WRCS acquisition mode, the steering information is provided in reference to the Radar/WRCS cursor position. In the TRACK mode, the range bar is utilized to indicate time-to-go (TTG) to weapon release.

3. ADI. In the track mode, the ADI also provides TTG information and steering commands to the target (or IP). The bank steering bar is utilized for steering commands. The displacement of the bank steering bar from the zero position indicates the angle between ground track and course to the target (or IP). The horizontal bar displays TTG with maximum TTG indicated by full down deflection of the bar and weapon release (TTG = 0), when the bar reaches the center of the display.

4. HSI and BDHI. In the track mode, the HSI and BDHI indications are identical to those for a normal WRCS target except that ground range is not displayed. Ground range is displayed on the DME dials when the system is in memory mode in order to enable the aircrew to more easily reacquire the target.

WRCS MANUAL INPUTS

(AFTER TO 1F-4E-588)

DELIVERY MODE	TARGET – FT X 100				DRAG COEF-FICIENT	RELEASE	
	N/S DIST	E/W DIST	ALT	RANGE		ADVANCE MILLI-SECOND	RANGE FT X 10 FT X 100
MAX SET	999	999	100	249	9.99	999	999
DIVE TOSS					X	X	
DIVE LAY						X	X
LAYDOWN				X		X	X
OFFSET BOMB	X	X	X			X	X
AGM-45			X			X	
TGT FIND/ LABS *	X	X	X			X	X
TGT FIND/ WRCS **	X	X	X		X	X	

*TARGET FIND SWITCH IN HOLD AND LABS DELIVERY MODE SELECTED.

**TARGET FIND SWITCH IN NORM, SLANT RANGE INDICATOR MODE KNOB IN WRCS AND TGT FIND DELIVERY MODE SELECTED.

Meanwhile, back at the swamp...

SECTION III - E

OPERATING MODES

1. PAVE SPIKE operation can be one of the most demanding tasks facing aircrews. Low altitude operations in high threat environments task both crewmembers to the maximum. It is mandatory that the aircrew break the required tasks down to their simplest form and thoroughly understand system operation. System proficiency, without reference to checklists, is required before the crew can use the full potential of the pod.

2. The three operating modes are:

a. Acquisition Modes

b. Tracking Mode, and

c. Memory Mode

3. ACQUISITION MODES: The three types of acquisition modes are 12-VIS, 9-VIS, and WRCS acquire. See figure 22.

a. 12-VIS. This is the simplest acquisition mode available and certainly the most reliable. The LOS of the pod is aligned to parallel the radar boreline (35 mil pipper) to enable visual acquisition of the target. Because of the simplicity and reliability of the 12-VIS mode, it should always be planned as a backup when other modes are primary. The optical sight is not drift stabilized.

(1) Switchology. To place the pod in 12-VIS, the acquisition switch on the TDS need only be moved to the 12-VIS position.

NOTE: The acquisition switch on the TDS control panel will command the pod to the selected position only if the pod is already in one of the Acquisition modes. If the pod is in Memory or the Track mode, the acquisition switch may be flipped continuously and the pod will stay in the Memory or Track. To return the pod to 12-VIS from Memory or Track, the acquisition switch must be placed to 12-VIS and then another switch action is required to "spur" the pod to 12-VIS. However, if the pod is in 9-VIS or WRCS ACQ, movement of the acquisition switch to 12-VIS will command the pod there.

In the front seat the sight mode knob may be placed to CAGE or A/G (WRCS in) to position the pipper to 35 mils. When the WRCS is integrated with the pod (WRCS OUT, light not illuminated), a holding relay positions the pipper to 35 mils when the pod is in an acquisition mode regardless of the setting in the sight depression window.

(a) WRCS OUT. When the WRCS OUT light is illuminated (WRCS not integrated), PAVE SPIKE operation is the same as WRCS In, except when the Acquisition switch is positioned to WRCS ACQ, then the pod will automatically position to 12-VIS, since WRCS Acquisition is impossible without integration. In the front seat, the sight mode knob must be positioned to CAGE or 35 mils dialed into the depression window since the WRCS holding relay is removed.

(b) INS OUT. If the INS OUT button is depressed and the light illuminated, WRCS OUT is automatically selected and switch actions are the same as WRCS OUT.

(2) Indications. When you desire to position the pod to the 12-VIS or any other acquisition mode, accomplish the required switchology and then ALWAYS check for proper indications. SPIKE has a mind of its own and will not always respond as directed the first time. Two indicators must be crosschecked to ensure the pod is actually in 12-VIS.

(a) Azimuth-Elevation Indicator (LOS). The pointer on the LOSI indicates the pod roll angle. During INS-IN operation, the pod is roll compensated to remain level

AVQ-23A/B ACQUISITION/TRACK MODES

(AFTER TO 1F-4E-588)

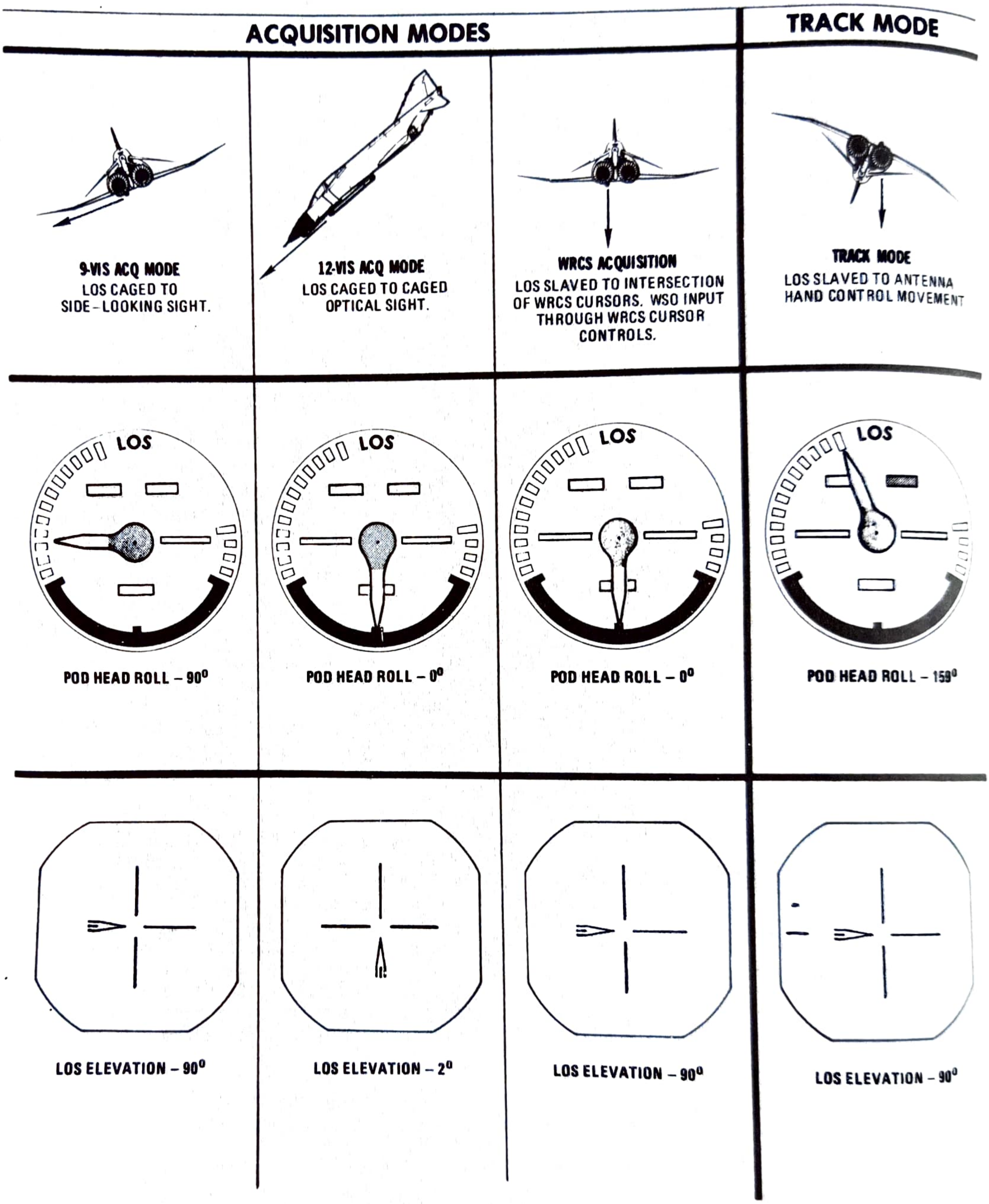


Figure 22, Acquisition/Track Modes

with the INS horizon in 12-VIS. Therefore, pod roll angle will be 0^{o} relative to the horizon, or you may think of it as plumb bobbed to the earth. See figure 22.

(b) Scope Reticle. The wedge indication on the reticle rotates clockwise to show pod elevation angle. Since the pod is parallel to the radar boreline in 12-VIS, the wedge will be approximately at the 6 o'clock position indicating 2^{o} depression (6 o'clock is actually zero depression).

(c) WRCS OUT. All indications remain the same, when WRCS OUT is selected.

(d) INS OUT. There is no roll compensation to keep the pod roll axis level with the horizon in this mode. Therefore, if the aircraft is placed in a bank, the pod head remains aligned with the aircraft axis. INS-IN vs INS-OUT roll compensation is roughly analogous to STAB IN vs STAB OUT radar antenna operation.

(3) Operation. To accomplish a 12-VIS Acquisition, the pilot will maneuver to place his 35 mil pipper on the desired target and call "tracking". The WSO will call "capture" when he has identified the target and is able to begin tracking with the pod. This informs the pilot that he is free to discontinue tracking with the pipper and maneuver the aircraft as necessary.

b. <u>9-VIS</u>. See figure 22. This is a backup acquisition mode which has serious limitations due to the difficulty of maneuvering the aircraft to place the target precisely in the pod FOV. The pod is rolled 90^{o} to achieve a 9 o'clock LOS.

(1) Switchology. Position the acquisition switch to 9-VIS, again this switch action alone will position the pod to 9-VIS only if the pod is already in one of the other Acquisition modes. No front cockpit switch actions are required.

(2) Indications.

(a) Azimuth-Elevation Indicator (LOS). Since the pod is rolled 90^{o} to the left, the pointer should be at the 9 o'clock position (Figure 22). There is no roll compensation in the 9-VIS mode, so if the aircraft is banked 90^{o} left, the pod LOS will be pointed directly at the ground under the aircraft.

(b) Scope Reticle. The elevation gimbal mirror is depressed 90^{o}, so the wedge will rotate to the 9 o'clock position.

(3) Operation. Accomplishing a 9-VIS target acquisition in minimum time with a high probability of success is a difficult if not impossible task. An aiming index (grease pencil marks) is established on the front canopy during ground operation. There is a widespread belief that a pylon turn is flown around the target until it is identified in the video by the WSO. Figure 23 points out why this is impossible at low altitude. The relatively small bank angles which must be flown to ensure the target is in the FOV of the pod, do not generate the turn rates required to fly a pylon turn (keep the target positioned at 9 o'clock indefinitely). Therefore, the pilot must maneuver the aircraft to position the target forward of 9 o'clock, set the bank angle to ensure the target will "pass through" the FOV, and then communicate with the WSO to indicate when his reference marks are on the target. If target acquisition is not accomplished, the whole procedure must be repeated. <u>The success rate of 9-VIS acquisitions at low altitude qualify it only as a backup mode and no delivery should be planned with this as a primary mode</u>.

(4) WRCS OUT/INS OUT. There is no change in the 9-VIS acquisition when operating in these degraded modes.

c. <u>WRCS Acquire</u>. See figure 22. The integration with the WRCS provides a capability to cue the pod from an initial point (IP) to the target by both radar and visual techniques. The steering provided in this mode is valuable in itself, in addition to the fact that the pod is cued to the target area before visual acquisition is possible. The system has

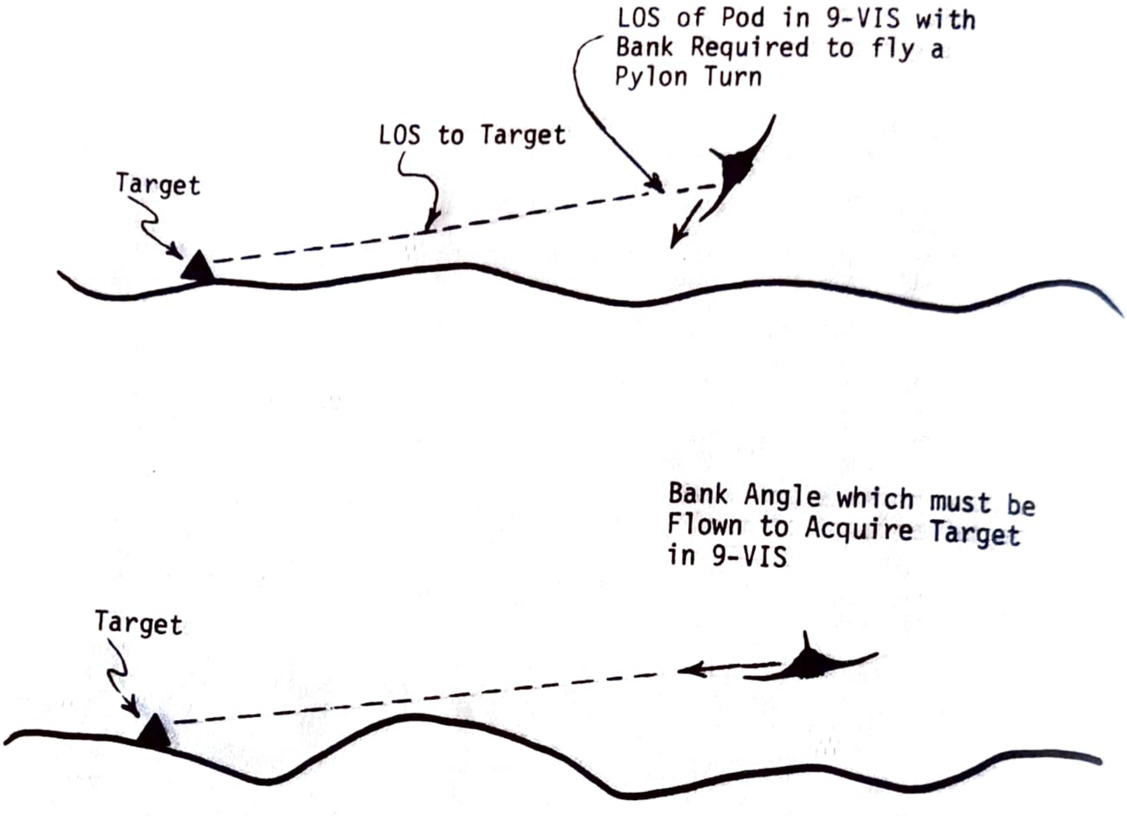


Figure 23, 9-VIS Acquisition

demonstrated excellent accuracy provided the offset distances from IP to target can be measured exactly. A simple, and correct, way to describe the WRCS Acquisition mode is to say that the pod head is "tied" to the radar cursors. When the cursors are placed over the IP return, assuming a radar acquisition, the pod will follow along and its LOS will be pointed at the IP. When the insert button is depressed and the cursors move from the IP to the target, the pod LOS goes along for the ride.

NOTE: Remember, the WRCS computer works only with horizontal distances. When offsets are measured, the distance is computed in the horizontal plane. Vertical development is taken into account by use of the target altitude window and a solution of the resulting triangle displays the cursors at the proper slant range. An understanding of basic WRCS operation is essential to the grasp of both WRCS Acquisition and Memory modes. If you have any questions on the WRCS, refer to Fighter Weapons School Air-to-Ground Weapons Delivery Systems Text.

(1) Switchology. Specific switch actions required for the different types of WRCS acquisition will be discussed under Operation, this section, although some actions are common to all. First, the WRCS OUT light must be extinguished to accomplish a WRCS Acquisition. This means that the WRCS OUT button must not be depressed, the Target Find Switch (702 panel) must be in the Normal position, and the Delivery mode selector in the front seat must be in Direct or Target Find. If the above three conditions are not met, the WRCS will be de-integrated (WRCS OUT light illuminated) and the pod will automatically rotate to the 12-VIS position when WRCS ACQ is selected on the PAVE SPIKE control panel. Provided the WRCS is integrated with SPIKE, positioning the acquisition switch to WRCS ACQ will align the pod with the radar cursors. Remember, if the pod is in a track or memory mode at this time, an additional switch action is required. (These actions will be covered under the sections on Tracking and Memory.) Other switchology depends upon the specific type of acquisition to be performed, but in general, offset distances are set in, altitude (corrected for D-value) of the return to be worked is set in the target altitude window, and the insert button is depressed to move the pod from IP to target.

(a) Azimuth-Elevation Indicator (LOS). The pod is roll compensated to INS level in WRCS ACQ, so the pointer will be "plumb bobbed" to the earth regardless of bank angle.

(b) Scope reticle. When WRCS acquire is initially selected, the cursors should be reset (positioned at the aircraft). The pod LOS will be positioned at the aircraft as well, i.e., it is depressed 90^{0} in elevation. This is the nadir position and the pod is looking directly under the aircraft. The wedge will be rotated to the 9 o'clock position to indicate 90^{0} depression on the elevation gimbal mirror. As the cursors are "run out" to the IP position, the pod head will follow along and assuming the IP is located in front of the aircraft, the reticle will rotate counterclockwise indicating less depression in elevation.

(c) Steering. Assuming NAV COMP is selected on display switches, INS bearing and DME will be displayed during all Acquisition modes. When the insert button is depressed in WRCS ACQ, the steering is provided by the WRCS, just as it would be if a pod was not loaded.

(2) Operation. Concepts involved with the three types of WRCS acquisition functions will be discussed next. Specific switchology is covered in detail in aircrew checklists and will not be republished here. However, those switch actions which have special consequence because the pod is loaded will be explained. Three types of acquisition can be accomplished in this mode: Visual Initial Point (VIP), Visual Offset Aimpoint (VOAP), and Radar Offset Aimpoint (ROAP).

NOTE: Always correct the target altitude window for D-value.

(a) VIP. This mode is the simplest and requires very little aircrew head down time. When the aircraft is directly over the IP with offsets to the target dialed in the WRCS, the WSO depresses the Freeze and Insert buttons and the radar cursors and pod head move to the target (Figure 24). The target altitude should be set in the WRCS computer. The drawback is the fact that the IP must be directly overflown.

(b) VOAP. The VOAP allows the aircrew to cue the pod to the target from a visually significant offset aimpoint (OAP) without directly overflying the OAP. The magic involved cannot be fully explained until the section on tracking is digested, but the concept is simple. The aircrew visually acquires the OAP (12-VIS or 9-VIS) and enters the Track mode. The WSO accurately tracks the OAP with the antenna control handle and simultaneously pushes the FRZ/INS buttons (offsets from VOAP to target dialed in the WRCS). The cursors and pod LOS then move from the OAP to the target. The OAP altitude must be set when the WSO is tracking the OAP. After the insert button is depressed, the target altitude must be set in. The VOAP technique does have some limitations: the aircraft must be within approximately 7-8nm slant range of the VOAP at insert. Because of the pod mechanization (this will be explained in the section on tracking), consistent results cannot be obtained from a VOAP elevation higher than aircraft altitude. This limits the VOAP acquisition to aimpoints which are below the aircraft (Figure 25).

(c) ROAP. This acquisition works exactly as a radar offset bomb. The SPIKE pod simply goes along for the ride. All radar techniques are the same as an offset bomb or target find operation except: the delivery mode select in the front seat must be positioned to Target Find to obtain the radar cursors. If the Target Find switch on the 702 panel is placed to Hold to get cursors, the WRCS is de-integrated (WRCS OUT light ON) and this acquisition will not work. WRCS ACQ must be selected on the PAVE SPIKE control panel to get cursors. When the cursors are placed on the ROAP, if the display is changed to TV, the OAP should appear in the pod FOV. After the insert button is depressed, the target altitude window must be changed from the OAP to the target altitude corrected for D-value. The radar display knob must be positioned out of a Plan Position Indicator (PPI) mode to allow use of the radar hand control for tracking functions. An ROAP may be selected above the altitude of the aircraft providing the WSO "inverts the triangle" for the target altitude window setting. The range at which an ROAP may be accomplished is limited only by the WRCS capabilities (Figure 26).

NOTE: The Map PPI mode is required during cursor placement on the radar ground map display. After cursors have been placed on the OAP and FRZ and INSERT with offsets to the target has taken place, the radar display switch must be moved out of PPI to a MAP-B display in order to allow initiation of the PAVE SPIKE track mode with the antenna control handle. The DSCG scope mode knob must be moved from RDR to TV in order to display the pod video. 12-VIS should always be selected on the PAVE SPIKE control panel acquisition switch after FRZ and INSERT (the pod is then in memory mode) in order to provide a rapidly available backup acquisition mode.

