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Flying Operations

INSTRUMENT FLIGHT PROCEDURES

COMPLIANCE WITH THIS PUBLICATION IS MANDATORY

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This instruction implements AFPD 11-2, Flight Rules and Procedures, by providing guidance and procedures for standard Air Force instrument flying. Since aircraft flight instrumentation and mission objectives are so varied, this instruction is necessarily general regarding equipment and detailed regarding accomplishment of maneuvers. The guidance found in this manual is both technique and procedure. ***Text depicted in bold italics is procedure.*** Individual aircraft flight manuals should provide detailed instructions required for particular aircraft instrumentation or characteristics. This manual, when used with related flight directives and publications, provides adequate guidance for instrument flight under most circumstances, but is not a substitute for sound judgment. Circumstances may require modification of prescribed procedures. Aircrew members charged with the safe operation of United States Air Force aircraft must be knowledgeable of the guidance contained in this manual. This publication applies to the Air National Guard (ANG). This publication is applicable to all USAF aircraft, to include Remotely Operated Aircraft (ROA), unless specifically exempted in the text of the manual. This manual applies to all military, civilian and/or contractor personnel operating USAF aircraft. This publication also applies to the Reserve.

NOTE: This manual is designed to complement AFI 11-202, Volume 3 *General Flight Rules*. While *General Flight Rules* instructs aircrews in WHAT to do, AFMAN 11-217 instructs aircrews in HOW to do it. In case of conflict between this manual and AFI 11-202, Volume 3 *General Flight Rules*, AFI 11-202, Volume 3 takes precedence.

WAIVERS: In general, waivers are not granted to AFMAN 11-217 as this manual describes procedures and techniques for complying with rules in AFI 11-202 Volume 3 *General Flight Rules*. Waivers are more appropriately granted to the rules in *General Flight Rules*. Waivers granted to AFI 11-202 Volume 3, *General Flight Rules* also apply to corresponding applicable sections of AFMAN 11-217. A separate waiver is not required. If a MAJCOM desires a waiver to a bold italic procedure in AFMAN 11-217 that is not addressed in *General Flight Rules*, comply with the Waiver and Exemption guidance in AFI 11-202 Volume 3.

NOTE: The Aeronautical Information Manual (AIM) published by the Federal Aviation Administration (FAA) is not regulatory. However, it provides information that reflects examples of operating techniques and procedures that may be requirements in other regulations. AIM is not binding on USAF aircrews. Furthermore, it contains some techniques and procedures not consistent with USAF mission requirements, regulatory guidance, waivers, exemptions, and accepted techniques and procedures. However, AIM is the accepted standard in the civil aviation community and reflects general techniques and procedures used by other pilots. Much information contained in this AFMAN is reproduced from AIM and adapted for USAF use. ***If a particular subject is not covered in this AFMAN or other USAF regulations, follow guidance in AIM unless mission requirements dictate otherwise.***

SUMMARY OF REVISIONS

General: Changed formatting to conform to AFI 33-360 guidance. Deleted unused and empty chapters. Some paragraphs and chapters renumbered as a result. Corrected grammar, spelling, and punctuation. Updated approach plate graphics and numerous other miscellaneous graphics. **Introduction**: Minor grammatical changes to applicability of AFMAN; Note added note to specify precedence of AFI 11-202 Volume 3 *General Flight Rules;* Added note to specify applicability of Aeronautical Information Manual (AIM). **2.3.** Added section on Instrument Takeoff procedures for fixed wing aircraft. Text was in prior versions of manual and inadvertently omitted in this one. **2.4.6.** Note clarified pitch change required for level off. **3.2.** Changed text to clarify how power is controlled in helicopters. **3.3.** Changed text to clarify the control and performance concept for helicopters. **3.3.10.** Changed text to clarify how to adjust attitude and power in helicopters. **4.2.** Deleted text on planning, as there was no value added. **4.2.3.** Changed text on ITO for helicopters; added text regarding the instrument takeoff under marginal power conditions for helicopters. **4.3.1.** Clarified techniques to maintain headings. **4.3.3.** Clarified procedures for acceleration and deceleration. **4.3.4.** Clarified techniques for altitude changes. **4.3.5.** Deleted redundant text on climbing turns; consolidated descending turn text. **4.5.** Added text clarifying applicability of helicopter-specific procedures. **4.5.1.** Clarified markings for multiple helipads in the same location; changed maximum descent gradient for Copter Only low altitude approaches from 500 ft/nm to 400 ft/nm. **4.7.4.** Added text on unusual attitude recovery during hover. **5.2.2.** Added reference to Chapter 7 for procedures to identify a NAVAID. **5.4.** Added text describing FMS. **6.1.1**. Changed procedures for identification of NAVAID to reflect current state of technology; refers to Chapter 7 for detailed guidance. **6.6.1.** Added text to allow substitutions for inoperative Outer and Middle Markers. **6.6.5.** Added warning to positively identify aural ident of ILS when flying an approach to a runway using the same frequency for both runways. **6.6.7.** Added text explaining hazards or false glideslope indications. **6.9.1.** Added information on LLZ approaches. **6.11.2.** Expanded text describing low powered compass locator. **6.12**. Changed, expanded, and clarified GPS. **6.12.4.** Added WAAS procedures. **Chapter 7.** Added word "AND" to chapter title. **7.1.** Clarified applicability of section to include only ground based radio NAVAIDS. **7.1.1.** Added bold/italic to text; changed and clarified procedures for identifying and monitoring NAVAID to reflect current state of technology; added note clarifying difference between ADF and NDB; deleted extraneous text on identifying ILS. **7.2.** Added bold/italic to homing procedures. **7.4.1.** Added techniques for determining intercept headings; added bold/italic to lead point determination; Added reference to Vol. 3 for techniques to determine lead point. **7.6.1.** Added info on how to determine station passage RMI only. **7.11.** RNAV information changed to reflect new standards. **7.12.** New paragraph added on GPS usage for general navigation. **7.13.** New paragraph added on database issues. **8.1.4.** Deleted ATC correction to Minimum Vectoring Altitudes (MVA) as ATC does not do this and is not contemplating doing this in the future. **8.2.** Updated, changed, and clarified entire NOTAM section to reflect current NOTAM system. **8.3.** Updates entire DoD NOTAM website information. **8.4.7**. Added procedures for enroute navigation with reference to true or grid heading. **8.5.1.** Added further definition of derivation of aircraft category for approaches; clarified requirement to carry hard copies of IAPs for departure base, destination, and all planned alternates; added text on approved sources of printed IAPs for use in aircraft; provided detailed guidance on use of IAPs downloaded from the internet; clarified that in case of discrepancy between GPS approach chart and onboard database, approach chart takes precedence; clarified direction regarding navigation equipment compatibility for approaches; added information to facilitate identification of approaches where runway is served by multiple approaches based on the same final approach guidance; clarified sequence of alphabetical identifiers for circling approaches and where a runway is served by multiple approaches based on the same final approach guidance. **8.5.2.** Added procedures for IAPs in higher latitudes. **8.5.4.** Clarified use of additional rings on IAP plan view; added clarification of VDP and obstacles; clarified holding pattern speeds; clarified missed approach holding pattern speeds; clarified definitions of minimum safe/sector and emergency safe altitudes depicted on approach charts; clarified text describing applicability of alternate minimums for USAF crews. **8.5.6.** Added information on review of RNAV(GPS) IAPs. **8.5.7.** Added information on symbology for RNAV(GPS) IAPs. **8.6.1.** Specified requirement for MAJCOM approval of all host nation procedures; added information on Jeppesen approach books to the publications check. **8.6.13.** Added VOR test facility (VOT) information; directs pilots to AFI 11-202 Volume 3, *General Flight Rules* for GPS database restrictions. **8.7.** Added information regarding IFR flight in uncontrolled airspace. **8.8.** Added procedures for instrument approaches to uncontrolled airports. **8.9.** Added information on flyability checks. **8.10.** Added procedure and problem reporting information. **Chapter 9.** Entire chapter revised and reorganized to reflect changes in USAF and FAA guidance. **Chapter 10.** Added text throughout chapter describing applicability to RNAV holding procedures. **10.1.2.** Clarified procedures for using TACAN to identify holding fixes and IAFs. **10.2.1.** Added explanation of EFC time. **10.2.4.** Changed holding speeds to align with FAA guidance. **10.3.3.** Aligned holding bank angles with FAA procedure. **10.3.4.** Clarified applicability of holding pattern entry techniques; clarified wording of parallel holding pattern entry; clarified specific distances used to define holding patterns. **10.4.** Added FMS holding procedures. **11.2.1.** Clarified enroute descent procedures; clarified clearance readback requirements. **11.3.** Adopted ICAO standard for "established on course". **11.7.** Clarified pilot responsibilities during radar vectors. **11.7.6.** Deleted text describing Profile Descents. They no longer exist. **11.8.** Clarified RNAV STAR procedures. **11.8.1.** Changed requirement for possession of STAR to chart, as annotated in AIM. **11.9.5.** Clarified STAR publication information. **11.9.** Added text detailing procedures for Flight Management System Procedures (FMSP). **13.1.1.** Added text clarifying applicability of approach procedures in ICAO nations.

13.2. Added text clarifying procedures for flying a high altitude approach in the low altitude structure. **13.3.1.** Clarified applicability of no PT routing. **13.10.** Added information on Terminal Area Arrivals (TAA). **13.10.14.** Added information on backup approaches when flying GPS approaches. **Chapter 14.** Entire chapter reorganized to categorize approaches with glide path guidance and those without glide path guidance. **14.2.1.** Aligned definition of "runway environment" with AIM; defined meaning of the appearance of the word "RADAR" on an approach plate. **14.1.2.** Moved MLS information from Vol. 2; text changed to align with tuning requirements in Chapter 7; added WARNING regarding false or erroneous glide slopes; added note regarding outer marker sensitivity adjustments for aircraft with the capability to select sensitivity; added text regarding erroneous glide slope indications during testing. **14.2.3.** Added information on RNAV/GPS final approach. **14.3.2.** Added "where available" to text requiring backup to radar approach. **14.3.5.** Clarified requirements for advising controller in the event of termination of radar approach without landing. **14.5.** Aligned definition of contact approach with AIM. **14.6.** Clarified definition of IAP with a visual segment. **14.9.** Added information on ILS/PRM approaches. **14.10.** Added information on SOIA approaches. **14.11**. Added information on TLS approaches. **15.2.4.** Added reference to Chapter 25 for HUD procedures during landing. **15.3.3.** Deletes visual glide path lighting systems detailed explanations and refers personnel to the Flight Information Handbook, which contains the most current information. **15.4.** Added reference to AFI 11-218 for airport lighting for ground operations. **15.4.1.** Added note stating threshold lights can be as much as 10 feet from threshold without a waiver. **15.5.** Added reference to AFI 11-218 for airport markings and signs for ground operations. **15.6.1.** Added information on circling out of RNAV/GPS approaches. **15.7.2.** Changed side-step maneuver to align with FAA guidance. **16.3.1.** Clarified climbout instructions applicability. **16.4.2.** Clarified procedures for executing a missed approach prior to the missed approach point. **16.4.3.** Changed minimum missed approach climb gradient to 200 feet per nautical mile to correct a typographical error from the last edition of 11-217 and AIM. **Chapters 20 and 21.** Entire chapter moved to Volume 3. **Chapter 17 (Old Chapter 22)**. Entire chapter revised to reflect latest information on spatial disorientation. Graphics updated. Added section on night vision goggles. **Chapter 18 (Old Chapter 23).** Entire chapter rewritten to reflect current guidance from ICAO SARPS, PANS OPS, and AFI 11-202 Vol. 3 *General Flight Rules*. **19.2.1 (Old Chapter 24).** Added definitions of ILS Category IIIa, b, and c. **Figure 20.1 (Old Chapter 25).** Fixed text boxes so all text is visible. **20.2.1.** Deleted text discussing concerns of insidious failure of HUDs; clarified use of HUDs not endorsed as PFR. **20.2.3.** Added text clarifying use of HUD for transition to landing; added WARNING regarding danger of duck under when using a HUD for transition to landing. **20.3.6.** Added WARNING regarding use of HUD-out procedures for practice approaches in IMC. **Appendices.** List of References added; Acronyms updated, Definitions updated; Index added.

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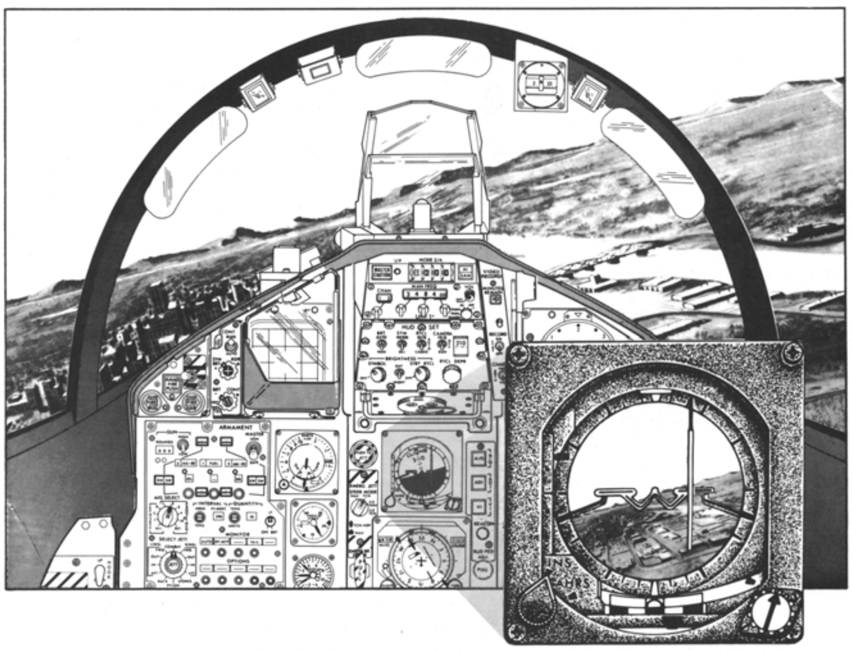
Chapter 1

BASIC INSTRUMENT FLYING-FIXED WING

1.1. Instrument Categories. Aircraft performance is achieved by controlling the aircraft attitude and power (angle of attack and thrust-to-drag relationship). Aircraft attitude is the relationship of its longitudinal and lateral axes to the Earth's horizon. An aircraft is flown in instrument flight by controlling the attitude and power as necessary to produce the desired performance. This is known as the "control and performance concept" of attitude instrument flying (Figure 1.1) and can be applied to any basic instrument maneuver. The three general categories of instruments are:

Figure 1.1. Attitude Instrument Flying.



1.1.1. Control Instruments. These instruments display immediate attitude and power indications and are calibrated to permit attitude and power adjustments in definite amounts. In this discussion, the term power is used to replace the more technically correct term thrust or drag relationship. Control is determined by reference to the attitude indicators and power indicators. Measures of power vary with aircraft and may include tachometers, engine pressure ratio (EPR), manifold pressure, fuel flow, etc.

1.1.2. Performance Instruments. These instruments indicate the aircraft's actual performance. Performance is determined by reference to the altimeter, airspeed or mach indicator, vertical velocity indicator, heading indicator, angle of attack indicator, and turn and slip indicator.

1.1.3. Navigation Instruments. These instruments indicate the position of the aircraft in relation to a selected navigation facility or fix. This group of instruments includes various types of course indicators, range indicators, glide slope indicators, and bearing pointers.

1.1.3.1. NOTE: The heads-up display (HUD) is a system capable of displaying some control, performance, and navigation data simultaneously in a relatively small area. Information received from HUD equipment that is not certified for sole-reference instrument flight must be verified with other cockpit indications.

1.2. Control and Performance Concept.

1.2.1. Effective Steps.

1.2.1.1. Establish. Establish an attitude or power setting on the control instruments that will result in the desired performance. Known or computed attitude changes and approximate power settings will help to reduce the pilot workload.

1.2.1.2. Trim. Trim until control pressures are neutralized. Trimming for hands-off flight is essential for smooth, precise aircraft control. It allows pilots to divert their attention to other cockpit duties with minimum deviation from the desired attitude.

1.2.1.3. Crosscheck. Crosscheck the performance instruments to determine if the established attitude or power setting is providing the desired performance. The crosscheck is both seeing and interpreting. If a deviation is noted, determine the magnitude and direction of adjustment required to achieve the desired performance.

1.2.1.4. Adjust. Adjust the attitude or power setting on the control instruments as necessary.

1.2.2. Attitude Control. Proper control of aircraft attitude is the result of maintaining a constant attitude, knowing when and how much to change the attitude, and smoothly changing the attitude a definite amount. Aircraft attitude control is accomplished by proper use of the attitude reference. The attitude reference provides an immediate, direct, and corresponding indication of any change in aircraft pitch or bank attitude.

1.2.2.1. Pitch Control. Changing the "pitch attitude" of the miniature aircraft or fuselage dot definite amounts in relation to the horizon makes pitch changes. These changes are measured in degrees or fractions thereof, or bar widths depending upon the type of attitude reference. The amount of deviation from the desired performance will determine the magnitude of the correction.

1.2.2.2. Bank Control. Changing the "bank attitude" or bank pointers a definite amount in relation to the bank scale makes bank changes. The bank scale is normally graduated at 0°, 10°, 20°, 30°, 60°, and 90° and may be located at the top or bottom of the attitude reference. Normally, use a bank angle that approximates the degrees to turn, not to exceed 30°.

1.2.3. Power Control.

1.2.3.1. Proper power control. Proper power control results from the ability to smoothly establish or maintain desired airspeeds in coordination with attitude changes. Power changes are made by throttle adjustments and reference to the power indicators. Power indicators are not affected by such factors as turbulence, improper trim, or inadvertent control pressures. Therefore, in most aircraft, little attention is required to ensure the power setting remains constant.

1.2.3.2. Power. From experience in an aircraft, you know approximately how far to move the throttles to change the power a given amount. Therefore, you can make power changes primarily by throttle movement and then crosscheck the indicators to establish a more precise setting. The key is to avoid fixating on the indicators while setting the power. Knowledge of approximate power settings for various flight conditions will help you prevent over-controlling power.

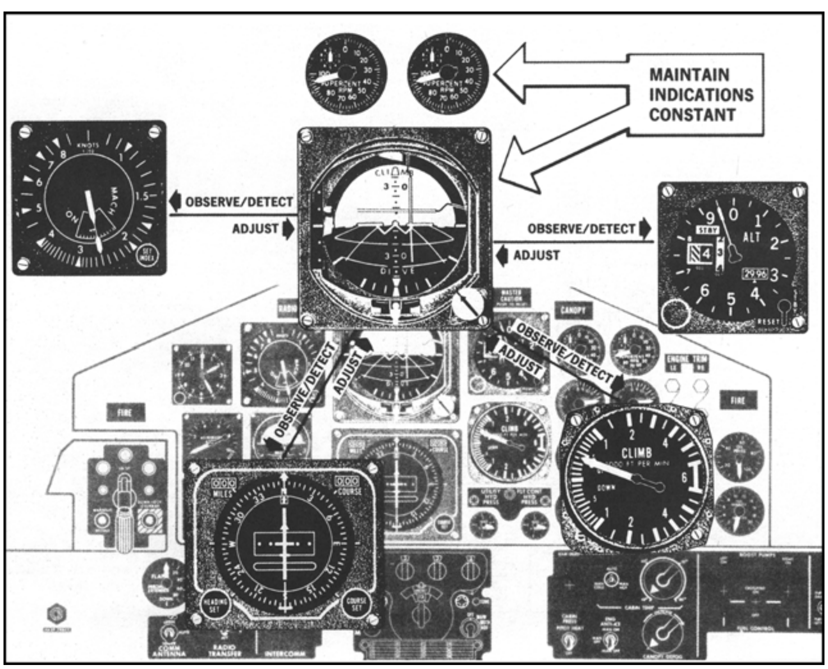
1.2.4. Trim Technique.

1.2.4.1. Proper trim technique. Proper trim technique is essential for smooth and precise aircraft control during all phases of flight. By relieving all control pressures, you will find it is much easier to hold a given attitude constant and you will be able to devote more attention to other cockpit duties.

1.2.4.2. Trimming an aircraft. Trim the aircraft by applying control pressures to establish a desired attitude and then adjust the trim so the aircraft will maintain that attitude when the flight controls are released. Trim the aircraft for coordinated flight by centering the ball of the turn and slip indicator using rudder trim in the direction the ball is displaced. Differential power control on multi-engine aircraft is an additional factor affecting coordinated flight. Use balanced power or thrust, when possible, to aid in maintaining coordinated flight.

1.2.4.3. Changes. Changes in attitude, power, or configuration will in most cases require a trim adjustment. Independent use of trim to establish a change in aircraft attitude invariably leads to erratic aircraft control. Smooth and precise attitude changes are best attained by a combination of control pressures and trim adjustments. Trim adjustment, correctly used, is an aid to smooth aircraft control.

Figure 1.2. Instrument Cross-Check Technique.

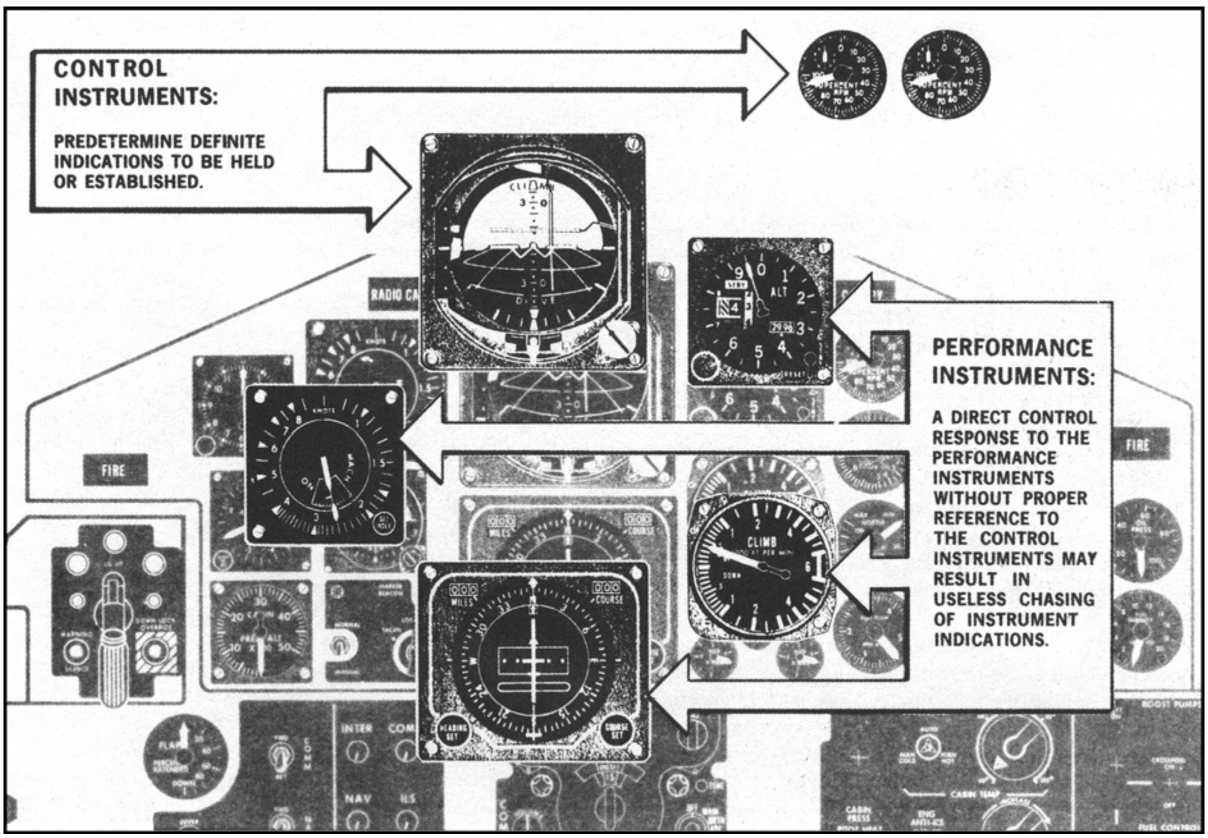


1.2.5. Cross-Check Technique (Figure 1.2).

1.2.5.1. The Control and Performance Concept. The control and performance concept of attitude instrument flying requires you to establish an aircraft attitude or power setting on the control instruments that should result in the desired aircraft performance. Therefore, you must be able to recognize when a change in attitude or power is required. By crosschecking the instruments properly, you can determine the magnitude and direction of the adjustment required.

1.2.5.2. Crosschecking. Crosschecking is the proper division of attention and the interpretation of the flight instruments. Attention must be efficiently divided between the control and performance instruments in a sequence that ensures comprehensive coverage of the flight instruments. Looking at each of the instruments at the proper time is of no value unless you can interpret what you see. Therefore, proper division of attention and interpretation are the two essential parts of a crosscheck.

Figure 1.3. Factors Influencing Cross-Check Techniques.



1.2.6. Factors Influencing Instrument Cross-Checks (Figure 1.3).

1.2.6.1. Instrument's Response to Attitude or Power Changes. A factor influencing crosscheck technique is the characteristic manner in which instruments respond to changes of attitude or power. The control instruments provide direct and immediate indications of attitude or power changes. Changes in the indications on the performance instruments will lag slightly behind changes of attitude or power. This lag is due to inertia of the aircraft and the operating principles and mechanisms of the performance instruments. Therefore, some lag must be accepted as an inherent factor. This factor will not appreciably affect the tolerances within which you control the aircraft; however, at times a slight unavoidable delay in knowing the results of attitude or power changes will occur.

1.2.6.2. Lag in Performance Instruments. Lag in the performance instruments should not interfere with maintaining or smoothly changing the attitude or power indications. When the attitude and power are properly controlled, the lag factor is negligible and the indications on the performance instruments will stabilize or change smoothly. Do not be lured into making a flight control movement in direct response to the lag in the indications on the performance instruments without first referring to the control instruments. Sufficient reference to the control instruments will minimize the effect of lag on the performance instruments and nullify the tendency to "chase" the indications.

1.2.6.3. Location of Flight Instruments. Another factor influencing crosscheck technique is the location of the flight instruments. In some aircraft the flight instruments are scattered over a wide area of the instrument panel, making it difficult to bring several instruments into your crosscheck at the same time. Therefore you must rapidly scan each instrument individually back and forth across the instrument panel. More advanced instrument systems, such as the flight director and integrated flight instrument systems have reduced the required scan to a small area so you can see more of the flight instruments with one look. The task of crosschecking these instruments is much easier because you can simultaneously observe the attitude indicator and the proper performance instruments.

1.2.6.4. Pilot's Ability. An important factor influencing crosscheck technique is the ability of the pilot. All pilots do not interpret instrument presentations with the same speed; some are faster than others are in understanding and evaluating what they see. One reason for this is that the natural ability of pilots varies. Another reason is that the experience levels are different. Pilots who are experienced and fly regularly will probably interpret their instruments more quickly than inexperienced pilots will. Pilots who interpret their instruments quickly and correctly do not have to refer back to them for information as often as pilots who are slow to interpret. They are also able to bring several instruments into their crosscheck with one glance, interpreting them simultaneously. Therefore, the speed with which they divide their attention does not have to be as rapid as the pilot's with less ability who must scan the instruments rapidly to stay ahead of the aircraft.

1.2.6.5. Observing Attitude Indicator. The attitude indicator is the only instrument that you should observe continuously for any appreciable length of time. Several seconds may be needed to accomplish an attitude change required for a normal turn. During this period, you may need to devote your attention almost exclusively to the attitude indicator to ensure good attitude control. The attitude indicator is the instrument that you should check the greatest number of times. This is shown by the following description of a normal crosscheck. A pilot glances from the attitude indicator to a performance instrument, back to the attitude indicator, then a glance at another performance instrument, back to the attitude indicator, and so forth. This crosscheck technique can be compared to a wagon wheel. The hub represents the attitude indicator and the spokes represent the performance instruments.

1.2.6.6. Method of crosschecking. The above example of a normal crosscheck does not mean that it is the only method of crosschecking. Often you must compare the indications of one performance instrument against another before knowing when or how much to adjust the attitude or power. An effective crosscheck technique may be one in which attention to the attitude indicator is inserted between glances at the performance instruments being compared. Devoting more attention to the attitude indicator is more desirable to minimize the effects of the fluctuations and lag indications of the performance instruments. This technique permits you to read any one performance instrument during a split-second glance and results in smooth and precise aircraft control.

1.2.6.7. Performance instruments. A proper and relative amount of attention must be given to each performance instrument. Pilots seldom fail to observe the one performance instrument whose indication is most important. The reverse is a common error because pilots often devote so much attention to one performance instrument that the others are omitted from the crosscheck. Additionally, they often fail to crosscheck the attitude indicator for proper aircraft control.