4. TRACKING MODE: The Track mode may be entered from an Acquisition or Memory mode. During Track the WSO aids the INS in keeping the pod LOS pointed at the target by making corrections with the radar hand control. The Track mode is the only mode in which the laser can be fired.

a. Switchology. Switch actions required to enter the Track mode were discussed in the description section. Simply stated, half-action and release on the antenna control handle changes modes between selected acquisition and Track; full action and release is an ON/OFF laser switch. If the pod is in an Acquisition or Memory mode when full action and release is selected, it will command the Track mode as well as fire the laser. Before entering Track, the radar hand control should be positioned to the center or null position. This will ensure that the pod LOS does not jump off the target when the action switch is depressed because error commands were inadvertently generated.

b. Indications. Scope indications during track were also covered in the description section. If the TTG and TO symbols are present on the video, the system is in track. If they are not visible, the system is either in an Acquisition or Memory mode and the Azimuth-Elevation Indicater (LOS) and reticle wedge must be checked to determine which it is. The

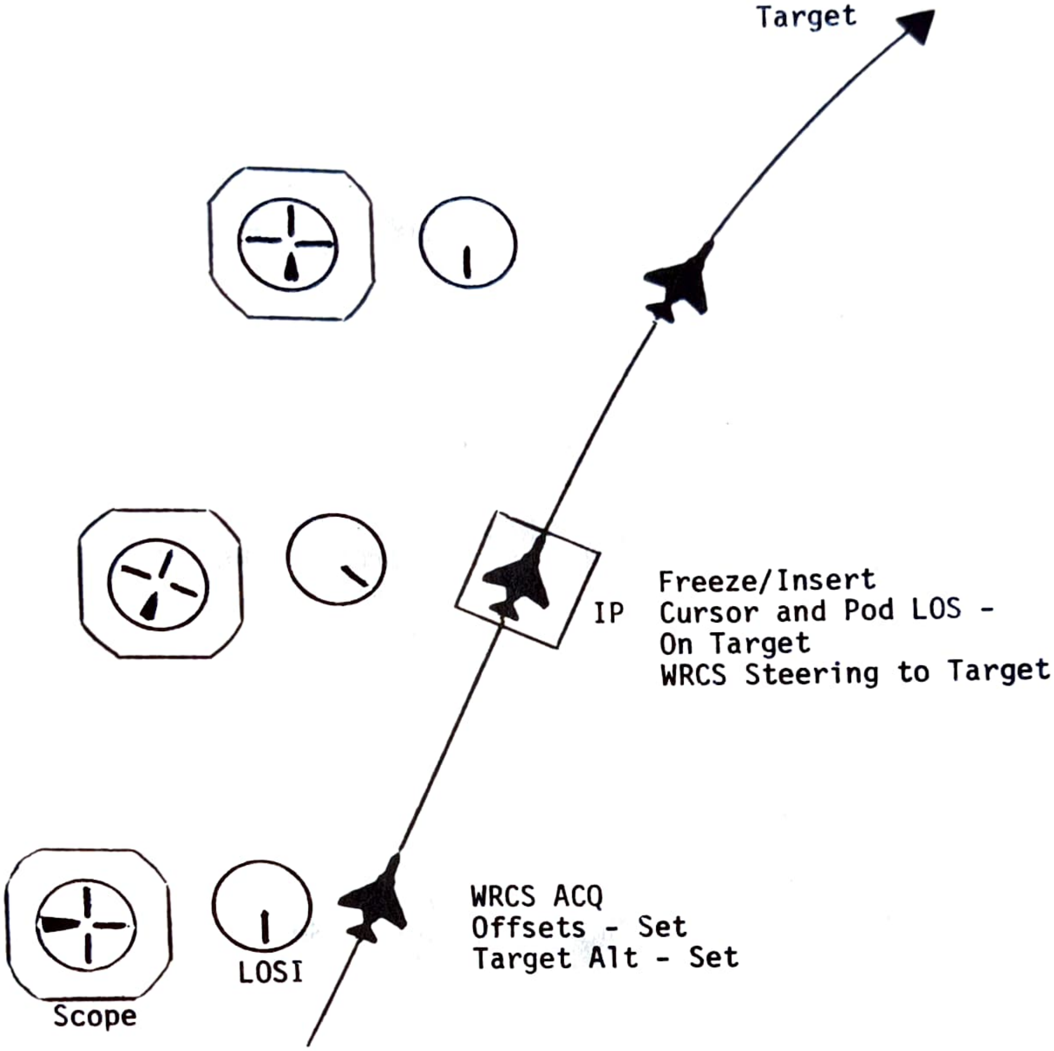


Figure 24, VIP

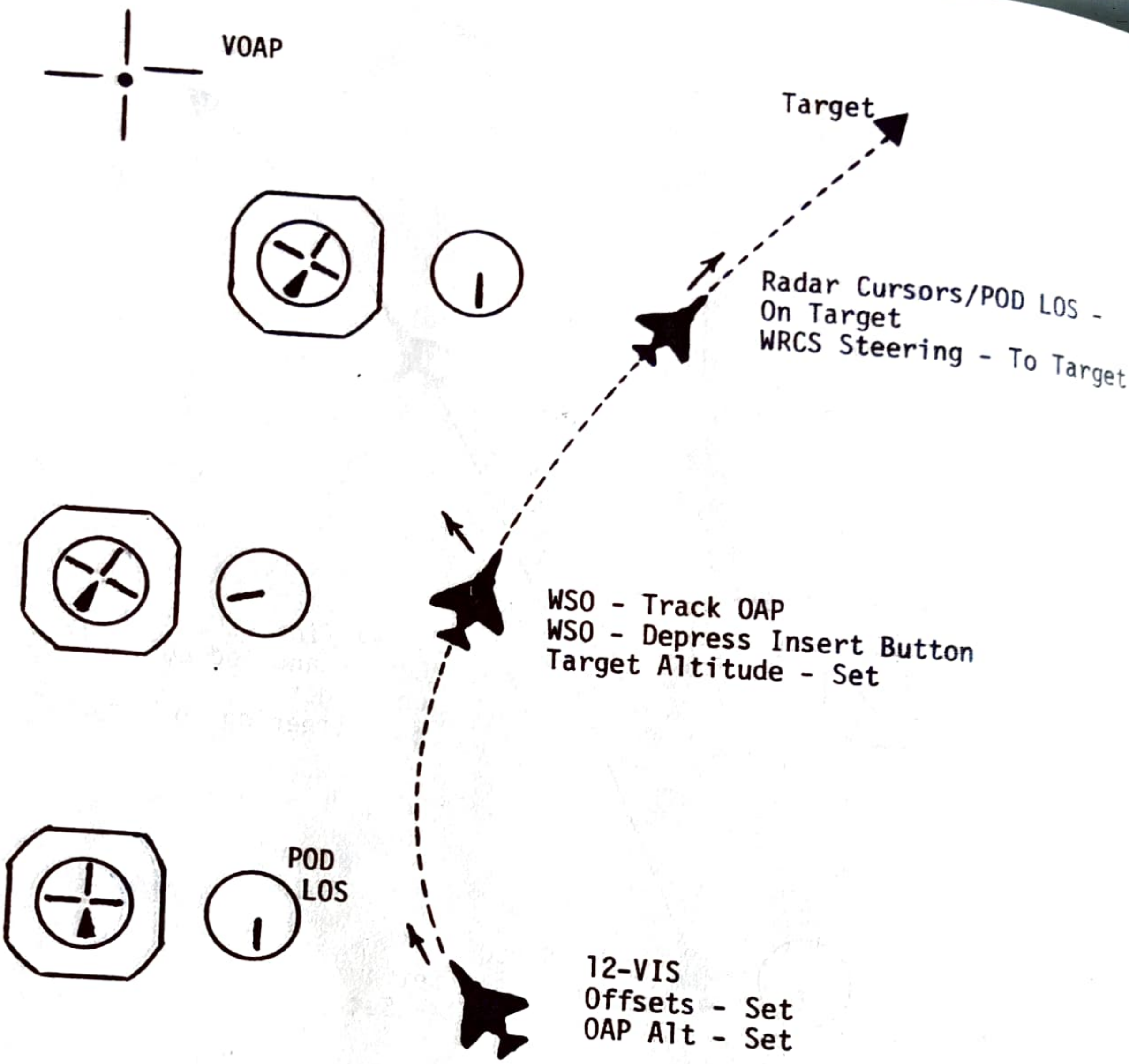


Figure 25, VOAP

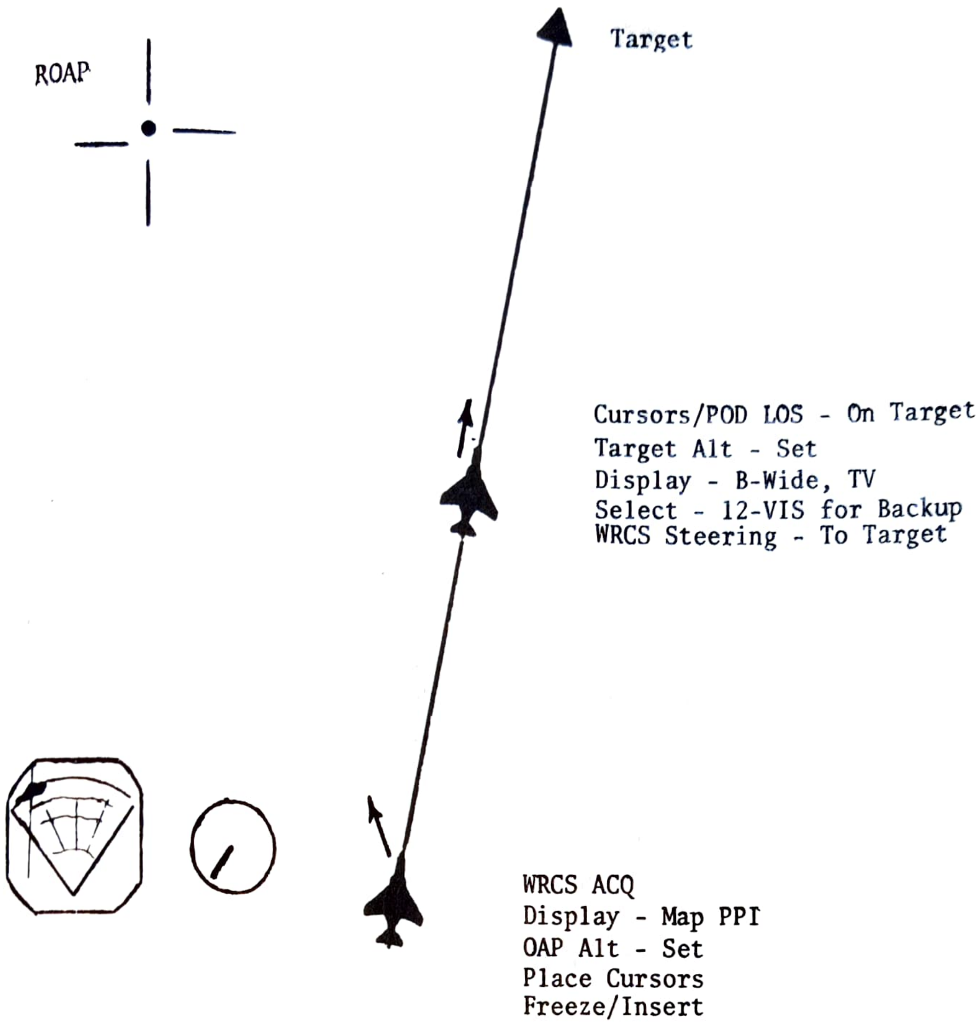


Figure 26, ROAP

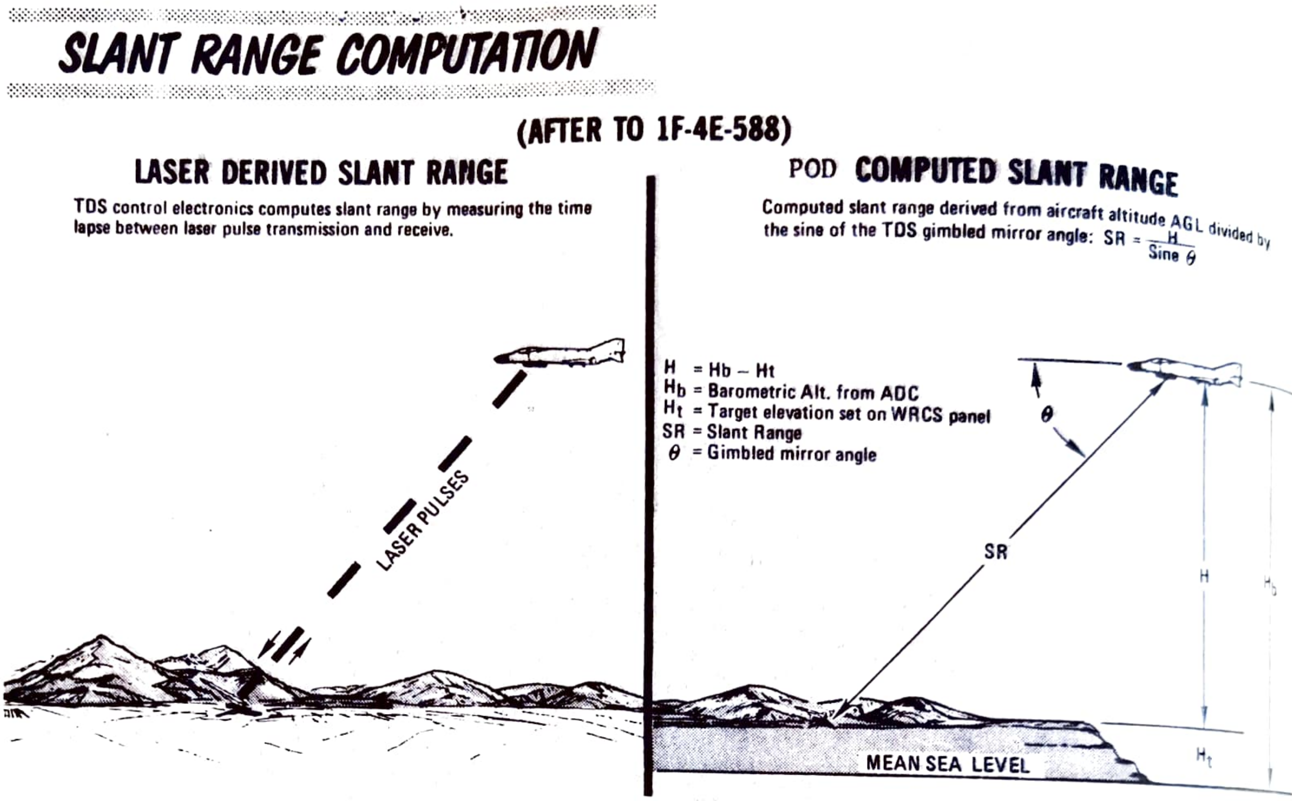


Figure 27, Slant Range Computation

WRCS holding relay on the optical sight is removed when the Track mode is entered, allowing the pipper to depress from the 35 mil position to that selected in the sight depression window. Steering information in track is supplied by the WRCS but an off flag is positioned over the DME window. How does the WRCS supply steering during the track mode you ask? Read on.

c. Computations (Pod Computed Slant Range). The SPIKE pod works trigonmetric problems from the moment it is turned on until you select power off in the chocks after the mission. The answer to these problems go to the SRI and the WRCS. It is mainly concerned with the horizontal and vertical triangles that will be described next.

(1) Horizontal triangle. The interface with the INS and WRCS is combined with a pickoff of pod gimbal angles to make the triangle solution possible (Figures 27 & 28). The position of the point being tracked (D_N and D_E) is updated in the WRCS computer continuously; therefore, the position of the point being tracked is known by the WRCS computer. This is essentially the same as the freeze function, since the position of the point of interest is continuously monitored. This feature is used in the VOAP acquisition and the Memory mode. The angle B is displayed on the Horizontal Situation Indicator (HSI) and BDHI to provide steering to the point of interest.

(2) Vertical triangle. The vertical triangle is continuously solved to provide slant range (SR) to the SRI in the absence of laser ranging. The SR obtained is broken down into horizontal and vertical components to provide aircraft altitude and horizontal range to the point being tracked. Figure 29 shows the SR computation which occurs continuously during PAVE SPIKE operation. The SR computed is displayed on the SRI, provided it is not rejected for laser SR. Mathematically speaking:

$$SR = (H_b - H_t)/\sin\theta$$

Where: H_b = Altitude MSL from CADC

H_t = Tgt Alt Window Setting

θ = SPIKE Gimbal Mirror Depression from INS Level

It follows that: $(H_b - H_t)$ = Aircraft Altitude Above the Target

$HR = (H_b - H_t)/\cos\theta$, this value is used in the horizontal triangle computation

It should be apparent that the computed SR is only as good as the value set in the Target Altitude window on the WRCS computer panel. Since the Central Air Data Computer (CADC) value (H_b) is always referenced to the 29.92 pressure level it is critical that the H_t value be corrected for D-value. D-value is the pressure difference aloft caused by non-standard temperature lapse rate and pressure systems. A good discussion on D-value computations is contained in Fighter Weapons School Nuclear Weapons Delivery Reference Text. Unlike the horizontal triangle, which is computed only in the Track mode, the vertical triangle computation is ongoing as long as there is power on the pod.

NOTE: No computations are made when operating in the INS OUT mode because required inputs are not available. The SRI will display its maximum value, approximately 70,000 feet, when operating INS OUT. Since the vertical triangle is continuously solved (INS IN), the SRI always displays SR. No matter what operating mode the pod is in, SR will be displayed and it will be as accurate as the Tgt Alt setting and pod LOS angle measurements. The fact that the angle θ is measured from INS level allows the computation to occur in all modes (Figure 30).

This angle is also measured in Acquisition and Memory modes, thanks to the INS. Figure 31 shows that in Acquisition mode, SR is computed to the position at which the pod LOS is pointed, provided H_t is set correctly.

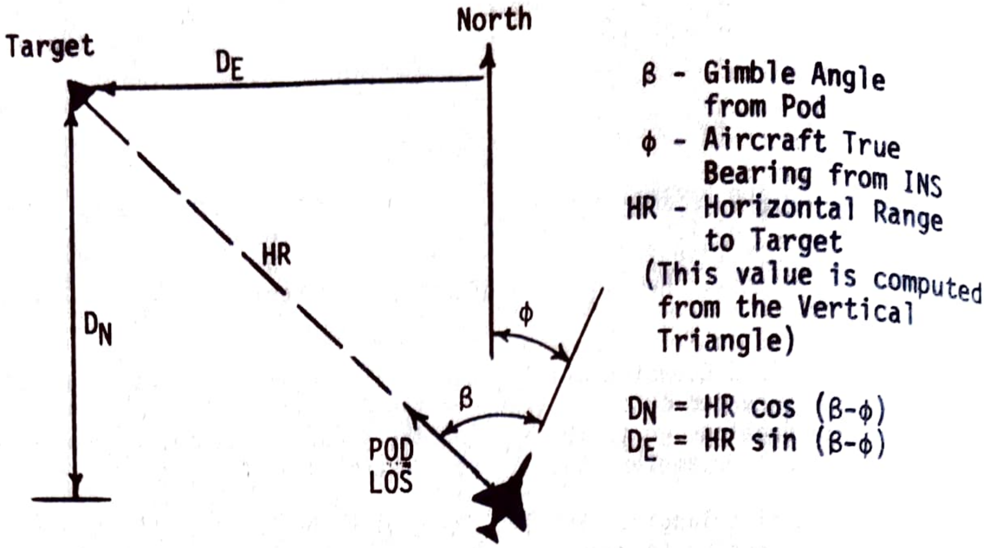


Figure 28, Horizontal Triangle

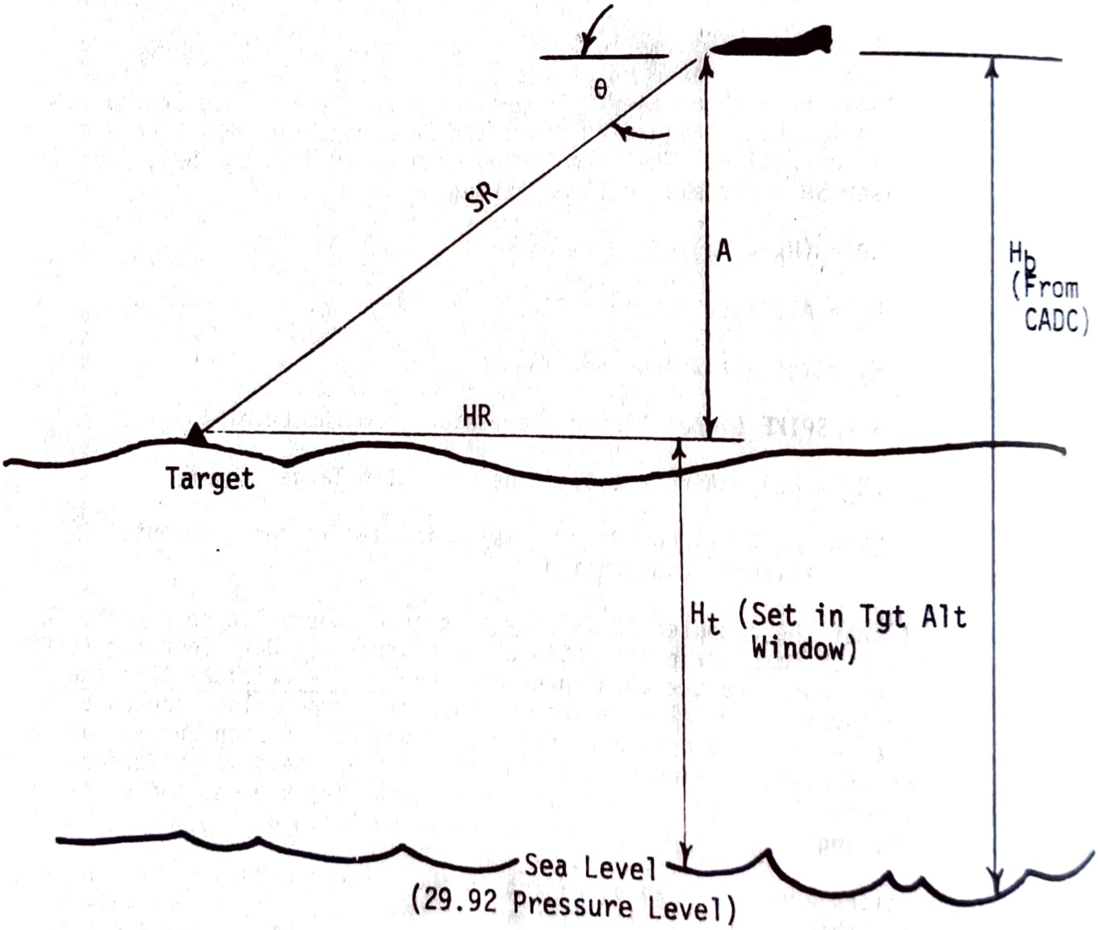


Figure 29, Vertical Triangle

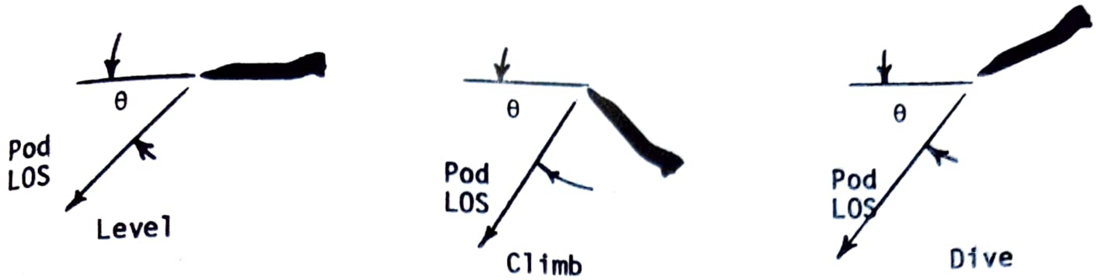


Figure 30, θ Measurement, Track Mode.