1.2.7. Cross-Check Analysis.

1.2.7.1. Incorrect crosscheck. An incorrect crosscheck can be recognized by analyzing certain symptoms of aircraft control. Insufficient reference to the control instruments is readily recognizable. If you do not have some definite attitude and power indications in mind and the other instruments fluctuate erratically through the desired indications, then you are not referring sufficiently to the control instruments. Imprecise aircraft control usually results in "chasing" the indications.

1.2.7.2. Too much attention. The problem of too much attention being devoted to the control instruments is rarely encountered, except for fixation on the power indicators. This is normally caused by your desire to maintain the performance indications within close tolerances. Positive and continuous inputs based only on the control instruments are not sufficient for maintaining the desired parameters; a systematic crosscheck of the performance instruments is also required.

1.2.7.3. Scanning process. An incorrect crosscheck can result in the omission of or insufficient reference to one or more instruments during the scanning process. You may omit some performance instruments from the crosscheck, although other performance instruments and the control instruments are being properly observed. For example, during a climb or descent, you may become so engrossed with pitch attitude control that you fail to observe an error in aircraft heading.

1.2.7.4. Instrument indications. The indications on some instruments are not as "eye-catching" as those on other instruments. For example, a 4° heading change is not as "eye-catching" as a 300 to 400 feet-per-minute change on the vertical velocity indicator. Through deliberate effort and proper habit, ensure all the instruments are included in your crosscheck. If this is accomplished, you will observe deviations on the performance instruments in their early stages.

1.2.7.5. Crosscheck technique. Analyzing the crosscheck technique will assist you in improving an incorrect crosscheck. A correct crosscheck results in the continuous interpretation of the flight instruments that enables you to maintain proper aircraft control at all times. Remember, rapidly looking from one instrument to another without interpretation is of no value. Instrument systems and the location of the flight instruments vary. Pilot ability also varies. Therefore, you should develop your own rate and sequence of checking the instruments that will ensure a timely and correct interpretation of the flight instruments.

1.2.8. Adjusting Attitude and Power. As previously stated, the control and performance concept of attitude instrument flying requires the adjustment of aircraft attitude and power to achieve the desired performance. A change of aircraft attitude or power is required when any indication other than that desired is observed on the performance instruments. However, it is equally important for you to know what to change and how much pitch, bank, or power change is required.

1.2.8.1. What to Change. Pitch attitude primarily controls altitude and the rate of climb or descent. Pitch attitude control may also be used to maintain airspeed during maneuvers requiring a fixed power setting. Bank attitude control is used to maintain a heading or desired angle of bank during turns. Power controls airspeed except for maneuvers using a fixed power setting; for example, full power for a prolonged climb.

1.2.8.2. How Much to Change. How much to adjust the attitude or power is, initially, an estimate based on familiarity with the aircraft and the amount you desire to change on the performance instruments. After you make a change of attitude or power, observe the performance instruments to see if the desired change occurred. If not, further adjustment of attitude or power is required. Remember, even though changes are estimates, they must be made in exact increments.

1.2.9. Vector Flying. The flight path marker (FPM), or velocity vector (VV), in conjunction with the flight path scale, is the symbol most used during instrument flight on displays capable of showing vector flight paths. Simply put, the FPM is a symbol that displays pitch compensated for angle of attack, drift, and yaw. It shows where the aircraft is actually going, assuming a properly functioning inertial navigation system (INS), and may be used to set a precise climb or dive angle relative to the flight path scale.

1.2.9.1. Command symbol. This ability to show the actual flight path of the aircraft makes the FPM a unique control and performance element. The major advantage of vector (FPM) flying over conventional attitude flying is the ease of setting a precise glide path instead of using the Attitude Director Indicator (ADI), vertical velocity indicator (VVI), and airspeed to approximate a glide path. On HUDs the FPM can also be used to determine where the aircraft will touchdown. Drawbacks to vector flying include the tendency of the display to float around, especially in crosswinds, the bobbing motion of the FPM as it lags behind the movement of the nose of the aircraft, and the degraded usefulness of the FPM when it exceeds the limits of the instrument's field-of-view at high angles of attack and in large drift or yaw situations.

1.2.9.2. Flight path scale. Typically on HUDs, the flight path scale is displayed in a

1:1 angular relationship with the "real world," though some may gradually compress the scale at steeper climb/dive angles to reduce movement of the symbols and create a global display similar to that found on an attitude indicator. On a HUD the expanded flight path scale allows the pilot to make smaller, more precise corrections than is possible using conventional head-down displays. Like the FPM, the flight path scale can be of limited use when it approaches the limits of the HUD's field-of-view.

1.2.9.3. Climb/Dive Marker (CDM). Newer flight instruments will use a CDM as the command flight symbol for vector flying. The CDM will utilize the concept of the above FPM and flight path scale, but both will be caged to the center of the display to prevent the symbology from drifting off the usable area of the instrument.

1.3. Use of Single Medium Displays. A single medium display is a HUD, Head-Down Display (HDD), or Helmet-Mounted Display (HMD) presenting flight instrumentation. Some single medium displays, including many HUDs, do not provide sufficient attitude cues to enable a pilot to maintain full-time attitude awareness or recover from some unusual attitudes. In addition to meeting the instrumentation requirements of AFI 11-202, Volume 3 *General Flight Rules*, ***single medium displays must also receive HQ USAF/XOO endorsement as a Primary Flight Reference (PFR) before they are used as the stand-alone reference for instrument flight***.

1.4. Display of Flight Instrumentation. Electronic displays allow the pilot to optimize cockpit instrumentation for a particular mission by decluttering, removing, or relocating presentations. Display options vary widely from aircraft to aircraft and incorporate different symbologies and terminology for similar functions. In some cases the pilot may be able to configure the cockpit to omit elements necessary for basic attitude awareness and aircraft control. Regardless of the type of aircraft, mission, or mission phase, attitude awareness is a full-time Air Force mission requirement. Persons charged with cockpit instrumentation design, layout, and capability; pilots or other crewmembers who can modify the cockpit display configuration; and implementing directives (for example, Dash 1's, Technical Orders (TOs), AFI 36-series manuals and handbooks, etc.) must adhere to the following:

1.4.1. Primary Flight Instrumentation. ***Primary flight instrumentation must always be present. It must provide full-time attitude, altitude, and airspeed information; an immediately discernible attitude recognition capability; an unusual attitude recovery capability; and complete fault indications***.

1.4.2. Position of Flight Instrumentation. ***The elements of information of Primary Flight Instrumentation must be positioned and arranged in a manner that enables the pilot to perform a natural crosscheck.***

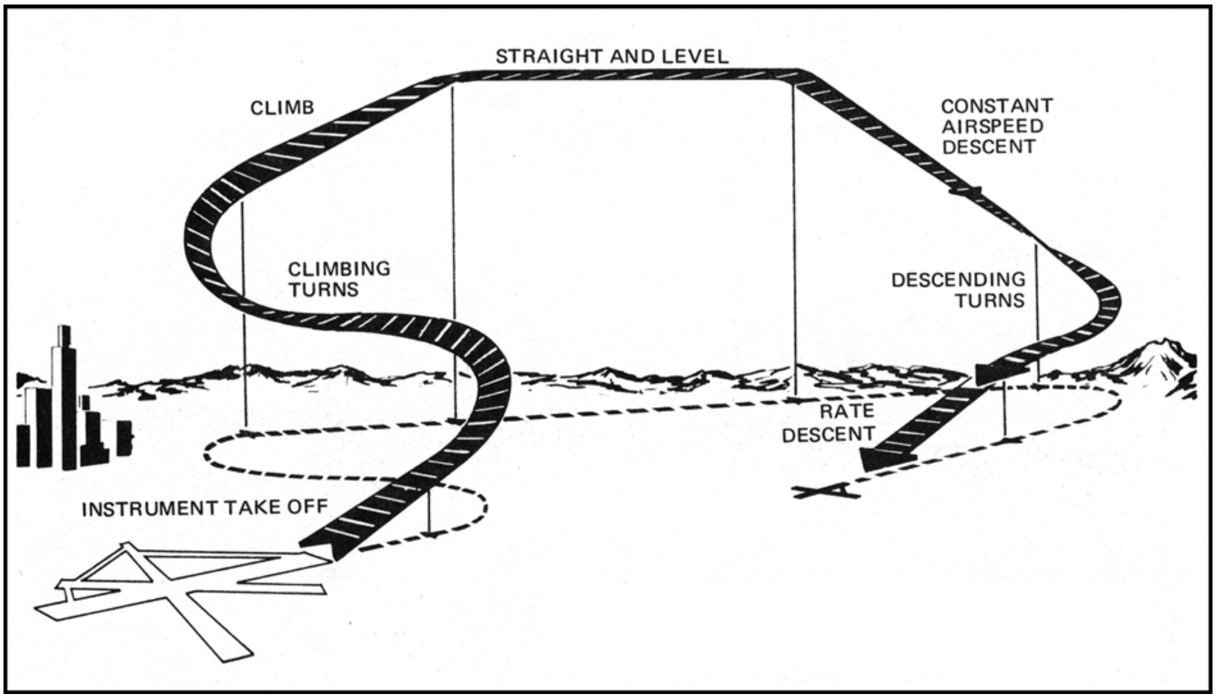
1.4.3. Standardization of Flight Instrumentation. ***Primary Flight Instrumentation must be standardized in terminology, symbology, mechanization, and arrangement***. Standardization of instrumentation display elements provides a common training base and allows the retention of good flying habits during transition to different aircraft. This standardization can only be effective when the pilot acknowledges attitude awareness as a full-time requirement and manages the cockpit accordingly.

Chapter 2

INSTRUMENT FLIGHT MANEUVERS--FIXED WING

2.1. Basic Maneuvers. The maneuvers described in this section are those most commonly used during instrument flight (Figure 2.1). Additional maneuvers or some modification of these maneuvers may be required for specific training requirements. The degree of proficiency attained in accomplishing these maneuvers will determine the ease by which you can adapt to actual instrument flight. An instrument flight, regardless of its length or complexity, is a series of connected basic instrument flight maneuvers. Failure to consider each portion of the flight as a basic instrument maneuver often leads to erratic aircraft control.

Figure 2.1. Typical Instrument Flight.



2.2. Planning. The information received from the navigation instruments or an air traffic controller should be considered as advising you what maneuver to perform, when to perform it, or what adjustments, if any, are required. Instrument approach procedure charts and similar publications should be considered as pictorial presentations of a series of connected instrument flight maneuvers. Keeping these considerations in mind and calling upon previous practice, you will find that you are always performing a familiar maneuver. By visualizing the next maneuver, and planning ahead, you can know exactly what crosscheck and aircraft control techniques to employ at the time of entry into the maneuver.

2.3. The Instrument Takeoff (ITO). The ITO is accomplished by referring to outside visual references and to the flight instruments. The amount of attention given to each reference varies with the individual, the type of aircraft, and existing weather conditions.

The ITO is a composite visual and instrument takeoff when conditions permit, and should not be confused with a "hooded takeoff." The ITO procedures and techniques are invaluable aids during takeoffs at night, toward and over water or deserted areas, and during periods of reduced visibility. It is important to ***immediately transition to instrument references any time you become disoriented or when outside visual references become unreliable***.

2.3.1. Preparing for the ITO. Before performing an ITO, perform an adequate before-takeoff check of all flight and navigation instruments to include publications. Select the appropriate navigational aids to be used for the departure, and set the navigation instruments and switches as required. The Air Traffic Control (ATC) clearance and departure procedures must be thoroughly understood before takeoff. It is a good operating practice to have the appropriate instrument approach procedure charts available in the event an instrument approach is necessary immediately after takeoff. Review of the approach for an emergency return should include frequencies, final approach course, decision height (DH) or minimum descent altitude (MDA), and minimum safe, sector, or emergency safe altitudes. Brief all crewmembers on specific duties during an emergency return.

2.3.2. Performing the ITO. A composite takeoff is accomplished using normal Visual Meteorological Conditions (VMC) procedures and combining reference to the flight instruments with outside visual references to provide a smooth transition from VMC to Instrument Meteorological Conditions (IMC) flight. Prior to takeoff, the attitude indicators should be adjusted according to you aircraft flight manual. These settings will provide a constant attitude reference for the ITO regardless of aircraft attitude at the time of adjustment.

2.3.3. The Takeoff. After a recheck of all instruments for proper operation, start the takeoff by applying thrust of a predetermined setting. As thrust is applied, maintain the desired heading with the rudder pedals and at the appropriate speed, establish the desired ITO pitch attitude. When a positive climb indication is obtained, adjust the pitch attitude as specified in the flight manual. As soon as the takeoff attitude is established, crosscheck the vertical velocity indicator and altimeter to ensure you are climbing.

2.4. Individual Maneuvers.

2.4.1. Straight and Level Flight. Straight and level unaccelerated flight consists of maintaining desired altitude, heading, and airspeed. Use pitch attitude control to maintain or adjust the altitude. Use bank attitude control to maintain or adjust the heading. Use power control to maintain or adjust the airspeed.

2.4.1.1. Maintaining a Desired Altitude.

2.4.1.1.1. Maintain a specific pitch. Maintaining a desired altitude requires the ability to maintain a specific pitch attitude and, when necessary, to smoothly and precisely adjust this attitude. This ability is developed through proper use of the attitude indicator and is simplified by good trim techniques.

2.4.1.1.2. After leveling off. After leveling off at cruise airspeed, you may adjust the pitch trim knob on the attitude indicator so that the miniature aircraft is aligned with the horizon bar if allowed by your aircraft flight manual. This will aid in detecting small pitch changes. Subsequent readjustments may be required because of changes in aircraft gross weight and cruise airspeeds. (Refer to your aircraft flight manual; on some equipment, this technique may not be appropriate.)

2.4.1.1.3. Small pitch corrections. The small pitch corrections required to maintain a desired altitude are made in fractions of degrees or bar widths. You should become familiar with the vertical velocity changes that result when specific pitch adjustments are made at various airspeeds and configurations so you can determine what pitch attitude adjustment is required to produce the desired rate of correction when an altitude deviation is observed.

2.4.1.1.4. Making pitch adjustments. When you make these pitch adjustments, the altimeter and vertical velocity indications may lag behind changes of pitch attitude on the attitude indicator. This lag should be recognized and accepted as an inherent error in pressure instruments. The error is even more pronounced at supersonic airspeeds. Because of this error, maintain the adjusted pitch attitude on the attitude indicator while waiting for changes on the altimeter and vertical velocity to occur. Do not make a snap decision that the adjusted pitch change is ineffective and be lured into over-controlling the pitch attitude.

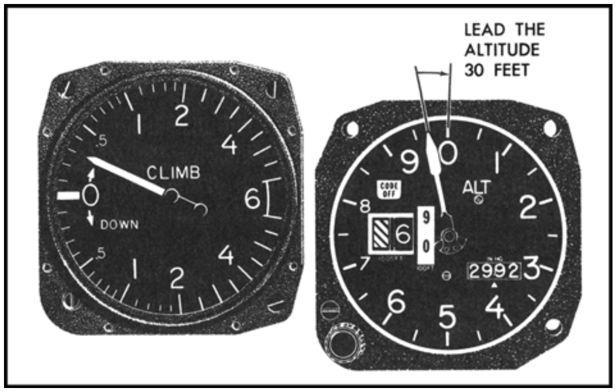
2.4.1.1.5. Vertical velocity indicator. The vertical velocity indicator is a trend instrument. With experience, you can usually estimate the suitability of a pitch adjustment by noting the initial rate of movement of the vertical velocity indicator. For example, assume a pitch adjustment has been made which is expected to result in 200 to 300 fpm rate of climb. If the initial rate of movement on the vertical velocity indicator is rapid and obviously will stabilize at a rate greater than desired, the pitch change was too large. Readjust the pitch attitude rather than wait for a stabilized indication on the vertical velocity indicator.

2.4.1.1.6. Altitude changes. When an aircraft first departs an altitude, an indication often appears on the vertical velocity indicator before one appears on the altimeter. By evaluating this initial rate of movement, you can estimate the amount of pitch change required on the attitude indicator and prevent large altitude deviations. If the estimated pitch change was correct, the vertical velocity will return to zero with a negligible change of altitude on the altimeter.

2.4.1.1.7. Altitude Deviations. When a deviation from the desired altitude occurs, use good judgment in determining a rate of correction. The correction must not be too large and cause the aircraft to "overshoot" the desired altitude, nor should it be so small that it is unnecessarily prolonged. As a guide, the pitch attitude change on the attitude indicator should produce a rate of vertical velocity approximately twice the size of the altitude deviation. For example, if the aircraft were 100 feet off the desired altitude, a 200 fpm rate of correction would be a suitable amount. Adjust the pitch an estimated amount to achieve this rate of correction. This estimated pitch change might require further adjustment after a stabilized vertical velocity is obtained.

2.4.1.1.8. Approaching the desired altitude. When approaching the desired altitude, determine a lead point on the altimeter for initiating a level-off pitch attitude change and determine the pitch change required to complete the level off as well as the appropriate pitch attitude for level flight. A suitable lead point prevents "overshooting" and permits a smooth transition to level flight. The amount of lead required varies with pilot technique and rate of correction. As a guide, the lead point on the altimeter should be approximately 10 percent of the vertical velocity. For example, if the rate of correction to the desired altitude is 300 feet per minute (fpm), initiate the level off approximately 30 feet before reaching the desired altitude (Figure 2.2).

Figure 2.2. Leading the Level Off.



2.4.1.2. Maintaining a Desired Heading.

2.4.1.2.1. Zero bank attitude. Maintaining a desired heading is accomplished by maintaining a zero bank attitude in coordinated flight. Heading deviations are not normally as "eye-catching" as altitude deviations. Therefore, be aware of this characteristic and develop a habit of crosschecking the heading deviations. This is especially helpful if there are slight precession errors in the attitude indicator.

2.4.1.2.2. Heading deviation. When a deviation from the desired heading occurs, refer to the attitude indicator and smoothly establish a definite angle of bank that will produce a suitable rate of return. As a guide, the bank attitude change on the attitude indicator should equal the heading deviation in degrees not to exceed 30°. For example, if the heading deviation is 10°, then 10° of bank would produce a suitable rate of correction. This guide is particularly helpful during instrument approaches at relatively slow airspeeds. At higher true airspeeds, a larger angle of bank may be required to prevent a prolonged correction. A correction to a heading deviation of 2° to 5° may be accomplished by application of rudder.

2.4.1.3. Establishing and Maintaining Airspeed.

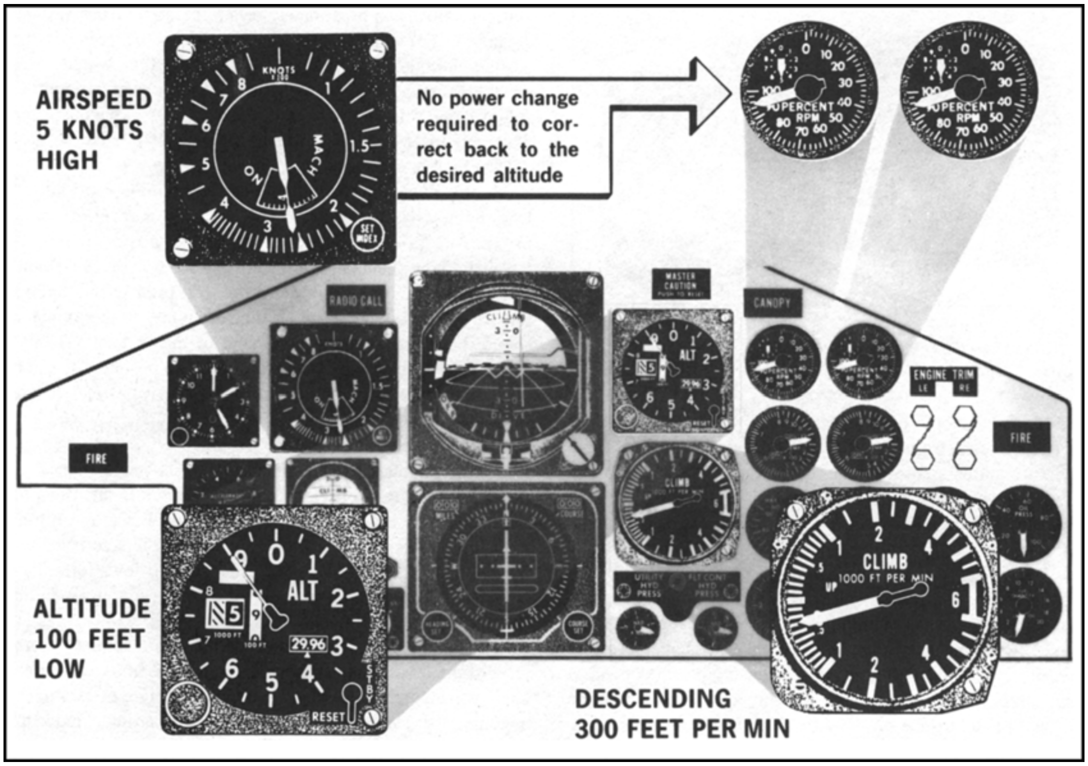
2.4.1.3.1. Airspeed. Establishing or maintaining an airspeed is accomplished by referring to the airspeed or mach indicator and adjusting the power or aircraft attitude. Knowledge of the approximate power required to establish a desired airspeed will aid in making power adjustments. After the approximate power setting is established, a crosscheck of the airspeed indicator will indicate if subsequent power adjustments are required. Make it a point to learn and remember the approximate power settings for the aircraft at various airspeeds and configurations used throughout a normal mission. Avoid fixation on power indicators when setting the power.

2.4.1.3.2. Airspeed deviation. When an airspeed deviation is observed, make a power or pitch adjustment or a combination of both to correct back to the desired airspeed. For example, if below the desired altitude with a higher than desired airspeed, a proper pitch adjustment may regain both the desired airspeed and altitude. Conversely, a pitch adjustment, if made at the desired airspeed, will induce the need for a power adjustment. This is more noticeable at slow airspeeds, particularly in jet aircraft.

2.4.1.3.3. Changes of airspeed. Changes of airspeed in straight and level flight are accomplished by adjusting the power or drag devices. To increase the airspeed, advance the power beyond the setting required to maintain the new airspeed (Figure 2.3). As the airspeed increases, the aircraft gains lift and will have a tendency to climb. Adjust the pitch attitude as required to maintain altitude. When the airspeed approaches the desired indication, reduce the power to an estimated setting that will maintain the new airspeed. To reduce the airspeed, reduce the power below the setting estimated for maintaining the new desired airspeed. As the airspeed decreases, the aircraft loses lift and will have a tendency to descend. Adjust the pitch attitude as required to maintain altitude. When the airspeed approaches the desired indication, advance the power to an estimated setting that will maintain the new airspeed. If available, drag devices may be used for relatively large or rapid airspeed reductions. If used, it is normally best to reduce the power to the estimated setting that will maintain the new airspeed and then extend the drag devices. Extending or retracting the drag devices may induce a pitch change. To overcome this tendency, note the pitch attitude on the attitude indicator just before operating the drag devices and then maintain that attitude constant as they are extended or retracted. When approaching the new airspeed, retract the drag devices and adjust power if required.

2.4.1.3.3.1. NOTE: Proper control of pitch and bank attitude requires you to recognize the effects of gyroscopic precession on some attitude indicators. This precession is most noticeable following a turn or change of airspeed. As a result, small altitude and heading deviations may occur when a wings level attitude is established on the attitude indicator following these maneuvers. Therefore, you may have to establish a pitch or bank attitude other than that ordinarily expected. For example, to maintain straight and level flight after completing a normal turn, the attitude indicator may depict a slight turn, climb or descent, or a combination of both. The attitude indicator will gradually resume its normal indications as the erection mechanism automatically corrects these errors. When these errors occur, apply the basic crosscheck techniques.

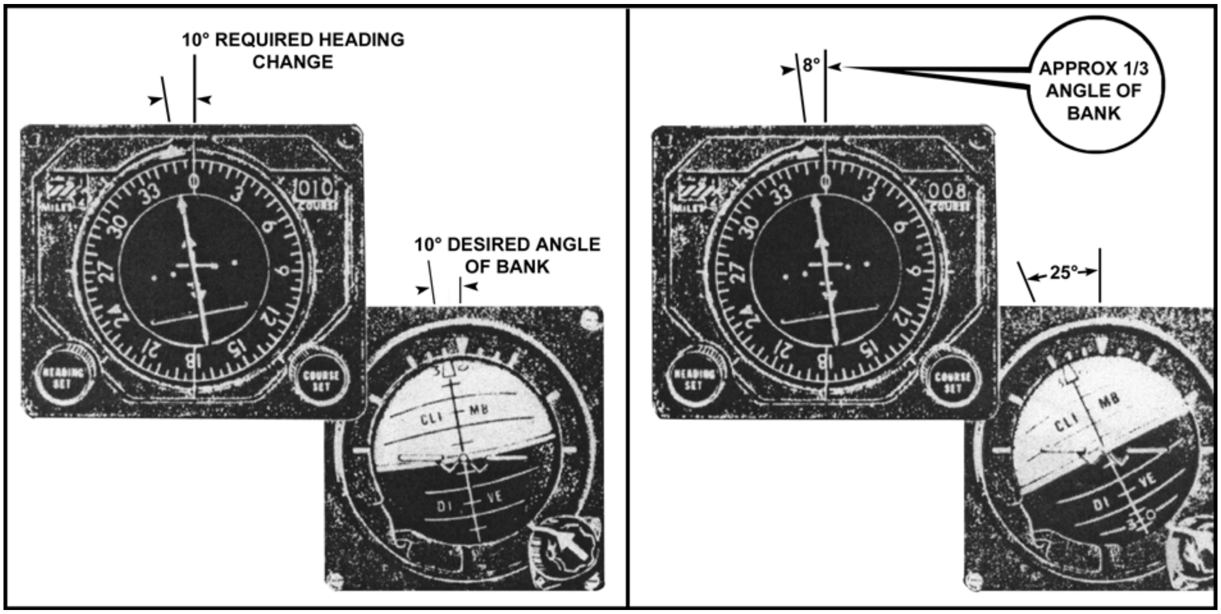
Figure 2.3. Use of Power.



2.4.2. Level Turns. Many of the pitch, bank, and power principles discussed in maintaining straight and level flight apply while performing level turns. Performing a level turn requires an understanding of several factors: how to enter the turn, how to maintain bank, altitude, and airspeed during the turn; and how to recover from the turn.

2.4.2.1. Bank Control. Before entering a turn you should decide upon a bank angle. Factors to consider are true airspeed and the desired rate of turn. A slow turn rate may unnecessarily prolong the turn, whereas a high rate of turn may cause overshooting of the heading and difficulty with pitch control. As a guide for turns of 30° or less (Figure 2.4), the bank angle should approximate the number of degrees to be turned. For turns of more than 30°, use a bank angle of 30°. High turn airspeeds or flight manual procedures may require other angles of bank. To enter a turn, you should refer to the attitude indicator while applying smooth and coordinated control pressures to establish the desired angle of bank. Bank control should then be maintained throughout the turn by reference to the attitude indicator. Crosscheck the heading indicator or turn needle to determine if the angle of bank is satisfactory. Trim may be helpful during prolonged turns to assist in aircraft control.

Figure 2.4. Level Turns.



2.4.2.2 Roll out of a turn. To roll out of a turn on a desired heading, a lead point must be used. The amount of lead required depends upon the amount of bank used for the turn, the rate the aircraft is turning, and your roll out rate. As a guide, a lead point of approximately one-third the angle of bank may be used (Figure 2.4). With experience and practice a consistent rate or rollout can be developed. A lead point can then be accurately estimated for any combination of bank angle or rate of turn. Make a note of the rate of movement of the heading indicator during the turn. Estimate the lead required by comparing this rate of movement with the angle of bank and the rate of roll out.

2.4.2.3. Altitude Control. The techniques for maintaining a constant altitude during a turn are similar to those used in maintaining altitude in straight and level flight. During the initial part of the roll-in, hold the same pitch attitude as was used to maintain altitude with the wings level. As the bank is increased, anticipate a tendency for the aircraft to lose altitude because of the change in lift vector. Adjust the pitch attitude as necessary by reference to the miniature aircraft relative to the artificial horizon. After the turn is established, small pitch adjustments may be required to correct for attitude indicator precession. When rolling out of a turn, anticipate a tendency for the aircraft to gain altitude. This results from a combination of an increase in the vertical component of lift and a failure to compensate for trim or back pressure used during the turn. Therefore, be aware of these factors, and monitor the pitch attitude during the rollout in the same manner as during the roll-in. During rollout, anticipate a decrease in pitch equal to the increase in pitch required during roll-in.

2.4.2.4. Airspeed Control. The power control techniques for maintaining an airspeed during a turn is similar to those used during straight and level flight. Anticipate a tendency for the aircraft to lose airspeed in a turn. This is caused by induced drag resulting from the increased pitch attitude required to compensate for loss of vertical lift. The increased drag will require additional power to maintain airspeed during a turn. The additional power required will be less at high true airspeeds than at low true airspeeds. At low airspeeds, particularly in jet aircraft, a large power change may be required. If your response to this power change is slow, the airspeed may decrease rapidly to the point where a descent is required to regain the desired airspeed. Therefore, at low airspeeds, it may be desirable to add an estimated amount of power as the turn is established rather than waiting for the first indication of a loss in airspeed.

2.4.3. Steep Turns. A steep turn is considered to be a turn in which the angle of bank used is larger than that required for normal instrument flying. For most aircraft the normal instrument turn bank angle is 30°.

2.4.3.1. Entry into a steep turn. Entry into a steep turn is accomplished in the same way as for a normal turn. As the bank is increased past normal, the changing lift vector requires a larger pitch adjustment. The use of trim in steep turns varies with individual aircraft characteristics and pilot technique. Additional power is required to maintain airspeed as the bank is increased.

2.4.3.2. Maintaining the steep turn. During the steep turn, pitch and power control are maintained in the same way as in a normal turn, however, larger pitch adjustments will be required for a given altitude deviation. Varying the angle of bank during the turn makes pitch control more difficult. Give sufficient attention to the bank pointer to maintain the bank angle constant. Precession error in the attitude indicator is more prevalent during the steep turns. If altitude loss becomes excessive, reduce the angle of bank as necessary to regain positive pitch control.

2.4.3.3. Rolling out of a steep turn. When rolling out of a steep turn, you should be alert to correct for the more than normal back trim, pitch attitude, and power used during the turn. Roll out at the same rate used with normal turns. The performance instruments must be crosschecked closely during rollout, since the attitude indicator may have considerable precession error.

2.4.4. Timed Turns and Use of the Magnetic Compass. Heading indicator failure may require use of the magnetic compass for heading information. Remember that this instrument provides reliable information only during straight, level, and unaccelerated flight. Because of this limitation, timed turns are recommended when making heading changes by reference to the magnetic compass.

2.4.4.1. Accomplishing a timed turn. A timed turn is accomplished by establishing a bank attitude on the attitude indicator that will result in a desired rate of turn as shown by the turn needle. A single needle width deflection on a 4-minute turn needle indicates 1 1/2° per second rate of turn, while a double needle width deflection indicates 3° per second rate of turn. A fraction of the preceding amounts can be used to simplify the timing problem. For example, 2/3-needle width deflection indicates 1° per second rate of turn while 1 1/3 needle widths indicates 2° per second rate of turn.

2.4.4.2. Heading change. The heading change is accomplished by maintaining the desired rate of turn for a predetermined time. Start timing when control pressures are applied to begin the turn. Control pressures are applied to rollout when the time has elapsed. As an example, assume that a 45° heading change is desired using a 4-minute turn needle. The aircraft's true airspeed is relatively high making it advisable to make a single needle width turn (1 1/2° per second). In this case, 30 seconds should elapse from the time control pressures are applied to enter the turn until control pressures are applied to rollout.

2.4.4.3. Alternate method. Although timed turns are preferred when using the magnetic compass as a heading reference, there is an alternate method. Turns to headings can be made by applying control pressures to roll out of a turn when reaching a predetermined "lead" point on the magnetic compass. When using the magnetic compass in this manner, do not exceed 15° of bank in order to minimize dip error. Dip error must also be considered in computing the lead point for rollout. This is particularly noticeable when turning to a heading of north or south. For example, turns to north require a normal lead point plus a number of degrees equal to the flight latitude. Turns to south require turning past the desired heading by the number of degrees equal to the flight latitude minus the normal lead. Dip error is negligible when turning to east or west; therefore, use the normal amount of lead when turning to either of these headings.

2.4.5. Climbs and Descents. Climbing and descending maneuvers are classified into two general types -- constant airspeed and constant rate. The constant airspeed maneuver is accomplished by maintaining a constant power indication and varying the pitch attitude to maintain a specific airspeed. The constant rate maneuver is accomplished by varying both power and pitch to maintain constant a specific airspeed and vertical velocity. Either type of climb or descent may be performed while maintaining a constant heading or while turning. These maneuvers should be practiced using airspeeds, configurations, and altitudes corresponding to those which will be used in actual instrument flight.

2.4.5.1. Constant Airspeed Climbs and Descents.

2.4.5.1.1. Power setting. Before entering the climb or descent, choose a power setting and estimate the amount of pitch attitude change required to maintain the airspeed. Normally, the pitch and power changes are made simultaneously.

2.4.5.1.2. Power change. The power change should be smooth, uninterrupted, and at a rate commensurate with the rate of pitch change. In some aircraft, even though a constant throttle setting is maintained, the power may change with altitude. Therefore, it may be necessary to occasionally crosscheck the power indicators.

2.4.5.1.3. Pitch and power changes. While the power is being changed, refer to the attitude indicator and smoothly accomplish the estimated pitch change. Since smooth, slow power applications will also produce pitch changes, only slight control pressures are needed to establish the pitch change. Additionally, very little trim change is required since the airspeed is constant. With a moderate amount of practice, the pitch and power changes can be properly coordinated so the airspeed will remain within close limits as the climb or descent is entered.

2.4.5.1.3.1. NOTE: Remember, the initial pitch attitude change was an estimated amount to maintain the airspeed constant at the new power setting. The airspeed indicator must be crosschecked to determine the need for subsequent pitch adjustments.

2.4.5.1.4. Airspeed deviation. When making a pitch adjustment to correct for an airspeed deviation, the airspeed indicator will not reflect an immediate change. The results of pitch attitude changes can be determined more quickly by referring to the vertical velocity indicator. For example, while climbing, you note that the airspeed is remaining slightly high and that a small pitch adjustment is required. If the pitch adjustment results in a small increase of vertical velocity, you know (even though the airspeed may not show a change) that the pitch correction was approximately correct.

2.4.5.1.5. Inadvertent pitch change. In a similar manner, the vertical velocity indication will help you note that you have made an inadvertent change in pitch attitude. For example, assume that the desired airspeed and the vertical velocity have been remaining constant but the pitch attitude is allowed to change. The vertical velocity indicator will generally show the result of this inadvertent pitch change more quickly than the airspeed indicator. Therefore, the vertical velocity indicator is an excellent aid in maintaining the airspeed constant.

2.4.5.1.6. Level-off lead point. Upon approaching the desired altitude, select a predetermined level off lead point. Ten percent of the vertical velocity in feet is a good estimate for the level-off lead point. At the level-off lead point, smoothly adjust the power to an approximate setting required for level flight and simultaneously change the pitch attitude to maintain the desired altitude.

2.4.5.2. Rate Climbs and Descents.

2.4.5.2.1. Maintain vertical velocity and airspeed. Rate climbs and descents are accomplished by maintaining both a desired vertical velocity and airspeed. They are proficiency maneuvers designed to practice the techniques used during instrument approaches. Pitch attitude controls the desired vertical velocity, and power controls the desired airspeed. Proper control techniques require coordinated pitch and power changes or adjustments.

2.4.5.2.2. Estimate pitch change. Before initiating a rate climb or descent, estimate the amount of pitch change required to produce the desired vertical velocity and the amount of power change required to maintain the airspeed constant. Enter the climb or descent by simultaneously changing the pitch and power the predetermined amount. Crosscheck the performance instruments to determine the resultant changes.

2.4.5.2.3. Vertical velocity. A crosscheck of the vertical velocity will indicate the need for subsequent pitch adjustments. A crosscheck of the airspeed will indicate the need for subsequent power adjustments. When approaching the desired altitude, use normal level-off techniques.

2.4.5.3. Pitch and Bank Attitude Control During Climbing and Descending Turns. Constant airspeed or rate climbs and descents may be performed on a constant heading or while turning. (For a constant heading, pitch and bank control techniques are the same as discussed under straight and level flight.) During a turn, the change in lift vector affects pitch control. For example, when entering a turn after a constant airspeed climb or descent has been established, the pitch attitude will have to be decreased slightly to maintain the airspeed. When entering a turn while performing a rate climb or descent, be prepared to increase the pitch attitude slightly to maintain the vertical velocity and add power to maintain the airspeed.

2.4.6. Level off. Level offs are required during all phases of instrument flight. The high rates of climbs or descents possible in some aircraft can cause an overshoot of the desired altitude. The following techniques are designed to allow for a precise, easily controlled level-off maneuver.

2.4.6.1. Desired airspeed. At least 1,000 feet below or above the desired altitude, reduce the pitch attitude to obtain a maximum of 1,000 to 2,000 fpm rate of climb or descent. Adjust the power to maintain the desired airspeed. Knowledge of approximate or known values of power and pitch simplifies aircraft control during this phase of flight. When the lead point for level off is reached, perform a normal level off.

2.4.6.1.1. NOTE: At 1,000 feet below or above the desired altitude, a pitch change of one-half the previous pitch angle will normally provide a more controllable vertical velocity at the lead point for level off.

2.4.6.2. Pitch change for level off. The total pitch change required for level off can be estimated by dividing the vertical velocity by the mach number times 1,000 (or miles per minute times 100). For example, an aircraft climbing or descending at .6 mach with a vertical velocity of 3,600 fpm would require approximately 6° of pitch change to obtain a level flight attitude.

$$\frac{3{,}600 \text{ fpm}}{0.6 \text{ mach} \times 1{,}000} = 6^\circ \quad \text{or} \quad \frac{3{,}600 \text{ fpm}}{6 \text{ mpm} \times 100} = 6^\circ$$

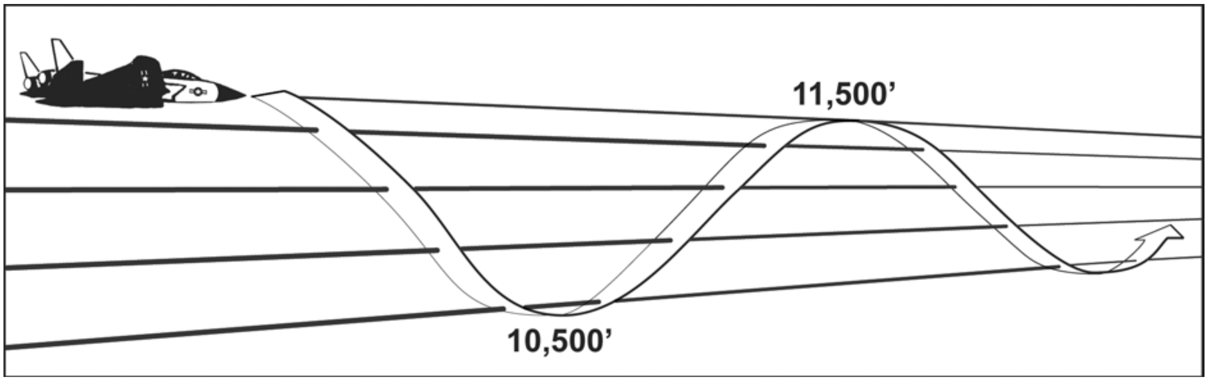
2.4.6.3. Selecting level-off point. Upon approaching the desired altitude, select a predetermined level off lead point. As a guide, use 10 percent of the vertical velocity. Smoothly adjust the power to an approximate setting required for level flight, and simultaneously change the pitch attitude to maintain the desired altitude.

2.5. Basic Aircraft Control Maneuvers.

2.5.1. Vertical "S" Series. The vertical "S" maneuvers are proficiency maneuvers designed to improved a pilot's crosscheck and aircraft control. There are four types: the A, B, C, and D.

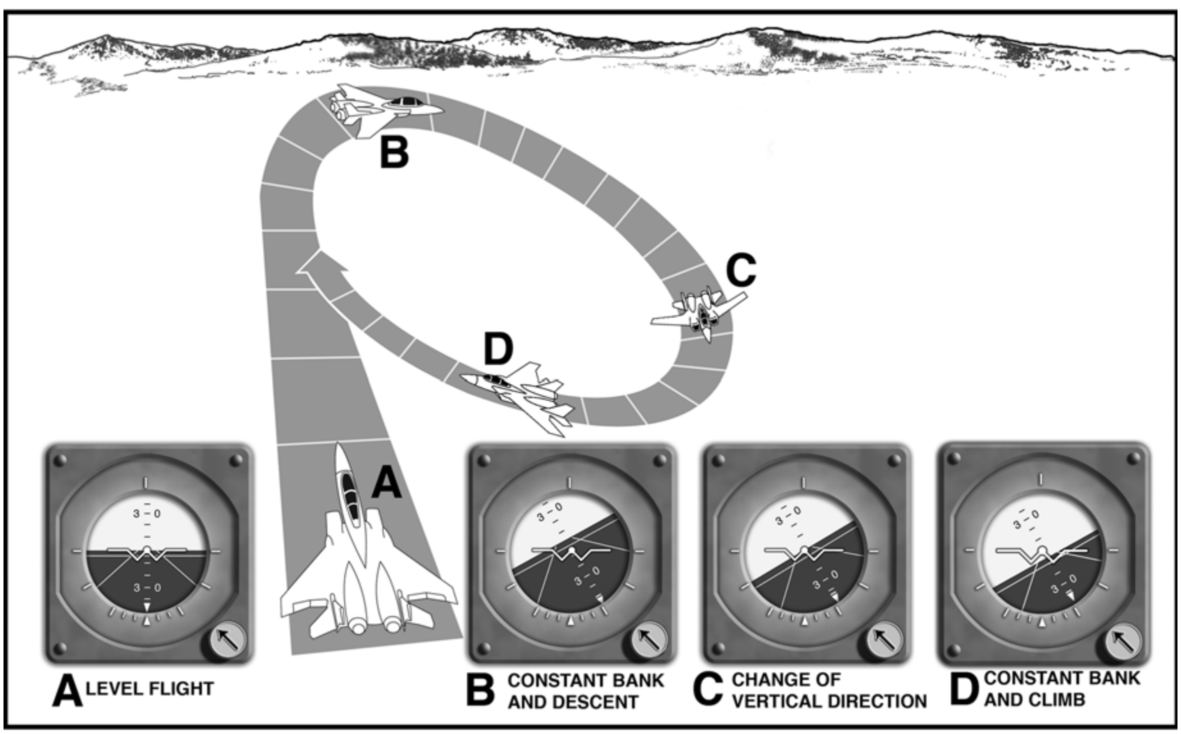
2.5.1.1. Vertical "S"- A. (Figure 2.5) The vertical "S"-A maneuver is a continuous series of rate climbs and descents flown on a constant heading. The altitude flown between changes of vertical direction and the rate of vertical velocity used must be compatible with aircraft performance. The vertical "S"- A if flown at final approach airspeed and configuration is excellent for practicing entry to and control of precision glide paths. The transition from descent to climb can be used to simulate the missed approach. However, allow sufficient altitude for "cleaning up" the aircraft and establishing the climb portion of the maneuver. Level off, reestablish configuration and airspeed, and repeat as required. When used for this purpose, select an altitude low enough to use realistic power settings.

Figure 2.5. Vertical "S"- A.



2.5.1.2. Vertical "S"- B. (Figure 2.6). The vertical "S"- B is the same as the vertical "S"- A except that a constant angle of bank is maintained during the climb and descent. The angle of bank used should be compatible with aircraft performance (usually that required for a normal turn). The turn is established simultaneously with the initial climb or descent. Maintain the angle of bank constant throughout the maneuver.

Figure 2.6. Vertical "S"- B.

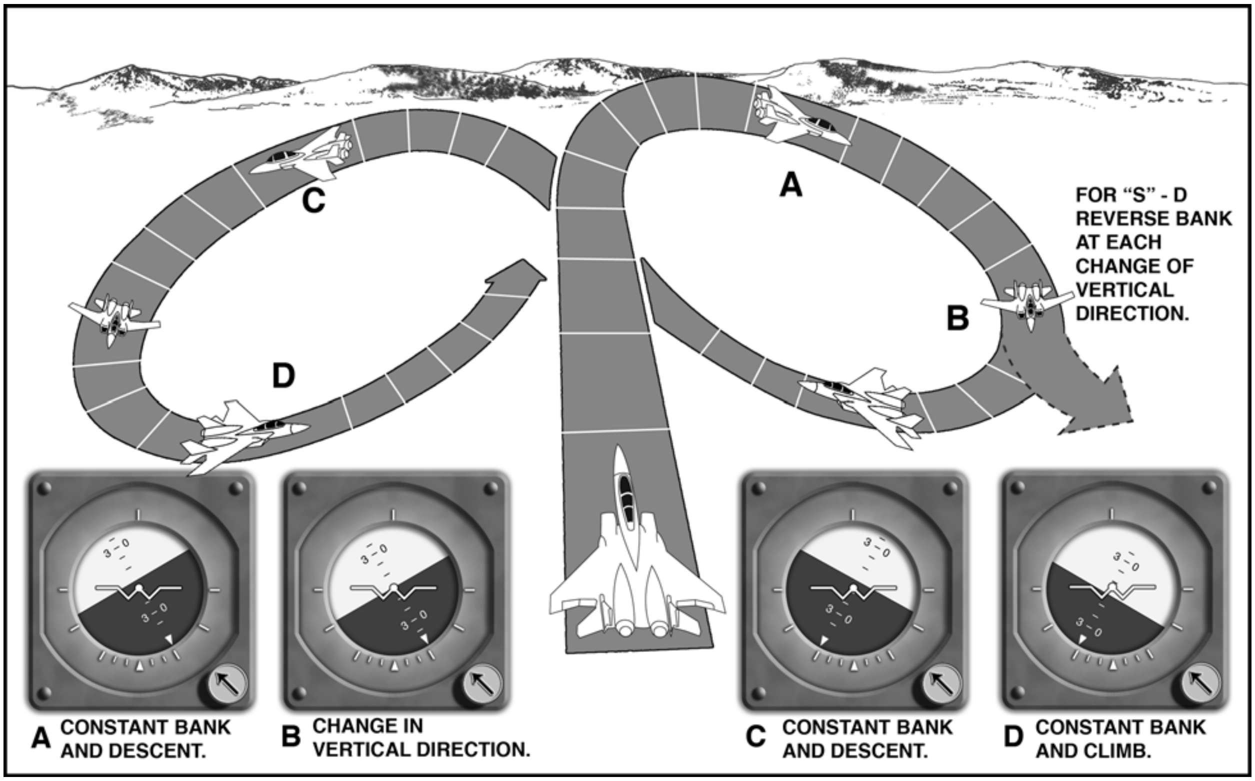


2.5.1.3. Vertical "S"- C. (Figure 2.7). The vertical "S"- C is the same as vertical "S"- B, except that the direction of turn is reversed at the beginning of each descent. Enter the vertical "S" - C in the same manner as the vertical "S"- B.

2.5.1.4. Vertical "S"- D. (Figure 2.7). The vertical "S"- D is the same as the vertical "S"- C, except that the direction of turn is reversed simultaneously with each change of vertical direction. Enter the vertical "S"- D in the same manner as the vertical "S"- B or "S"- C.

2.5.1.5. Vertical "S" initiation. Any of the vertical "S" maneuvers may be initiated with a climb or descent. Conscientious practice of these maneuvers will greatly improve the pilot's familiarity of the aircraft, instrument crosscheck, and overall aircraft control during precision instrument approaches. For this reason, the maneuvers should be practiced at approach speeds and configurations, and at low altitudes, as well as at cruise speeds, clean, and at higher altitudes.

Figure 2.7. Vertical "S"- C and "S"- D.

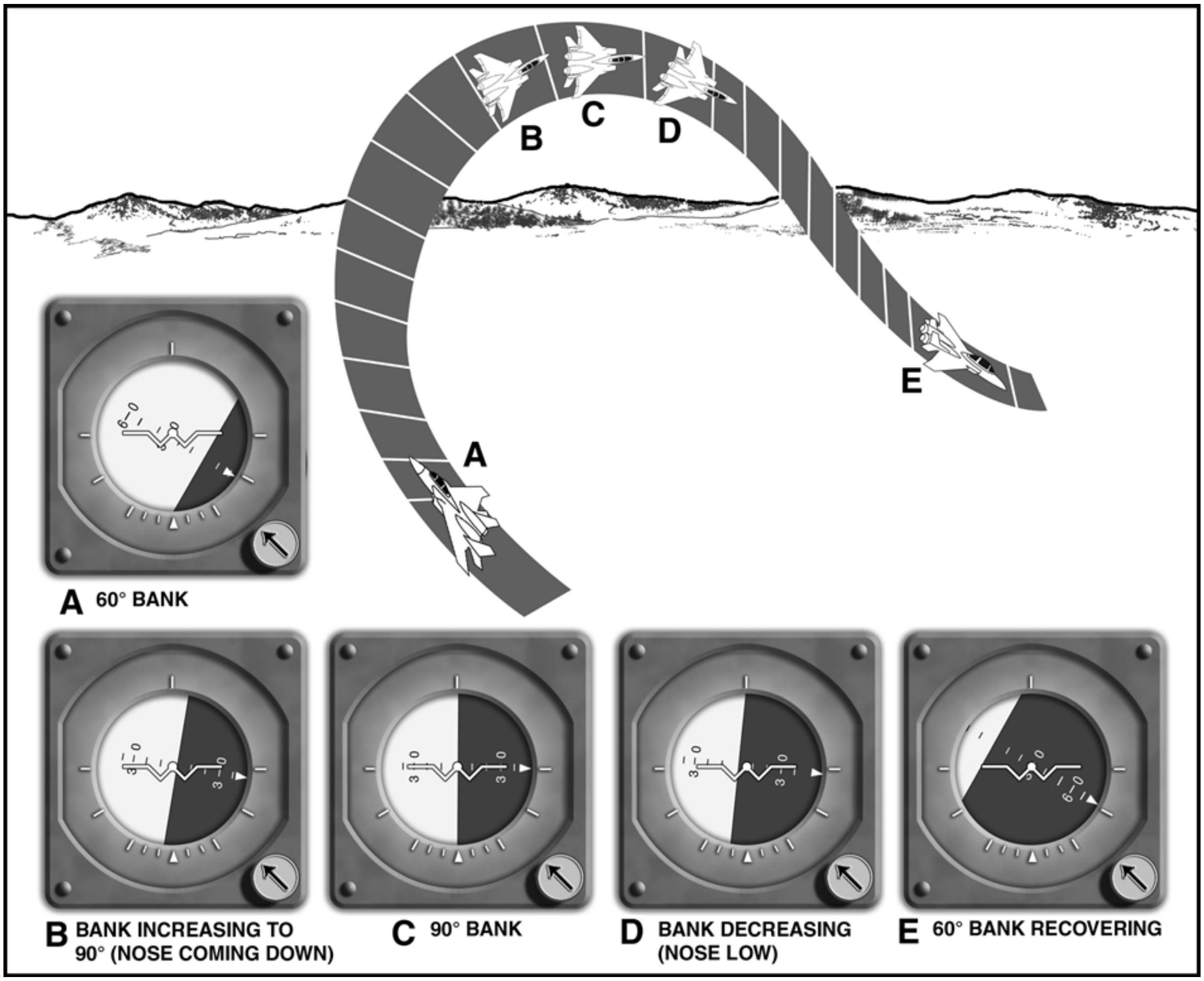


2.5.2. Confidence Maneuvers. Present missions require some aircraft to be flown in all attitudes under instrument conditions. Such aircraft have attitude indicators capable of indicating these attitudes. Confidence maneuvers are basic aerobatic maneuvers designed to gain confidence in the use of the attitude indicator in extreme pitch and bank attitudes. In addition, mastering these maneuvers will be helpful when recovering from unusual attitudes. The pilot should consult the aircraft flight manual for performance characteristics and limitations before practicing these maneuvers.

2.5.2.1. Wingover (Figure 2.8). Begin the maneuver from straight and level flight. After obtaining the desired airspeed, start a climbing turn in either direction while maintaining the wing tip of the miniature aircraft on the horizon bar until reaching

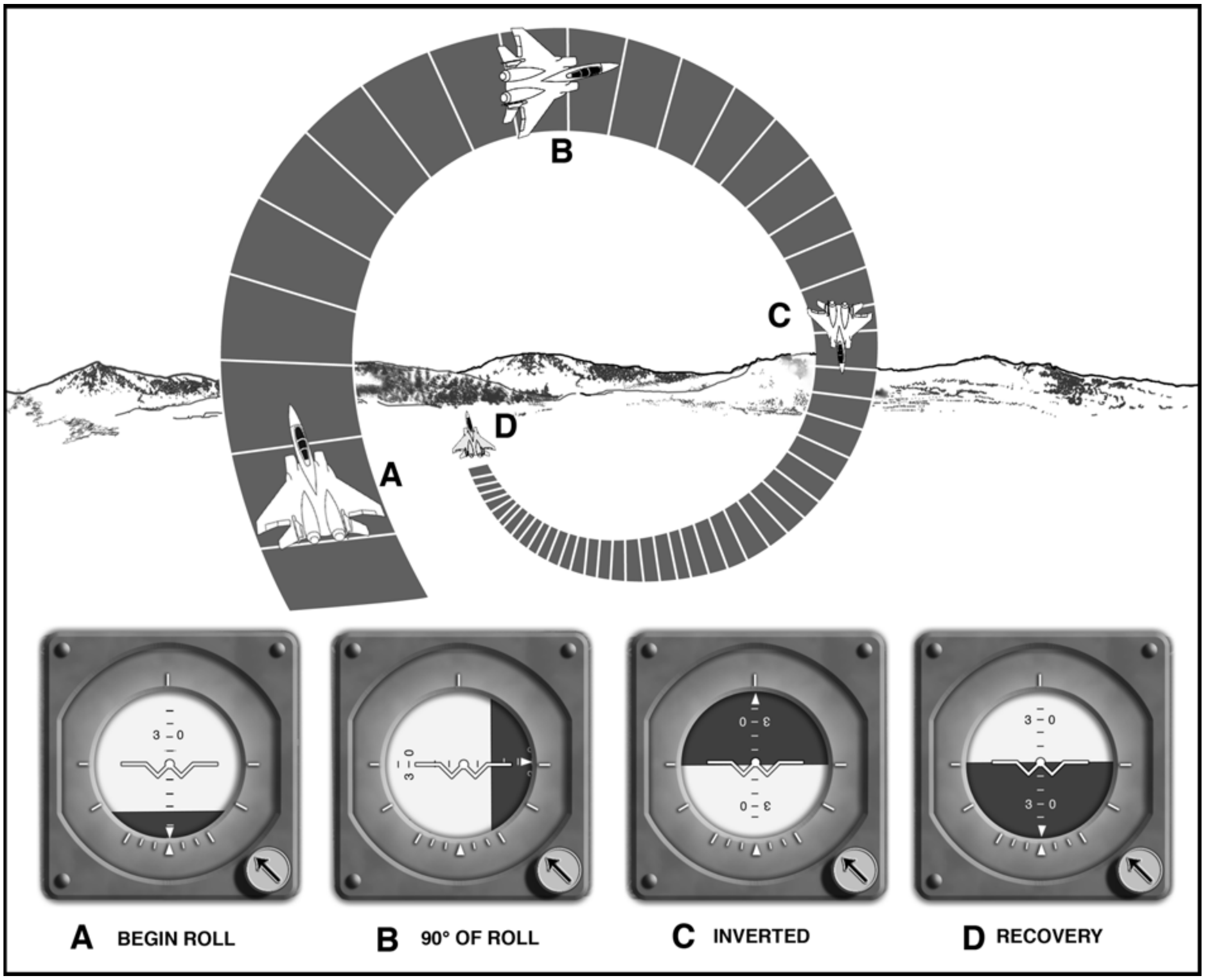
60° of bank. Allow the nose of the aircraft to start down while continuing to increase the angle of bank, planning to arrive at 90° of bank as the fuselage dot of the miniature aircraft reaches the horizon bar. Begin decreasing the angle of bank as the fuselage dot of the miniature aircraft reaches the horizon bar so that the wing tip of the miniature aircraft reaches the horizon bar as 60° of bank is reached. Maintain the wing tip on the horizon bar while rolling to a wings level attitude. The rate of roll during the recovery should be the same as the rate of roll used during the entry. Control pitch and bank throughout the maneuver by reference to the attitude indicator.

Figure 2.8. Attitude Indications During Wingover.



2.5.2.2. Aileron Roll (Figure 2.9). Begin the maneuver from straight and level flight after obtaining the desired airspeed. Smoothly increase the pitch attitude, with the wings level, to 15° to 25° nose up on the attitude indicator. Start a roll in either direction and adjust the rate of roll so that, when inverted, the wings will be level as the fuselage dot of the miniature aircraft passes through the horizon bar. Continue the roll and recover in a nose low, wings level attitude. The entire maneuver should be accomplished by reference to the attitude indicator. Use sufficient back pressure to maintain normal seat pressures (approximately 1 g) throughout the maneuver.

Figure 2.9. Attitude Indications During Aileron Roll.