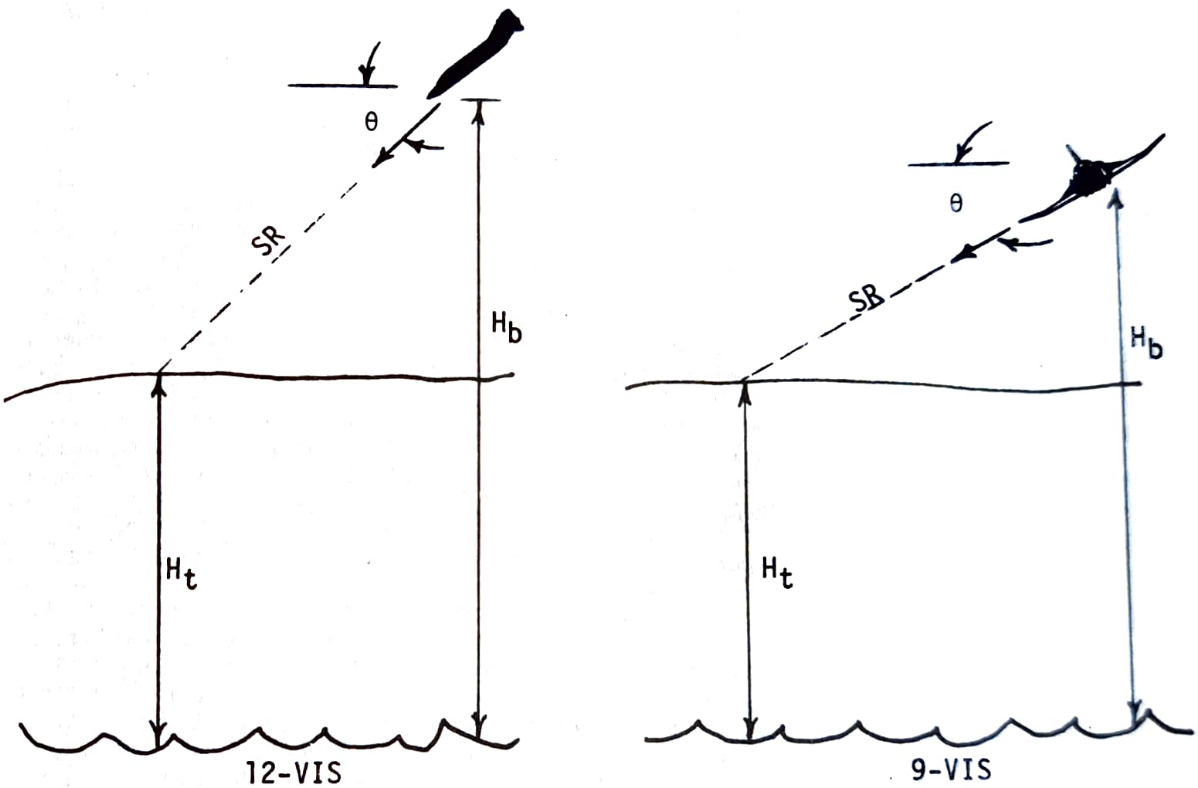


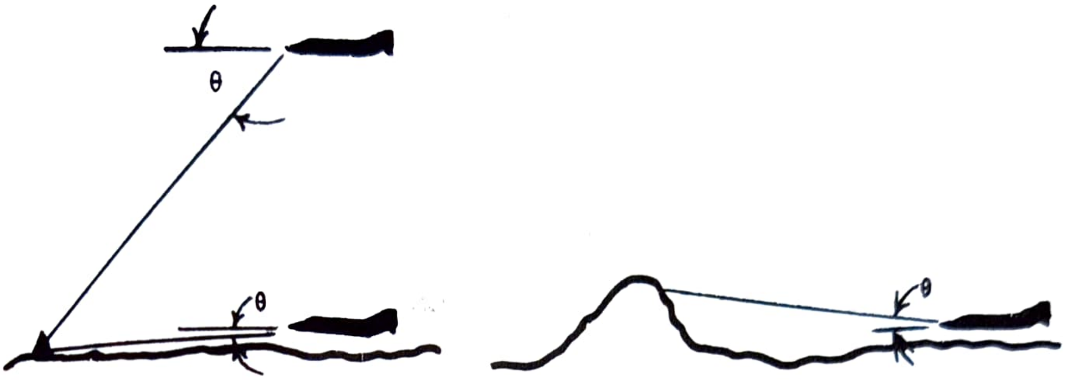
Figure 31, θ Measurement, Acquisition Mode

(3) Limitations. The pod's computations are very accurate for the medium altitude regime for which it was designed. When the pod is employed in the low altitude environment, several limitations become apparent:

(a) Angle Limitations. The angle θ obviously becomes a smaller value as altitude is reduced. As the angle approaches zero two things happen. First, the trigonometric functions change drastically for any change in angle. The difference in the sin 45^{o} vs sin 44^{o} is only 0.0024 while the difference in the sin 2^{o} vs 1^{o} is 0.0174. This is over 7 times as great and, therefore, the equation $SR=(H_b - H_t)/\sin\theta$ is much more sensitive to angle measurement in the low altitude regime. This means that any error in this angle measurement will cause a large error in the computation of SR. The other problem unique to low altitude employment is the fact that SPIKE is mechanized to work only with a positive value for θ, if θ becomes negative (the point tracked is above the aircraft), the SR is not valid simply because the system was not designed to compute this function. See Figure 32.

(b) Altitude Limitations. Typically, the greatest error in SR computation at low altitude is caused by inaccuracies in the (H_b - H_t) portion of the equation. The H_b input from the CADC is reliable but it is difficult for the aircrew to accurately determine or apply D-value to input the proper H_t. The "weather wizard" gives it his best shot, but weather systems are difficult to predict to the accuracy required. As with the angle limitations, the target altitude problem has two faces. First, at low altitude a relatively small error can cause huge errors in the SR equation. Suppose that the aircraft in Figure 33 is flying at 100 feet AGL. An error of just 50 feet in the H_t setting, assuming H_b is perfect will result in a SR that is either one-half or double (depending on whether the error is high or low) the actual SR, since: $SR=(H_b - H_t)/\sin\theta$. If H_t is in error by 50 feet, it will either halve or double the dividend. For this reason, and coupled with the fact that any error in angle readout will cause gross errors in SR, the pod computed SR is almost never accurate at low altitude. This is unfortunate since it requires an additional switch action to force the system to accept the laser SR as we will see in the next section. What happens if the solution to the SR equation is zero or negative? This will happen, of course, when the value of H_t is equal to or greater than H_b. When this happens, the pod cannot be controlled in the Track mode by the WSO and the infamous "IDIOT MODE" occurs. The normal sequence of events in the Idiot Mode are: WSO selects track (one-half or full action), pod runs off in any direction it chooses and cannot be controlled by the radar hand control, pod hits a gimbal limit and goes into memory on no point in particular. What can the WSO do to regain control of the pod? First he must break the unwanted memory, and next he must reduce the value in the target altitude window (if possible, since zero is the lowest value that can be set into the WRCS computer control panel). Why does the arrogant SPIKE pod behave this way when $(H_b-H_t) \leq 0$? It does this because the INS uses SR and the change in SR (velocity) to attempt to keep the pod LOS pointed at the target. When the SR is zero or negative, the trig hamsters in the pod get confused and cannot compute a solution. The only recourse the operator has is to reduce target altitude. If he already has zero set for H_t, he cannot track INS IN and must accept the degraded performance available in INS OUT. This occurs when operating near sea level on a high pressure day. Figure 34 represents the situation that occurs when the aircraft is flown at sea level on a day when the surface altimeter setting (QNH) is 30.42. This means that a high pressure system is in the area and the 29.92 pressure level occurs 500 feet AGL. Since D-value is the difference between the altitude at which a pressure level actually occurs vs the level it would occur on a standard day, D-value is equal to plus 500 feet. If the aircraft flies at 200 feet AGL, the CADC (which is always referenced to the 29.92 pressure level) believes the aircraft is -300 feet. Thus, H_b = -300 and the solution to the equation is negative. A climb to exactly 500 feet AGL would result in (H_b-H_t) = zero and the pod would still go "idiot." Thus, when operating near sea level on high pressure days, the aircraft must fly above the "D-value" with zero set in the target altitude to be able to operate in the Track mode INS IN. The pod will still function in the Acquisition and Memory modes at low altitudes, but since the laser can't be fired, the limitations are serious.

d. Laser Ranging. See FWS Text, Laser Guided Weapons Delivery, Part II, for indepth discussion. The above discussion on computations considered only pod computed SR which



Small θ at Low Altitude　　Cannot Compute a Negative θ

Figure 32, Angle Measurement Limitations

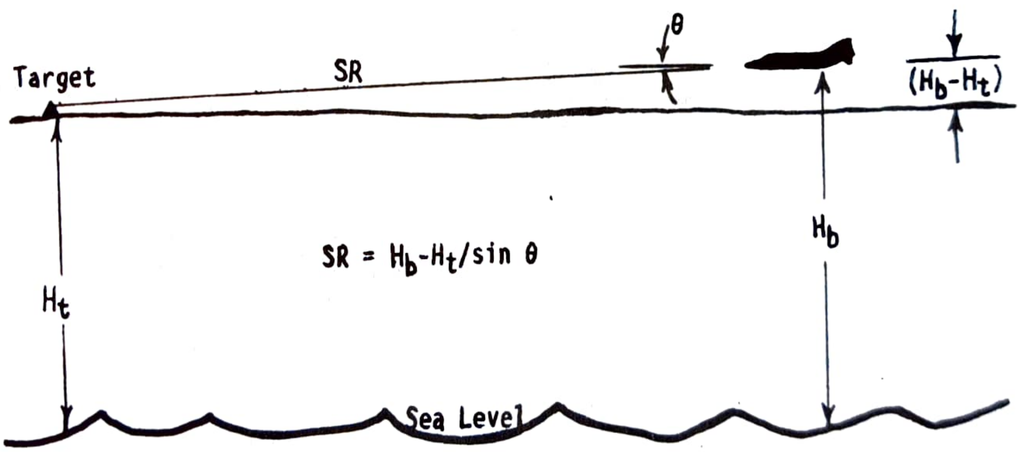


Figure 33, Low Altitude H_t Problem

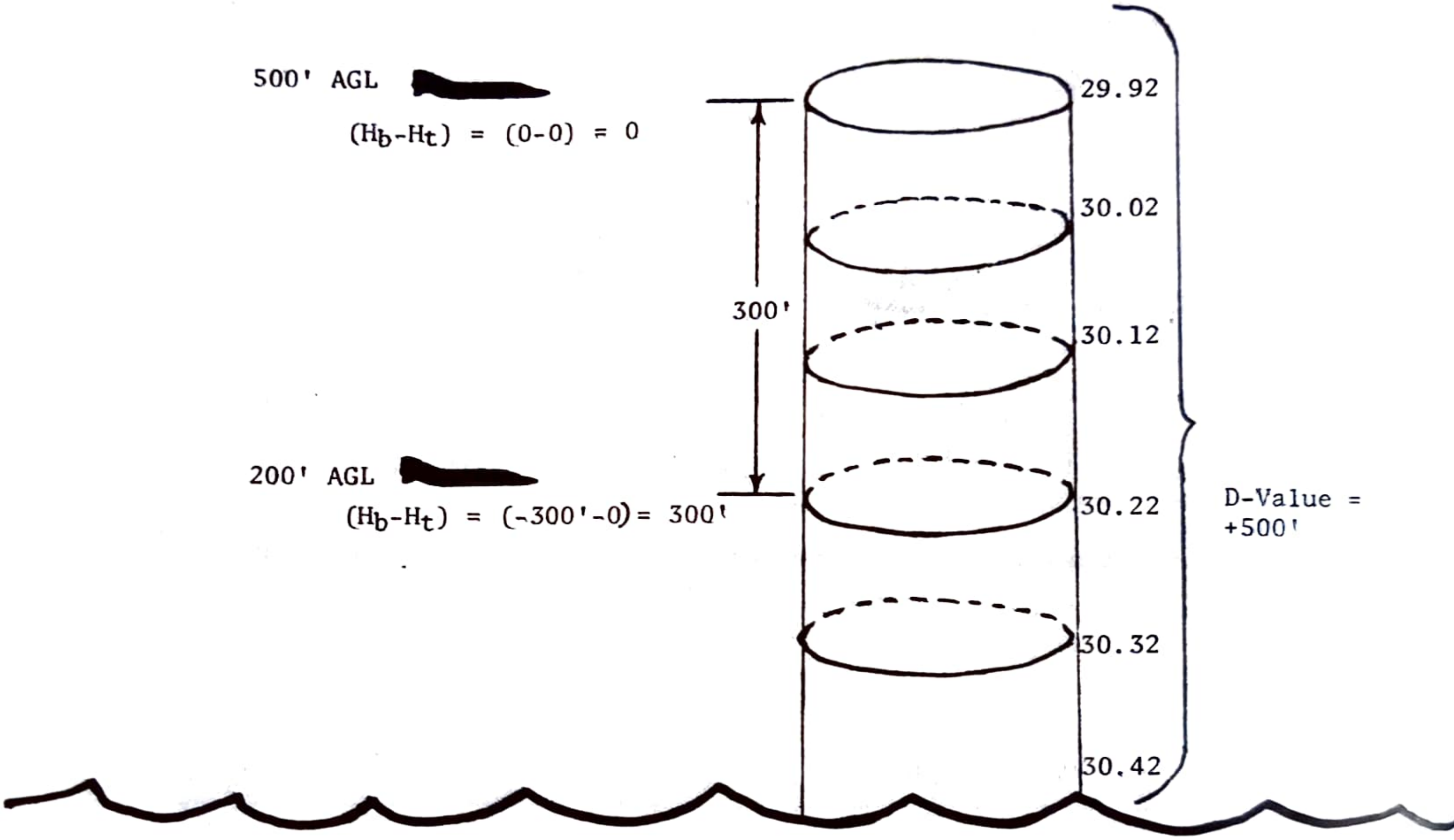


Figure 34, Operating Near Sea Level on a High Pressure Day is available in all operating modes. When the system is in track with the laser firing, laser SR is available by measuring the time from transmission to receipt of each reflected laser pulse (similar to radar ranging). Laser SR is used in lieu of pod computed range, once it is accepted, in all the functions discussed under pod computed range. Once laser ranging is accepted, the SR equation (H_b-H_t/sin θ) is no longer used. The angle functions are still used to compute the horizontal range to the target and aircraft height above the target, but the dreaded altitude portion is out. This means that as long as we fire the laser, we can operate as low as we like near sea level without experiencing any of the problems associated with pod computed range. Right? Wrong! If the TTG dot is flashing at 2 Hz, laser range exceeds 20% of the slant range computed using aircraft systems data and is rejected. WSO can override this rejection by momentarily depressing the REJOVRD button. Laser reject may occur during a low graze angle at low altitude, or when the wrong target altitude is set in the WRCS panel (including D-value). If operator tracking is erratic, laser range may be rejected. This is really no problem since tracking proficiency with SPIKE is not difficult. Since laser ranging is very accurate, it is always desired in lieu of pod computed ranging and WSOs should get in the habit of pushing the REJOVRD button immediately after selecting full action and release (firing the laser). This will ensure that accurate range acceptance is achieved in minimum time, which can be critical in a tactical environment.

e. Operation. Now that we have the theory down, how do we track with this system? To develop a good habit pattern, we can start by centering the radar hand control and then always selecting full action and release and immediately pushing the reject override button. This will put us in the Track mode, fire the laser, and get us laser range acceptance as fast as possible. The requirement for activation of the reject override button is especially important in the low altitude regime where laser range hardly ever agrees within 20 percent of the bogus pod computed range. If the hand control is not centered, the pod LOS will jump off the target and will require an immediate correction. The INS, using the computations described above, attempts to keep the pod LOS pointed at the target as long as the hand control is held in the null position. The WSO displaces the hand control in the direction he wishes to move the reticle (pod LOS) to correct for errors in the INS pointing. Given a perfect system, the WSO could initiate track with the hand control in the null and just hold it there while the pilot changed his G-program, aircraft attitude, and altitude, and the INS would keep the pod LOS on the target. Practically speaking, little effort is required to keep the target centered. Ten minutes of tracking practice with the system is worth 10,000 words, but simply stated: the top of the display always represents the most forward point within the pods FOV relative to aircraft motion; radar hand control movements are directional with the scope display, i.e., if the WSO desires to move the reticle to the 2 o'clock position on his display, he moves the hand control toward 2 o'clock. The fact that the pod rolls to achieve full hemispheric coverage below the aircraft causes the display to boggle the mind of the neophyte operator in certain situations. No matter how badly the WSO's gyros are tumbled he need only remember this: "If I want to move the reticle to 10 o'clock, etc." The fact that the azimuth mirror is limited to ± 15° movement causes confusion in display interpretation for the new guy. Because of the very limited movement available to the system in azimuth, the pod attempts to keep the azimuth mirror centered. It does this by rolling and then using depression in the elevation mirror to allow azimuth tracking. For instance, a point at 9 o'clock to the aircraft would be tracked by rolling to nearly 90° and then depressing the elevation mirror 90°. This is difficult to explain using words, but hands on practice with the system, even a trip to the sensor shop to operate a pod on the bench, will clarify the operation.

(1) WRCS OUT. Tracking WRCS OUT is different in only one respect. Since the WRCS is de-integrated, the H_t setting in the target altitude window is not fed into the SR equation. Instead, a value is used that is set in a potentiometer in the pod by maintenance personnel. This has to be set before flight and cannot be changed by the aircrew. Once laser range is accepted, the altitude portion of the equation is not used and tracking becomes the same as WRCS IN. No steering indications are available in this mode.

(2) INS OUT. When INS OUT is selected, all SR computations are disabled and the

radar hand control supplies angle commands to the pod head to direct LOS changes. This is similar to Maverick and TISEO operation. The further the hand control is displaced from the null position, the greater the angle rate commanded. Operation in this mode is not difficult, provided the tracking inputs are smooth. The derotation loop is taken out of the TV stabilization system, but this is no problem since hand control movements are still directional on the scope. No pod SR computations are made, and the SRI will indicate its maximum value. Laser SR will be displayed only if the reject override function is selected. Since the pod computations are out, the system may be operated below the 29.92 pressure level with no problems. Finally no steering indications are available in this mode.

5. MEMORY MODE: The final operating mode of PAVE SPIKE is the Memory mode. The discussion on acquisition and tracking has provided the basis for an understanding of this mode which is heavily involved with the WRCS. We saw that in the WRCS Acquisition mode, the pod head was "tied" to the radar cursors. In the Track mode (WRCS IN), the position of the point being tracked is continuously updated in the WRCS computer. That is, the WRCS "knows" where this point is in terms of distances north and east from the aircraft position. We said that tracking a point with SPIKE was essentially the same as freezing it in the WRCS. To take this one step further, we can say that in the Track mode, the radar cursors are "tied" to the point that we are tracking. Of course, they are not displayed since a TV picture must be chosen, but they are there in spirit. So what is all this got to do with the Memory mode? When you are tracking a point (WRCS IN), and reach a PAVE SPIKE gimbal limit or depress the insert button, the system switches from Track to Memory. At this time, the T_0 and TTG symbols are removed from the scope, the laser is shutoff, the position that was being tracked is "memorized" (gimbal limit entry), and the offset distances are added from the WRCS computer panel (insert button entry). WRCS steering (bearing and DME) is displayed in both cockpits to the memorized point. Confused? Let's take a look at each case separately.

a. Gimbal Bump. If when the aircraft is maneuvered and a gimbal limit is reached, the pod changes from the Track mode to the Memory mode. At the instant the gimbal is reached the DN and DE are known by the WRCS computer. From that point it integrates INS velocities as it does standard WRCS operations to keep the point of reference updated. The pod attempts to point at the target, but it cannot physically do this because it is still resting against a gimbal stop. If the WSO were to attempt to take track at this point, it would be impossible since the pod is resting against a gimbal. As the aircraft continues its repositioning turn, the pod LOS will eventually fall within the gimbal limits again and the target will appear in the FOV and cockpit video (assuming reasonable INS operation). The system will never automatically resume track and laser fire. The WSO may select full action and release at any time after the pod is positioned within its gimbal limits to reinitiate track and laser fire. The cursors are positioned over the target by the WRCS and the pod LOS is slaved to them. How did the cursors get there you ask? Remember in the Track mode (WRCS IN) the cursors are slaved to the position being tracked. Since the WRCS knows the DN and DE, and the altitude of the aircraft above the point, it has all the information necessary to position the cursors. The altitude information is $(H_b - H_t)$ if pod computed range is used and laser derived if laser SR has been accepted. When the gimbal bump is hit, the cursors are maintained on the target and the pod LOS is slaved to the intersection.

b. Insert Button. This function is exactly the same as a gimbal bump memory, except it has one extra feature--offset distances may be added to the point being tracked. We have said that tracking a point is the same as freeze as far as the WRCS is concerned. If the insert button is now depressed, the point being tracked is memorized and the offset distances are added. Does this sound something like a VOAP Acquisition? It should, because that is exactly what happens. The VOAP is tracked using laser ranging to increase accuracy. The DN and DE from the aircraft position to the VOAP is continuously updated in the WRCS computer. When the insert button is depressed, the VOAP position is memorized and the pod follows the radar cursors (not displayed) to the target. The WSO then changes the target altitude setting to the target altitude corrected for D-value. This centers the target in elevation in the pods FOV. What will happen if the WSO depresses the Reset button? The cursors will reset to the memorized point, not back to the aircraft's nadir.

In this case, the cursor will reset to the VOAP and, of course, the pod LOS will be slaved to them.

c. WRCS Acquire. It may be helpful to take another look at this Acquisition mode, now that we understand Memory. When WRCS acquire is selected, the pod slaves to the radar cursors at the nadir position. Assuming a VIP for simplicity, when the freeze/insert buttons are depressed, the cursors move out to the target and the pod LOS follows along. If the reset button is depressed, the cursors (and pod LOS) will return to the VIP. If the insert button is now depressed, the cursors and pod position over the target again, and so on. The key point to remember is the fact that once the insert button is depressed, the pod is in the Memory mode, not Acquisition. WRCS ACQ is simply another means of getting a memory on the target to cue the pod LOS and supply steering information.

d. Memory Update. Once a Memory mode is entered, whether a gimbal bump, WRCS ACQ (VIP, ROAP), or insert from track (VOAP), the pod LOS may be updated by the use of the WRCS computer control panel. The WSO is actually moving the radar cursors--the pod LOS is just along for the ride. Let's assume that after attempting an acquisition, the pod LOS is positioned to the right and beyond the desired target. The WSO identifies the target in the lower left corner of the scope. He could, of course, take track and move the pod LOS to the target, but this would cause loss of WRCS range information which is desirable in many tactical situations. It also requires the WSO to devote his full attention to tracking the target while the Memory mode can keep it in the FOV automatically. To update the Memory, the WSO simply taps the cross track cursor control to the left to center the target in azimuth. He next decreases the target altitude setting to move the target toward the top of the display. The target is positioned toward the top of the video display instead of the center, because to do so, requires a decrease in the target altitude setting. If the Track mode is to be entered at low altitude (INS IN), it is mandatory that (H_b-H_t) be a positive number. At low altitude, there is nothing the aircrew can do to increase H_b, since it is read out from the CADC. We can, however, reduce H_t to a value which will keep the target comfortably in the FOV toward the top of the display. The lower the value of H_t, the better the chance that (H_b-H_t) will be positive, and the less the chance of the "idiot mode". Why use the cross-track cursor control instead of the target offset distance windows to center the target in azimuth? Simply because no matter what compass heading you happen to be flying at the time, this will move the pod LOS to the left or right. The offset distance windows require more head down time if the aircraft is not on a cardinal heading, since both the North/South and East/West counters must be adjusted. The final point to underscore is that the target altitude is used to position the target in elevation, not the along track cursor. This is very important since the WRCS range information will be inaccurate if the along track cursor is moved. Figure 35 assumes that the pod LOS intersects beyond the target but is centered in azimuth. The target may now be centered in elevation by the two methods discussed above. Experience has shown that by far the majority of errors with an intersection long or short of the target are caused by the interface between pod LOS and target altitude. If the offset distances are measured correctly from IP to target, the WRCS has a proved capability to provide accurate bearing and DME. This means that the cursors are placed accurately in the horizontal plane and that HR in the figure is correct. The target altitude window affects only the display, to convert the horizontal distances used by the WRCS computer to SR for radar display and SPIKE LOS pointing. After the initial insert the WRCS is displaying proper DME and azimuth steering, but the pod is looking above the target because of a bad tie-in with target altitude. If the WSO decreases target altitude, it does not effect the WRCS computer position (bearing and DME), but does move the LOS on the display. He may center the target by decreasing target altitude without causing WRCS steering errors. This is accomplished by moving the pod LOS from point 1 to point 2. The WSO may also center the target by moving of the along track cursor control. By doing this, he is moving the horizontal position of the cursors and pod LOS to make it appear that the LOS is pointed at the target. The DME will be in error by the amount ▲HR if this method is used. At low altitude the errors caused by this method of update are significant and render WRCS steering useless. To center the target with the along track cursor control, the WSO actually moves the target position in the WRCS from point 1 to point 3. Finally, the optimum position of the target for low altitude employment would be

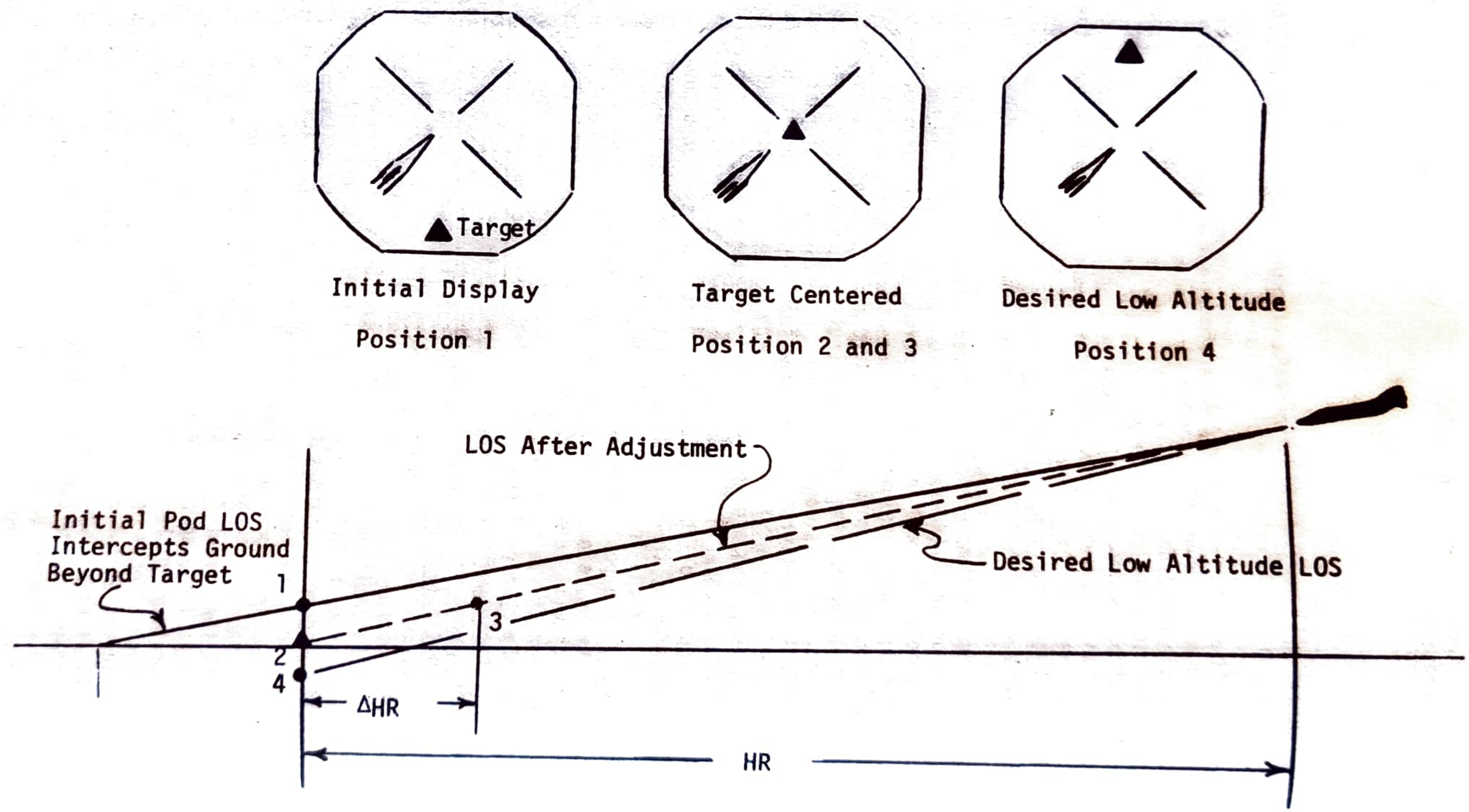
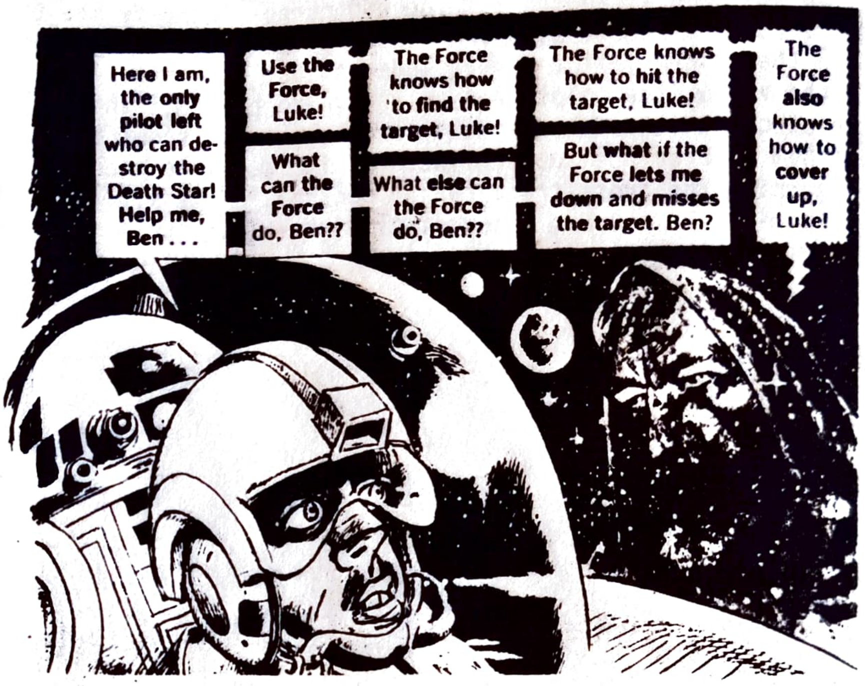


Figure 35, Memory Update Geometry.

position 4 to reduce H_t to a minimum value.

e. Azimuth Track. One technique that can aid in target acquisition if the pilot visually detects the target at long range is azimuth tracking (AZ TRACK). Suppose some type of WRCS acquisition has been attempted but the WSO cannot identify the target in the scope video. This is normally a result of poor mission planning (bogus offsets). The crew may desire to keep the system in the Memory mode and use WRCS steering. To help acquire the target in the video, the pilot need only turn to point at the target and call "AZ TRACK". Since the aircraft is pointed at the target, the WSO knows that the WRCS steering (BDHI) should now be over the lubber line. If it is not he need only align it with the lubber line using the cross track cursor control. This will slew the pod in azimuth to center the target. Of course, a target altitude window setting change may be required to position the target vertically.

Meanwhile, somewhere over the swamp...



SECTION III - F

SYSTEMS CHECKS

1. All functions of the pod may be checked enroute to the target area to ensure that operation is normal; except laser fire which must be held until within established range safety boundaries. Two of these checks will be discussed now; the first, because it provides a valuable systems integration check, and the second because it will add to our understanding of system operation. The pilot has Target Find selected in the FCP.

a. CADC check. This procedure compares the SR computation in WRCS ACQ to the pressure altimeter in the aircraft. If the SPIKE system is set up in the following manner, the SR readout on the SRI is routed through the INS and the Output Signal Distribution Unit (OSDU), but originates in the CADC (Figure 36). The WSO selects WRCS ACQ, this slaves the pod LOS to nadir. The target altitude window is set to zero and 29.92 set in the aircraft pressure altimeter. As shown in the figure, SR is equal to the aircraft altitude above the 29.92 level. Therefore, the SR readout should equal the altitude in the pressure altimeter if it is set to 29.92. In properly calibrated systems these readings usually agree within 100 feet. Since there is some slop in each system, 75 feet scale error allowable in the pressure altimeter, and a 200 foot tolerance in the SRI BIT check, it is recommended that the system be written up if the difference exceeds 300 feet. Most errors have been traced to the CADC output voltage to the OSDU.

b. Memory check. This is a very simple procedure which may be followed to ensure the memory function is operating properly. It may be preferable to use pod computed range rather than laser SR. The WSO first sets in the terrain elevation, corrected for D-Value, of the ground over which the aircraft is positioned. He next initiates track of an easily identifiable point with the pod. The pilot then verifies that the SR is within system limits. The Memory mode may be entered by rolling to hit a gimbal limit or depressing the insert button. The tracking symbology should be removed from the display and the pod LOS held on the point by the memory function. One of the common errors made on this check is to leave the target altitude window set at zero. If the terrain over which the aircraft is flying has any significant MSL altitude, this will induce substantial errors (Figure 37). If zero is left in the target altitude window, the WSO will be inserting SR_1, into the WRCS, although he is tracking point 2. Point 1 is memorized and as the aircraft continues on its flight path the LOS will change as shown in the figure. The bogus memory is caused by setting an improper target altitude.

2. The value of systems checks for determining the capability of your system cannot be over emphasized. These checks must be completed on all missions.

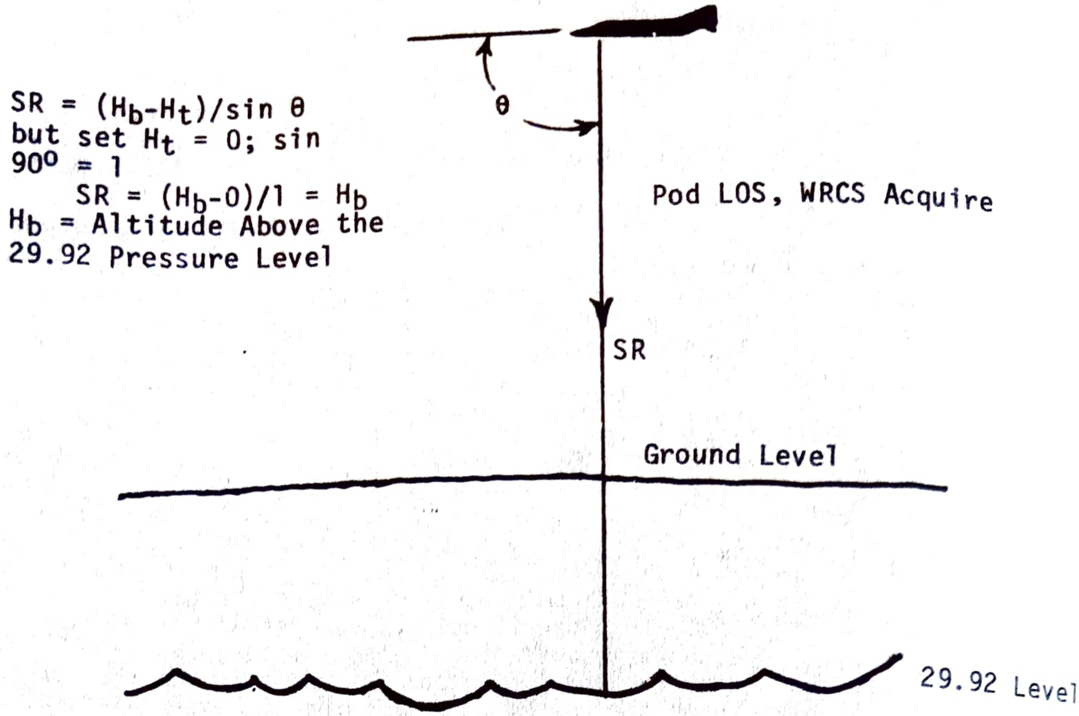


Figure 36, CADC Check

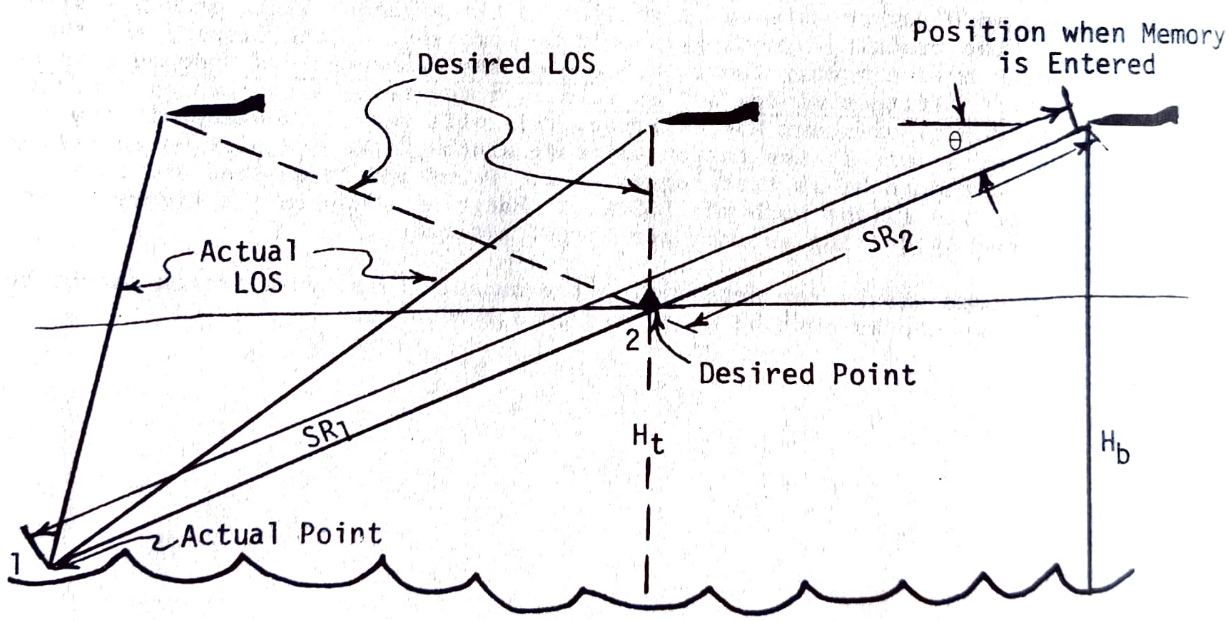


Figure 37, Memory Check

SECTION III - G

DELIVERY MODES GENERAL

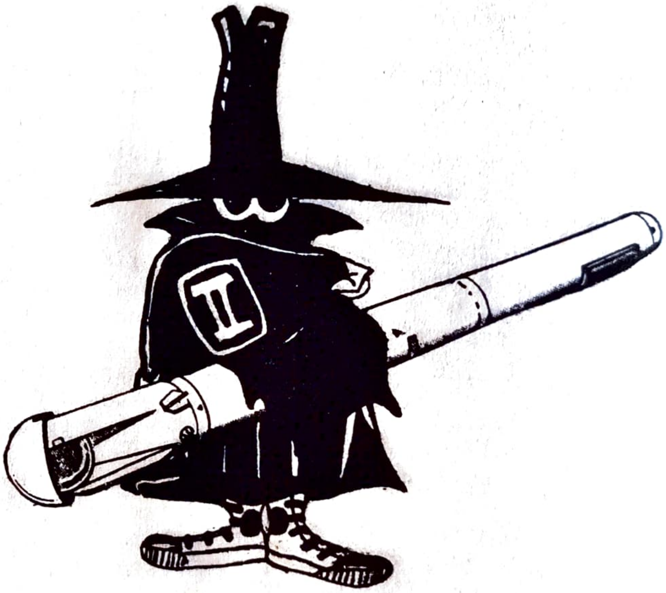
1. When equipped with a PAVE SPIKE pod, two automatic weapon release modes are available to you in addition to the normal F-4 release modes. These two modes are release-on-range (ROR) and WRCS automatic, and are available when the delivery mode selection knob is placed to the target find position. The pod supplies laser generated SR data to the WRCS computer and to a digital readout in the front cockpit. Accurate aircraft derived altitude AGL is also obtained and sent to the WRCS for release computation. Both release modes are selectable on the SRI in the front cockpit and use laser generated or computed SR in the weapon release solution. Weapon release occurs when the release signal is generated, if the bomb button is depressed. The WRCS automatic release mode uses the dive toss equation ($H = [\frac{1}{2}G\ C_B\ T_F^2]-[V_V\ T_F]$) to produce a release solution and generate a release signal. The difference between a dive toss and a WRCS automatic release computation follow. In dive toss SR to the target is inserted into the computer at pickle. Range to target from this point on is computed by continuous ground speed integration. Altitude information is computed by the integration of vertical velocity. WRCS automatic uses laser derived range and altitude which is updated all the way to release, not integrated from pickle. There is not a significant improvement in weapon delivery accuracy when WRCS automatic is used instead of dive toss, since INS errors (which cause by far the greatest errors in dive toss) are still present. The WSO must set in a drag coefficient and target elevation on the WRCS panel. The ROR release mode is an automatic mode which can be used in the event of a WRCS or INS failure, as weapon release is solely dependent on laser SR with an INS or WRCS failure. Laser range acceptance must be forced by depressing the reject-override button when operating INS OUT.