2.6. Unusual Attitudes.

2.6.1. Definition. An unusual attitude is an aircraft attitude occurring inadvertently. It may result from one factor or a combination of several factors such as turbulence, channelized attention, instrument failure, inattention, spatial disorientation, lost wingman, and transition from VMC to IMC. In most instances these attitudes are mild enough to recover by reestablishing the proper attitude for the desired flight condition and resuming a normal crosscheck. As a result of extensive tactical maneuvering, the pilot may experience unusual attitudes even in VMC. This may be aggravated by the lack of a definite horizon or by lack of contrast between the sky and ground or water.

2.6.1.1. WARNING: It is important to ***immediately transition to instrument references any time you become disoriented or when outside visual references become unreliable***.

2.6.2. Techniques of recovery. Techniques of recovery should be compatible with the severity of the unusual attitude, the characteristics of the aircraft, and the altitude available for the recovery. The procedures in this section are not designed for recovery from controlled tactical maneuvers.

2.6.3. Principles and considerations. The following aerodynamic principles and considerations are applicable to the recovery from unusual attitudes:

2.6.3.1. Elimination of bank. The elimination of a bank in dive aids pitch control

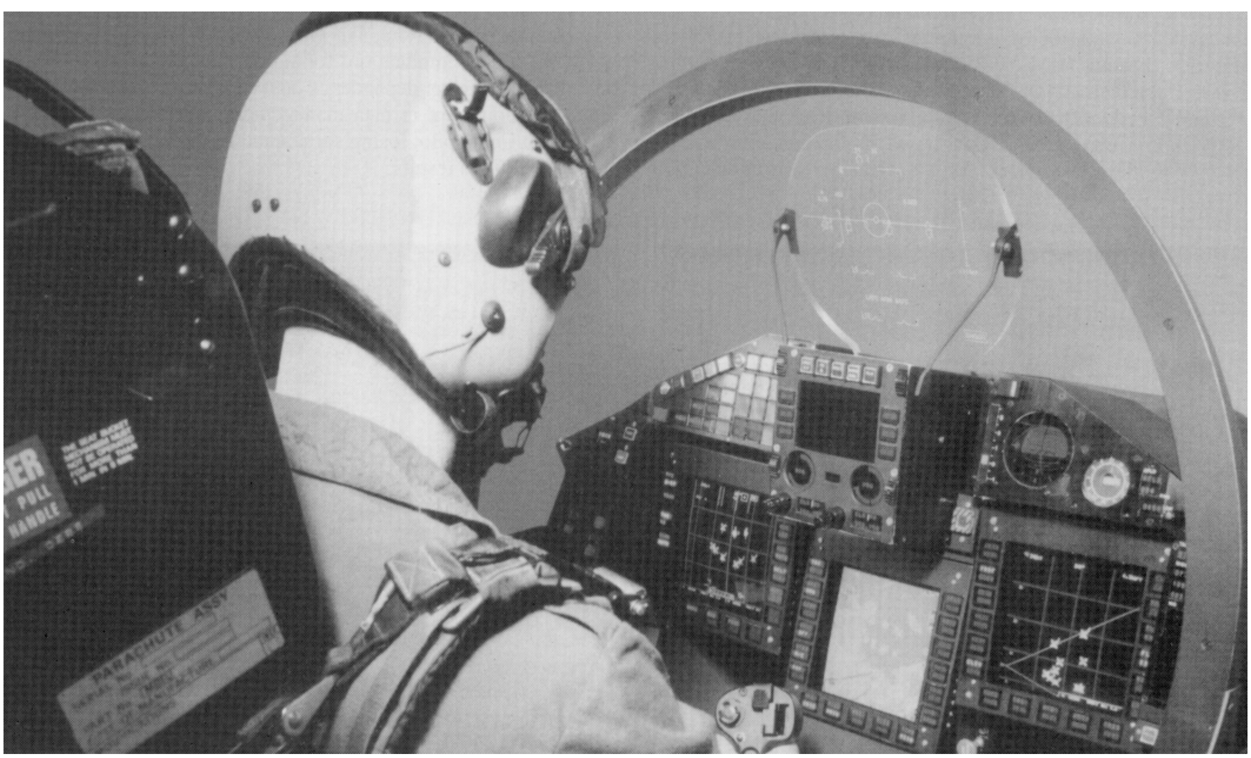
2.6.3.2. Use of bank. The use of bank in a climb aids pitch control.

2.6.3.3. Power and drag. Power and drag devices used properly aid airspeed control.

2.6.3.4. Bank control. It should be emphasized that bank control will assist recovery.

2.6.4. Recognizing an Unusual Attitude. Normally, an unusual attitude is recognized in one of two ways -- an unusual attitude "picture" on the attitude indicator or unusual performance on the performance instruments. Regardless of how the attitude is recognized, verify that an unusual attitude exists by comparing control and performance instrument indications prior to initiating recovery on the attitude indicator (Figure 2.10). This precludes entering an unusual attitude as a result of making control movements to correct for erroneous instrument indications. During this process, the attitude must be correctly interpreted. Additional attitude indicating sources (stand by attitude indicator, copilot's attitude indicator, etc.) should be used. In some aircraft, the bank steering bar (manual mode) may aid in maintaining level flight (refer to flight manual). If there is any doubt as to proper attitude indicator operation, then recover using attitude indicator inoperative procedures. The following techniques will aid aircraft attitude interpretation on the attitude indicator.

Figure 2.10. Verify That an Unusual Attitude Exists.



2.6.4.1. Sky pointer. For attitude indicators with a single bank pointer and bank scale at the top, the bank pointer can be considered a sky pointer. It always points up and should be in the upper half of the case. Rolling towards the bank pointer to place it in the upper half of the case will correct an inverted attitude.

2.6.4.2. Ground pointer. For those attitude indicators with the bank scale at the bottom, rolling in the direction that will place the pitch reference scale right side up will correct an inverted attitude.

2.6.4.2.1. NOTE: Ease of pitch interpretation varies with the type of attitude indicator installed. Attitude indicators having pitch reference scales in degrees and gray or black attitude spheres can easily be interpreted for climb or dive indications. For those aircraft not so equipped, the airspeed indicator, altimeter, or vertical velocity indicator generally presents the most easily interpreted indication of a climb or a dive. Attitude interpretation is a skill that must be highly developed by practice in flight and on the ground in simulators or with mockups.

2.6.5. Recovery Procedures--Attitude Indicators Operative. For fixed-wing aircraft, use the following procedures if specific unusual attitude recovery procedures are not in the flight manual.

2.6.5.1. Diving. If diving, adjust power or drag devices as appropriate while rolling to a wings level, upright attitude, and correct to level flight on the attitude indicator. Do not add back pressure until less than 90° of bank.

2.6.5.2. Climbing. If climbing, use power as required and bank as necessary to assist pitch control and to avoid negative G forces. As the fuselage dot of the miniature aircraft approaches the horizon bar, adjust pitch, bank, and power to complete recovery and establish the desired aircraft attitude. When recovering from a steep climb, care must be exercised in some aircraft to avoid exceeding bank limitations.

2.6.5.3. Bank and power. During unusual attitude recoveries, coordinate the amount of bank and power used with the rate at which airspeed and pitch are being controlled. Bank and power used must be compatible with aircraft and engine characteristics.

2.6.6. Recovery Procedures--Attitude Indicators Inoperative. With an inoperative attitude indicator, successful recovery from unusual attitudes depends greatly on pilot proficiency and early recognition of attitude indicator failure. For example, attitude indicator failure should be immediately suspected if control pressures are applied for a turn without corresponding attitude indicator changes. Another example would be satisfactory performance instrument indications that contradict the "picture" on the attitude indicator. Should an unusual attitude be encountered with an inoperative attitude indicator, the following procedures are recommended:

2.6.6.1. Climb or dive. Determine whether the aircraft is in a climb or a dive by referring to the airspeed, altimeter, and vertical velocity indicators.

2.6.6.2. Diving. If diving, roll to center the turn needle and recover from the dive. Adjust power or drag devices as appropriate. (Disregarding vertical attitudes, rolling "away" from the turn needle and centering it will result in an upright attitude).

2.6.6.3. Climbing. If climbing, use power as required. If the airspeed is low or decreasing rapidly, pitch control may be aided by maintaining a turn of approximately standard rate on the turn needle until reaching level flight. If the turn needle in a flight director system is used, center the turn needle. This is because it is very difficult to determine between a standard rate turn and full needle deflection.

2.6.6.4. Level flight. Upon reaching level flight, center the turn needle. The aircraft is level when the altimeter stops. The vertical velocity indicator lag error may cause it not to indicate level until the aircraft passes level flight.

2.6.6.4.1. WARNING: Spatial disorientation may become severe during the recovery from unusual attitudes with an inoperative attitude indicator. Extreme attitudes may result in an excessive loss of altitude and possible loss of aircraft control. Therefore, ***if a minimum safe altitude for unusual attitude recovery is not in the flight manual, decide upon an altitude at which recovery attempts will be discontinued and the aircraft abandoned***. On aircraft equipped with an operative autopilot, it may be used to assist in a last chance recovery from unusual attitudes.

2.6.6.4.2. WARNING: Due to the inadequate attitude information possibly found on HUDs presently in the inventory, attempts to recover from unusual attitudes using the HUD may further aggravate the situation.

Chapter 3

BASIC INSTRUMENT FLYING-HELICOPTER

3.1. Instrument Categories. This chapter contains helicopter unique instrument procedures that are not covered elsewhere in this manual. In addition, you should be very familiar with the navigation instruments (chapter 5), electronic aids to navigation (chapter 6), and navigation procedures (chapter 7) that apply to all aircraft. Instrument flights should be planned and conducted according to chapters 8 through 11 and 13 through 20 (as applicable) of this manual. Helicopter performance is achieved by controlling the aircraft attitude and power. This attitude is the relationship of the longitudinal and lateral axes to the Earth's horizon (Figure 3.1). An aircraft is flown in instrument flight by controlling the attitude and power as necessary to produce the desired performance. This is known as the "control and performance concept" of attitude instrument flying and can be applied to any basic instrument maneuver.

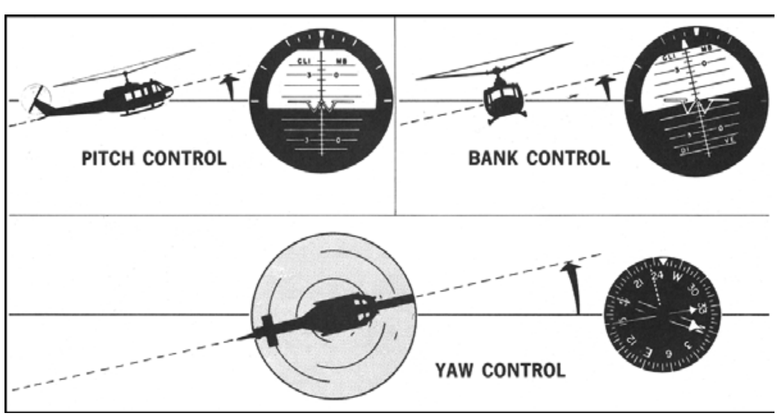
3.2. **Instrument Types**. The three general categories of instruments are:

3.2.1. Control Instruments. These instruments display attitude and power indications and are calibrated to permit attitude and power adjustments in definite amounts. In this discussion, the term power is used to replace the more technically correct term thrust to drag relationship. Power is controlled by reference to the power indicators. These vary with different helicopters but typically measure torque in either pounds or percentage of maximum rated torque.

3.2.2. Performance Instruments. These instruments indicate the aircraft's actual performance. Performance is determined by reference to the altimeter, airspeed, vertical velocity indicator, heading indicator, and turn and slip indicator.

3.2.3. Navigation Instruments. These instruments indicate the position of the aircraft in relation to a selected navigation facility, fix, or relative position. This group of instruments includes various types of course indicators, range indicators, glide slope indicators, bearing pointers, and Flight Management Systems (FMS)/Global Positioning Systems (GPS) displays.

Figure 3.1. Attitude Instrument Flying.



3.3. Control and Performance Concept.

3.3.1. Procedural Steps.

3.3.1.1. ***Set***. Set an attitude or power setting on the control instruments that should result in the desired performance.

3.3.1.2. ***Trim***. Trim using tail rotor controls, stick or force trim and friction as needed.

3.3.1.3. ***Crosscheck***. Crosscheck the performance instruments to determine if the established attitude or power setting is providing the desired performance.

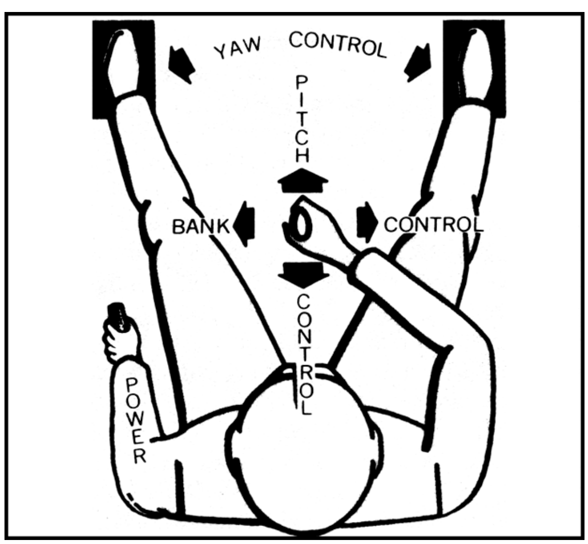
3.3.1.4. ***Adjust***. Adjust the attitude or power setting on the control instruments if a correction is necessary.

3.3.2. Attitude Control. Proper control of aircraft attitude is the result of maintaining a constant attitude, knowing when and how much to change the attitude, and smoothly changing the attitude a definite amount. Helicopter attitude is maintained by proper use of the flight controls, and referenced by proper use of the attitude indicator. The attitude indicator provides an indication of any change in aircraft pitch or bank attitude.

3.3.2.1. Pitch Control. Pitch changes are made by cyclic inputs to change the "pitch attitude" of the miniature aircraft or fuselage dot definite amounts in relation to the horizon. These changes are referred to as bar widths, or degrees depending upon the type of attitude indicator. A bar width is approximately 2 degrees on most attitude indicators. The amount of deviation from the desired performance will determine the magnitude of the correction.

3.3.2.2. Bank Control. Bank changes are made by cyclic inputs to change the "bank attitude" or bank pointer by definite amounts in relation to the bank scale. The bank scale is normally graduated at 0°, 10°, 20°, 30°, 60°, and 90° and may be located at the top or bottom of the attitude indicator.

Figure 3.2. Attitude and Power Control.



3.3.3. Power Control (Figure 3.2).

3.3.3.1. Proper power control. Proper power control results from the ability to smoothly establish or maintain desired airspeeds and altitudes in coordination with attitude changes. Power changes are made by collective pitch adjustments and reference to the power indicator. Power indicators are not usually affected by such factors as turbulence, improper trim, or inadvertent control pressures.

3.3.3.2. Collective Inputs. From experience in your aircraft, you know approximately how far to move the collective to change the power a given amount. Therefore, you can make power changes primarily by collective movement and then crosscheck the indicator to establish a more precise setting. The key is to avoid over fixation on the indicator while setting the power. A knowledge of power settings for various flight conditions will help prevent over controlling power.

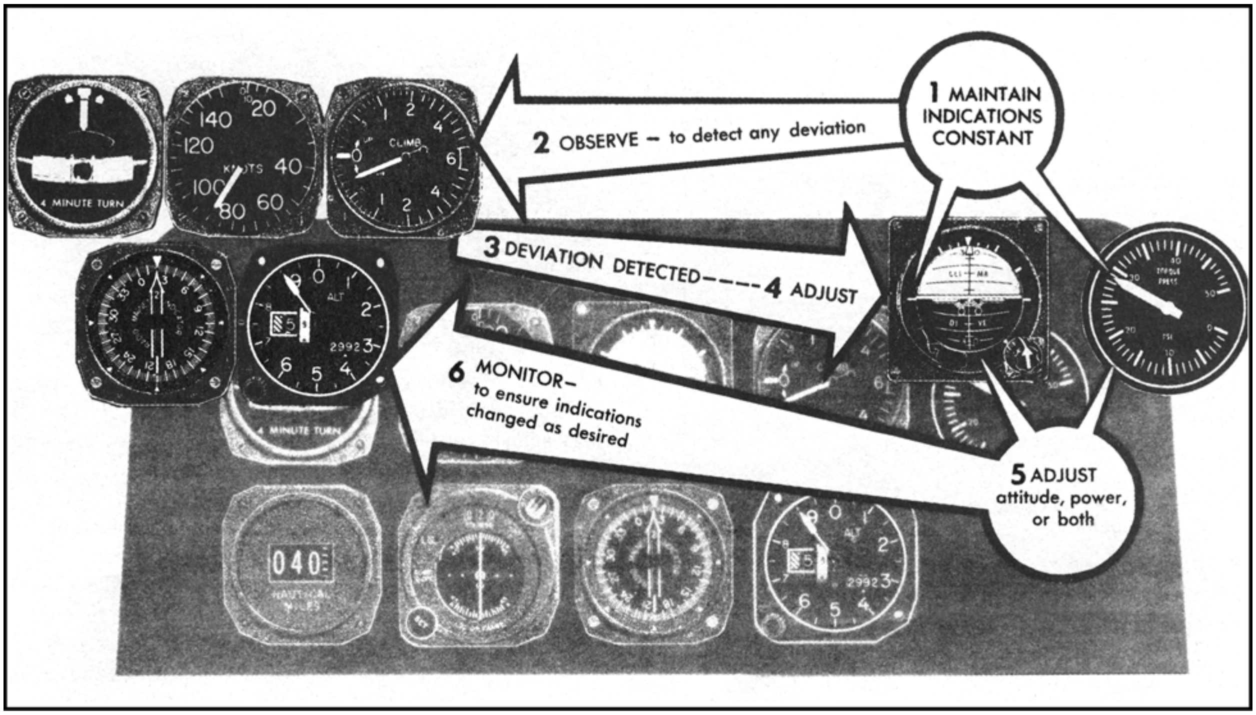
3.3.4. Trim Techniques. The inherent instability of helicopters requires the pilot to trim the aircraft accurately in order to reduce the workload to an acceptable level.

3.3.4.1. Independent trim systems. For those helicopters equipped with independent trim systems, trimming nose up/down, lateral right/left planes are relatively simple. Small changes are made in the desired direction until the control pressures are neutralized and the aircraft maintains a relatively stable flight path.

3.3.4.2. Force trim systems. For those helicopters equipped with a force trim system, the ability to trim the aircraft accurately is somewhat difficult and comes only with experience. Depressing the force trim button releases all trim axes simultaneously. The pilot must ensure those in trim are maintained exactly, while the corrections to the out of trim axes are made.

3.3.4.3. Yaw axis control. The key to smooth and accurate instrument flight in a helicopter is the ability to maintain coordinated flight. This is because the yaw axis is usually the most unstable axis in helicopters, particularly in those aircraft not equipped with a Stability Augmentation System (SAS). The instability in the yaw axis is compounded by power changes that cause a yawing moment and require an immediate pedal correction. Induced vertigo is commonly the result of this moment. Therefore power changes should be kept to a minimum and, when required, should be applied slowly and smoothly. Pilot anticipation of pedal adjustments during power changes will help to keep yaw moments to a minimum.

Figure 3.3. Instrument Cross-Check.



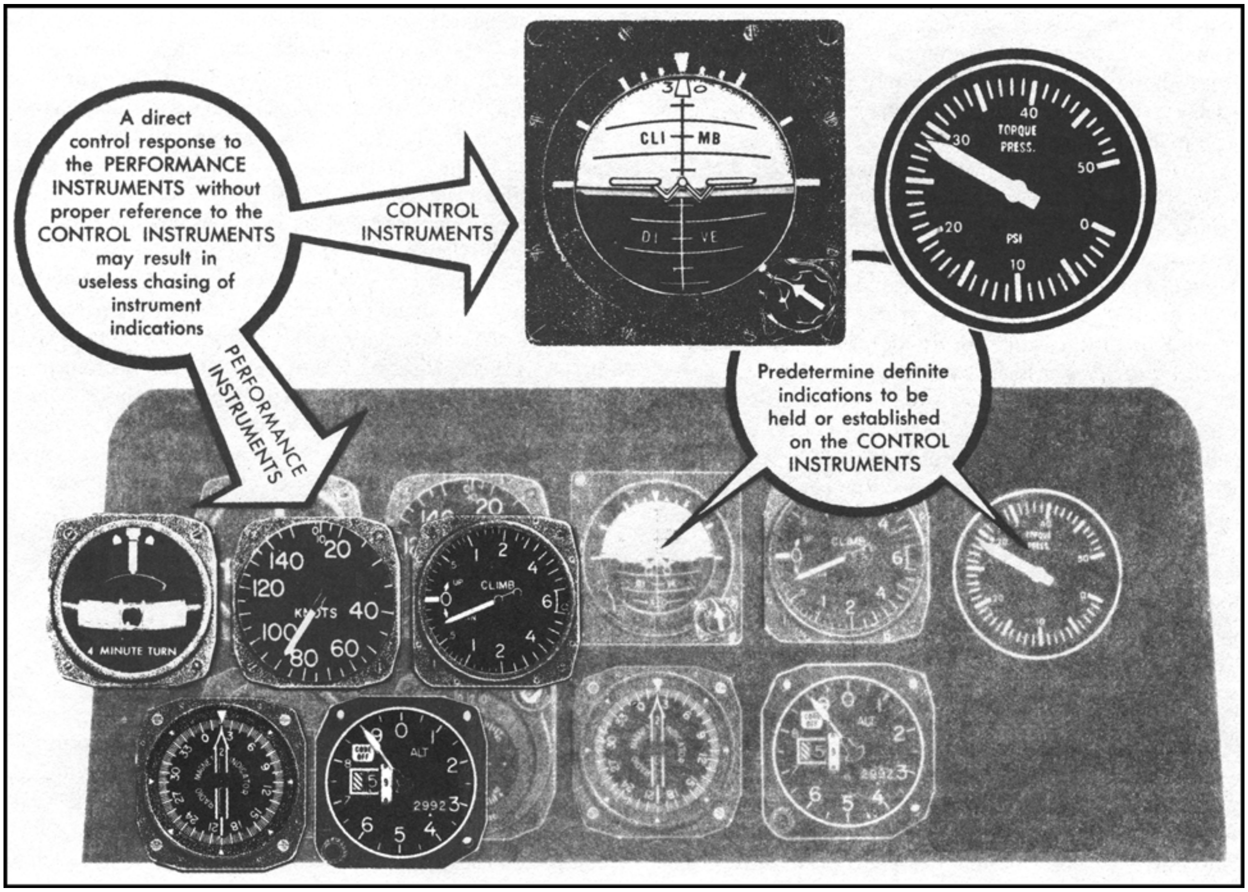
3.3.5. Cross-Check Technique (Figure 3.3).

3.3.5.1. Control and performance concept. The control and performance concept of attitude instrument flying requires you to establish an aircraft attitude or power setting on the control instruments that should result in the desired aircraft performance. Therefore, you must be able to recognize when a change in attitude or power is required. By cross-checking the instruments properly, you can determine the magnitude and direction of the adjustment required.

3.3.5.2. Cross-checking. Cross-checking is a proper division of attention and the interpretation of the flight instruments. Attention must be efficiently divided between the control and performance instruments in a sequence that ensures comprehensive coverage of the flight instruments. Looking at each of the instruments at the proper time is of no value unless you can interpret what you see. Therefore, proper division of attention and interpretation are the two essential parts of a crosscheck.

3.3.5.3. Crosscheck techniques. Crosscheck techniques or the sequence for checking the instruments varies among pilots and throughout various phases of flight. Therefore, you should become familiar with the factors to be considered in dividing your attention properly, and you should know the symptoms that will help you to recognize an incorrect crosscheck technique.

Figure 3.4. Factors Influencing Cross-Check Techniques.



3.3.6. Factors Influencing Instrument Cross-Checks (Figure 3.4).

3.3.6.1. Instrument's Response to Attitude or Power Changes. A factor influencing crosscheck technique is the characteristic manner in which instruments respond to changes of attitude or power. The control instruments provide direct and immediate indications of attitude or power changes.

3.3.6.2. Performance Instrument Lag. Changes in the indications on the performance instruments will lag slightly behind changes of attitude or power. This lag is due to inertia of the aircraft and the operating principles and mechanisms of the performance instruments. Therefore, some lag must be accepted as an inherent factor. This factor will not appreciably affect the tolerances within which you control the aircraft; however, at times a slight unavoidable delay in knowing the results of attitude or power changes will occur. Lag in the performance instruments should not interfere with maintaining or smoothly changing the attitude or power indications. When the attitude and power are properly controlled, the lag factor is negligible and the indications on the performance instruments will stabilize or change smoothly. Do not be lured into making a flight control movement in direct response to the lag in the indications on the performance instruments without first referring to the control instruments or allowing performance indications to stabilize. Sufficient reference to the control instruments will minimize the effect of lag on the performance instruments and nullify the tendency to "chase" the indications.

3.3.6.3. Location of Flight Instruments. Another factor influencing crosscheck technique is the location of the flight instruments. In some aircraft the flight instruments are scattered over a wide area of the instrument panel, making it difficult to bring several instruments into your crosscheck at the same time. Therefore, you must rapidly scan each instrument individually back and forth across the instrument panel. More advanced instrument systems, such as the flight director and integrated flight instrument systems have reduced the required scan to a small area so you can see more of the flight instruments with one look. The task of cross-checking these instruments is much easier because you can simultaneously observe the attitude indicator and the proper performance instruments.

3.3.6.4. Pilot's Ability. An important factor influencing crosscheck technique is the ability of the pilot. All pilots do not interpret instrument presentations with the same speed; some are faster than others are in understanding and evaluating what they see. One reason for this is that the natural ability of pilots varies. Another reason is that the experience levels are different. Pilots who are experienced and fly regularly will probably interpret their instruments more quickly than inexperienced pilots. Pilots who interpret their instruments quickly and correctly do not have to refer back to them for information as often as pilots who are slow to interpret. They are also able to bring several instruments into their crosscheck with one glance, interpreting them simultaneously. Therefore, the speed with which they divide their attention does not have to be as rapid as the pilot's with less ability, who must scan the instruments rapidly to stay ahead of the aircraft.

3.3.6.5. Observing Attitude Indicator. The attitude indicator is the only instrument that you should observe continuously for any appreciable length of time. Several seconds may be needed to accomplish an attitude change required for a normal turn. During this period, you may need to devote your attention almost exclusively to the attitude indicator to ensure good attitude control. The attitude indicator is the instrument that you should check the greatest number of times. This is shown by the following description of a normal crosscheck. A pilot glances from the attitude indicator to a performance instrument, back to the attitude indicator, then a glance at another performance instrument, back to the attitude indicator, and so forth. This crosscheck technique can be compared to a wagon wheel. The hub represents the attitude indicator and the spokes represent the performance instruments.

3.3.7. Normal Crosscheck. The above example of a normal crosscheck does not mean that it is the only method of cross-checking. Often you must compare the indications of one performance instrument against another before knowing when or how much to adjust the attitude or power. An effective crosscheck technique may be one in which attention to the attitude indicator is inserted between glances at the performance instruments being compared. Devoting more attention to the attitude indicator is more desirable to minimize the effects of the fluctuations and lag indications of the performance instruments. This technique permits you to read any one performance instrument during a split-second glance and results in smooth and precise aircraft control.

3.3.8. Performance Instrument Attention. A proper and relative amount of attention must be given to each performance instrument. Pilots seldom fail to observe the one performance instrument whose indication is most important. The reverse is a common error because pilots often devote so much attention to one performance instrument that the others are omitted from the crosscheck. Additionally, they often fail to crosscheck the attitude indicator for proper aircraft control.

3.3.9. Cross-Check Analysis.

3.3.9.1. Incorrect crosscheck. An incorrect crosscheck can be recognized by analyzing certain symptoms of aircraft control. Insufficient reference to the control instruments is readily recognizable. If you do not have some definite attitude and power indications in mind and the other instruments fluctuate erratically through the desired indications, then you are not referring sufficiently to the control instruments. Imprecise aircraft control usually results in "chasing" the indications.

3.3.9.2. Control Instrument Fixation. The problem of too much attention being devoted to the control instruments is rarely encountered, except for fixation on the power indicators. This is normally caused by your desire to maintain the performance indications within close tolerances. Positive and continuous inputs based only on the control instruments are not sufficient for maintaining the desired parameters; a systematic crosscheck of the performance instruments is also required.

3.3.9.3. Scanning Process. An incorrect crosscheck can result in the omission of or insufficient reference to one or more instruments during the scanning process. You may omit some performance instruments from the crosscheck, although other performance instruments and the control instruments are being properly observed. For example, during a climb or descent, you may become so engrossed with pitch attitude control that you fail to observe an error in aircraft heading.