a. The WRCS automatic release gives the F-4 the capability to perform standoff weapon deliveries with the accuracy required to ensure LGB guidance. It may be used in a Loft or Toss mode to increase standoff from a low altitude posture. The term loft indicates a low altitude approach to the target, a pull at a predetermined SR, and weapon release at a planned release angle. We will use the term toss to indicate a maneuver similar to a pop-up to a long range, low angle dive at the target. At a preplanned SR and altitude, a pull is started and the weapon will be released at a planned positive angle. Essentially the final portion of a toss is the same as a loft, except the pull is started from a higher altitude AGL. Testing has shown that the WRCS automatic release is the only delivery available to the F-4 that will consistently provide enough accuracy for standoff deliveries. This is because of the fact that we have a dynamic solution to the problem. If we pull 500 feet early, use 3-Gs instead of a planned 4-Gs, and are 50 knots fast, the dive toss computer will do its best to compensate and determine the correct release point for the new parameters. If we miss our parameters on a gyro or timed loft, we will miss--plain and simple. This does not mean that release parameters are not critical on a WRCS automatic release, only that the system will make up for reasonable errors and provides the F-4 with a credible standoff delivery. However, the dive toss systems must be maintained in peak conditions for this to work. Note that the Optical Sight is not drift stabilized.

b. The ROR delivery has limited application. Parameters (dive angle, airspeed, altitude, G-loading) must be "wired" for this delivery to work. The release is generated on the laser SR set in the SRI. Ballistics tables presented in horizontal ranges, must be converted to SR. Level deliveries appear to be the best application for the ROR. Parameters are relatively easy to reach and maintain. If you attempt to use this instead of a sight setting for dive deliveries, you'll get a release at the set SR, no matter how far off your planned parameters you find yourself. This takes away all of the in-flight error analysis capabilities for normal dive deliveries. If a level release is planned from medium altitude it is critical that D-value be corrected for. This can easily cause 1,000 to 2,000 feet of error. The second problem with a medium altitude level release is azimuth alignment with the target. This is almost impossible to judge visually (on most deliveries the target will be obscured by the nose, anyway) and the steering information tolerance on the WRCS is not stringent enough to just "center the needles" and be assured of alignment. In summary, the ROR delivery has very limited practical value.

NOTE: Both the WRCS automatic and the ROR deliveries may be accomplished using pod computed range instead of laser SR if you can accept the decreased accuracy. Pod computed range should never be used for a low altitude loft delivery.

2. For more information see TO 1F-4E-34-1-1; and also FWS Text, Laser Guided Weapons Delivery, Part II, for tactical deliveries.



SECTION III - H

"MORE" PAVE SPIKE NOTES

1. NOTE APX-80 USE: In order to initiate IFF interrogation and display it on the RCP scope, the WSO must select RDR on the RCP DSCG scope mode knob and press the interrogate button on the antenna control handle (or use the TEST/CHAL CODE switch). However, if the pilot has TV selected for display (on his scope display select switch) the WSO must also deselect PAVE SPIKE (i.e., ASQ-153) on the RCP video select button prior to interrogation in order to allow display of APX markers on the radar scope. (The WSO does not have to deselect ASQ-153 if the pilot has RDR selected on his scope display select switch). Also note that APX markers may be displayed on only the FCP radar scope if the pilot has RDR selected on his scope display select switch and the WSO uses the TEST/CHAL Code switch to initiate interrogation (in this case, the WSO is using the PAVE SPIKE pod and has a TV picture; the antenna control handle is functioning in the PAVE SPIKE mode and cannot be used for interrogation).

2. NOTE (Revisited): The MAP PPI mode is required during cursor placement on the radar ground map display for a ROAP WRCS acquisition. MAP PPI does not permit initiation of the PAVE SPIKE track mode. The radar control panel display mode must be switched from MAP PPI to either MAP-B or RDR after the display is switched from radar to TV on the DSCG scope mode knob in order to permit proper antenna hand control operation.

3. NOTE (Revisited):

a. PAVE SPIKE can be operated with WRCS OUT and the delivery mode select switch in any position including OFF. However, the FOV switch, action switch, and radar hand control are operational with PAVE SPIKE only when the pod is ON and ASQ-153 is selected on the video select switch (RCP).

b. In addition for the FOV switch to be operational TV must be selected on the RCP DSCG scope mode knob; or TV selected on the FCP scope display select switch (pedestal panel) with the RCP DSCG scope mode knob out of OFF.

c. For the hand control to be operational, the radar power control switch must be out of OFF and TV selected on the RCP DSCG scope mode knob.

d. For the action switch to be operational, TV must be selected on the RCP DSCG scope mode knob and the radar system must be on, but not in a MAP PPI mode.

4. TCTO 518 provides Automatic Laser Range Acceptance at low altitude and large ground range offset conditions. It removes the requirement to depress the REJOVRD switch on the PAVE SPIKE control panel at low altitudes. The system is now mechanized such that if the elevation gimbal angle is less than 7.5 degrees, the system will automatically accept the measured laser range. Since the automatic acceptance is dependent on gimbal angle, no exact altitude for automatic acceptance can be specified. There are, however, still some potential pitfalls with the system (after TCTO 518) depending on the attack profile.

5. TCTO 519. Commonly called the "Fast Track" modification provides increased gimbal tracking rate capability in the PAVE SPIKE pod. After TCTO 519, the pod has the ability to slew the gimbal at 60 degrees per second, an increase of 45 degrees per second. This capability was incorporated to allow low altitude, high-speed tracking of designated targets. Generally speaking, overflight of targets at 1,000 feet at 550 knots ground speed is possible.

6. NOTE FOR NORMAL WEAPONS RELEASE, when not using the PAVE SPIKE pod which is loaded on the aircraft (i.e., delivering dumb bombs), it is highly recommended that the aircrew select INS OUT on the PAVE SPIKE control panel. This will prevent bogus inputs to the optical sight (thus caging the sight to RBL) if the pod becomes unstowed due to air loads during the attack. WRCS OUT would serve the same purpose. It is not recommended that

power be taken off the pod during maneuvering, since air loads will cause wear and tear on the pod head gimbals.

7. NOTE when a value is inserted in the WRCS target ALT RANGE window other than 000, do not select the Target Find mode unless the aircraft altitude MSL is greater than the value (times 100); or unless the WSO is performing the Target Find/Offset Bomb WRCS BIT check. This is necessary to prevent possible damage to the pitch servo in the WRCS computer.

"Canted-Wing Fighter"

SECTION IV

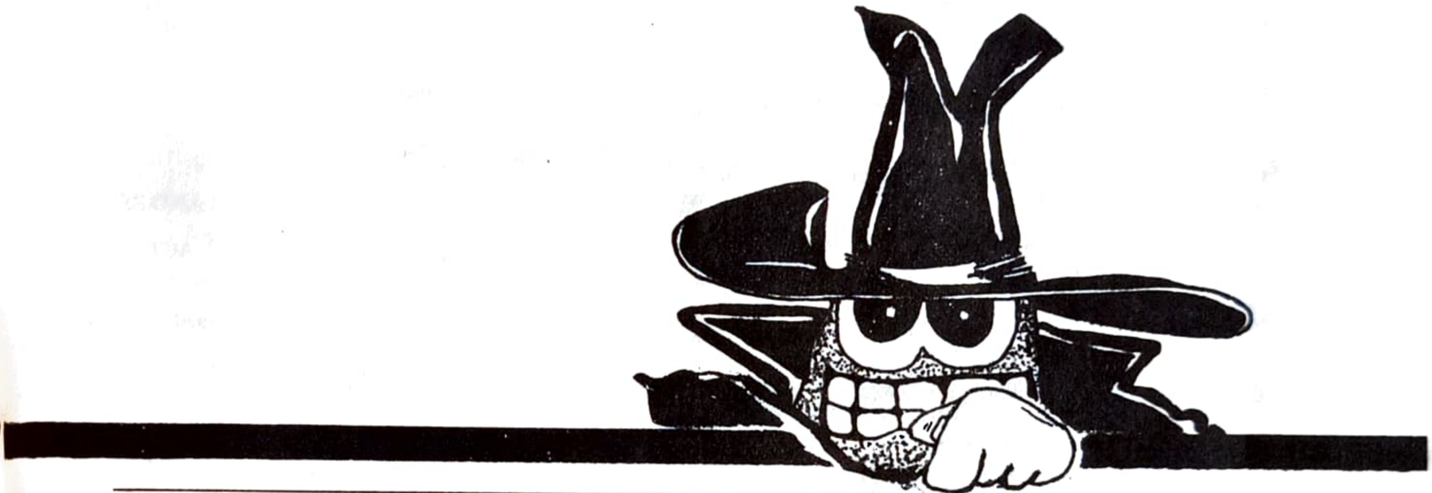
-34 EXCERPT

1. This excerpt is provided for your convenience. Note the following limitations.

a. The terminology is, in some cases, different from that given in the FWS Text or this NIP.

b. This switchology described is basic. It does not discuss tactical switchology implications.

2. PAY PARTICULAR ATTENTION TO THE INFLIGHT TROUBLE-SHOOTING GUIDE, page 77.



LASER TARGET DESIGNATOR (PAVE SPIKE) (AFTER TO 1F-4E-588)

PREFLIGHT

TDS BIT CHECKS

Pre–BIT

1. (P) Delivery mode knob – TGT FIND
2. (P) Scope display switch – TV
3. (P) Slant range indicator mode knob – WRCS
4. WRCS BIT selector knob – OFF
5. Cursor control panel FRZ and TGT INS (insert) button lights – OFF
6. INS mode select switch – ALIGN or NAV
7. Weapon delivery panel switches (3) – NORM
8. Radar power knob – STBY
9. Radar range knob – AI–10
   The AI 10 range is used to tune the TV display during DSCG BIT check
10. Radar display – B–WIDE
11. Scope mode knob – TV
12. Video select button – ASQ–153 ON
13. TDS BIT indicator - 0
    The BIT selector push button is functional with power off. Each depression advances the indicator one unit.
14. TDS ACQ switch – 12–VIS

(WSO) TDS Turn On and BIT

1. POWER ON button – PUSH ON
   a. All TDS lights – ON
      BIT 0 tests the TD panel lamps. The LT BRT knob is not functional in BIT 0.
2. TDS BIT switch – 1
   a. POWER ON light – ON

b. STOW light - ON
c. WRCS OUT light - ON
d. All other TDS lights - OFF

BIT 1 continuously monitors the TDS during normal operation. The MALF light illuminates to indicate a malfunction in the TV sensor, laser triggers, low voltage power supply, or the servo loop. The GO light is inoperative.

3. After 30 sec from POWER ON, TDS STOW button - PUSH
   a. STOW light - OFF
   b. WRCS OUT light - OFF
   c. MALF light - OFF
4. Adjust 12–VIS TV display for optimum picture.
5. TDS BIT switch - 2
   a. TV scene should dim. After 15 seconds, either GO or MALF light - ON

The track mode and TV performance is checked in BIT 2. A TV display is produced to simulate low light level conditions. This is accomplished by driving the filter wheel to maximum density: the TV scene should dim. The track mode test starts when BIT 2 is selected. After approximately 15 seconds, either a GO or MALF is presented on the status of the track mode.

NOTE

- BIT 2 cannot be performed while taxiing or airborne. The aircraft must be stationary to receive the required INS inputs for a GO indication.
- Under high light levels, filter wheel operation may not be apparent: the TV scene may not dim.

6. TDS BIT switch - 3
   a. Immediate GO or MALF light - ON
   b. TV reticle rotates 180° clockwise.

WARNING

Ensure ground crew is clear of the TDS pod while performing BIT 3 to prevent injury from laser energy. Refer to AFR 161–24 and AFM 161–32.

The laser systems are checked during the first part of BIT 3 to produce either a GO or MALF indication, and the TV reticle is rotated 180°. If a GO is received, the WSO fires the laser by holding the REJOVRD button depressed. The GO light goes out when REJOVRD is depressed. After approximately 5 seconds, either a GO or MALF light is presented and the REJOVRD button may be released.

7. After GO light ON, REJOVRD button - PRESS AND HOLD
   a. Immediate GO light - OFF
   b. After approximately 5 seconds, GO or MALF light - ON
8. REJOVRD button - RELEASE
9. TDS BIT switch - 4
   a. (WSO) After 4 to 15 seconds, GO or MALF light - ON
   b. (P) After 4 to 15 seconds, slant range indicator displays 021 ±002.

Laser slant range computation is checked in BIT 4 by simulating a range input of 2100 ±200 feet. The slant range indicator should display 021 ±002. Circuit operation is confirmed approximately 5 seconds after selecting BIT 4 by either a GO or MALF light.

10. TDS BIT switch - 1

TDS Functional Check

1. FOV button (IFF button) - PRESS AND RELEASE
   a. Narrow FOV selected.
2. Antenna action switch - HALF ACTION AND RELEASE
   a. Track mode entered.
3. Move antenna hand control forward and aft, left and right.
   a. TV LOS follows hand control movement.

NOTE

If track gimbal limits are reached, track mode is broken and should be re–entered to complete LOS movement check.

4. Antenna action switch - HALF ACTION AND RELEASE
   a. 12–VIS scene appears.
5. (P) Slant range indicator TEST button - DEPRESS
   a. (P) Digit readout check - 888

BEFORE TAKEOFF

1. TDS STOW button - PRESS
   a. STOW light - ON
      After approximately 5 seconds,
   b. WRCS OUT light - ON
   c. (P) TDS LOS indicator pointer - +160°

CAUTION

TDS POWER ON is required to maintain pod stowed position which should prevent FOD damage to the optical glass dome during the takeoff run.

TDS BIT FAULT ANALYSIS

Step	Problem	Additional Tests	Status
BIT 0			
1a	All indicators do not illuminate.		Mission may be flown with burned out lamps.
BIT 1			
3c	MALF light ON.	Press WRCS OUT button to light.	If MALF light goes out when WRCS OUT light illuminates, operate TDS without WRCS. If MALF light remains ON, mission should not be flown until problem is corrected.
BIT 2			
5a	MALF light ON.		Mission may be flown. TDS track mode may be severely degraded.
5a	TV scene does not dim.		Filter wheel malfunction. TV scene may washout in extreme high light level areas.
BIT 3			
6a	MALF light ON immediately.		No laser fire capability.
BIT 4			
9a	MALF light ON.	Check slant range indicator readout.	If 9a and 9b fail, ranging capability may be degraded. Perform inflight check of system operation.

INFLIGHT

TDS TURN ON

1. Radar power knob – STBY OR OPR
2. Scope mode knob – TV
3. Video select button – ASQ-153 ON
4. TDS BIT – 1
5. TDS ACQ switch – 12-VIS
6. TDS POWER ON button – PUSH
   a. POWER ON light – ON
   b. STOW light – ON
   c. WRCS OUT light – ON
7. TDS STOW button – PUSH
   a. STOW light – OFF
   b. WRCS OUT light – ON (if WRCS not selected).

NOTE

Do not unstow TDS pod while in a right bank of 20° or greater.

The WRCS OUT light remains illuminated if WRCS integration with the TDS is not accomplished. To select WRCS, refer to TDS BORESIGHT CHECK.

TDS BORESIGHT CHECK

Select WRCS/TDS Integration

1. Weapon delivery panel target find switch – NORM
2. TDS illuminated WRCS OUT button – PUSH
3. (P) Optical sight mode knob – A/G
4. (P) Delivery mode select knob – TGT FIND
   a. (WSO) WRCS OUT light – OFF
5. (P) Scope display switch – TV
   The WRCS OUT light goes off when the delivery mode select knob is positioned to TGT FIND or DIRECT and the weapon delivery panel target find switch is in NORM; indicating WRCS/TDS integration is selected.

12-VIS Boresight Check

1. (P) Hold pipper on distant point. Advise WSO of pipper position and subsequent movements (CALL).
2. FOV button – DEPRESS
   a. Narrow FOV selected.
3. Observe TV reticle position over distant object selected by pilot. Adjust TV reticle position as required using the AZ and EL 12-VIS boresight

knobs. Inform pilot when boresight completed (CALL).

BEFORE ACQUISITION (WRCS IN)

The following aircrew inputs or switch positions should be accomplished prior to IP/target acquisition. If WRCS is OUT, proceed to Before Acquisition (WRCS OUT).

WRCS Auto Mode, Before IP

The WRCS is integrated with the following release modes when the WRCS OUT light is off and TDS POWER ON is selected:

a. The WRCS automatic release mode is selected when the delivery mode knob is in TGT FIND and the slant range indicator mode knob is in WRCS.

b. The ROR automatic release mode is selected when the delivery mode knob is in TGT FIND and the slant range indicator mode knob is in ROR.

c. The DIRECT release mode is selected when the delivery mode knob is in DIRECT.

1. (P) Slant range indicator mode knob – WRCS or ROR
2. (P) Delivery mode knob – TGT FIND or DIRECT
3. (P) Sight mode knob – A/G or CAGE
4. (P) Reticle depression knob – SET AS DESIRED
   During all TDS acquisition modes, the optical sight is caged 35 mils below FRL and 0° azimuth. When the WSO selects TDS track mode, the optical sight depresses to the angle set in the RETICLE DEPR window, providing the A/G sight mode is selected. With CAGE sight mode selected, the sight reticle remains caged during TDS track mode.
5. (P) Navigation mode selector knob – COMP
6. (P) HSI mode switches – NAV COMP (if desired)
   If the HSI indicators are to be used select NAV COMP.
7. (WSO) INS mode selector knob – NAV
8. (WSO) BDHI mode switch – NAV COMP
9. (WSO) Weapon delivery panel – SET
   a. Activate switch – NORM
   b. Target find switch – NORM
   c. Range switch – NORM
      The position of the range switch has no effect because the release RANGE input on the WRCS panel is not accepted by the WRCS computer.
10. (WSO) WRCS input counters – SET
    a. Target distance N/S – 100-ft increments.
    b. Target distance E/W – 100-ft increments.
    c. IP altitude MSL – 100-ft increments.
       If an IP is not used, set N/S and E/W to 000 and set ALT to the target altitude MSL.
    d. Drag coefficient.
    e. Release advance – milliseconds (if desired)
11. (P) Weapon release controls – SET
    a. Weapon selector knob – BOMBS
    b. Nose/Tail arm switch – SET
    c. Intrvl switch – SET (if required)
    d. Station select – LOADED STATION

NOTE

The ADI will not provide steering if the weapon selector knob is on AGM-45.

12. (WSO) Target designator panel:
    a. WRCS OUT light – OFF
    b. ACQ switch – WRCS
    c. POWER ON light – ON
    d. OVHT/INS OUT lights – OFF
13. (WSO) TDS LASER READY button – PUSH ON
    a. LASER READY light – ON
14. (WSO) Radar controls:
    a. Radar power – OPR
    b. Radar display – PPI WIDE
    c. Radar mode – MAP
    d. Scope mode – RDR

BEFORE ACQUISITION (WRCS OUT)

ROR mode

The WRCS is removed from the TDS when the WRCS OUT light is illuminated. The following assumes the selection of the ROR automatic release mode with WRCS OUT and the delivery mode knob in TGT FIND. The DIRECT release mode can be used if desired. The level delivery profile is best suited for ROR mode.

NOTE

The TDS pod can be used with WRCS OUT and the delivery mode knob in any position (including off). However, TDS track mode is not available when the antenna hand control is non-function, as in the WRCS Dive Toss delivery mode.

1. (P) Slant range indicator mode knob – SET
2. (P) Enter the release slant range to target, times 100 feet
3. (P) Slant range indicator mode knob – ROR
4. (P) Delivery mode – TGT FIND
5. (P) Sight mode – A/G or CAGE
   During all TDS acquisition modes, the optical sight is caged 35 mils below FRL and 0° azimuth. When the WSO selects TDS track mode, the optical sight depresses to the angle set in the RETICLE DEPR window providing the A/G sight mode is selected. With CAGE sight mode selected, the sight reticle remains caged during TDS track mode.
6. (WSO) Weapon delivery panel switches – NORM
7. (WSO) Target designator panel:
   a. ACQ switch – 12-VIS or 9-VIS
   b. POWER ON light – ON
   c. OVHT/INS OUT lights – OFF
   d. WRCS OUT light – ON

NOTE

If the INS is OUT, the ROR automatic release mode can be accomplished using the antenna hand control to manually track the target.