3.3.9.4. Indications. The indications on some instruments are not as "eye-catching" as those on other instruments. For example, a 4° heading change is not as "eye-catching" as a 300 to 400 feet per minute change on the vertical velocity indicator. Through deliberate effort and proper habit, ensure that all the instruments are included in your crosscheck. If this is accomplished, you will observe deviations on the performance instruments in their early stages.

3.3.9.5. Analyzing the Crosscheck Technique. Analyzing the crosscheck technique will assist you in improving an incorrect crosscheck. A correct crosscheck results in the continuous interpretation of the flight instruments that enables you to maintain proper aircraft control at all times. Remember, rapidly looking from one instrument to another without interpretation is of no value. Instrument systems and the location of the flight instruments vary. Pilot ability also varies. Therefore, you should develop your own rate and sequence of checking the instruments that will ensure a timely and correct interpretation of the flight instruments.

3.3.10. Adjusting Attitude and Power. As previously stated, the control and performance concept of attitude instrument flying requires the adjustment of aircraft attitude and power to achieve the desired performance. A change of aircraft attitude or power is required when any indication other than that desired is observed on the performance instruments. However, it is equally important for you to know what to change and how much pitch, bank, or power change is required.

3.3.10.1. What to Change. Pitch attitude primarily controls airspeed and the rate of change in airspeed. Bank attitude control is used to maintain a heading or desired angle of bank during turns. Collective inputs control altitude changes and the rate of altitude change. Remember that power is used primarily to maintain your altitude and control the rate of climb or descent and cyclic inputs are used primarily to maintain airspeed and bank angle.

3.3.10.2. How Much to Change. How much to adjust the attitude or power is, initially, an estimate based on familiarity with the aircraft and the amount you desire to change on the performance instruments. In a UH-1N for example, 2% of torque approximates 100 feet per minute of climb or descent or 5 knots of increase or decrease in airspeed. After you make a change in attitude or power, observe the performance instruments to see if the desired change occurred. If not, further adjustment of attitude or power is required. Remember, even though changes are estimates, they must be made in exact increments.

3.4. Display of Flight Instrumentation. The advent of electronic displays has given the pilot the ability to optimize cockpit instrumentation for a particular mission by adding, removing, or relocating presentations on multi-function displays. This new dimension in cockpit management can be an asset if the selection of instrument displays is based on the requirement that, regardless of the type of mission, the pilot must always be aware of the aircraft's attitude. No mission can be safely or effectively executed if attitude awareness is lost.

3.4.1. Primary Flight Instrumentation. ***Primary flight instrumentation must always be present and must provide full-time attitude, altitude, and airspeed information; an immediately discernible attitude recognition capability; an unusual attitude recovery capability; and complete fault indications.***

3.4.2. Position of Flight Instrumentation. ***The elements of information of Primary Flight Instrumentation must be positioned and arranged in a manner that enables the pilot to perform a natural crosscheck.***

3.4.3. Standardization of Flight. ***Primary flight instrumentation will be standardized in terminology, symbology, mechanization, and arrangement***. Standardization of instrumentation display elements provides a common training base and allows the retention of good flying habits during transition to different aircraft. This standardization can only be effective when the pilot acknowledges attitude awareness as a full-time requirement and manages the cockpit accordingly.

3.5. Single-Medium Displays. ***For a single-medium display (e.g., head-up or head-down multifunction display) to solely satisfy flight instrumentation requirements, it will always display***:

3.5.1. ***Climb/dive angle (or pitch and vertical velocity)***

3.5.2. ***Bank angle***

3.5.3. ***Barometric altitude***

3.5.4. ***Indicated or calibrated airspeed***

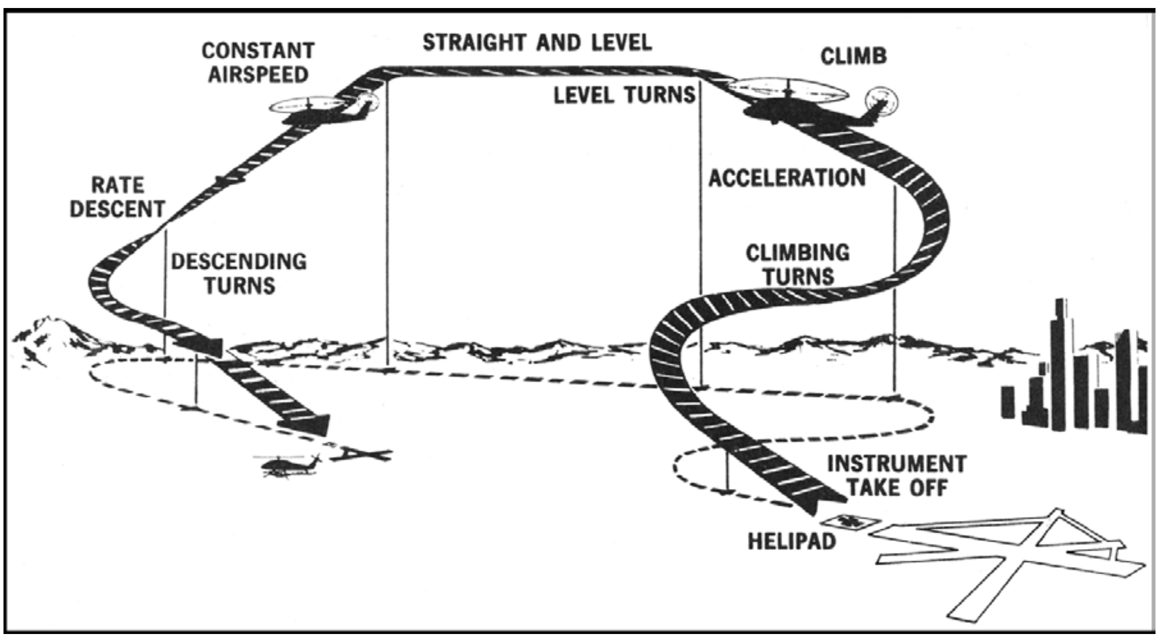
3.5.5. ***Prominent horizon reference***.

Chapter 4

INSTRUMENT FLIGHT MANEUVERS - HELICOPTER

4.1. Application. This section outlines techniques for accomplishing commonly used flight maneuvers in helicopters. Any instrument flight, regardless of how long or complex, is simply a series of connected basic flight maneuvers as illustrated in Figure 4.1. Failure to consider each portion of the flight as a basic instrument maneuver often leads to erratic aircraft control. The maneuvers that are described here are general in nature; therefore, slight variations may be required for specific helicopters and in-flight situations. The degree of proficiency developed while accomplishing the maneuvers outlined will allow you to execute any variation or additional maneuver. The information received from the navigation instruments or an air traffic controller should be considered as advising you what maneuver to perform, when to perform it, or what adjustments, if any, are required. Instrument approach procedure charts and similar publications should be considered as pictorial presentations of a series of connected instrument flight maneuvers. Keeping these considerations in mind and calling upon previous experience, you will find that you are always performing a familiar maneuver. By visualizing the next maneuver, you can plan ahead and know exactly what crosscheck and aircraft control techniques to employ.

Figure 4.1. Typical Instrument Flight.



4.2. The Instrument Takeoff. The ITO is accomplished by referring to outside visual references and to the flight instruments. The amount of attention given to each reference varies with the individual, the type of aircraft, and existing weather conditions. The ITO is a composite visual and instrument takeoff when conditions permit, and should not be confused with a "hooded takeoff." The ITO procedures and techniques are invaluable aids during takeoffs at night, toward and over water or deserted areas, and during periods of reduced visibility. It is important to ***immediately transition to instrument references any time you become disoriented or when outside visual references become unreliable***.

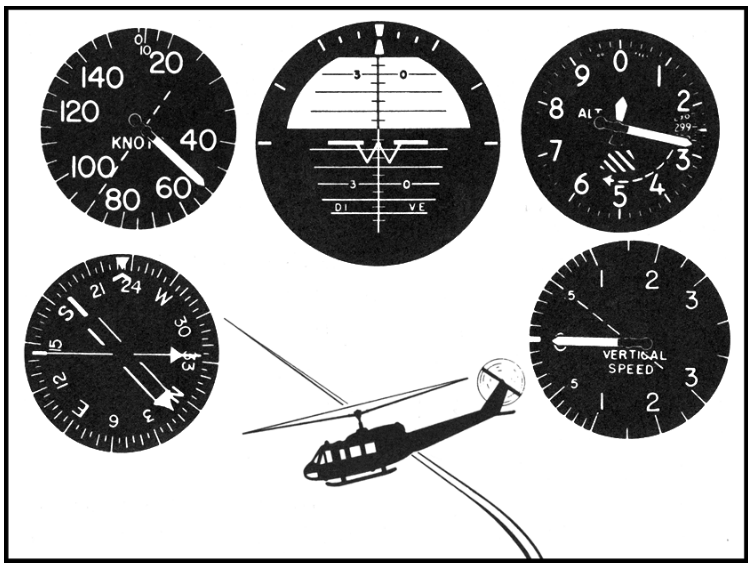
4.2.1. Preparing For The ITO. Before performing an ITO, perform an adequate before-takeoff check of all flight and navigation instruments to include publications. Select the appropriate navigational aids to be used for the departure, and set the navigation instruments and switches as required. The ATC clearance and departure procedures must be thoroughly understood before takeoff. It is a good operating practice to have the appropriate instrument approach procedure charts available in the event an instrument approach is necessary immediately after takeoff. Review of the approach for an emergency return should include frequencies, final approach course, DH or MDA, and minimum safe, sector, or emergency safe altitudes. Brief all crewmembers on specific duties during an emergency return.

4.2.2. Performing The ITO From A Hover Or The Ground. In helicopters, an ITO may be accomplished from a hover or from the ground as visibility restrictions permit. Normally, a composite takeoff is accomplished using normal VMC procedures and combining reference to the flight instruments with outside visual references to provide a smooth transition from VMC to IMC flight. Helicopter ITOs may have to be accomplished entirely on instruments due to restrictions to visibility induced by rotor downwash on dust, sand, or snow. This downwash may reach 60 to 100 knots, depending upon the size and weight of the aircraft. Since helicopters often operate from unprepared or remote locations in the presence of loose dirt or snow, downwash can easily result in the loss of visual references. This downwash also effects pitot-static instrumentation. In fact, aircrew manuals warn that airspeed indications should be considered unreliable when forward airspeed is less than 25 to 40 knots, depending upon size and weight of aircraft. Additionally, altimeters and vertical velocity indicators will actually indicate a loss of altitude as power is applied for takeoff. Prior to takeoff, the attitude indicators should be adjusted by aligning the adjustment knobs with the zero trim dots (the J-8 attitude indicator is adjusted by aligning the miniature aircraft with the 90° bank indexes). These settings will provide a constant attitude reference for the ITO regardless of aircraft attitude at the time of adjustment. After the aircraft is aligned with the runway or takeoff pad, to prevent forward movement of helicopters equipped with wheel-type landing gear, set the parking brakes or apply the toe brakes. If the parking brake is used, it must be unlocked prior to the ITO. Apply sufficient friction to the collective pitch control to minimize over controlling and to prevent collective pitch creep. However, in order not to limit pitch control movement, the application of excessive friction should be avoided.

4.2.3. The Takeoff. After rechecking all instruments for proper operation, start the takeoff (Figure 4.2) by applying collective pitch to a predetermined power setting. Ensure power applied is sufficient to gain airspeed and altitude simultaneously and to prevent settling to the ground. (Helicopters with wheel-type landing gear may also elect to make running takeoffs if operating from smooth surfaces.) As power is applied and the helicopter becomes airborne, maintain the desired heading with the pedals, check for positive climb indications, and set the desired ITO pitch attitude as specified in the flight manual. When a positive climb indication is obtained, adjust the pitch attitude as specified in the flight manual. As soon as the takeoff attitude is established, crosscheck the vertical velocity indicator and altimeter to ensure you are still climbing. While the aircraft is below airspeeds required for accurate altitude or VVI readings, the radar altimeter may provide the most reliable source of climb information. A rapid crosscheck must be started at the time the aircraft leaves the ground and should include all available instruments in order to provide you a smooth transition to coordinated flight.

4.2.3.1. Marginal power conditions may prevent establishing a significant climb prior to passing through effective translational lift (ETL). In such cases, ensure the takeoff run is clear of obstacles before pulling power in a dusty area, then perform a marginal power takeoff in accordance with the flight manual (using instrument references as required) until reaching a speed that will allow a climb. Consider increasing power margin or aborting the mission if obstacle clearance can't be assured while in IMC.

Figure 4.2. The Instrument Takeoff.



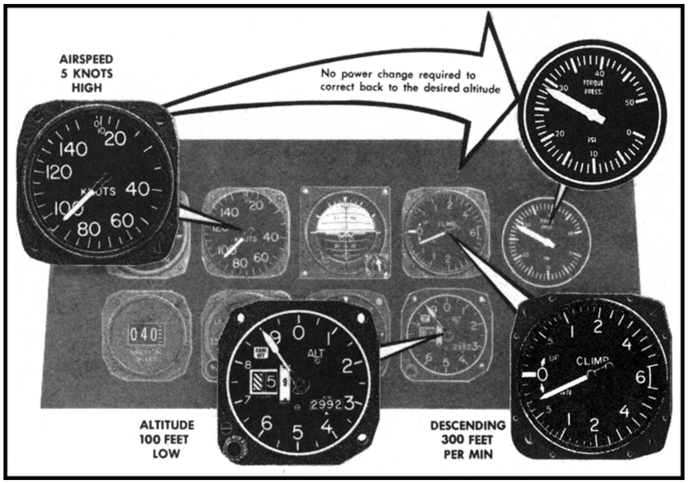
4.3. Individual Maneuvers.

4.3.1. Straight and Level Flight. Straight and level unaccelerated flight consists of maintaining desired altitude, heading, and airspeed. Use power control to maintain or adjust the altitude; use pitch attitude to maintain or adjust the airspeed; and use bank control to maintain or adjust the heading.

4.3.1.1. Establishing And Maintaining An Altitude. Establishing or maintaining an altitude is accomplished by referring to the altimeter and VVI for actual aircraft performance and adjusting the power or aircraft attitude to obtain or maintain the desired altitude. A knowledge of the approximate power required to establish a desired altitude or rate of change of vertical velocity will aid in making power adjustments. After the approximate power setting is established, a crosscheck of the altimeter and the VVI will indicate if subsequent power adjustments are required. You should make it a point to learn and remember the approximate power settings for your aircraft at various altitudes, airspeeds, and configurations used throughout a normal mission.

4.3.1.1.1. Altitude Deviation. When an altitude deviation is observed, a power or pitch adjustment (or a combination of both) may be required to correct back to the desired altitude. For example, if below the desired altitude with a higher than desired airspeed, an increase in pitch may regain both the desired altitude and airspeed. Conversely, a pitch adjustment (if made at the desired altitude) will induce the need for a power adjustment (Figure 4.3).

Figure 4.3. Altitude Control.



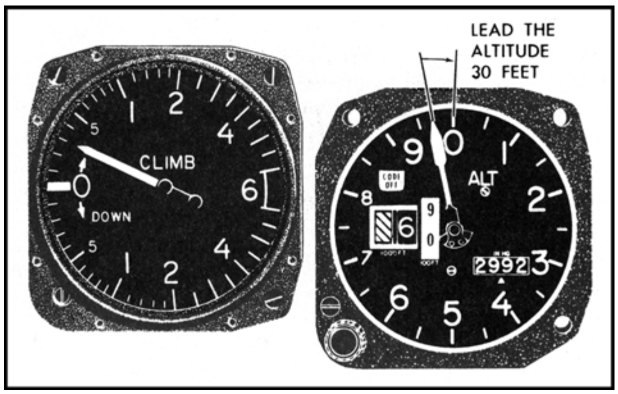
4.3.1.1.2. Power Adjustment. With experience, you can usually estimate the suitability of power adjustment by noting the initial rate of movement of the VVI. If the initial rate of movement on the VVI is rapid and obviously will stabilize at a rate greater than desired, the power change was too large. Readjust the power rather than wait for a stabilized indication on the VVI.

4.3.1.1.3. Initial Altitude Deviation. When you first deviate from an altitude, an indication often appears on the VVI before appearing on the altimeter. By evaluating this initial rate of movement, you can estimate the amount of power change required to prevent large altitude deviations. If the estimated power change is correct, the vertical velocity will return to zero with a negligible change of altitude.

4.3.1.1.4. Vertical Correction. When a deviation from the desired altitude occurs, determine a rate of vertical correction and apply a power change to correct back to the desired altitude. The correction must not be too large, resulting in the aircraft "overshooting" the desired altitude, nor should it be so small that the correction is unnecessarily prolonged. As a guide, the power change should produce a rate of vertical velocity approximately twice the value of the altitude deviation. For example, if the aircraft is 100 feet off the desired altitude, a 200 foot per minute rate of correction would be a suitable amount. By knowing the present rate of climb or descent and the results to be expected from a power change, you can closely estimate how much to change the power. The adjusted power must be held constant until the rate of correction is observed on the VVI. If it differs from that desired, then further adjustment of the power is required.

4.3.1.1.5. Lead Point. When approaching the desired altitude, determine a lead point on the altimeter for initiating a level-off power change. A suitable lead point prevents "overshooting" and permits a smooth transition to level flight. The amount of lead required varies with pilot technique and rate of correction. As a guide, the lead point on the altimeter should be approximately 10 percent of the vertical velocity. For example, if the rate of correction to the desired altitude is 300 feet per minute, initiate the level off approximately 30 feet before reaching the desired altitude (Figure 4.4).

Figure 4.4. Leading the Level Off.

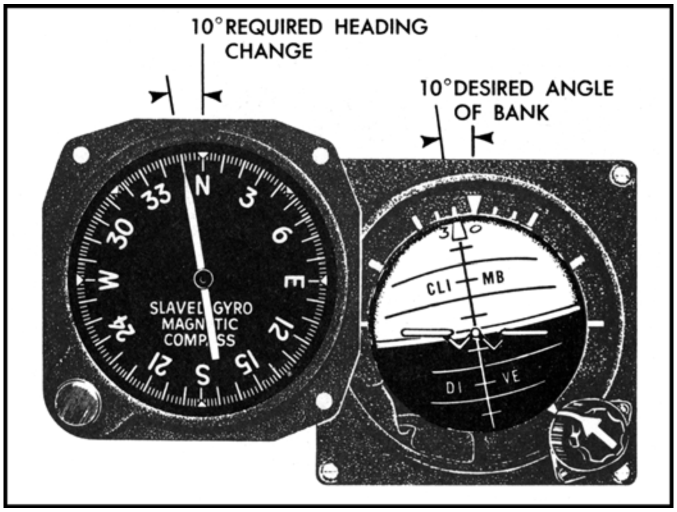


4.3.1.1.6. Chasing Indications. Devoting too much attention to the VVI can lead to "chasing" its indications and result in erratic power control. Although the VVI is an important performance instrument, limitations, such as oscillations in rough air, lag, etc., should be thoroughly understood to prevent over controlling the power. For this reason, you must recognize and understand that sufficient reference to the power indicator is necessary to ensure smooth and precise power adjustments for effective altitude control.

4.3.1.2. Maintaining a Desired Heading. Maintaining a desired heading is accomplished by maintaining a zero bank attitude and coordinated flight. Heading deviations are not normally as "eye-catching" as altitude deviations. Therefore, be aware of this characteristic and develop a habit of cross-checking the heading indicator frequently to prevent significant heading deviations.

4.3.1.2.1. Heading Deviation. When a deviation from the desired heading occurs, refer to the attitude indicator and smoothly establish a definite angle of bank that will produce a suitable rate of return. As a guide, the bank attitude change on the attitude indicator should equal the heading deviation in degrees not to exceed a standard rate turn (unless compensating for wind in a holding pattern or as required on radar final). For example, if the heading deviation were 10°, then 10° of bank on the attitude indicator would produce a suitable rate of correction (Figure 4.5). Maintaining a desired heading is simplified by good trim control.

Figure 4.5. Bank Control.



4.3.1.3. Establishing And Maintaining A Desired Airspeed. Maintaining a desired airspeed requires smooth and precise cyclic inputs to maintain a specific pitch attitude. This ability is developed through proper use of the attitude indicator and is simplified by good trim techniques.

4.3.1.3.1. Adjusting Attitude Indicator. After leveling off at cruise airspeed, you may adjust the pitch trim knob on the attitude indicator so that the miniature aircraft is aligned with the horizon bar. This will aid in observing small pitch changes. Subsequent readjustments may be required because of the changes in aircraft center of gravity and cruise airspeeds.

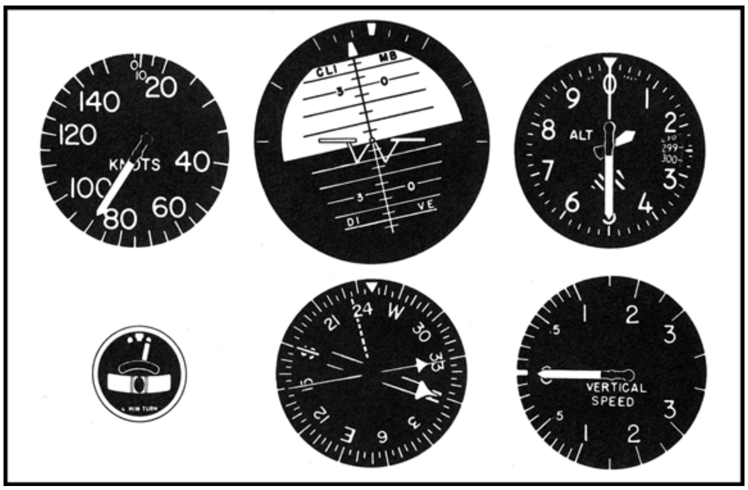
4.3.1.3.2. Small Corrections. The small corrections required to maintain a desired airspeed are made in degrees of pitch. With practice you can determine what pitch attitude adjustments are required to produce the desired rate of correction.

4.3.1.3.3. Pitch Adjustments. When you make these pitch adjustments, airspeed and vertical velocity indications will lag behind changes of pitch attitude. This lag should be recognized and accepted as an inherent error in the differential pressure instruments. Because of this error, do not make a premature decision that the pitch change is ineffective. This can lure you into over controlling the pitch attitude.

4.3.1.3.4. Changes of Airspeed. Changes of airspeed in straight and level flight are accomplished by adjusting the pitch attitude and power. To increase airspeed, decrease the pitch attitude to a predetermined number of degrees and increase power to maintain altitude. When airspeed approaches the desired indication, adjust pitch to a setting that will maintain the new airspeed and adjust power to maintain altitude. To reduce airspeed, increase the pitch attitude to a predetermined number of degrees and reduce power to maintain altitude. When the airspeed approaches the desired indication, adjust pitch to a setting that will maintain the new airspeed and adjust power to maintain altitude.

4.3.2. Turns. Many of the pitch, bank, and power principles discussed in maintaining straight and level flight apply while performing level turns. Performing a level turn requires an understanding of the following factors: how to enter the turn; how to maintain bank, altitude, and airspeed during the turn; and how to recover from the turn. Turns can be classified as either normal (standard rate or less) or steep. In either case, the pitch, bank, and power principles of straight and level flight apply. Helicopters normally operate under instrument conditions between 80 and 120 knots. From Figure 4.6, we can see that at these speeds, 15° to 20° of bank will result in a standard rate turn, which is 3° per second. While any rate greater than standard is considered a steep turn, most helicopters practice steep turns using 30° of bank, which is the maximum angle of bank recommended under instrument conditions.

Figure 4.6. Level Turns.



4.3.2.1. Bank Control.

4.3.2.1.1. Before Turning. Before entering a turn, decide upon the angle of bank to be used. Factors to consider are true airspeed and the desired rate of turn. A slow turn rate may unnecessarily prolong the turn, whereas a high rate of turn may cause overshooting of the heading and difficulty with aircraft control. As a guide, for small turns (15° or less), the angle of bank should approximate the number of degrees to be turned. For turns of more than 15°, a standard rate turn is normally used.

4.3.2.1.2. Turning. To enter a turn, refer to the altitude indicator while applying smooth, coordinated control pressures to establish the desired angle of bank. Bank control should then be maintained throughout the turn by reference to the attitude indicator. Crosscheck the heading indicator or turn needle to determine if the rate of turn is satisfactory. Trim may be helpful during prolonged turns to assist in aircraft control.

4.3.2.1.3. Rolling Out. To roll out of a turn on a desired heading, a lead point must be used. The amount of lead required depends upon the amount of bank used for the turn, the rate the aircraft is turning, and the rate at which you roll out. As a guide, use a lead point on the heading indicator equal to approximately one-third of the angle of bank. With experience and practice, a consistent rate of rollout can be developed. A lead point can then be accurately estimated for any combination of bank angle and rate of turn. Make a note of the rate of movement of the heading indicator during the turn. Estimate the lead required by comparing this rate of movement with the angle of bank and the rate of rollout.

4.3.2.2. Altitude Control.

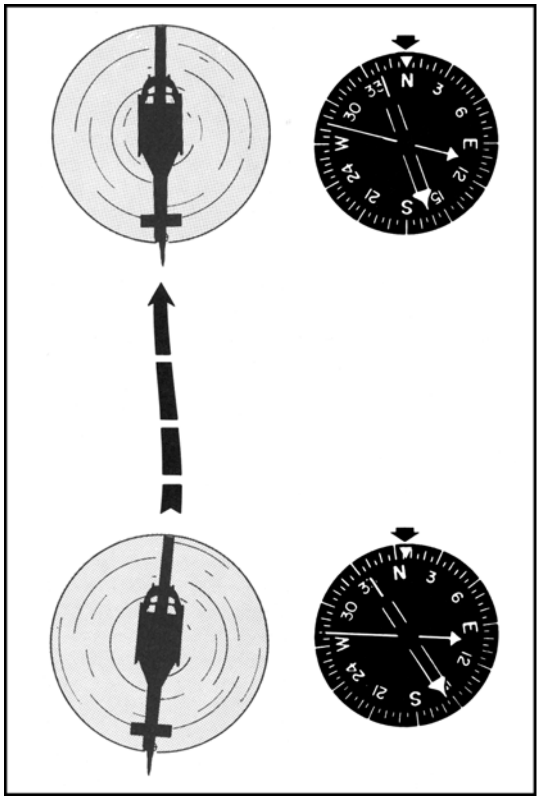
4.3.2.2.1. Techniques. The techniques for maintaining a constant altitude during a turn are similar to those used in maintaining straight and level flight. During the initial part of the roll-in, hold the same pitch and power that was used to maintain altitude with the wings level. As the bank is increased, anticipate a tendency for the aircraft to lose altitude because of the change in lift vector. Adjust the power as necessary after referring to the VVI and altimeter. After the turn is established, small power adjustments may be required to maintain the desired altitude.

4.3.2.2.2. Altitude Gaining. When rolling out of a turn, anticipate a tendency to gain altitude due to an increase in the vertical component of lift. Therefore, be aware of this factor, anticipate its effect, and monitor pitch and power during rollout in the same manner as during roll-in.

4.3.2.3. Airspeed Control. The pitch control techniques for maintaining an airspeed during a turn are similar to those used during straight and level flight. Anticipate a tendency for the aircraft to lose airspeed in a turn. Accomplish changes of airspeed during a turn as described under straight and level flight.

4.3.2.4. Turns to Headings. A turn to a heading (Figure 4.7) consists of a level turn to a specific heading as read from the heading indicator and is performed at normal cruise. Turns to specified headings should be made in the shortest direction. The turn is entered and maintained as described in the level turn maneuver. Since the aircraft will continue to turn as long as the bank is held, the rollout must be started before reaching the desired heading. The rollout on a heading is performed in the same manner as the rollout of the level turn. When the lead point is reached, cyclic control is applied in the direction opposite the turn.

Figure 4.7. Turns to Headings.



4.3.3. Accelerations and Decelerations. An acceleration or a deceleration is a proficiency maneuver that can be practiced during straight and level flight.

4.3.3.1. Practicing. To practice this maneuver, establish normal cruise airspeed. Coordinate power changes with all available attitude instruments.

4.3.3.2. Decelerate. To decelerate from normal cruise to slow cruise, reduce power below what is required to maintain slow cruise airspeed and adjust attitude as necessary to maintain level flight; then as the desired airspeed is approached, adjust attitude to maintain slow cruise airspeed and power to maintain level flight.

4.3.3.3. Accelerate. To accelerate from slow cruise to normal airspeed, increase power to slightly above that required to maintain normal cruise and adjust attitude to maintain appropriate altitude; then as the desired airspeed is approached, adjust attitude to maintain the desired airspeed and reduce power to normal cruise power setting to maintain level flight.