8. (WSO) TDS LASER READY button – PUSH ON
   a. LASER READY light – ON

ACQUISITION

The following procedures assume the TDS to be in the acquisition mode of operation selected by the TDS ACQ switch. The TDS pod automatically enters the acquisition mode selected when initially turned on. The presence of the acquisition mode can be determined by the absence of the TT_G and T_O cues on the TV display.

(WSO) WRCS Offset Radar IP Acquisition

1. TDS ACQ switch – WRCS
2. Operate the along track cursor to position the range cursor over the RIP.

NOTE

Do not position the range cursor below zero range. This can cause the cursor and the along track control to become 180° out of phase; i.e., knob motion forward (increase range) produces cursor motion downward (decrease range). Range steering information would be in error by 180°. If this condition occurs, push the reset button and roll the knob/cursor out to the desired range.

3. Operate the cross track cursor to position the offset cursor over the RIP.
4. Freeze button – PUSH ON

NOTE

The along track cursor must be moved first to initiate cursor control. Position the intersection of the cursors over the RIP and then push the freeze button ON; the cursors begin tracking the RIP. The cursor can be moved to touch-up the intersection location over the RIP after the Freeze button is pushed on.

5. Target insert button – PUSH ON
   The steering instruments display steering command when the target insert button is pushed ON, and the cursor intersection will position over the target location and track the target. If the target is on the scope, set the target elevation on the ALT/RANGE counter and touch-up the cursors over the target.
6. Scope mode – TV
   a. TV reticle identifies cursor intersection.
      Adjust TV display and touch-up TV reticle position over target using WRCS cursor controls.
7. Radar display – B-WIDE
   The PPI radar display must be deselected to obtain antenna hand control operation during track mode.
8. When target is in TV FOV, enter TDS track mode.

(WSO) WRCS Visual IP Fly-Over Acquisition

1. WRCS panel ALT/RANGE counter, set in target altitude MSL.
2. TDS ACQ switch – WRCS
3. Scope mode – TV
4. When over IP, target insert button – PUSH ON
   Target elevation must be set in the ALT/RANGE control on the WRCS panel. When the aircraft is directly over the IP, depress the target insert button. The steering instruments supply steering commands to the target, and the cursors position over and start tracking the target. If the target is visible on the scope, the WSO may touch-up the cursor position.
5. When target is in TV FOV, enter TDS track mode when desired.

12-VIS/9-VIS IP/Target Acquisition

1. (WSO) TDS ACQ switch – 12-VIS or 9-VIS
2. (WSO) Scope mode – TV
   a. TV reticle identifies pipper position.
3. (P) Position pipper on IP/target location (CALL).
   The target designator pod LOS is boresighted to the pipper. Identify IP/target area for the WSO by pipper position. The WSO should enter TDS track mode at the call signal. After TDS track is established proceed to LGB release.
4. (WSO) When pipper is on IP/target area, enter TDS track mode.

(WSO) TDS TRACK AND LASER FIRE

1. Enter track mode: action switch – HA and RELEASE
   a. TT_G and T_O cues appear on TV display and flash of 5 Hz.
      Observe target in TV FOV and enter track mode. Correct minor tracking errors through movement of the antenna hand control.
2. TV field-of-view – AS DESIRED
3. Fire laser until bomb impact: action switch – FA and RELEASE (CALL)
   a. TT_G and T_O symbols – NOT FLASHING

WARNING

Strict adherence to laser safety regulations must be observed at all times during non-combat operation. Refer to AFR 161-24 and AFM 161-32.

NOTE

If the TT_G symbol flashes at 2 Hz, laser range is not valid. If the TT_G flashes at 5 Hz, transmitter laser energy is low. If both the T_O and TT_G flash at 5 Hz, system is in track but laser is not operating.

Laser must be fired before weapon release and continued until bomb impact. Inform the pilot of laser fire and commence bomb run. Correct tracking errors during laser fire through movement of the antenna hand control

4. After bomb inpact, stop laser fire: action switch – FA or HA and RELEASE
   a. TT_G and T_O cues flash at 5 Hz if FA selected. TT G and T_O removed if HA selected.

Observe TV scene of weapon impact. Laser fire stops and the track mode is retained when the action switch is depressed to FA and released. Laser fire stops and track mode is broken when the action switch is depressed to HA and released. Track memory is entered with WRCS IN when LOS gimble limits are reached: track is broken and the laser stops firing. If TT_G is flashing at 2 Hz, the REJOVRD button must be momentarily depressed to use laser derived slant range data. TT_G and T_O cues flash at 5 Hz to indicate laser has stopped firing while in the track mode.

5. To break track and enter acquisition mode: action switch – HA and RELEASE
   a. TT_G and T_O cues removed from TV display.
   b. TV LOS returns to acquisition mode.

NOTE

With WRCS acquisition mode selected and WRCS OUT, the 12–VIS acquisition mode is automatically selected when track is broken.

6. When leaving target area, LASER READY button – PUSH OFF
   a. LASER READY light – OFF

(P) LGB RELEASE

1. Master arm switch – ARM
   a. Selected station amber light – ON
2. Observe laser tracking, TT_G and T_O cues steady (NOT FLASHING)
3. Bomb button – DEPRESS AND HOLD
   a. WRCS tone on until bomb release.
   b. After bomb release, pullup light – ON and TONE OFF
   c. After station is empty, amber light – OFF
4. After weapon release, bomb button – RELEASE
   a. After bomb button release, pullup light – OFF
5. LOS indicator pointer – IN LIMITS
   Maintain target in TDS pod FOV until weapon impact.

WRCS Automatic Release Mode

Depress and hold the bomb button after laser fire is confirmed and initiate delivery maneuver. (Various delivery maneuvers are described in section I.) Maintain a course through the target (or upwind aimpoint) until weapon release. TT_G cue moves toward T_O as weapon release point approaches. Weapon release occurs when TT_G reaches T_O, the optical sight range bar is at 3:00 position, and the pullup light illuminates. After release, release the bomb button and maintain the target in TDS pod FOV until weapon impact.

ROR Automatic Release Mode

Confirm laser fire: TT_G and T_O cues not flashing. If the WRCS is integrated with the ROR mode, TT_G moves toward T_O as in the WRCS auto release; however, weapon release will not occur at T_O. If WRCS is OUT, TT_G remains stationary above T_O. As release slant range is approached, depress and hold bomb button, and maintain a course through the target (or upwind aimpoint) while in level flight. Weapon release occurs when the slant range indicator displays the preset slant range (or any slant range less than the preset slant range), if the bomb button is depressed. After release, release the bomb button and maintain target in TDS pod FOV until weapon impact.

(WSO) BEFORE LANDING

(WSO) TDS Pod Stowed

1. TDS POWER ON light – ON
2. TDS STOW light – ON

CAUTION

TDS POWER ON is required to maintain pod stowed position. The pod should be stowed before landing to prevent FOD damage to the optical glass dome during the landing roll.

(WSO) BEFORE ENGINE SHUT DOWN

(WSO) TDS Turn–off

1. TDS POWER ON button – PUSH OFF
   a. All TD panel lights – OFF

NOTE

When the illuminated POWER ON button is depressed, power remains to automatically complete the pod stow sequence if not previously accomplished.

SECTION V

INFLIGHT TROUBLESHOOTING GUIDE

MALFUNCTION FOLLOWED BY POSSIBLE SOLUTIONS	
1. No lights illuminate on PAVE SPIKE control panel when power button is depressed during turn-on.	1a. Check that LT BRT control knob is turned full up. 1b. Check TDS circuit breakers in place.
2. Pod does not unstow with no MALF in BIT 1.	2a. Reset all TGT DESIG PWR circuit breakers. 2b. Use INS-OUT mode. 2c. Select 9-VIS mode. Press the lighted stow button in an attempt to unstow the pod. Report malfunction after landing even if this procedure corrects the situation.
3. No control of pod in track mode.	3a. Check TGT ALT setting on WRCS panel. If TGT ALT is above aircraft altitude, track mode not possible with WRCS-IN. 3b. Try WRCS-OUT. 3c. Try INS-OUT. 3d. Check radar display out of PPI
4. Slant Range Indicator (SRI) displays wrong range.	4a. Check BIT 4: Observe readout (21 ± 2) closely for fluctuations. 4b. Adjust TGT ALT to see if adjustment affects readout. 4c. Use INS-OUT if 4b adjustment produces a large jump in slant range readout. 4d. Check that SRI is not in the SET mode.
5. Cannot select WRCS-IN.	5a. (P) Check: delivery mode knob is in TGT FIND or DIRECT. 5b. Check: weapon delivery panel target find switch is NORM. 5c. Check: INS-OUT light must be off.
6. With WRCS-IN, pod slews in opposite direction of slew commands from cursor control.	6a. Turn pod off and operate cursor controls to determine which direction each cursor moves. Press Reset button on cursor control panel if necessary.
7. With WRCS-IN, wrong steering information supplied.	7a. (P) (WSO) Check: NAV COMP must be selected in both cockpits. 7b. Check: Compass control switch is in PRIMARY.
8. With WRCS-IN, pod does not track target after FREEZE or TARGET INSERT.	8a. Check: TD panel ACQ switch is in WRCS. 8b. (P) Check: delivery mode knob is in DIRECT or TGT FIND. 8c. Check: TGT ALT setting on WRCS panel must be below aircraft altitude.
9. No TV display on scope (Power is ON).	9a. Check: pod STOW light must be off. 9b. (P) Check: Scope display switch is in TV.

	9c. Check: ASQ-153 light is ON (selected) on RCP video select button. 9d. Check: Scope mode knob is in TV.
10. No release in WRCS automatic mode.	10a. (P) Check: delivery mode selector is in TGT FIND. 10b. (P) Check: weapon selector knob is in BOMBS. 10c. (P) Check: SRI mode knob is in WRCS.
11. No release in ROR mode.	11a. (P) Check: SRI mode knob is in ROR. 11b. (P) Check: delivery mode knob is in TGT FIND. 11c. (P) Check: weapon selector knob is in BOMBS.
12. Laser does not fire.	12a. Check: LASER READY light is on. 12b. Check: TDS is in track mode, action switch FA. 12c. Check radar display not in PPI. 12d. (P) Cycle landing gear to reset nose wheel switch.
13. Cannot enter track.	13a. Select a radar mode and check hand control operation in FA. 13b. (P) Pod could be stuck in a gimble limit check LOS pointer indication. 13c. Check radar display is out of PPI.
14. Cannot break track.	14a. Run pod into a gimble limit. Then select WRCS OUT to place TDS in correct acquisition mode. 14b. Check that half action is selected (not full action).
15. Cannot clear memory track.	15a. (P) Position delivery mode knob to OFF (or to any position other than DIRECT or TGT FIND). 15b. Press WRCS OUT button: WRCS OUT light goes out. 15c. Cycle TARGET FIND switch on weapon delivery panel to HOLD, then back to NORM.
16. TT_G flashing 2 Hz.	16a. Laser fired. Laser range not accepted.
17. TT_G flashing 5 Hz.	17a. Attempted laser fire. No or low laser energy.
18. TT_G and T_o flashing 5 Hz.	18a. Track mode selected. Laser fire not attempted.
19. TT_G and T_o steady.	19a. Laser operation normal. Laser fired and laser range accepted.
20. TT_G and T_o removed.	20a. Acquisition mode selected or memory mode entered.

SECTION VI

LASER TARGET DESIGNATOR SCORING SYSTEM (LTDSS)

INTRODUCTION. The AN/DSQ-T34, commonly referred to as the LTDSS, was developed to aid in the training and proficiency evaluation of personnel using laser target designators currently in the Air Force inventory, as well as future designator systems. It is a self-contained, portable, battery-operated unit that can be used on either scored to tactical ranges. The system may be operated by ground range personnel or left unattended when documented scoring is not required. Scoring of laser pulses striking the target is accomplished by an electromechanical counter and, in addition, an audible tone pulse is transmitted to the designator aircraft by a UHF radio. The typical operational concept of the LTDSS is shown in Figure 38. No special test equipment is required for LTDSS checkout or repair. A built-in self-test feature is included in the system. Standard test equipment, common to most avionics/electronic maintenance facilities, is sufficient for system troubleshooting and parts repair or replacement.

DESCRIPTION. The LTDSS consists of three main assemblies: the Basic Chassis, Remote Control, and the Pulse Detector. The Remote Control Assembly contains the transceiver radio, two electromechanical counters, radio control switches, and associated wiring. The Pulse Detector Assembly is housed in a sealed nu-metal box mounted on a machined aluminum block. This assembly consists of a variable f-stop photographic lens, light filter, light detector diode, and pulse amplifier. The Basic Chassis Assembly is constructed on a flat aluminum plate secured in a standard, ruggedized aerospace ground equipment (AGE) container. The container is shockproof and watertight. Electronic circuit boards, self-test unit, power transformer, and associated wiring are located on the underside of the aluminum plate. The POWER ON/OFF switch, STROBE ON/OFF, HI/LOW battery charge switch, BATTERY CHECK meter, and fuses are located on the top side of the aluminum plate. A 28-volt nickel-cadmium battery pack is mounted in the bottom of the system container. The battery pack provides power to the entire LTDSS and is rechargeable from a 115-volt AC supply.

The LTDSS weights approximately 75 pounds and is easily transportable by two people. Time for the operational assembly or disassembly of the system is approximately 5 minutes. When set up for operation, the mast is screwed into the basic chassis aluminum plate or the top of the system. The mast consists of aluminum rods, 1 inch in diameter and 1 foot in length, which can be screwed together to extend the height up to 6 feet above the container. The Pulse Detector Assembly is attached to the mast, and cables connected.

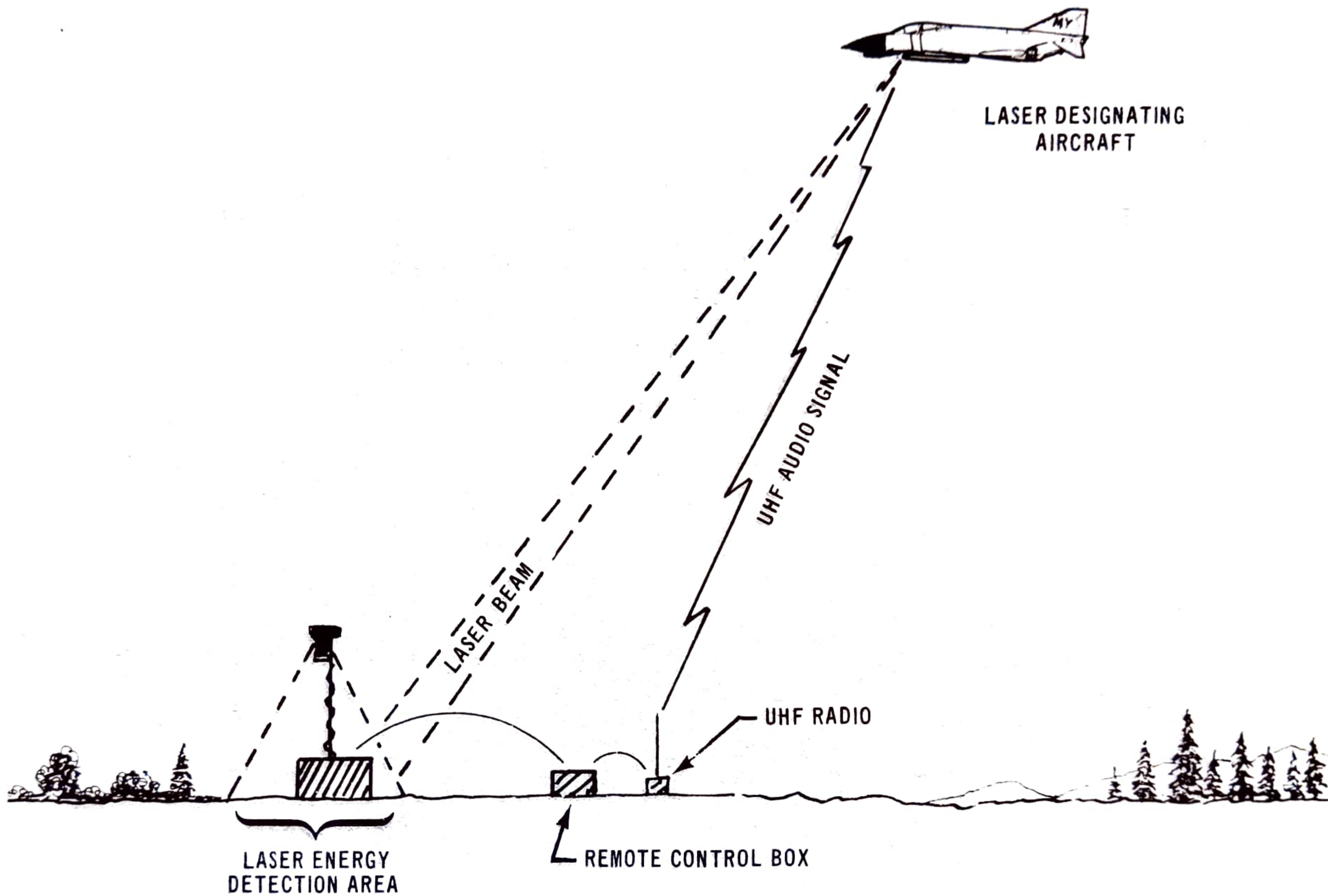


Figure 38 LTDSS Operational Concept.

SECTION VII - A

347TFW PAVE SPIKE/LGB TRAINING/MAINTENANCE/OPERATIONS
GENERAL

1. PAVE SPIKE pod carriage and employment

Airspeed Knots/Mach	Accel G Sym/Unsym
550/1.2	+6.0 to -1.0/+4.0 to 0.0
See Note 2	
600/1.2	+3.0 to 0.0/+2.4 to 0.0

NOTE 1: Rocket launches are not authorized on Station 5 when PAVE SPIKE is loaded.

NOTE 2: With visor closed, speeds are aircraft limits.

2. How do you keep a PAVE SPIKE program going? Aircrews must have good systems knowledge and write-up the PAVE SPIKE/associated systems accurately. Close examination of the WRCS and cursor calibration checks is necessary. Maintenance personnel must be well-trained in order to effectively trouble-shoot the system. The PAVE SPIKE Shop must be equipped with adequate vehicles and equipment to respond to "Redball" requests and perform maintenance tasks. Coordination between maintenance shops is essential. A quick look "CND" by one shop won't hack it. We're not talking about just one system with PAVE SPIKE. There's the INS, WRCS, WCS systems. The WRCS should be calibrated to center spec., not just "in tolerance" calibration. The pod is very sensitive to voltage fluctuations and to bogus WRCS or INS inputs. Proper maintenance of these associated systems is a must and will not only provide PAVE SPIKE capable aircraft; but will also improve Dive Toss and integrated radar/visual bombing systems. If your Dive Toss systems are Tango Uniform, your PAVE SPIKE integration will not be far behind. When that happens, you give up your automatic acquisition and release modes and most of your standoff capability. IS THIS THE COMBAT CAPABILITY YOU WILL ACCEPT?! A top notch Wing/Squadron will not settle for that.

3. Fortunately the PAVE SPIKE aircraft configuration is compatible with our usual air-to-ground training and combat configurations. Unfortunately it must be noted that an ECM pod cannot be loaded in the left forward missile well when a PAVE SPIKE pod is loaded. And in the F-4E, the gun fairing on the nose gear door prevents an ECM pod from being loaded in the right forward missile well. Serious consideration, therefore must be given to aircraft/flight configurations during combat operations. There are definitely trade-offs in this situation.

4. INS - OPERATIONS AND MAINTENANCE

a. Good INS maintenance and a good INS alignment is needed for PAVE SPIKE operations due to the system's integration with the INS and WRCS systems. The "quickie" BATH alignment is not satisfactory. As a minimum get a full Gyro Compass (GC) alignment. A double alignment would be better. A full GC alignment for PAVE SPIKE should be nothing new. A poor alignment adversely affects INS navigation capability, Dive Toss, and all your integrated radar/visual bombing modes also. If the INS is out of tolerance, write it up!

b. You may have noticed difficulty in aligning the INS during some surge operations when aircraft are parked close together. The starter cart (Dash 60) for the aircraft on your left may be located extremely close to your left wing. "SO WHAT?", you say. "HERE'S WHAT", he says. The INS flux value (senses magnetic variation) is located in the aircraft's left wing tip. The Dash 60 running (or just sitting there--or any large amount of metal) under your left wing will cause one to two outcomes. Either no alignment or an extremely slow or poor alignment. This is because the object disturbs the earth's magnetic field (in the object's vicinity) and changes the magnetic variation (in the object's vicinity). Your options are 1) don't put any Dash 60s under the left wing, or 2) perform a full alignment elsewhere. This last option must consider taxi flow requirements and arming area procedures during surge/ORI/combat operations.