4.3.4. Climbs and Descents.

4.3.4.1. Before Starting. Before entering a climb or descent, determine what power setting will be required. If airspeed is to be changed in the climb, estimate the amount of pitch attitude change required to establish the desired airspeed; especially if the pitch and power changes are to be made simultaneously. The power change should be smooth, uninterrupted and at a rate commensurate with the rate of pitch change. Only slight control pressures are needed to establish the pitch change.

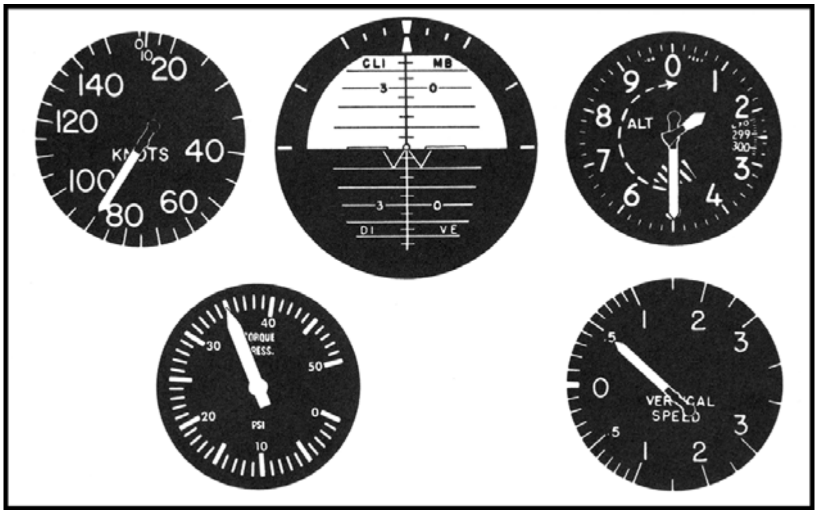
4.3.4.2. Immediate Changes. When making a pitch adjustment on the attitude indicator to correct for an airspeed deviation, the airspeed indicator will not reflect an immediate change. The results of pitch attitude changes can often be determined more quickly by cross-checking the change in vertical velocity indication. For example, while climbing, a pilot notes that the airspeed is remaining slightly high and realizes that a small pitch adjustment is required. If the pitch adjustment results in a small increase of vertical velocity, the pilot knows, even though the airspeed may not yet show a change, that the pitch correction was approximately correct. When properly used in attitude instrument flying, the vertical velocity indicator is an excellent aid in maintaining airspeed.

4.3.4.3. Desired Altitude. Prior to reaching desired altitude, determine a lead point on the altimeter. As a guide, use 10 percent of the vertical velocity. When the lead point is reached, smoothly adjust the power to an approximate setting required for level flight and simultaneously adjust the pitch attitude, if required to maintain the desired airspeed.

4.3.4.4. Rate Climbs and Descents. Rate climbs and descents are accomplished by maintaining both a desired vertical velocity and airspeed. They are proficiency maneuvers designed to practice the techniques used during instrument approaches. Pitch attitude control is used to establish and maintain the desired airspeed. Power control is used to maintain the desired vertical velocity. Proper control techniques require coordinated pitch and power changes or adjustments.

4.3.4.5. Normal Cruise Climb. To enter a climb from normal cruise, increase power to the setting that will produce the desired rate of climb (Figure 4.8). As power is increased, a correction for trim is made with pedals. If cruise and climb airspeeds are the same, there will be no apparent change of attitude, as read from the attitude indicator. If the amount of power applied does not produce the desired rate, make minor adjustments. During climb, the heading, attitude, and airspeed are maintained with cyclic control. Rate of climb is controlled with power and trim is maintained with pedals. Once established in a constant rate maneuver, deviations in desired VVI/airspeed must be properly interpreted. For example, VVI excursions can result because of incorrect power or inadvertent changes in pitch attitude (airspeed). Corrections are made on the control instruments with reference to the performance instruments.

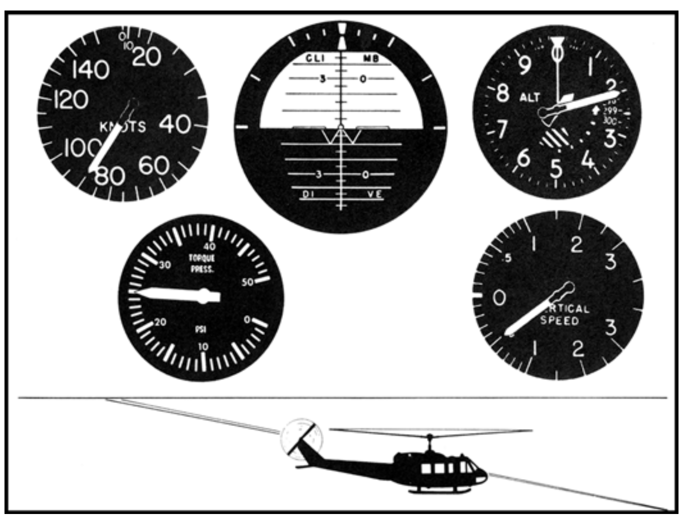
Figure 4.8. Rate Climb.



4.3.4.6. Normal Cruise Level Off. To level off at a cruise altitude, adjust the cyclic to maintain the desired airspeed with reference to the attitude indicator. Adjust collective to maintain altitude.

4.3.4.7. Entering Descent. To enter a descent, reduce power to a setting that results in the desired rate of descent (Figure 4.9). Maintain trim as the power is reduced. If the initial power reduction does not produce the desired rate of descent, make additional adjustments.

Figure 4.9. Rate Descent.



4.3.4.8. During Descent. During descent, the heading, attitude, and airspeed are maintained with cyclic control. Rate of descent is controlled with collective and trim is maintained with pedals. To level off from the descent, increase power prior to reaching the desired altitude. This will arrest the descent rate in sufficient time to prevent going below the desired altitude. The amount of lead depends on the weight of the aircraft and the rate of descent. A good rule of thumb is to use about 10% of your VVI as a lead point to begin adding power. For example, if you have a 500 fpm rate of descent, begin adding power about 50 feet above the desired altitude.

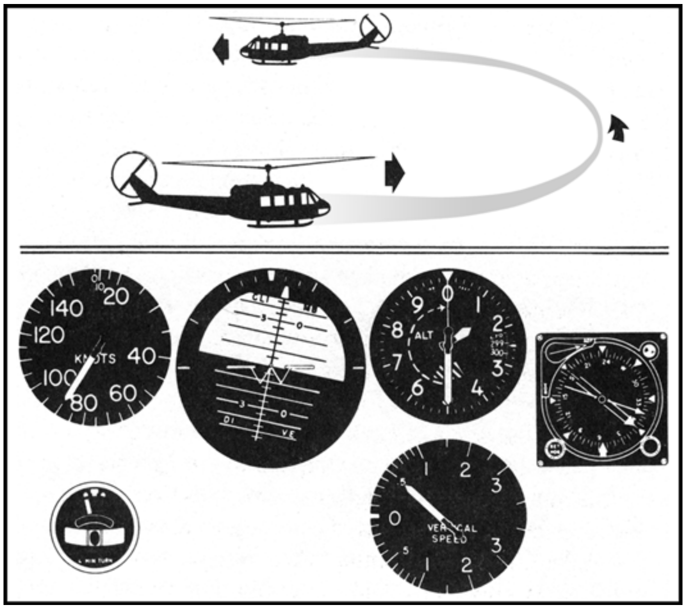
4.3.4.9. Level Off Lead Point. When the proper altitude for starting the level off is reached, apply power to the predetermined power setting and check the vertical speed to determine if level flight has been established. Check altimeter and airspeed to ensure the proper airspeed and altitude are being maintained.

4.3.5. Turns.

4.3.5.1. Climbing Turns. A climbing turn is a combination of a climb and a turn as previously discussed. For practice, a climbing turn consists of a climb of 500 feet and a turn of 180° in 60 seconds. In this maneuver the rate of climb and the rate of turn are both checked against time. The climbing turn is generally performed at normal cruise and requires a very rapid crosscheck for precise execution.

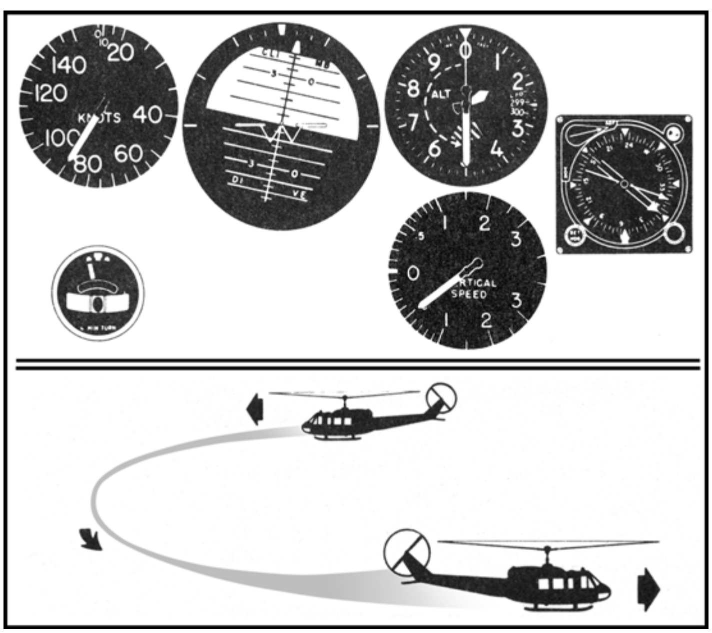
4.3.5.1.1. Climbing Turn Technique. The climbing turn (Figure 4.10) is started as the second hand of the clock passes the 3-, 6-, 9-, or 12-o'clock positions. As the power is applied to the predetermined setting, torque corrections should be made with pedals to maintain trim. The initial bank should be established with reference to the attitude indicator. To maintain the rate of turn, minor bank corrections are made with reference to the turn-and-slip indicator. During the climbing turn, the rate of turn and airspeed are maintained with cyclic control; the rate of climb, with power; and trim, with pedals. After 30 seconds, the aircraft will have turned approximately 90° and climbed approximately 250 feet. If the instruments indicate other than the desired readings, adjust the rate of climb and/or turn to achieve the desired performance. Make another check after 45 seconds have elapsed and adjust the aircraft's performance again, if necessary. Normally, the recovery should be started as the second hand reaches the original starting position (60 seconds). However, regardless of the time factor, a recovery should be made when the desired heading and altitude have been reached.

Figure 4.10. Climbing Turns.



4.3.5.2. Descending Turns. A descending turn (Figure 4.11) is a combination of a descent and a turn as previously discussed. For practice, a descending turn consists of a descent of 500 feet and a turn of 180° in 60 seconds. In this maneuver, the rate of descent and the rate of turn are both checked against time. The descending turn is generally performed at normal cruise airspeed and requires a very rapid crosscheck for precise execution.

Figure 4.11. Descending Turns.



4.3.5.2.1. Descending Turn Technique. This maneuver is flown in the same manner as the climbing turn technique described in 4.3.5.1.1 using a 500 feet/minute descent.

4.3.6. Steep Turns. A turn is considered to be a steep turn if the angle of bank used is larger than that required for normal instrument flying. Most helicopters use a 30° bank for practicing steep turns.

4.3.6.1. Entry. Entry into a steep turn is accomplished in the same way as for a normal turn. As the bank increases, the change in lift vector requires an increase in power to maintain level flight. The use of trim in steep turns varies with individual helicopter characteristics and pilot techniques. However, proper coordination will aid aircraft control and reduce pilot workload. Adjust pitch to maintain airspeed as the bank is increased.

4.3.6.2. During The Steep Turn. Pitch and power control are maintained in the same way as in a normal turn; however, larger power adjustments may be required for a given altitude deviation. Inadvertently varying the angle of bank during the turn makes altitude control more difficult. Give sufficient attention to the bank pointer to maintain a constant bank angle. Precession error in the attitude indicator is more prevalent during steep turns. If altitude loss becomes excessive, reduce the angle of bank as necessary to regain positive altitude control.

4.3.6.3. Rolling Out Of A Steep Turn. Be alert to correct for the more than normal trim, pitch, and power used during the turns. Attempt to roll out at the same rate used during normal turns. Proper pitch and bank attitude control require you to recognize the effects of gyroscopic precession on attitude indicators. Precession is most noticeable following a turn or change of airspeed and varies between attitude indicators. As a result, small airspeed, altitude, and heading deviations may occur when a wings level attitude is established on the attitude indicator following maneuvers. Therefore, you may have to temporarily establish an adjusted pitch or bank attitude on the attitude indicator to maintain straight and level flight with reference to the performance instruments. The attitude indicator will gradually resume its normal indications as the erection mechanism automatically corrects these errors.

4.4. Emergency Descent. Basic instrument techniques may be used to safely perform an emergency descent in instrument meteorological conditions (IMC). Because there is no set procedure for executing an emergency descent, you must consider all variables when executing an emergency descent. If your helicopter is equipped with a radar altimeter, it is a good technique to set the low altitude warning marker at or slightly above the required flare altitude. This will give you a reminder to start a flare if the flare altitude is reached prior to breaking out of IMC.

4.4.1. Power-On Descent. If a long distance must be covered, then a constant airspeed descent could be selected using higher than normal airspeeds. If a short distance is to be covered, then a constant rate descent could be selected using high rates of descent and slower than normal airspeeds.

4.4.2. Power-Off Descent (Autorotation). If an emergency exists that requires the execution of an autorotation, enter smoothly by lowering the collective and closely cross-checking the control and performance instruments. Pay particular attention to keeping the helicopter in coordinated flight. Using the techniques described for constant airspeed descents will aid in flying the autorotation. Turns during autorotation are accomplished by using the same techniques as outlined in descending turns. If required, determine the angle of bank required by considering the time and altitude available to accomplish the turn. The rotor rpm will tend to increase during turning autorotations and must be incorporated into the crosscheck. Knowing (and briefing) the approximate ceiling will aid in determining when to begin a systematic scan for outside references. Crew coordination will be critical and should be briefed prior to flight by the aircraft commander.

4.5. Instrument Approaches. The ability of the helicopter to maneuver in a smaller amount of airspace has led to some differences between fixed-wing and helicopter instrument procedure obstacle clearance criteria. AFJMAN 11-226 *Terminal Instrument Procedures (TERPS)* outlines these differences as they apply to the rotary-wing environment. Except where specifically addressed in this chapter, helicopters should apply normal procedures to flying instrument approaches, departures, and enroute operations.

4.5.1. Helicopter Only Approaches. Helicopter only approaches are identified by the term "COPTER", the type of facility producing final approach course guidance, and a numerical identification of the final approach course; for example, COPTER VOR 336 (Figure 4.12), COPTER TACAN 001 (Figure 4.13). The criteria for copter only approaches are based on the unique maneuvering capability of the helicopter at airspeeds not exceeding 90 knots. On the basis of this airspeed, these special helicopter only approaches may be used with the helicopter being considered an approach Category A aircraft. Currently, the nomenclature for these approaches in the minima block may be an H-(Army and Air Force, Figure 4.13), an S- or S-L.A, (Navy). These approaches should all be considered "straight-in" and, therefore, a visibility only approach may be accomplished. Once the instrument approach has been accomplished, you should plan to touch down on the threshold of the procedure runway or helipad. If there are several helipads, the designated instrument helipad will be identified using “negative symbology”.

4.5.1.1. NOTE: Numerical identification of the final approach course in the procedure title (Figure 4.12) is only used for approaches to heliports and point-in-space procedures.

Figure 4.12. Copter Only Approach.

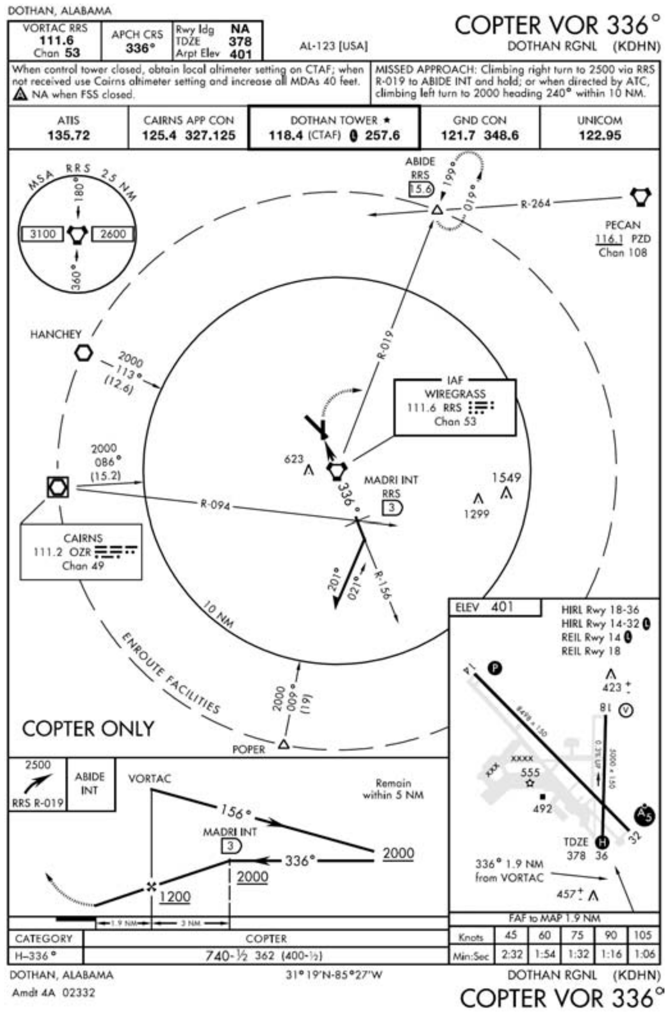
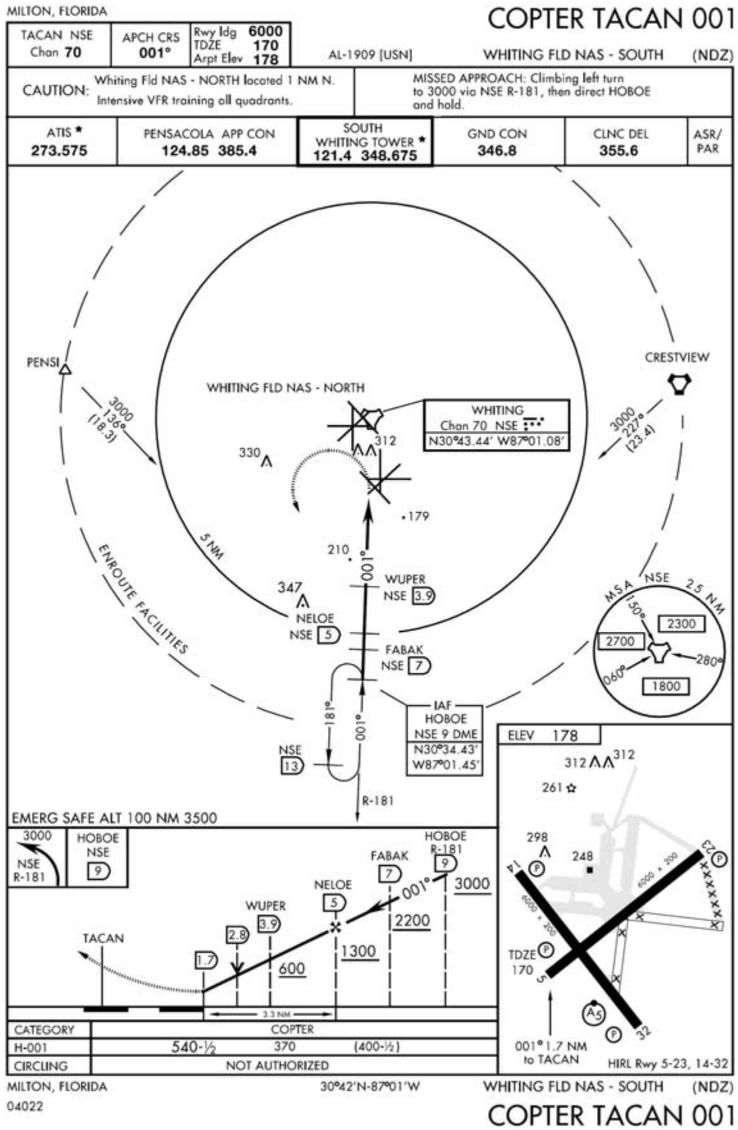


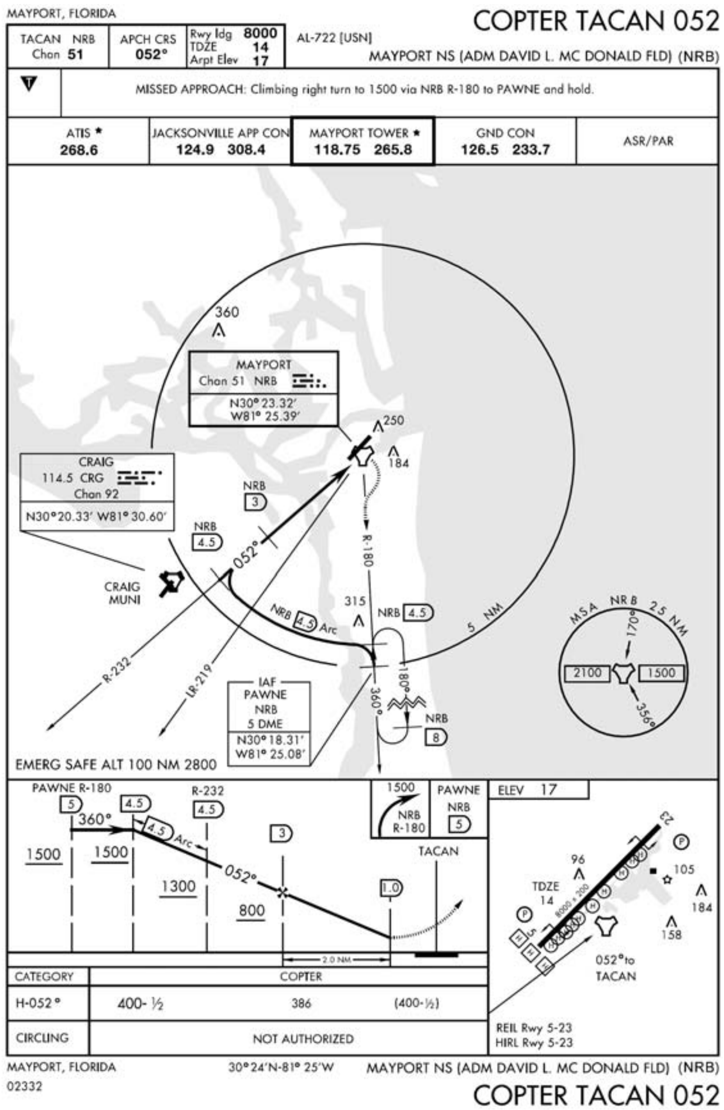
Figure 4.13. Copter TACAN.



4.5.1.2. Low Altitude Approach. In a low altitude approach, a maximum 400 feet per nautical mile descent is normally planned. In copter only approaches, however, the gradient may be as high as 800 feet per nautical mile.

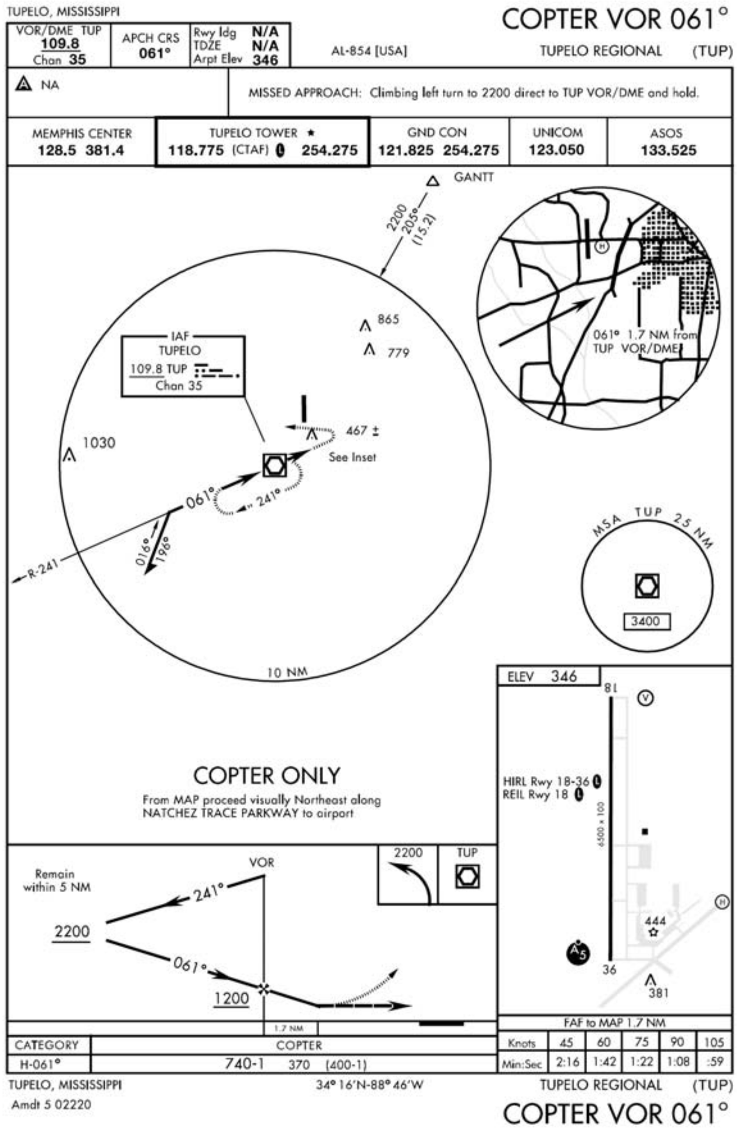
4.5.1.3. Short Procedures. Looking at Figure 4.14, we can see an example of a very short procedure. The initial approach fix is only .5 miles from the distance measuring equipment (DME) arc procedural track. From the final approach fix (FAF) to the missed approach point (MAP) is 2.3 miles. While this approach should not be difficult to accomplish, careful review could prevent you from becoming rushed during the maneuver.

Figure 4.14. Short Final Approach.



4.5.1.4. Point In Space. While the point in space approach (Figure 4.15) is rare, it does illustrate how approach design takes advantage of helicopter capability. This approach (see AFJMAN 11-226 *TERPS*) places the helicopter up to 2,600 feet from the landing pad, and the pilot is expected to proceed visually, by ground reference, to the pad. If planning to use this type of approach, pay careful attention to weather conditions upon arrival, as VMC conditions are required to maneuver.

Figure 4.15. Point in Space Approach.



4.5.1.5. Review Missed Approach. Review the published missed approach departure instruction to ensure you can achieve the published climb gradient. For copter only procedures, the missed approach is based on a climb gradient of at least 304 feet per mile; twice the angle used for fixed-wing instrument approach procedures (IAP). If a 90 knot missed approach is performed, then this climb gradient equates to a 456 foot per minute minimum rate of climb, no wind.

4.5.1.6. RNAV Departure Procedures. Helicopter-only GPS departure procedures are to be flown at 70 knots or less since turning areas and segment lengths are based on this speed.

4.6. Altimeter Setting Procedures. The altitude indicated on the altimeter may be in error if the altimeter check is conducted with the rotors turning. This error is due to the difference in pressure caused by the rotor downwash. The difference in pressure causes the altimeter to indicate lower than actual. Use one of the following procedures to obtain a valid altimeter check prior to takeoff. The specific procedure to use depends upon the situation and the sequence of items in the checklist for each helicopter model. The overpressure condition resulting from the rotor downwash varies with different helicopters (model or design). If this condition is significant, the aircraft flight manual should contain this information.

4.6.1. Procedure Number 1. Use this procedure if the check is completed prior to rotor engagement at a known elevation and with a current altimeter setting.

4.6.1.1. Set altimeter. Set the reported altimeter setting on the barometric scale.

4.6.1.2. Compare. ***Compare the indicated altitude to the elevation of a known checkpoint.*** The maximum allowable error is 75 feet. If the altimeter error exceeds 75 feet, the instrument is out of tolerance for instrument flight.

4.6.2. Procedure Number 2. Use this procedure if at a known elevation but a current altimeter setting is not obtained prior to rotor engagement.

4.6.2.1. Prior to rotor engagement. Set the altimeter to the known elevation and note the barometric setting.

4.6.2.2. After rotor engagement. Obtain and set the current altimeter setting on the barometric scale.

4.6.2.3. Compare. Compare the current field barometric pressure set in the altimeter with the altimeter setting noted prior to rotor engagement. If the difference exceeds 0.075, the instrument is out of tolerance for instrument flight.

4.6.3. Procedure Number 3. Use this procedure if the rotor is engaged at an unknown elevation.

4.6.3.1. Check point. Taxi to a check point of known elevation and set the current altimeter setting on the barometric scale.

4.6.3.2. Compare. ***Compare the indicated altitude to the elevation of a known checkpoint.*** The maximum allowable error is 75 feet. If the altimeter exceeds 75 feet, the instrument is out of tolerance for instrument flight.

4.6.3.2.1. NOTE: Due to difference in pressure caused by rotor downwash, the altimeter will show a decrease after the rotor is engaged. Consider this temporary altimeter error when determining tolerance limits. Do not reset the altimeter for this decrease.

4.7. Unusual Attitudes.

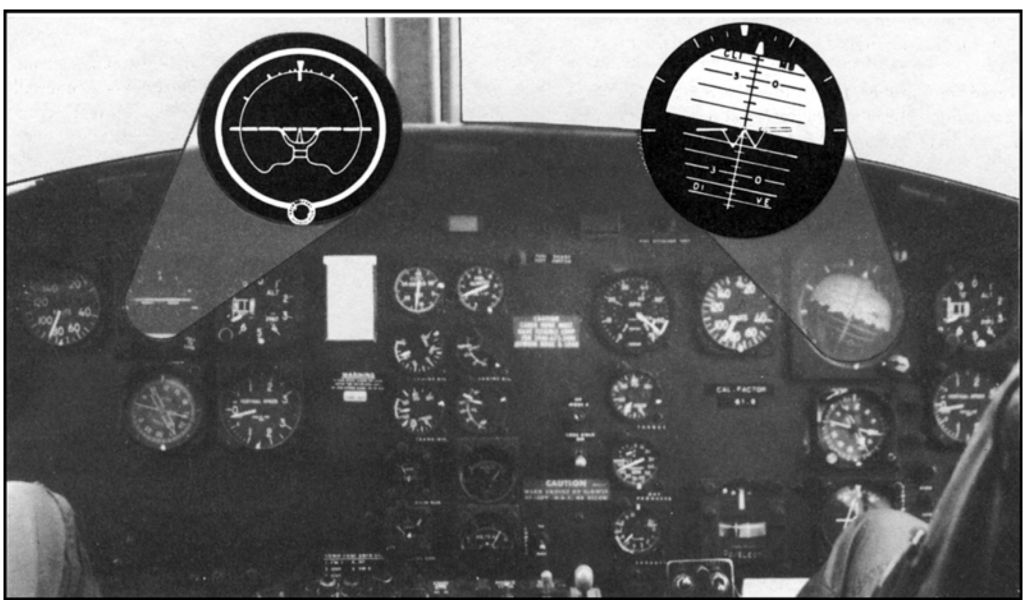
4.7.1. Inadvertent Attitude. An unusual attitude is an aircraft attitude occurring inadvertently. It may result from one factor or a combination of several factors such as turbulence, distraction from cockpit duties, instrument failure, inattention, spatial disorientation, and transition from VMC to IMC. In most instances, these attitudes are mild enough to recover from by reestablishing the proper attitude for the desired flight condition and resuming a normal crosscheck.

4.7.2. Techniques. Techniques of recovery should be compatible with the severity of the unusual attitude, the characteristics of the helicopter, and the altitude available for the recovery. The procedures outlined in this section are not designed for recovery from controlled tactical maneuvers.

4.7.2.1. WARNING: It is imperative to immediately transition to instrument references any time you become disoriented or when outside visual references become unreliable.

4.7.3. Recognizing an Unusual Attitude. Normally, an unusual attitude is recognized in one of two ways: an unusual attitude "picture" on the attitude indicator or unusual performance on the performance instruments. Regardless of how the attitude is recognized, verify that an unusual attitude exists by comparing control and performance instrument indications prior to initiating recovery on the attitude indicator (Figure 4.16). This precludes entering an unusual attitude as a result of making control movements to correct for erroneous instrument indications. During this process, the attitude must be correctly interpreted. Additional attitude indicating sources (stand by attitude indicator, copilot's attitude indicator, etc.) should be used. In some aircraft the bank steering bar (manual mode) may aid in maintaining level flight (refer to flight manual). If there is any doubt as to proper attitude indicator operation, then recover using attitude indicator inoperative procedures. The following techniques will aid aircraft attitude interpretation on the attitude indicator.

Figure 4.16. Recognizing an Unusual Attitude.



4.7.3.1. Bank Scale At The Top. For attitude indicators with a single bank pointer and bank scale at the top, the bank pointer can be considered a sky pointer. It always points up and should be in the upper half of the case. Roll towards the bank pointer to place it in the upper half of the case.

4.7.3.2. Bank Scale At The Bottom. For those attitude indicators with the bank scale at the bottom, roll in the direction that will place the pitch reference scale right side up.

4.7.3.2.1. NOTE: Ease of pitch interpretation varies with the type of attitude indicator installed. Attitude indicators having pitch reference scales in degrees and gray or black attitude spheres can easily be interpreted for climb or dive indications. For those aircraft not so equipped, the airspeed indicator, altimeter, or vertical velocity indicator generally present the most easily interpreted indication of a climb or a dive. Attitude interpretation is a skill that must be highly developed by flight practice, ground simulators and experience.

4.7.4. Recovery Procedures -- Attitude Indicators Operative. Recoveries from helicopter unusual attitudes are unique due to rotary-wing aerodynamics as well as application of the control and performance concept to helicopter flight. Application of improper recovery techniques can result in blade stall, power settling, or an uncontrollable yaw if recovery is delayed. Due to these differences, unusual attitude recoveries for helicopters are decidedly different from fixed-wing recoveries and require immediate action. Use the following guidance if specific unusual attitude recovery procedures are not contained in the flight manual:

4.7.4.1. Diving. If diving, consider altitude, acceleration limits, and the possibility of encountering blade stall. If altitude permits, avoid rolling pullouts. To recover from a diving unusual attitude, roll to a wings level indication then establish a level flight attitude on the attitude indicator. Adjust power as necessary and resume a normal crosscheck.

4.7.4.2. Climbing. If climbing, consider pitch attitude and airspeed. If the inadvertent pitch attitude is not extreme (10° or less from level flight), smoothly lower the miniature aircraft back to a level flight indication, level the wings, and resume a normal crosscheck using power as required. For extreme pitch attitudes (above 10°), bank the aircraft in the shorter direction toward the nearest 30° bank index. The amount of bank used should be commensurate with the pitch attitude and external conditions, but do not exceed 30° of bank in making the recovery. Allow the miniature aircraft to fall toward the horizon. When the aircraft symbol is on the horizon, level the wings and adjust the aircraft attitude to a level flight indication. Use power as necessary throughout the recovery.

4.7.4.3. Hover. If the aircraft is in a hover or low speed when the unusual attitude is recognized, smoothly but immediately roll to a wings level attitude and apply maximum power available. Once attitude control is reestablished, execute an ITO, or refer to hover velocity instrumentation to maintain position (if available). This condition is most common during dust or white out situations, or when performing terminal operations at night and/or over water.

4.7.4.3.1. NOTE: In helicopters encountering an unusual attitude as a result of blade stall, collective must be reduced before applying attitude corrections if the aircraft is in a climbing unusual attitude. This will aid in eliminating the possibility of aggravating the blade stall condition. To aid in avoiding blade stall in a diving unusual attitude recovery, reduce power and bank attitude before initiating a pitch change. In all cases avoid abnormal positive or negative G loading which could lead to additional unusual attitudes or aircraft structural damage.

4.7.5. Recovery Procedures -- Attitude Indicators Inoperative. With an inoperative attitude indicator, successful recovery from unusual attitudes depends greatly on pilot proficiency and early recognition of attitude indicator failure. For example, attitude indicator failure should be immediately suspected if control pressures are applied for a turn without corresponding attitude indicator changes. Another example would be satisfactory performance instrument indications that contradict the "picture" on the attitude indicator. Should an unusual attitude be encountered with an inoperative attitude indicator, the following procedures are recommended:

4.7.5.1. Climb or dive. Determine whether the aircraft is in a climb or a dive by referring to the airspeed, altimeter, and vertical velocity indicators.

4.7.5.2. Diving. If diving, roll to center the turn needle and recover from the dive. Adjust power as appropriate. (Disregarding vertical attitudes, rolling "away" from the turn needle and centering it will result in an upright attitude.)

4.7.5.3. Climbing. If climbing, use power as required. If the airspeed is low or decreasing rapidly, pitch control may be aided by maintaining a standard rate turn on the turn needle until reaching level flight. If the turn needle in a flight director system is used, center the turn needle. This is because it is very difficult to determine between a standard rate turn and full needle deflection.

4.7.5.4. Level off. Upon reaching level flight, center the turn needle. The aircraft is level when the altimeter stops. The vertical velocity indicator lag error may cause it not to indicate level until the aircraft passes level flight.

Chapter 5

NAVIGATION INSTRUMENTS

5.1. Application. The navigation instruments explained in this chapter are common to the majority of USAF aircraft. These instruments are the radio magnetic indicator (RMI), course indicator (CI), range indicator, bearing-distance-heading indicator (BDHI), flight director (Figure 5.1), and Flight Management System (FMS).

5.2. Basic Systems.

5.2.1. Radio Magnetic Indicator (RMI) (Figure 5.1).

5.2.1.1. RMI Displays. The RMI displays aircraft heading with navigational bearing data. It normally consists of a rotating compass card and two bearing pointers. The compass card is actuated by the aircraft compass system. The aircraft magnetic heading is displayed on the compass card beneath the top index. The bearing pointers display automatic direction finding (ADF), VHF Omni directional Range (VOR), or Tactical Air Navigation (TACAN) magnetic bearing to the selected navigation station. Placards on the instrument or near a selector switch are normally used to identify the bearing pointer display. VOR or TACAN radials are displayed under the tail of their respective bearing pointers. Bearing pointers do not function in relation to instrument landing system (ILS) signals.

5.2.1.2. Compass System Malfunction. If there is a malfunction in the compass system or compass card, the ADF bearing pointer continues to point to the station, and displays relative bearing only. With a malfunction in the compass system or compass card, the VOR or TACAN bearing may still indicate magnetic bearing. Until verified by radar or other navigational equipment, consider this bearing information unreliable.

5.2.1.2.1. NOTE: VOR and TACAN bearing pointers do not "point" to an area of maximum signal strength, as does an ADF. VOR and TACAN navigation receivers electronically measure the magnetic course that is displayed by the pointers.

5.2.2. Course Indicator (CI) (Figure 5.2). The course indicator operates independently of the RMI. It displays aircraft heading and position relative to a selected VOR/TACAN course, and lateral and vertical position relative to an ILS localizer and glide slope.

5.2.2.1. VOR or TACAN Display.

5.2.2.1.1. Course indicator. When the course indicator is used to display VOR or TACAN information, aircraft heading and position are indicated relative to a selected course. The desired course is set in the course selector window with the course set knob.

5.2.2.1.2. The Heading Pointer. The heading pointer connected to the course set knob and the compass system, displays aircraft heading relative to the selected course. When the aircraft heading is the same as the course selected, the heading pointer indicates 0° heading deviation at the top of the course indicator. The heading deviation scales, at the top and bottom of the course indicator, are scaled in 5° increments up to 45°. The TO-FROM indicator indicates whether the course selected, if properly intercepted and flown, will take the aircraft to or from the station (Figure 5.3). When the aircraft passes a line from the station perpendicular to the selected course, the TO-FROM indicator changes. Aircraft heading has no effect on the TO-FROM indications.

Figure 5.1. Navigation Instruments.

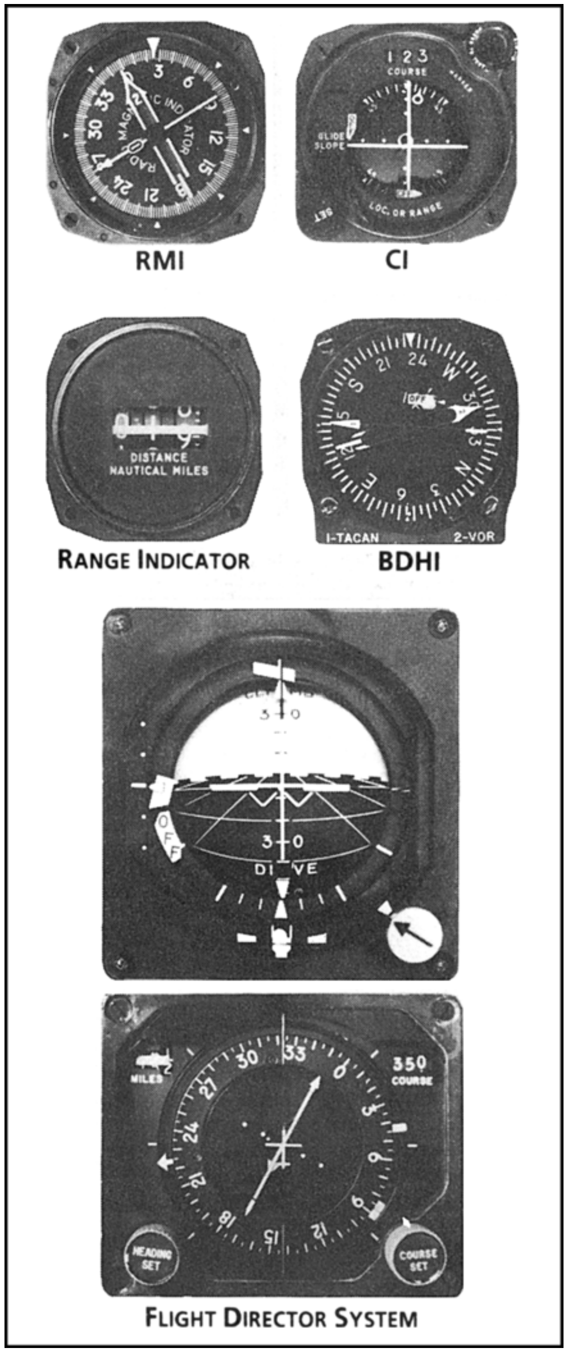


Figure 5.2. Radio Magnetic Indicator (RMI) and Course Indicator (CI).

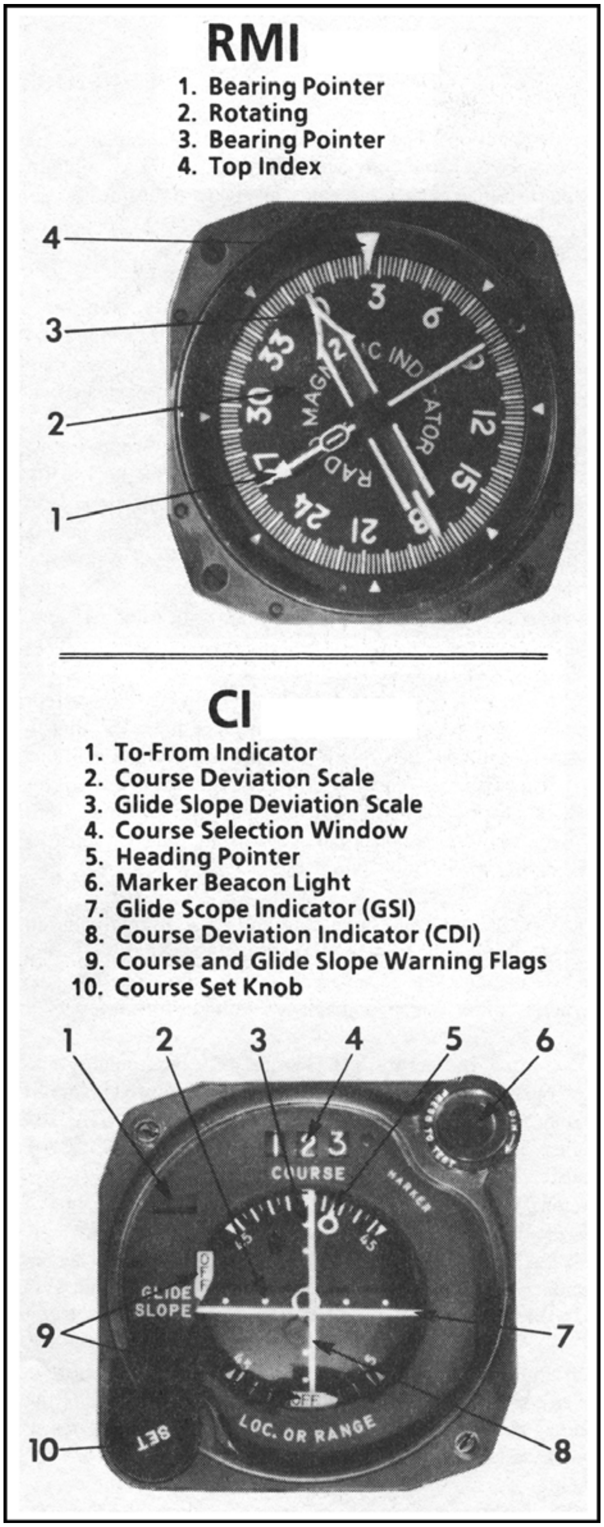
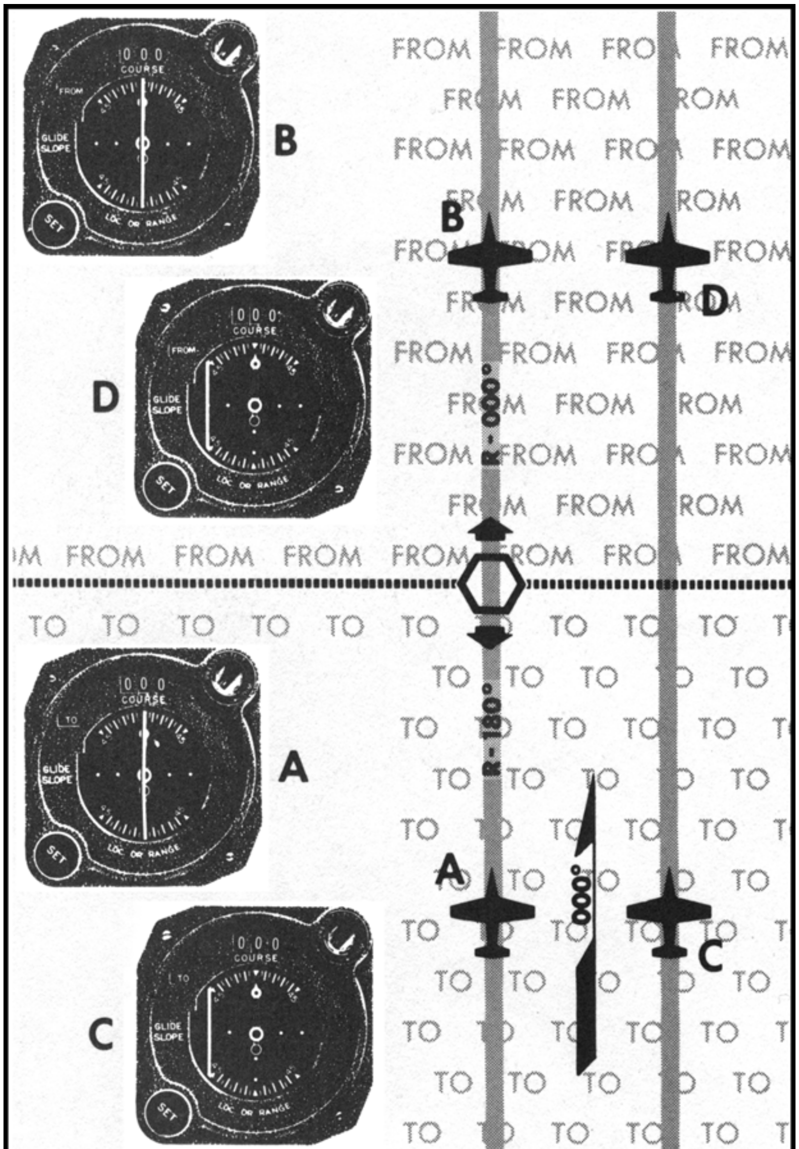


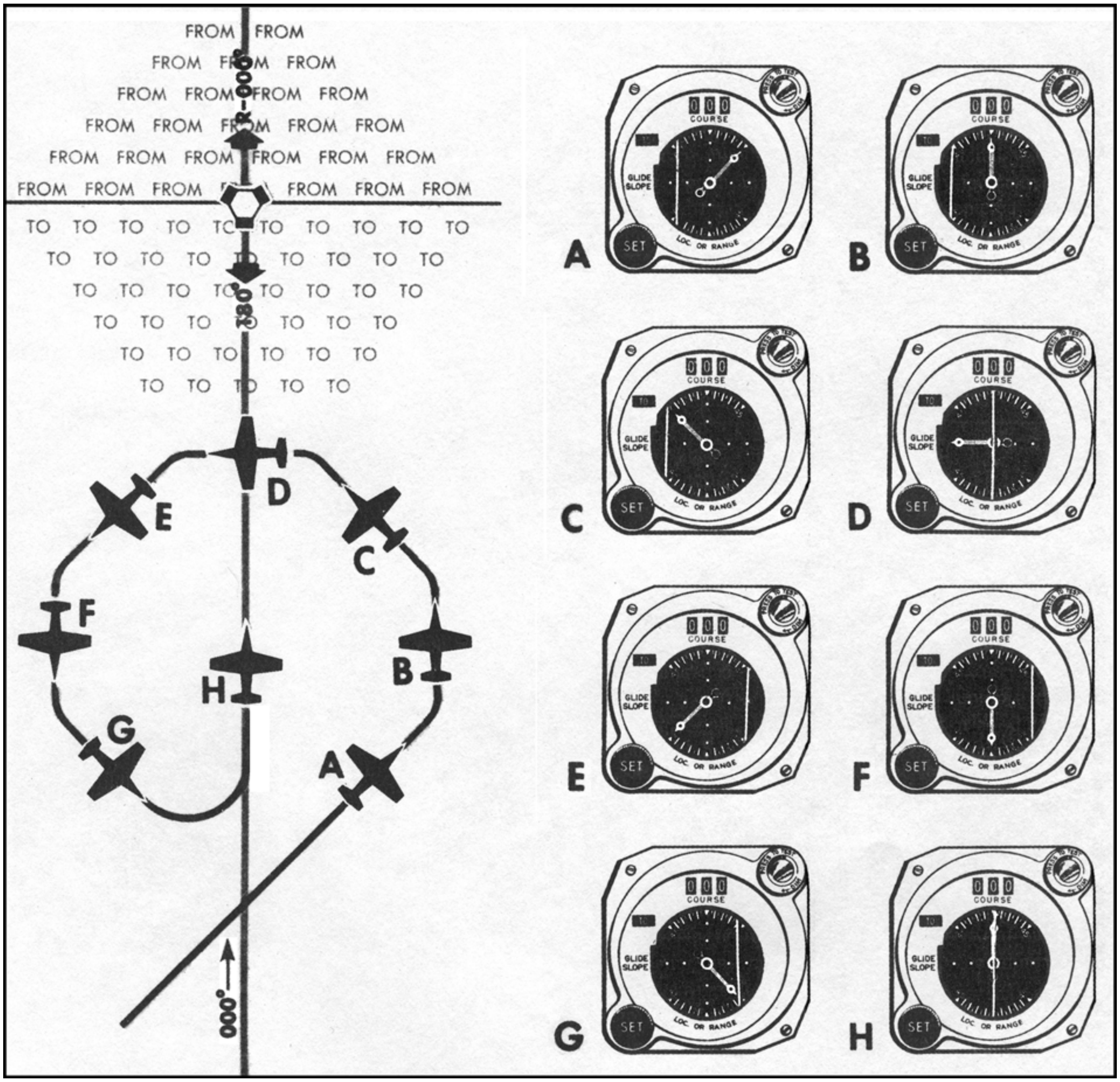
Figure 5.3. Principle of TO-FROM Indicator.



When aircraft passes station or a line drawn from the station perpendicular to the selected course, the TO-FROM indicator changes to FROM. All other indications remain the same and corrections must be made toward CDI.

5.2.2.1.3. Course Deviation Indicator. The course deviation indicator (CDI) displays aircraft course deviation relative to the course selected (Figure 5.4). Most course indicators are adjusted so the CDI is fully displaced when the aircraft is off course more than 10°. Each dot on the course deviation scale represents 5°.

Figure 5.4. Course Indicator Displays in Relation to the Selected Course.



5.2.2.1.4. Course Warning Flag. Appearance of the course warning flag indicates that the course indicator is not receiving a signal strong enough for reliable navigation information. See Chapter 7 for discussion on Navigation Aid (NAVAID) identification.

5.2.2.1.4.1. NOTE: Although the course indicator may be receiving a signal strong enough to keep the course warning flag out of view, reliability is indicated only if the warning flag is not displayed, the station identification is being received, and the bearing pointer is pointing to the station.

Figure 5.5. ILS Course Indicator Presentations for a 5°-Wide Localizer and a 1°-Wide Glide Slope (Front Course).

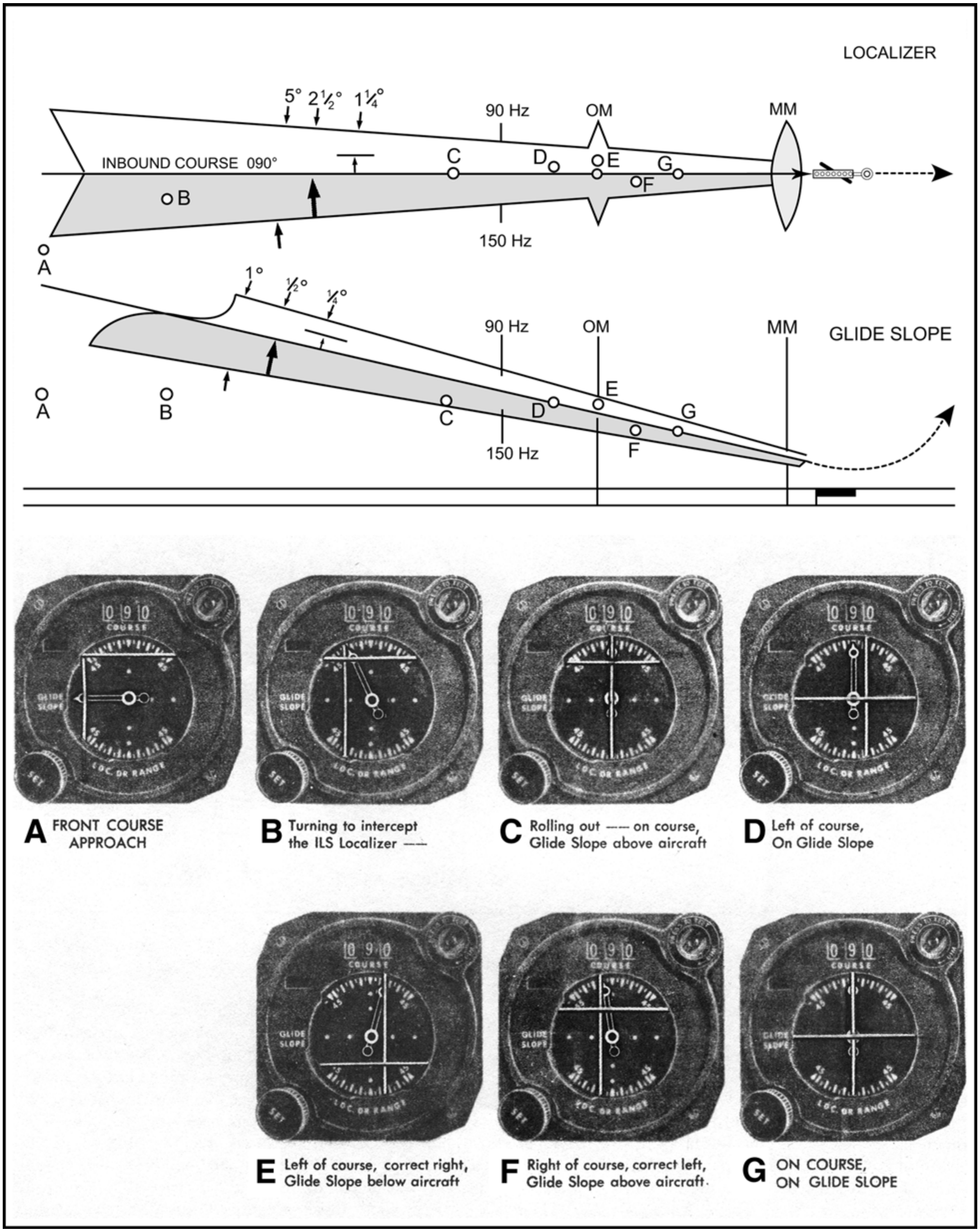
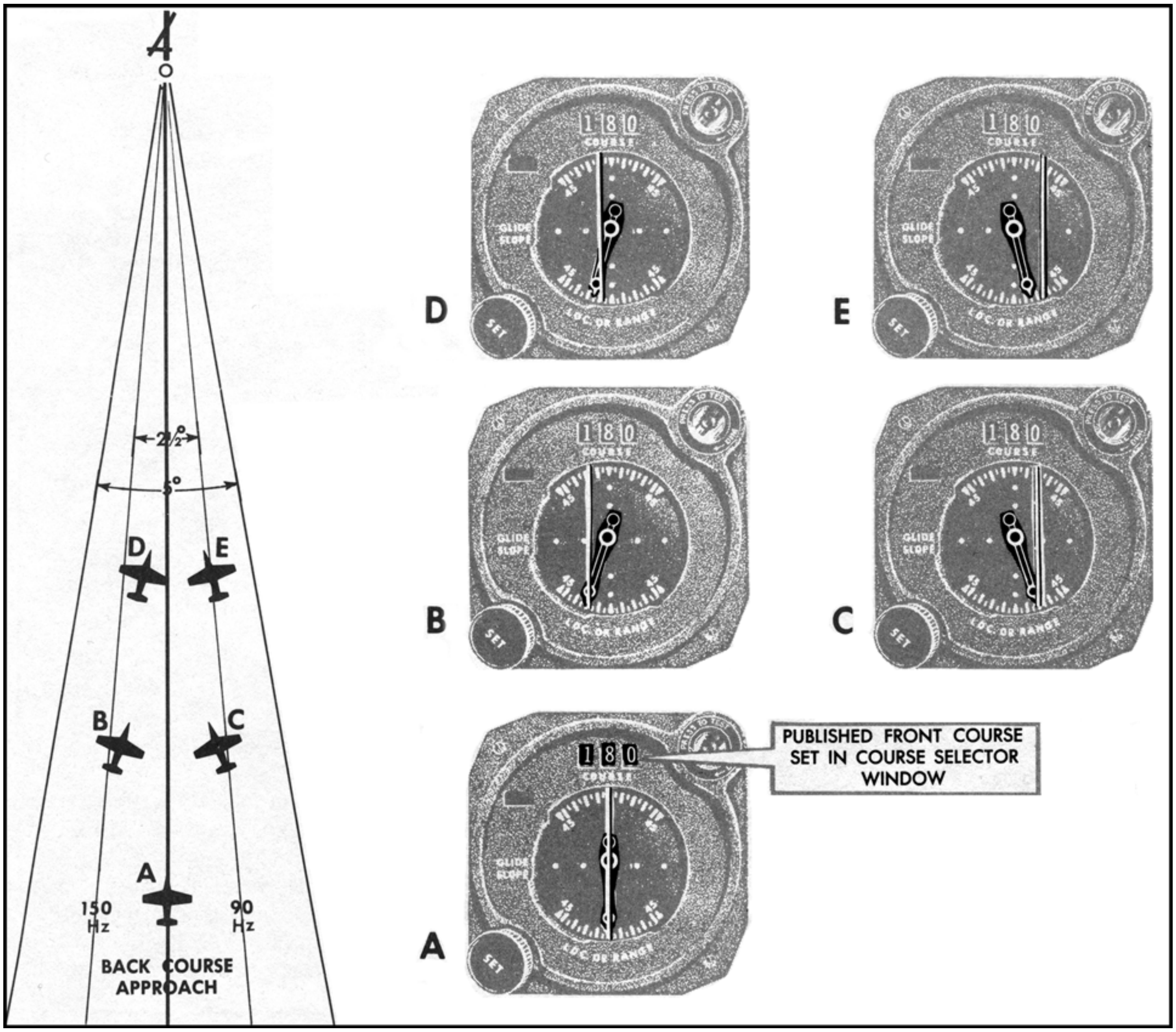


Figure 5.6. Localizer Course Indicator Presentations for a 5°-Wide Localizer (Back Course).