5. DEBRIEF! An indepth post mission debrief between the aircrew and the PAVE SPIKE sho is essential. In all cases, fill out a PAVE SPIKE Debrief Sheet (MAFB Form 0-45) during maintenance debrief. Notify someone in charge if these forms are not available. If you need to discuss the problems with the PAVE SPIKE Shop call Ext 3339 and speak to one of the technicians. An over-the-phone debrief is highly recommended. A sample debrief shee is shown on page 110.

6. Crews are encouraged to visit the PAVE SPIKE Shop to practice BITS, switchology and system operation. The PAVE SPIKE Shop is CRS/MACAP (Photo-Sensor) and will be located in building 758, Ext 3339.

7. Laser Ranges. The authorized laser use airspace/ranges available to the 347TFW are:

a. Eglin Range C-52 (160nm) (LTDSS is available on C-52).

b. Eglin Range C-62 (160nm).

c. Pinecastle (R-2910) (135nm)

d. Avon Park (215nm)

NOTE: Aircrews will insure that range personnel understand that laser operations are to be conducted during the check-in on range frequency.

We all know the problems of distance, weather, and priority associated with these ranges. 'Nuff said.

8. Laser Safety: The following precautions will be adhered to by 347TFW aircrews:

a. Ground crews will be clear of the pod when performing BIT 3 IAW TO 1F-4E-34-1-1.

b. The laser will not be fired outside authorized laser use airspace (LASER READY button - Not Depressed; LASER READY Light - Out).

c. The target will be positively identified before lasing begins.

d. Aircrews will positively insure that range personnel understand that laser operations are being conducted. This will allow for use of personnel safety precautions and devices.

e. Under no circumstances will an airborne target be lased.

9. For PAVE SPIKE/LGB weapons qualification requirements consult TACM 51-50.

SECTION VII - B

PAVE SPIKE/LGB TRAINING PROFILES

The following PAVE SPIKE/LGB mission outlines are included for your convenience. See MAFBR 51-1 for the complete 347TFW training program. (Practice Bombs or Full Scale Inert LGB's Will be Delivered Whenever Possible.)

1. LG-1: PAVE SPIKE Orientation. Upgrading Pilots and WSO's will fly LG-1 in the rear cockpit.

a. Aircraft requirements: One (may be flown as two ship) with pod and BDU-33's.

b. PS Instructor requirements: One in each aircraft.

c. Objectives: System Orientation and Operations.

(1) D-Value computations.

(2) PAVE SPIKE pod and LGB preflight.

(3) BIT Checks.

(4) Ground Systems Checks (Track check, CADC check).

(5) Airborne Systems checks (Memory check, CADC check).

(6) Boresight.

(7) Target acquisition and Area Correlation.

(8) Interpretation of TV symbology, SRI, and LOS indicator.

(9) Crew Coordination.

(10) Tracking techniques for various slant ranges, "g" loads, attitudes, and altitudes.

(11) Front and rear cockpit switchology.

(12) Demonstrations of blanking, pod gimbal limits, memory mode, and "idiot" mode.

(13) Demonstrate limitations of 9-VIS acquisition.

(14) Practice 12-VIS, and WRCS acquire modes of acquisition. This will include VIP, VOAP, and ROAP acquisitions.

(15) Demonstrate INS out and WRCS out operations.

(16) Practice PAVE SPIKE deliveries to include Release on Range (ROR); WRCS Automatic Releases including Toss and Loft. Discuss manual backups if applicable.

d. Mission Planning: Mission planning for LG-1 will center on thorough familiarization with the AN/ASQ-153 PAVE SPIKE System including preflight, BITS, systems checks, boresight, symbology, switchology, malfunction analysis, and modes of acquisition and delivery. Upgrading crewmembers will compute D-Value and the resulting target altitude correction.

e. Briefing: The PS instructor will brief the mission. Upgraders will be prepared to answer questions concerning the areas mentioned in the Mission Planning paragraph above.

f. Mission Overview:

(1) Conduct the systems preflight, BITS, ground and airborne systems checks, and boresight. Practice tracking, switchology, and scope and indicator interpretation enroute to the range/area. Initial passes should emphasize system switchology, symbology interpretation, and target tracking. Techniques should improve as the mission progresses and the passes become more demanding. Pilots in the rear cockpit will be demonstrated a realistic attack and delivery in order to increase awareness of system operation and limitations at combat speeds, various "g" loads, and aircraft attitudes. Crew coordination will be practiced. Purposely demonstrate blanking, pod gimbal limits, memory mode, and "idiot" mode. Demonstrate target tracking with INS OUT selected. Demonstrate tracking in WFOV and NFOV. Deliver practice bombs when airspace permits. LG-2 should continue where this mission ends.

(2) Demonstrate the following with visual acquisition.

(a) 12-VIS acquire, track in WFOV, shallow dive.

(b) 12-VIS acquire, track in NFOV, shallow dive. Demonstrate tracking problems.

(c) 12-VIS acquire, track in WFOV INS OUT shallow dive.

(d) 9-VIS acquire, roll-in, shallow dive, memory mode demonstration.

(e) Demonstrate low and high (5M') altitude left/right designation at various slant ranges from the target.

(3) Demonstrate Radar/WRCS acquisition modes:

(a) VIP: Fly over visual IP, insert to target.

(b) VOAP: Using a Visual offset Aim Point in the TV, insert to target.

(c) ROAP: Using a Radar offset Aim Point on the radar, insert to the target and acquire the target in TV.

(4) Demonstrate basic weapon deliveries: Release on Range (ROR), Loft, Toss.

g. Effectiveness Criteria: As a minimum, all acquisition and tracking modes will be demonstrated. An operational PAVE SPIKE pod must be loaded on the aircraft.

h. Documentation: PS Instructor completes PAVE SPIKE/LGB Grade Sheet.

i. Safety: THE LASER WILL NOT BE FIRED OUTSIDE AUTHORIZED LASER USE AIRSPACE (LASER READY BUTTON - NOT DEPRESSED; LASER READY LIGHT - OUT).

2. LG-2: PAVE SPIKE Proficiency (and Tactics Introduction if desired).

a. Aircraft requirements: One (two-ship if Tactics Intro included). Pod and BDU-33's loaded.

b. PS Instructor requirements: One in each aircraft.

c. Objectives: Same as LG-1 with the following notes:

(1) Upgraders will demonstrate proficiency in:

(a) System preflight.

(b) System BITS.

(c) System Boresight.

(2) Tactics Introduction (if desired) will be flown to act as a building block to succeeding missions. Tactics work will include low altitude awareness, limited comm maneuvering and attacks such as:

(a) Split.

(b) Delayed split.

d. Mission Planning: Same as LG-1.

e. Briefing: Upgrading aircrew members (Pilots and WSO's) will brief system preflight and BITS. Instructor will brief the remaining items as described in LG-1.

f. Mission Overview: Same as LG-1 with pilots applying knowledge from LG-1 to the front cockpit and WSOs refining system operation and techniques. If tactics introduction is included, increase the difficulty on succeeding passes if the upgrader's progression permits. Practice bombs will be delivered if airspace permits.

g. Effectiveness Criteria: An operational PAVE SPIKE pod must be loaded on the aircraft and all modes of acquisition and weapons delivery will be demonstrated for an effective PAVE SPIKE sortie.

h. Documentation: PS Instructor completes PAVE SPIKE/LGB Grade Sheet.

i. Safety: THE LASER WILL NOT BE FIRED OUTSIDE AUTHORIZED LASER USE AIRSPACE (LASER READY BUTTON - NOT DEPRESSED; LASER READY LIGHT - OUT).

3. LG-3: PAVE SPIKE Proficiency and Tactics Orientation.

a. Aircraft requirements: Two. Pod and BDU-33's loaded.

b. PS Instructor requirements: One instructor in each aircraft.

c. Objectives: System Proficiency and Tactics Orientation.

(1) PAVE SPIKE Proficiency. Upgrading crewmember demonstrates proficiency in:

(a) D-Value Computations.

(b) Ballistic Computations.

(c) System Preflight.

(d) BITS.

(e) Boresight.

(f) System checks.

(g) Interpretation of TV symbology.

(h) Interpretation of SRI and Azimuth-Elevation (LOS) indicator.

(i) WSO will demonstrate proficiency in Target tracking.

(j) Area Correlation and Target ID.

(k) Crew coordination.

(1) System Switchology.

(2) Tactics Orientation.

(a) PAVE SPIKE/LGB planning considerations.

(b) Low altitude tactical formation and mutual support responsibilities.

(c) Preplanned target attacks using visual acquisition and automatic release with individual aimpoint.

(d) Low angle standoff deliveries from low altitude pop-up attacks using WRCS acquisition and WRCS automatic release with individual aimpoints.

(e) Practice current attacks and deliveries at realistic altitudes and airspeeds while using the various acquisition modes as required by the attack/target/ranges. Some examples may be, but are not limited to the following:

1. Split.

2. Delayed Split.

3. Single Attack.

4. Double Attack.

5. In-trail Attack.

6. Adverse Weather Attacks.

7. Toss Options/Deliveries.

8. Loft Options/Deliveries.

9. Long Range Dive Toss Deliveries for LGB delivery without a pod.

10. Backup Direct Deliveries (if applicable).

These attacks are examples only. Tactics must be refined to suit the target area and threat.

(f) Limited comm maneuvering.

(g) Ballistic Computations.

d. Mission Planning: Extensive planning is required for the mission. Pick targets and preplan low level tactics to pop-up or loft deliveries. Use limited comm tactics. Upgraders will compute D-Value corrections and ballistic computations. The instructor will aid as necessary.

e. Briefing: Upgrading crewmembers (Pilots and WSO's) will brief systems preflight, BITS, system checks and D-Value computations. Instructor will brief tactics and attacks. He will also cover techniques and procedures for use of the system in a tactical environment.

f. Mission Overview: This mission will primarily focus on tactics orientation. Enter the range from a selected IP to tactical PAVE SPIKE weapons delivery. Exit the target area with mutual support and proceed to another IP for the following tactical deliveries. Practice different types of attacks and modes of acquisition. Practice single designator tactics with one aircraft dropping. Also practice single designator tactics with both aircraft dropping ordnance. See para. 3c Objectives above. Practice bombs will be delivered if airspace permits.

g. Effectiveness Criteria: An operational PAVE SPIKE pod must be loaded on the aircraft for an effective PAVE SPIKE mission. Additionally, two-ship PAVE SPIKE/LGB tactics must be practiced, BDU-33's will be dropped or LDTSS will be used when the mission is flown in authorized laser airspace.

h. Documentation: PS instructor completes PAVE SPIKE/LGB Grade Sheet.

i. Safety: THE LASER WILL NOT BE FIRED OUTSIDE AUTHORIZED LASER USE AIRSPACE (LASER READY BUTTON - NOT DEPRESSED; LASER READY LIGHT - OUT).

4. LG-4: PAVE SPIKE/LGB Tactics Proficiency.

a. Aircraft requirements: Two. Pod and BDU-33s loaded.

b. PS Instructor requirements: One in the flight.

c. Objectives:

(1) PAVE SPIKE/LGB planning considerations.

(2) Ballistic Computations.

(3) Low altitude comm-out formation and maneuvering.

(4) Mutual support responsibilities.

(5) Preplanned attacks using visual acquisition and automatic releases with individual aimpoints.

(6) Low angle standoff deliveries from low angle pop-up attacks using WRCS acquisition and WRCS automatic releases.

(7) Specific laser aimpoints.

(8) Delayed lasing.

(9) Multi-laser considerations.

(10) Crew coordination.

(11) Area Correlation and Target ID.

(12) Attacks such as, but not limited to:

(a) Split.

(b) Delayed Split.

(c) Single Attack.

(d) Double Attack.

(e) Adverse Weather Attacks.

(f) Loft Deliveries.

d. Mission Planning: The upgrading crewmember(s) will pre-plan the tactics, ballistics, type delivery, etc., for the first attack. A high threat comm-out scenario will be simulated. The upgrading crew will receive a scenario from the PS instructor. The scenario will include realistic threats for the unit's primary theater of operations. Attacks should be planned to include ingress, target destruction, and egress while maintaining mutual support. If possible, the attacks should be accomplished on a range with the expenditure of BDU-33's.

e. Briefing: Upgrading crewmembers (Pilots and WSOs) will brief system preflight, BITS, system checks, and D-value computations. In addition they will brief the first attack including ballistic computations, tactics, and type delivery. The instructor will brief the remaining attacks and discuss delayed lasing technqiues, multi-laser environment tactics, and techniques for system use in a high threat environment.

f. Mission Overview: This is a tactics mission. Enter the range from an IP simulating a high threat comm out environment. Conduct the preplanned attack. Egress the target area to the IP for the next attack while re-establishing mutual support. Practice several types of attacks and deliveries. See also para 4c Objectives above.

g. Effectiveness Criteria: An operational PAVE SPIKE pod must be loaded on the aircraft for an effective PAVE SPIKE mission. Additionally two-ship PAVE SPIKE/LGB tactics must be practiced.

h. Documentation: PS instructor completes PAVE SPIKE/LGB Grade Sheet.

i. Safety: THE LASER WILL NOT BE FIRED OUTSIDE AUTHORIZED LASER USE AIRSPACE (LASER READY BUTTON - NOT DEPRESSED; LASER READY LIGHT - OUT).

5. LG-5: PAVE SPIKE Multi-ship tactics.

a. Aircraft requirements: 2 minimum (4 desired). Pod and BDU-33's loaded.

b. PS Instructor: One in the flight.

c. Objectives:

(1) Mission Planning.

(2) Multi-ship PAVE SPIKE tactics.

(3) Minimum exposure attacks in high threat environment.

(4) Low altitude comm out formations and maneuvering.

(5) Considerations for multi-laser environment.

(6) Ballistic considerations.

(7) Lasing techniques and aimpoints.

(8) Crew coordination.

(9) Demonstrated knowledge of, and proficiency in PAVE SPIKE tactics, system operation, and employment considerations.

d. Mission Planning: Extensive and thorough mission planning is required by the upgrading crew members to insure that all players understand their responsibilities (inter-flight and inter-cockpit) during multi-ship PAVE SPIKE employment in a high threat environment. The PS instructor will provide a scenario similar to LG-4. Give consideration to multi-laser environments and plan specific aimpoints.

e. Briefing: The upgrading crew (Pilot and WSO) will brief the mission. Emphasis should be placed on employment of the PAVE SPIKE system in a high threat environment.

f. Mission Overview:

(1) This mission is very important because of the high probability of being

fragged for multi-ship PAVE SPIKE/LGB attack missions. This is due primarily to the limited number of LGBs which may be carried on any given aircraft.

(2) The mission is a tactics mission and should be flown in a simulated high threat, comm out environment. If the target array(s) allow, simulate a multi-laser environment. Techniques such as delayed lasing should be practiced if the scenario allows Egress the target area re-establishing mutual support.

g. Effectiveness Criteria: An operational PAVE SPIKE pod must be loaded on designator aircraft. A minimum of two pods per four ship are required. Pod loaded designator aircraft will log PAVE SPIKE LG-5 sorties. Non-pod equipped aircraft (if any) will log a WPN DEL/SAT (LGB) training sortie. A minimum of two tactical PAVE SPIKE/LGB attacks are required. Mutual support will be maintained. Effective use of low altitude comm out maneuvering. Upgrading crew successfully planned the mission.

h. Documentation: LG instructor completes PAVE SPIKE/LGB Grade Sheet.

i. Safety: THE LASER WILL NOT BE FIRED OUTSIDE AUTHORIZED LASER USE AIRSPACE (LASER READY BUTTON - NOT DEPRESSED; LASER READY LIGHT - OUT).

6. CONTINUATION TRAINING (CT):

a. Aircraft requirements: Minimum of two. Four desired for multi-ship tactics. Pods and BDU-33's.

b. Aircrew requirements: PAVE SPIKE/LGB qualified aircrews.

c. Objectives: System and tactics proficiency.

(1) Demonstrate proficiency in PAVE SPIKE/LGB systems operation.

(2) Crew coordination.

(3) Practice low altitude, limited comm PAVE SPIKE/LGB designator and bomber tactics in a simulated high threat environment.

(4) See also objectives of LG-4 and LG-5.

d. Mission Planning: Plan tactical deliveries on known targets in a high threat scenario.

e. Briefing: Pilots and WSOs will brief the mission.

f. Mission: LG-4, LG-5 and SAT profiles. Also:

(1) CT-1 Review: To be flown if crewmember exceeds 60 days between PAVE SPIKE sorties - PSI in flight; over 120 days PSI in aircraft.

(a) Two-Ship Tactics.

(b) Boresight, acquisition, tracking, and delivery procedures.

(c) Pod capabilities and limitations.

(d) BDU-33 or LTDSS required.

(e) Emphasis of this mission should be toward single ship - PAVE SPIKE reorientation.

(2) CT-2 and 3. Review of minimum altitude, limited comm attack tactics.

(a) Two-ship tactics.

(b) Emphasis on mutual support, various target acquisition modes. Practice self-contained and buddy designation delivery modes.

(3) CT-4 and Beyond, Continuation Training. Four/three ship mission desired.

(a) These missions must be designed to simulate combat environment of the various theater operations. The squadron weapons office should develop a variety of AST/SAT scenarios for aircrew training. Target types and threats should be varied to encourage use of different weapon employment methods.

(b) Flight leaders will use Fighter Weapons Instructor Course instruction texts. TCM 3-1, Tactical Analysis Bulletins, PAVE SPIKE introduction tactics addendum, and unit tactics manuals as points of departure for the development of workable solutions to problems caused by environmental conditions likely to be encountered. Utilization of PAVE SPIKE to enhance aircrew survival and increase the probability of target destruction is the goal of this training.

(c) The complexity of the PAVE SPIKE system and the high aircrew workload associated with low altitude, high speed, limited communications tactics requires that a majority of the continuation sorties be utilized toward improving the aircrew readiness in this difficult area. It is highly desirable that one sortie per training cycle include an LGB drop. All other sorties, BDU-33s, or the LTDSS should be utilized on two separate attacks (if authorized laser airspace is available).

7. LGB Training: (Proposed training; Ref. TACM 51-50, Vol V.) Aircrews assigned to a PAVE SPIKE tasked unit and are not qualified as PAVE SPIKE designator crews should accomplish the following missions to enhance the unit's overall LGB capability.

a. LGB-1: LGB Delivery Orientation.

(1) Aircraft Requirements: Two with BDU-33's. (One with PAVE SPIKE pod)

(2) Aircrew Requirements: One qualified PAVE SPIKE Crew and one LGB Crew.

(3) Objectives:

(a) Knowledge and practice of LGB weapons delivery parameters.

(b) Practice range events (BDU-33)

1. Tactical pops

2. Loft

3. Dive toss options

4. Manual (direct) deliveries

(c) Practice low altitude, limited comm maneuvering, and attacks such as:

1. Split

2. Delayed split

3. Loft options

4. Toss options

b. LGB-2: LGB Delivery Proficiency.

(1) Aircraft Requirements: Two with BDU-33's (one with PAVE SPIKE pod).

(2) Aircrew Requirements: One PAVE SPIKE qualified crew and one LGB crew.

(3) Objectives:

(a) Proficiency in achieving LGB delivery parameters.

(b) Practice low altitude comm out maneuvering.

(c) Practice attacks such as:

1. In-Trail

2. Split Options

3. Loft Options

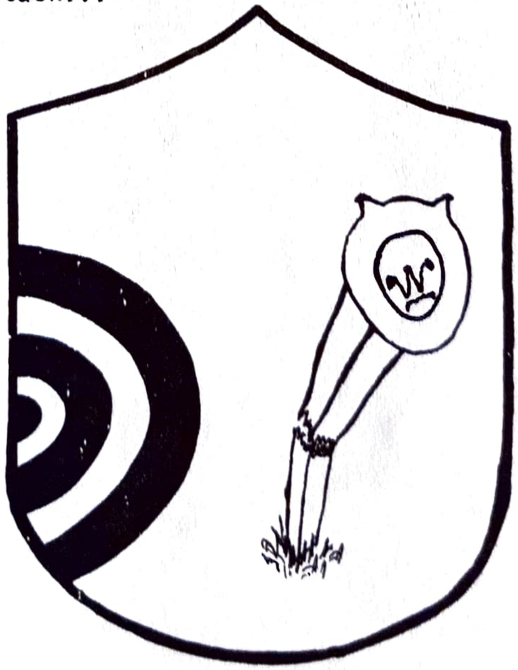
4. Toss Options

(d) Practice tactical deliveries of BDU-33's (airspace permitting).

8. For PS Instructor upgrade requirements see MAFBR 51-1.

Results of a PAVE SPIKE/LGB Attack...

Results of a poorly planned, poorly executed (or both) PAVE SPIKE/LGB Attack...



SECTION VIII

PAVE SPIKE EXPANDED BRIEFING GUIDE

Pilots and WSOs will be actively involved in briefing PAVE SPIKE missions. The following is a guide of items you may wish to brief for PAVE SPIKE missions. There may be other items you wish to brief. A detailed but concise brief is essential for effective PAVE SPIKE employment.

1. Personal Equipment:

   a. Grease pencil.

   b. Barf bag.

2. Weather:

   a. D-Value computations and target altitude corrections.

   b. Target area winds.

   c. Target area ceilings.

3. Weapons parameters and release settings including bomb time of fall (TOF).

4. PAVE SPIKE pod preflight (see also TO 1F-4E-34-1-1CL-1 and TO 1F-4F-34-1-1):

   a. Aircraft boarding steps - retracted.

   b. Nitrogen pressure indicator - extended.

      - "Redball" PAVE SPIKE shop for nitrogen servicing ASAP if servicing required.

   c. Missile well adapter lock pin - installed.

   d. Swaybraces - tightened; pod secure.

   e. Pod head - no damage, secure, rotates freely, detent.

   f. Visor - closed when pod in stowed position.

   g. Dome heater wire cable - no damage.

   h. Surface heat exchanger - no damaged fins.

   i. End cap (aft end) - secure.

5. Armament preflight (GBUs or BDUs):

   a. See TO 1F-4E-34-1-1.

   b. See TO 1F-4E-34-1-1CL-1.

6. Ground Systems Checks (Internal Power):

   a. BITS (PAVE SPIKE)

      (1) BIT 0 - Lamp Test.

      (2) BIT 1 - System Status Test. Normal position for all operations.

(3) BIT 2 - Servo Dynamic Track and TV performance. Accomplish while stationary.

(4) BIT 3 - Laser Test. Recommend accomplishment after leaving chocks and during taxi to arming area. Ensure ground crews are clear of the pod while performing BIT 3.

(5) BIT 4 - Check SRI and Laser Slant Ranging.

During upgrade missions discuss the function of each BIT and BIT fault analysis.

b. Get good Gyro-Compass (GC) INS alignment.

c. Track check (INS in NAV).

d. CADC check.

e. 9-VIS Boresight.

7. Pod stowed for takeoff.

8. Airborne Systems Checks.

a. The usual non-SPIKE airborne systems checks.

b. 12-VIS boresight. On prominent ground point, or 6-9,000' in trail with another aircraft.

c. Memory check.

d. CADC check.

9. Review of cockpit indicators and controls.

a. FCP

(1) SRI

(2) AZ-EL (LOS) Indicator

(3) ADI

(4) HSI

(5) Optical Sight

(6) MILS

(7) LABS/WPN release switch

(8) WPN Select Knobs

(9) Station Select

(10) AWRU

(11) ARM/NOSE/TAIL SWITCH

(12) Master Arm

(13) Pickle Button

(14) Scope display select switch (pedestal panel)

b. <u>RCP</u>

(1) DSCG-TV

(2) Video Select Switch - ASQ-153

(3) PAVE SPIKE (TDS) Control Panel

(4) Radar Antenna Control Handle

(5) WRCS Control Panel

(6) INS

(7) Weapons Delivery (702) panel

(8) Cursor Control Panel

(9) Radar Control Panel

(10) BDHI

(11) Coder Control Unit (CCU)

10. Review Switchology (for both cockpits):

a. Modes of Acquisition

(1) 9-VIS Acquire

(2) 12-VIS Acquire

(3) WRCS Acquire

(a) VIP

(b) VOAP

(c) ROAP

b. Type of weapons deliveries

(1) Direct

(2) SPIKE toss (WRCS auto)

(3) Long range dive toss

(4) Loft

(5) Release on Range (ROR)

c. For upgrade missions discuss step-by-step the positioning and repositioning of switches required to perform each type of acquisition, attack, and delivery.

11. TGT Altitude Window corrections and when you must change them.

- "Idiot" Mode

12. Display Symbology during:

a. Acquisition

b. Track without lasing

c. Track with lasing

d. Laser range acceptance (use of REJOVRD)

e. Memory Mode

f. Malfunction Analysis

13. Memory Mode

a. Gimbal limit

b. Target Insert

14. INS-OUT Operation

15. WRCS OUT Operation

16. Crew Coordination and Responsibilities.

a. Verbal calls/terminology

b. Pod Gimbal limits

c. Blanking

d. Laser Range acceptance and REJOVRD

e. Low Altitude responsibilities

f. Visual lookout

17. Tactics/Attacks/Deliveries

a. Target Considerations

(1) Threat

(2) Effects of WX, Winds, Ceilings, Smoke, Sun Angle, Target reflectivity.

(3) Terrain

b. Specific laser aimpoints

(1) Area correlation

(2) TGT ID

c. Type weapon

(1) Paveway I

(2) Paveway II

d. Designator Techniques (as required)

(1) Multi-laser environment

(2) Delayed lasing

(3) Elevated Aimpoints

(4) Wind Corrections

(5) Moving Targets

(6) Bomb TOF

(7) Maritime Operation Considerations

e. Delivery Options

(1) Weapons release parameters and settings

(2) Type ballistics

(3) Type Attack

(4) Back-up delivery and switchology

f. Attacks (and reattack options)

(1) Split

(2) Delayed Split

(3) Single Attacks

(4) Double Attacks

(5) "Buddy" Designator Tactics for "blind" LGB bombers.

(6) In-Trail

(7) Loft Options

(8) Toss Options

(9) Exposure Time

(10) Target Area Egress

<u>Emphasize mutual support, target destruction and force survival.</u>

g. Low Altitude Considerations/Awareness

(1) Reafirm low altitude ROE

(2) Reafirm low altitude contract

(3) Flight and crew responsibilities (interflight and intercockpit)

(4) Comm-out maneuvering

(a) #1A - wingman consideration/planning/navigation.

(b) #2B - understands turn geometry/able to direct comm out turns

h. Abort plan (3-ship option)

i. Reattack plan (if applicable)

Pilots must completely understand low altitude tactical maneuvering, attack geometry weapons release parameters, system limitations, and mutual support considerations.

WSO's must know how to direct comm-out turns. Minimum in-cockpit time is the goal of WSO training in order to allow for maximum tactical flexibility and mutual support. This requires in depth systems and tactics knowledge.

18. Full scale (Live or Inert) GBU Delivery - Contact DOW

a. Collect data for TAFSWAT - Contact DOW

b. Hung live or inert GBU's will be treated like other hung live or inert full scale weapons IAW 347TFW directives.

19. Special subjects:

a. No supersonic flight through precipitation with pod unstowed (stowed okay if POWER-ON).

b. Pod will be stowed (POWER-ON illuminated and STOW illuminated) for takeoff and landing.

c. Insure ground crew is clear of the PAVE SPIKE (TDS) pod while performing BIT 3. Conduct BIT 3 during taxi to arming area.

d. Beware of TV target fixation at low altitude. The,"that picture is great!", syndrome could be hazardous to your health.

e. THE LASER WILL NOT BE FIRED OUTSIDE AUTHORIZED LASER USE AIRSPACE (LASER READY BUTTON - NOT DEPRESSED; LASER READY LIGHT - OUT).

f. Lasing will not be initiated until the target has been positively identified and is being tracked.

g. Insure range personnel understand that laser operations are being conducted.

h. Under no circumstances will an airborne target be lased.

i. GBU-10 (2000 lb) hung bomb/assymetric considerations.

SECTION IX

347 TFW AIRCREW STUDY GUIDE
PAVE SPIKE/LGB

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Refer to FWS TEXT, LASER GUIDED WEAPONS DELIVERY , PART TWO (S), and other sources.

A. LASER THEORY: The upgrading crewmember will be able to discuss the following:

1. From four pictoral diagrams of an atom in various energy states caused by photon interaction, label correctly the diagram that depicts:

a. Ground State

b. Absorption

c. Spontaneous emission

d. Stimulated emission

2. List three characteristics of laser energy which make it different from "normal" light.

3. List two surfaces that will give specular reflectivity to laser energy.

4. Describe the difference between specular and diffuse reflectivity as they effect laser energy.

5. Draw a diagram depicting the direction of laser reflective energy from a tactical target.

6. State the rule of thumb for the angular relationships between designator line-of-sight and bomb line-of-sight.

B. LASER SAFETY:

* 1. Define SEED, and list SEED distances for the PAVE SPIKE laser.

2. Define Hazard Zone in general terms.

3. Describe the importance of controlling specular reflectors within the Hazard Zone.

C. LASER GUIDED BOMBS:

1. Given a table depicting Computer Control Group (MAU) and Airfoil Group (MXU) numbers of various GBU configurations, list the components required to buildup LGB's.

2. List the reason the PAVEWAY II LGB's are less susceptable to rain impact damage than PAVEWAY I LGB's.

* Answer to these questions are classified and are to be safeguarded IAW AFR 205-1.

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* 3. List the gimbal angle and fields of view for the PAVEWAY I and PAVEWAY II LGBs and describe the difference between these figures, and the importance of each.

4. Describe the three LGB requirements that must be met to insure guidance on a laser illuminated target.

5. Define "Bang Bang" guidance concept.

6. Describe the general characteristics of the flight path of Laser Guided Bombs during guidance.

7. List the two(2) power sources in LGB's, what they power, and any significant limitations.

8. Describe the difference between oil dampened canards and canards with centering springs.

9. Explain the difference between "high speed" and "slow speed" LGBs and why we want to carry "slow speed" LGB on the F-4.

10. Why would a PAVEWAY II LGB be superior to a PAVEWAY I weapon in a multi-laser environment.

11. Explain the difference between tail assemblies of PAVEWAY I and PAVEWAY II bombs.

12. Describe how the thermal battery is activated at weapon release.

13. List two physical characteristics that limit the maneuverability of LGB weapons.

* 14. List the determinants of the front and rear limits of the LGB release envelopes.

15. Which release point should be planned for in low altitude LGB deliveries?

16. Explain why the "basket" or "cone" theory does not apply when computing a LGB delivery envelope.

* 17. List four (4) factors which led to the "magic bomb" misunderstandings about LGBs in the medium altitude environment, and contributed to the unrealistic figures in JMEM.

18. List two aircraft release parameters that affect LGB maneuverability enroute to the target.

19. How can you increase the potential energy of a LGB?

20. Explain the advantages of a ballistic release point as compared to a centroid release point loft LGB delivery.

21. Would you use a GBU-10 (2000 lb) to crater a runway from a low altitude standoff delivery? Why not?

22. List two (2) reasons why the GBU-10/B is worthless.

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23. List three (3) rules of thumb for planning and executing LGB deliveries.

24. Draw a diagram to show the difference between a miss in the ground plane and a miss in the normal plane.

* 25. Briefly describe the following concepts as they relate to laser coding:

(a) Look Gate

(b) Signal acceptance window

(c) Last Pulse Logic

(d) Tracking Threshhold.

(e) Missing Pulse Logic

(f) PRF Coding

(g) PIM Coding

26. Draw on a sheet of paper a "sideview" laser envelope on a "Altitude versus Ground Range" chart. It will include the following items.

(a) FOV limitation lines

(b) Maneuverability limit lines

(c) Ballistic reference line

(d) Acquisition line (as assumed by -34 charts)

(e) CEP lines with typical numbers

27. Define and contrast the following points, giving advantages and disadvantages of releasing on each.

(a) Minimum

(b) Ballistic

(c) Centroid

(d) Maximum

28. Explain what effect delayed lasing will have on impact point.

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D. PAVE SPIKE: From this Chapter, the upgrading crew member will from memory be able to:

1. Explain what the following displays tell the operator about the system's operational capability:

(a) TTG dot/T_0 line is steady

(b) TTG Dot flashes at two (2) Hz and the T_0 line is steady

(c) TTG Dot flashes at five (5) Hz and the T_0 line is steady

(d) Both TTG dot and T_0 line flash at five (5) Hz.

2. Draw a pictorial diagram of the PAVE SPIKE gimbal limits in both roll and elevation.

3. Describe the functions of the following TDS control switches and indicators.

(a) Power on light/switch

(b) Laser ready switch interlock

(c) Stow switch

(d) Acquisition switch

(e) WRCS out switch

(f) WRCS out light

(g) Boresight controls

(h) BIT switch

(i) GO/MALF indicator

(j) RET BRT control

(k) LT BRT control

(l) REJOVRD control

(m) OVHT/INS OUT indicator and control

4. List 6 switches that can be used to deintegrate the PAVE SPIKE and WRCS, thereby illuminating the WRCS OUT light.

5. Describe what the pod will do if WRCS acquisition is selected

(a) WRCS IN

(b) WRCS OUT

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6. Briefly describe each of the 5 PAVE SPIKE BIT checks.

7. Describe the functions of the following Slant Range Indicator controls and indicators.

(a) Test control

(b) BRT control

(c) RNG SET control

(d) Mode switch

8. Describe the functions of the Dial Pointer on the Azimuth-Elevation indicator.

9. Describe the function of the following Antenna Control switches.

(a) Forward and aft movement of control

(b) Left and right movement of control

(c) FOV switch

(d) Trigger switch

(e) First detent (half action)

(f) Second detent (full action)

10. Describe the purpose of the following video display visual cues.

(a) Reticle

(b) Distance between TTG dot and T_0 index line

(c) Reticle fiducial marks

11. Describe the function of the Coder Control Unit.

12. Explain what happens to all DME Indicators except the PAVE SPIKE Range Indicator when the PAVE SPIKE is in the track mode.

13. List the operator required switch actions required for the following acquisition modes.

(a) 12-VIS

(b) 9-VIS

(c) Visual IP (VIP)

(d) Visual OAP (VOAP)

(e) Radar OAP (ROAP)

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14. Describe the visual cues that are displayed on the Scope and Line-of-Sight Indicator during the following acquisitions modes.

(a) 12-VIS

(b) 9-VIS

(c) Visual IP

(d) Visual OAP

(e) Radar OAP

15. Describe the three operating modes of the PAVE SPIKE pod.

16. Draw a diagram of the vertical triangle, depicting and labeling the following.

(a) Pod gimbal angle θ

(b) Altitude

(c) H_b

(d) H_t

(e) Ground Level

(f) Sea Level

17. Describe in general terms the low altitude problem with pod computed range.

18. State two sources of error in the PAVE SPIKE Slant Range equation which cause significant inaccuracies in displayed slant range when operating at low altitude.

19. Describe the "automatic reject override" modification (TCTO 518) and list two limitations.

20. Describe the "Idiot Mode" and its cause.

21. Describe how to get the pod out of "Idiot Mode".

22. State the source of target altitude when tracking a target WRCS OUT.

23. Describe the problem encountered when flying near sea level with a large positive "D" value, and one way to get around this problem.

24. List the 4 actions that should always be accomplished after pushing the INSERT button in any WRCS acquisition.

25. Describe how the pod LOS can be updated in the memory mode without entering the track mode (3 ways).

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26. Describe how to boresight the PAVE SPIKE system.

27. List two ways in which the pod will enter memory mode.

28. List 5 things that will happen when memory is entered by hitting a gimbal, and list the additional thing that happens when memory is entered through the insert button.

29. List four ways to get the pod out of memory.

30. Describe what effect the WRCS RESET button has after the pod has been placed in memory by the insert button.

31. The optical gun sight will not depress with the INS OUT light illuminated on the PAVE SPIKE (TDS) Control Panel. True or False.

32. Describe the conditions under which the PAVE SPIKE pod will cage your gunsight.

33. The LOS indicator displays pod head roll position and TV reticle displays pod head depression positions. True or False.

34. Given typical weather data. Understand ΔD (Delta-D) and D-Value; and be able to compute target altitude corrections.

35. The target find NORM-HOLD switch on the R/C/P Weapons Delivery Panel (702 Panel) will override the PAVE SPIKE tie-in to the WRCS when in the HOLD position. True or False.

36. List the two factors which make PAVE SPIKE WRCS automatic delivery more accurate than Dive Toss.

37. Turning the azimuth and elevation boresight knobs clockwise causes the pod head to move right and up respectively.

38. BIT 3 should not be accomplished when ground personnel are in the immediate area.

39. BIT 2 should be accomplished with the aircraft stationary.

40. Describe the CADC check and explain what it tells you.

41. To receive a slant range read out on the SRI of laser ranging, the ROR mode or the WRCS mode must be selected on the SRI.

42. When using a ROAP, what switches must you change to use the system in TV (assume a 12-VIS backup mode of acquisition).

43. If you want to stop laser firing, but still track the target, what must you do? (Full action and Release). Will slant range be displayed? (Yes, but it is pod computed slant range - not laser range).

44. With INS or WRCS out the only delivery mode available for PAVE SPIKE is DIRECT? (True or False)

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45. Taking track with pod (antenna control handle) serves the same function as depressing the FREEZE button? (True or False)

46. The WSO must set the proper drag coefficient and corrected target altitude on the WRCS panel for proper WRCS release? (True or False)

47. When using the WRCS acquisition mode, the front cockpit steering indications (before WSO takes track) are identical to offset bomb. (True or False)

48. The laser automatically shuts off when the pod hits a gimbal limit? (True or False)

49. With WRCS OUT, the pod will go into an idiot mode if a gimbal limit is reached? (True or False)

50. When track is initiated (half action), slant range is computed from 1) pod head angle, 2) the target altitude set in the WRCS panel, and 3) barometic pressure altitude of the aircraft? (True or False)

E. <u>PAVE SPIKE - LGB EMPLOYMENT:</u> From this chapter the crew member will be able to:

* 1. Briefly explain applicability of laser guided bombs to the interdiction, battlefield interdiction, and close air support mission.

2. List the major limitation faced by the aircrew when operating the PAVE SPIKE pod WRCS OUT.

3. Describe the best low altitude delivery profile (is there a "best"?).

4. Explain the reflectivity rule of thumb.

5. Explain the consequences of blanking during a designator turn.

6. List and describe three types of designation maneuvers available to the aircrew at low altitude.

7. Briefly state what laser guidance corrects for.

8. Explain why a computer generated release should be planned for a loft or toss delivery.

* 9. Explain the advantages of elevating the laser spot when designating a target with significant vertical development in the low altitude environment.

10. Discuss the preferred delivery aircraft wind corrections for the following deliveries:

(a) Dive

(b) Level

(c) Toss

(d) Loft

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11. List the rule of thumb for designator wind corrections.

12. State the rule of thumb for bomb time of flight.

13. The most critical time for LGB guidance is the first 75% of bomb TOF? (True or False)

14. What is the rule of thumb for minimum horizontal separation of the laser spot, when two aircraft are delivering and lasing the same target area simultaneously.

15. Diagram the WRCS auto delivery, listing crew duties, flight paths, and back up considerations.

16. How would you "ideally" designate for an LGB delivery on an 84' long boat moving at 40kts?

* 17. List rules of thumb for ceiling requirements for standoff toss (GBU-12) and level (GBU-10)

* 18. Discuss five limitations of a Ground Located Laser Designator (GLLD). (e.g., a "grunt" is designating the target for you.)

* 19. Briefly discuss advantages and limitations of the following LGB options:

(a) Dive

(b) Level

(c) Toss

(d) Loft

* 20. Given a tactical situation, including threat, weather, terrain and sun angle; devise and execute an LGB delivery tactic which will optimize the trade off between target destruction and force survival. (Practice while flying LG-4 and LG-5 and during SAT sorties.)

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SECTION X

PAVE SPIKE QUICKIE REVIEW

PAVE SPIKE has three (3) modes of system operation:

1. Acquisition Mode (used for target acquisition).

    a. Types:

        (1) 12-VIS

        (2) 9-VIS

        (3) WRCS Acquire (WRCS must be IN, and INS must be IN). This mode helps provide the standoff capability of the system.

            (a) VIP

            (b) VOAP

            (c) ROAP

    b. T_o line and TTG dot are removed from the TV display.

2. Tracking Mode (entered by use of the trigger on the antenna control handle). This is the only mode in which the laser can be physically fired.

    a. Optical Sight (if sight is in A/G) moves from RBL to position determined by mils selection when track mode is entered. Sight is not drift stabilized.

    b. T_o line and TTG dot appear on TV display.

3. Memory Mode (must be WRCS IN, and INS IN).

    a. Mode is entered by:

        (1) Hitting pod gimbal while tracking target.

        (2) Pressing Insert Button on WRCS cursor control panel.

    b. T_o line and TTG dot are removed from TV display.

OPERATING MODES ↓	WRCS IN	WRCS OUT	INS OUT
Acquisition Mode	12-VIS 9-VIS WRCS Acquire 1. VIP 2. VOAP 3. ROAP } Provides steering and DME to target	12-VIS 9-VIS (No steering and DME to target is available)	12-VIS 9-VIS (No steering and DME to target is available)
Tracking Mode	1. Tracking is INS stabilized 2. Steering (not DME) to target is available	1. Tracking is INS stabilized 2. No steering (and no DME) to target is available	1. Tracking is not stabilized 2. No steering (and no DME) to target is available
Memory Mode	YES 1. If Insert button depressed or, 2. if pod gimbal is hit while tracking the target, the system enters memory and will provide steering and DME to the target. In addition, once the aircraft has maneuvered so that the target is within the pod gimbal limits, the target will appear in the TV FOV.	NO (if pod gimbal is hit while tracking the target, the pod head proceeds directly to the acquisition mode selected on the PAVE SPIKE control panel [12-VIS or 9-VIS] and does not collect $200. Results... you just lost the target, ACE!)	NO (same as WRCS OUT)
Deliveries Available for LGBs (Assumming Self-designating)	WRCS Automatic 1. WRCS TOSS (SPIKE TOSS) 2. WRCS LOFT } Provides System Standoff		
	ROR (Limited tactical application; SRI computes release point from pod ranging or laser ranging)	ROR (SRI computes release point from pod ranging or laser ranging)	ROR (SRI computes release point from pod ranging or laser ranging). Note that tracking is not INS aided and, therefore, extreme care must be used when tracking in order to provide accurate ranging.
	Direct Timed LADD/ Loft/Level Gyro Loft } Limited Release Accuracies	Direct Timed LADD/Loft/Level Gyro Loft	Direct Timed LADD/Loft/Level Gyro Loft