5.2.2.2. ILS Display (Figures 5.5 and 5.6).

5.2.2.2.1. Localizer Course. When used to display ILS signals, the course indicator provides precise ILS localizer course information for a specified approach. The following information pertains to course indicator functions and displays when used with an ILS:

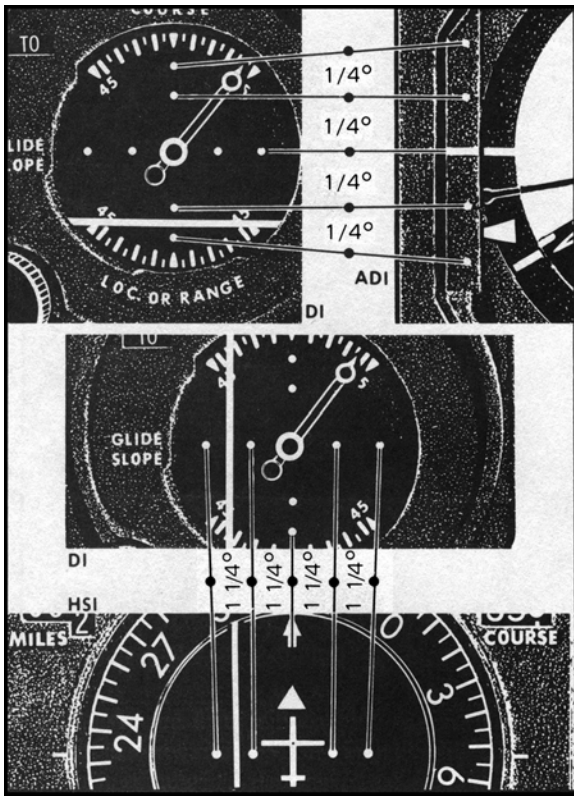
5.2.2.2.1.1. TO-FROM indicator. The TO-FROM indicator is unusable.

5.2.2.2.1.2. Full-scale deflection. Full-scale deflection on the course deviation scale differs with the width of the localizer course (up to 6°). Example: If the localizer course is 5° wide, then full-scale deflection is 2½° and each dot is 1¼°; if the localizer course is 3° wide, then full-scale deflection is 1½° and each dot is ¾°.

5.2.2.2.1.3. Course selected. The course set knob and course selected have no effect on the CDI display. The CDI displays only if the aircraft is on course or in a 90- or 150-Hz zone of signals originating from the ILS localizer transmitter. The CDI always deflects to the left of the instrument case in the 150-Hz zone and to the right in the 90-Hz zone. It centers when the signal strength of both zones is equal. (Although the course selected has no effect on the CDI, always set the published inbound FRONT COURSE of the ILS in the course selector window. This will ensure the heading pointer is directional in relation to the CDI displacement.

5.2.2.2.2. The glide slope indicator (GSI) displays glide slope position in relation to the aircraft. If the GSI is above or below center, the glide slope is above or below the aircraft respectively. Full-scale deflection of the GSI is dependent upon the width of the glide slope (1.4°). Example: The glide slope width is 1.4°, full-scale deflection would be .7°, and each dot would be .35° (Figure 5.7).

Figure 5.7. Example of Course and Glide Slope Deviation Indications vs. Actual Displacement Relative to Distance From Touchdown for a 5°- Wide Localizer and a 1° - Wide Glide Slope.



The GSI is more sensitive than the CDI, HSI, or the ADI.

1. Actual deviation figures may vary due to atmospheric conditions and transmitter-receiver errors.
2. Deviation figures do not take into consideration the distance an aircraft's main gear may be BELOW the location of its glide slope antenna.
3. Figures are based on localizer width of 5°, runway length of 8,000' localizer transmitter 1,000' beyond the departure end of the runway, touchdown point 1,000' from threshold, and a 1°-wide glide slope.
4. Dot values shown in this illustration are valid for most aircraft. Consult your aircraft flight manual to ensure correct display interpretation.

VERTICAL DEVIATION FROM GLIDE SLOPE

MILES FROM TOUCHDOWN	5	4	3	2	1
ONE DOT (¼°) DEVIATION	130'	104'	78'	52'	26'
TWO DOT (½°) DEVIATION	260'	208'	156'	104'	52'

LATERAL DEVIATION FROM LOCALIZER COURSE

MILES FROM TOUCHDOWN	5	4	3	2	1
ONE DOT (1¼°) DEVIATION	838'	706'	573'	441'	308'
TWO DOT (2½°) DEVIATION	1677'	1412'	1147'	882'	617'

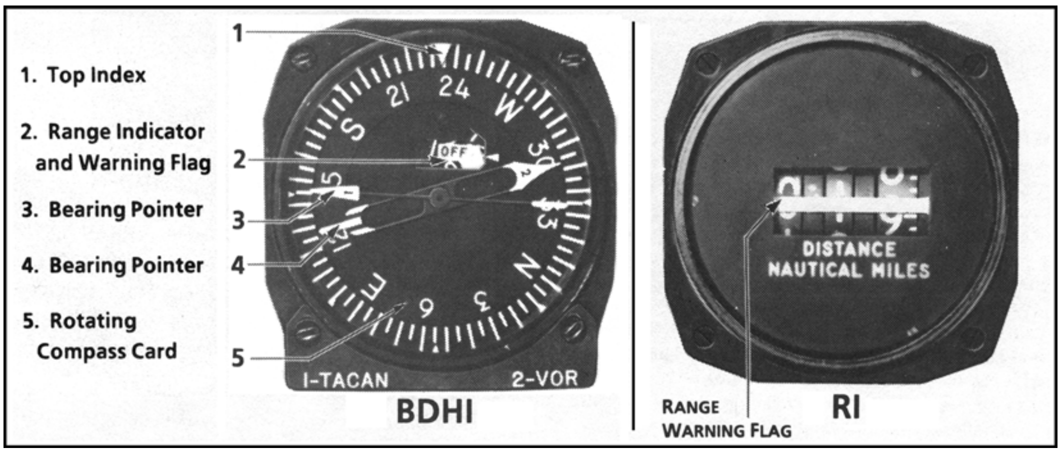
5.2.2.2.3. Warning Flags. Appearance of the course or glide slope warning flags indicate that the course or glide slope signal strength is not sufficient. Absence of the identifier indicates the signal is unreliable. See Chapter 7 for discussion on NAVAID identification.

5.2.2.2.3.1. WARNING: It is possible under certain conditions for the CDI or GSI to stick in any position with no warning flags while reliable station identification is being received. Pilots should use extreme caution and maintain good situational awareness while flying an ILS or localizer approach in actual weather conditions.

5.2.2.2.4. Marker Beacon. The marker beacon light and aural tone indicate proximity to a 75-MHz marker beacon transmitter; for example, ILS outer marker (OM), middle marker (MM), inner marker (IM), etc. As the aircraft flies through the marker beacon signal pattern, the light flashes and the aural tone sounds in Morse code indicating the type of beacon. The marker beacon light functions independently of ILS/VOR/TACAN signals.

5.2.3. Range Indicator. Range indicators display slant range distance in nautical miles to a DME transponder. For practical purposes, you may consider this a horizontal distance except when the aircraft is very close to the station. DME range information is subject to line-of-sight restrictions and altitude directly affects the reception range.

Figure 5.8. Bearing Distance Heading Indicator (BDHI).



5.2.4. Bearing-Distance-Heading Indicator (BDHI) (Figure 5.8).

5.2.4.1. BDHI Display. The BDHI displays aircraft heading with navigational bearing data and range information. Except for the range indicator, the BDHI is similar in appearance and function to the RMI previously described.

5.2.4.2. BDHI Components. The BDHI consists of a rotating compass card, two bearing pointers, a range indicator, and a range warning flag. Some BDHIs also have a heading marker, a heading set knob, and a power warning flag.

5.2.4.3. Compass Card Actuation. The compass card is actuated by the aircraft compass system, which normally includes pilot-operated controls that permit the BDHI compass card to operate in a slaved or non-slaved direct gyro (DG) mode. In the slaved mode, the aircraft magnetic heading is displayed beneath the top index or lubber line. In the nonslaved DG mode, the compass card serves as a heading reference after being corrected to a known heading. The card is manually corrected for the DG mode by a switch on the compass control panel.

5.2.4.4. Heading Marker. The heading marker, if incorporated, may be positioned on the compass card by use of the heading set knob. Once positioned, the marker remains fixed relative to the compass card. When the aircraft is on the selected heading, the heading marker is aligned beneath the upper lubber line.

5.2.4.5. Bearing Pointers. The bearing pointers indicate the ADF, VOR, or TACAN magnetic bearing to the selected navigation station. Placards on the instrument or near a selector switch are used in most aircraft to identify the bearing pointer display.

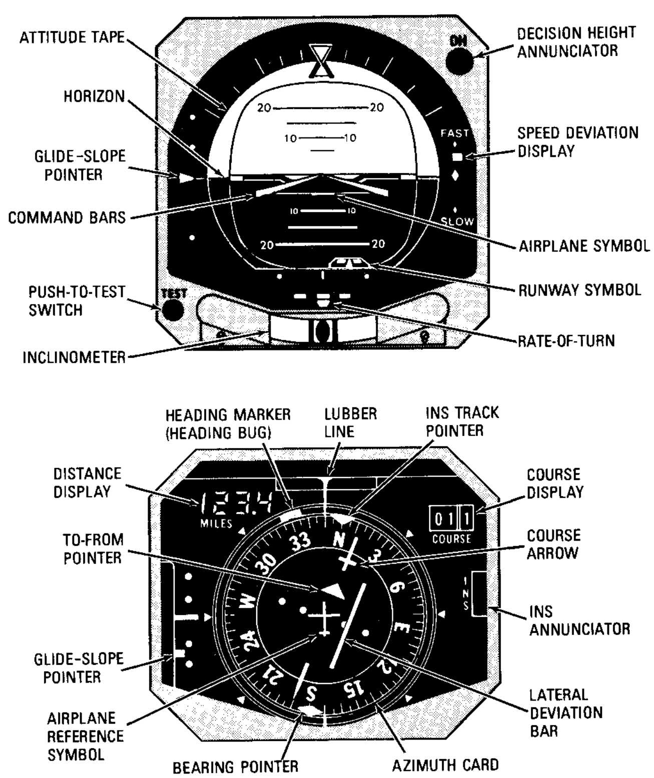
5.2.4.5.1. NOTE: The bearing pointers do not function in relation to ILS signals.

5.2.4.6. Malfunctions. If there is a malfunction in the compass system or compass card, an ADF bearing pointer continues to point to the station and displays relative bearing only.

5.2.4.7. TACAN/VOR Pointers. With a malfunction in the compass system or compass card, TACAN/VOR pointers may continue to indicate proper magnetic bearings. Until verified by radar or other navigation equipment, consider this bearing information unreliable.

5.3. Flight Director. The flight director provides the pilot with displays of pitch and bank attitudes and the navigation situation of the aircraft. The flight director when combined with round dial performance instruments is termed the flight director system (FDS). When the flight director is combined with vertical scale instruments it is termed the integrated flight instrument system (IFIS). The three components of the flight director of major interest are the attitude director indicator (ADI), the horizontal situation indicator (HSI), and the flight director computer.

Figure 5.9. Typical Flight Director.



5.3.1. Attitude Director Indicator (ADI) (Figure 5.9).

5.3.1.1. Parts of Attitude Director Indicator. The ADI consists of attitude indicator, rate of turn and slip indications, glide slope indicator, command bars, attitude warning flag, glide slope warning flag, and course warning flag. Additional information displayed on some ADIs includes radar altitude information, approach speed deviation, and a runway symbol that displays lateral and vertical displacement from the runway.

5.3.1.2. Glide Slope Pointer. The glide slope pointer (GSP) displays glide slope position in relation to the aircraft. If the GSP is above or below center the glide slope is above or below the aircraft respectively. GSP scale deflection differs with the width of the glide slope (1° to 1.8°). Example: If the glide slope width was 1°, full-scale deflection would be ½° and each dot would be ¼° (Figure 5.7).

5.3.1.3. Command Bars. The command bars display command steering information to fly or to maintain a desired flight path. The attitude of the aircraft must be adjusted as necessary to satisfy the pitch or bank commands. To satisfy these commands, the aircraft must be maneuvered so that the airplane symbol (fixed delta shape) is "flown into" the bars until the two are snugly aligned. Keeping the airplane symbol and command bars snugly aligned will provide the amount of bank necessary to roll in, turn, roll out, and maintain a selected heading or ILS course and the proper pitch attitude necessary to fly to, or maintain the desired flight path. When the airplane symbol and command bars are aligned, the aircraft is either correcting to or is on the desired flight path.

5.3.1.3.1. NOTE: Warning flags are incorporated in the ADI to indicate failure or unreliability of presentations. Check the aircraft flight manual for specific warning flags applicable to your aircraft. In some ADIs, if power fails to the pitch and bank steering bars, no warning flags will appear, and the pitch and bank steering bars will center. Monitor the identifier to ensure that the signal is reliable. In most aircraft a warning flag appears when the signal strength is insufficient.

5.3.2. Horizontal Situation Indicator (HSI) (Figure 5.9).

5.3.2.1. Horizontal Situation Indicator. The horizontal situation indicator is, in most respects, a combination of a heading indicator, radio magnetic indicator, course indicator, and range indicator. The aircraft heading is displayed on a rotating compass card under the upper lubber line. The card is calibrated in 5° increments. The bearing pointers indicate the magnetic bearing from the aircraft to the selected ground station (VOR, TACAN, or ADF): The fixed aircraft symbol and course deviation indicator display the aircraft relative to a selected course as though the pilot was above the aircraft looking down. When used with VOR or TACAN, full-scale deflection, on most aircraft, indicates 10° of course deviation (each dot indicates 5°). When used with ILS, full-scale deflection differs with the width of the localizer course. Example: If the localizer course is 5° wide, the full-scale deflection is 2 ½°

and each dot is 1¼°. If the localizer course is 3° wide, then full-scale deflection is 1½° and each dot is ¾° (Figure 5.7). The range indicator displays slant range distance in nautical miles to the selected DME transponder and may or may not operate when ILS modes have been selected depending on equipment installation. Additional displays available on electronic horizontal situation indicators include ARC formats to display a segment of the standard display as well as MAP formats used to pictorially display bearing and distance to NAVAIDS or waypoints.

5.3.2.2. Course Selector Knob. The course selector knob on most flight directors may be used to select any of 360 courses. To select a desired course, rotate the head of the course arrow to the desired course on the compass card and check the course selector window for the precise setting. The TO-FROM indicator is a triangular-shaped pointer. When the indicator points to the head of the course arrow, it indicates that the course selected, if properly intercepted and flown, will take the aircraft to the selected facility.

5.3.2.3. Heading Set Knob. The heading set knob on most flight directors is used to set the heading marker to a desired heading. With the proper mode selected on the flight director control panel, the heading marker can be slaved to the flight director computer. Thus, when a heading is set, the command bars will command the bank attitude required to turn to and maintain the selected heading.

5.3.3. Flight Director Computer.

5.3.3.1. Flight Director Computer Information. The flight director computer receives navigation information from the navigation systems and attitude information from the attitude gyro. Depending on the modes available and selected, the computer supplies pitch or bank commands to the command bars of the ADI. The functions of the computer vary with systems, and a number of inputs (NAVAIDs, datalink, Doppler, etc.) may be electronically processed by the system.

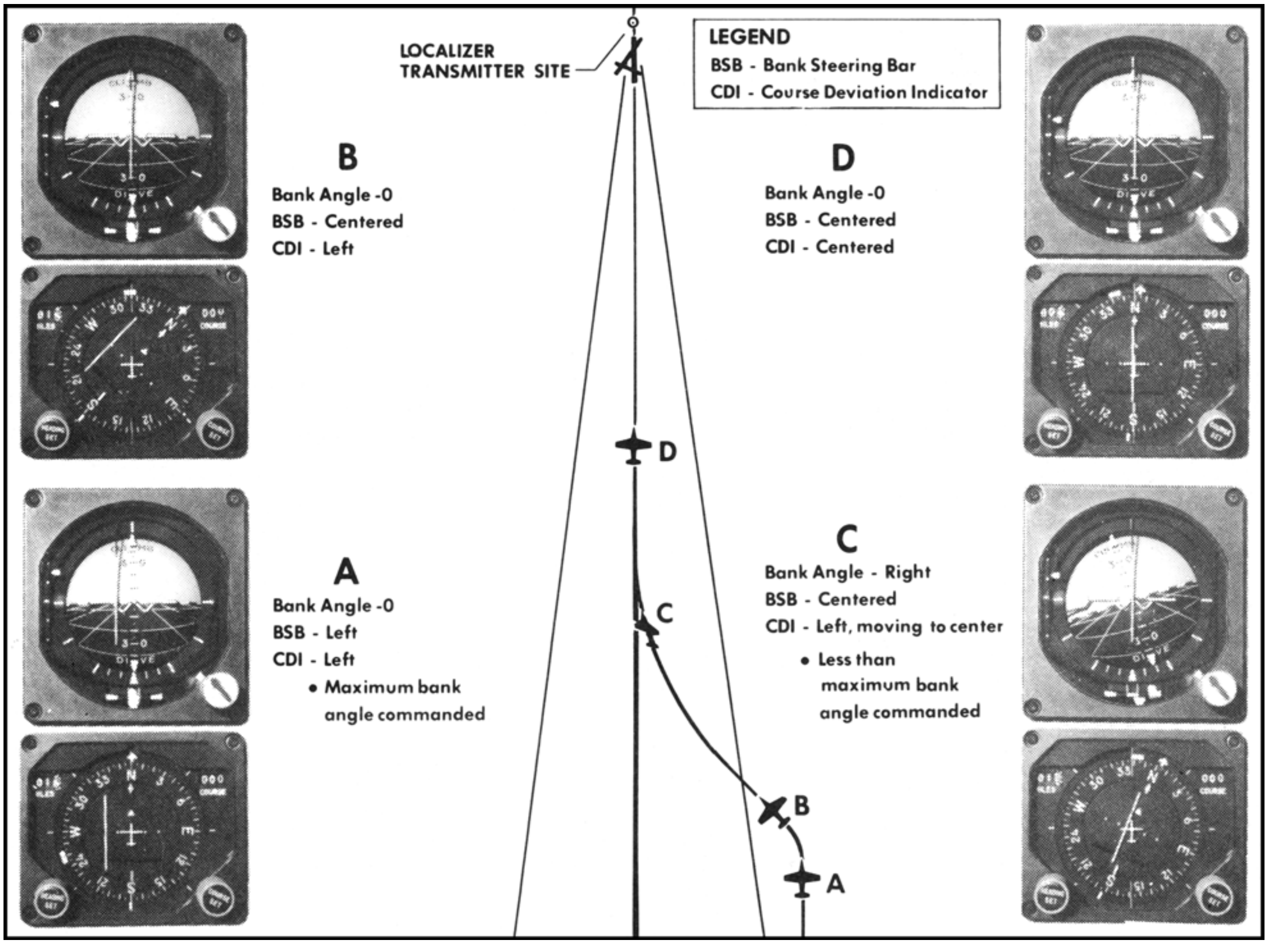
5.3.3.2. Flight Director Systems. In some flight director systems, the command bars can be used for other maneuvers such as intercepting VOR, TACAN, and Doppler courses or performing data link intercepts. Pitch command information can vary from terrain avoidance commands to commanding a selected altitude. In all cases, the command bars display command information and do not reflect actual aircraft position. This section is limited to command information pertaining to selected headings and ILS approaches and is common to most flight director systems. Refer to the appropriate flight manual for the specific capabilities of the system installed in your aircraft.

5.3.4. Flight Director Modes.

5.3.4.1. Heading Mode. The flight director usually has mode selectors that allow the pilot to select command steering to a heading or to various navigation systems.

5.3.4.2. ILS Intercept Mode (Figure 5.10). This mode is designed to direct the aircraft to, place it upon, and maintain it on the localizer course. This is accomplished by positioning the bank steering bar to command the pilot to fly flight director computed headings.

Figure 5.10. Flight Director Computer Inputs (ILS Intercept Mode).



5.3.4.2.1. Wind drift. Some computers supply wind drift compensation.

5.3.4.2.2. Bank angle. Maximum bank angle commanded is usually 25° to 35°, depending on the system.

5.3.4.2.3. Intercept angle. Maximum intercept angle commanded is normally about 45°.

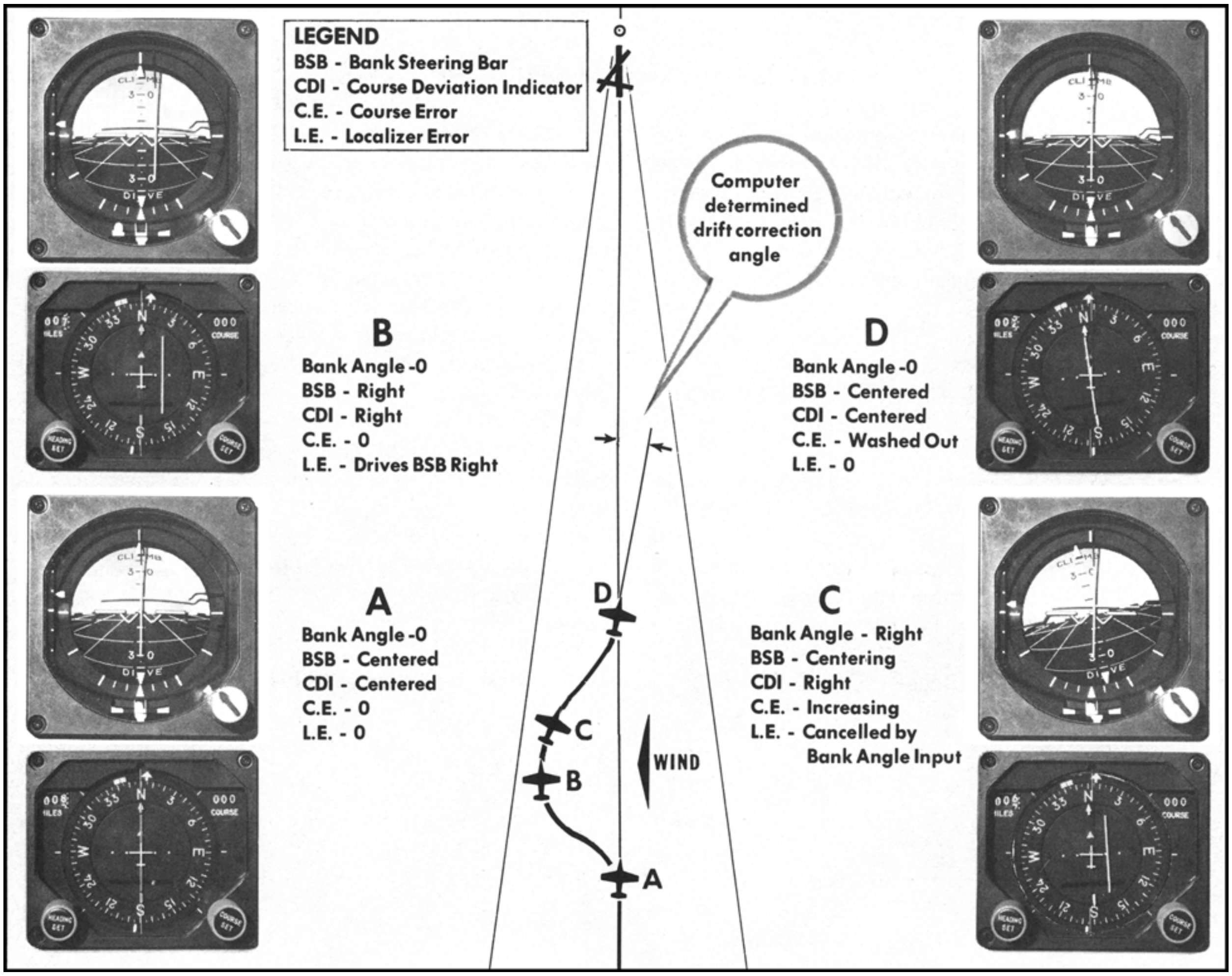
5.3.4.2.4. ILS Final Approach Mode (Figure 5.11). This mode is designed to place and maintain the aircraft on the localizer course and glide slope. This is accomplished by positioning the pitch and bank steering bars to command the pilot to fly flight director computed headings and pitch attitudes.

5.3.4.2.5. Drift. Wind drift compensation is provided to maintain the aircraft on the final approach course.

5.3.4.2.6. Bank Angle. Bank angle commanded is a maximum of 15°.

5.3.4.2.7. Pitch. Maximum pitch attitude commanded is 10° to 17°, depending on the system.

Figure 5.11. Flight Director Inputs (ILS Final Approach Mode).



5.3.5. ILS Display. As in the CI, the course set knob and course selected have no effect on the CDI display. The CDI displays only if the aircraft is on course or in a 90- or 150-Hz zone of signals originating from the ILS localizer transmitter. When on course, the CDI will center regardless of the course selected; however, the CDI and course arrow will not necessarily be directional to the aircraft symbol. Set the published localizer front course in the course selector window in order to have the CDI and aircraft symbol directional.

5.4. Flight Management System (FMS).

5.4.1. Flight Management System (FMS). Many newer aircraft are equipped with a Flight Management System (FMS) consisting of a Flight Management Computer (FMC), one or more Control Display Units (CDU), an internal navigation database, and various displays and annunciators. The FMS utilizes aircraft sensors and navigation database information to compute and display aircraft position, performance data, and navigation information during all phases of flight. The FMS may interface and provide guidance commands to autopilot, flight director, and auto-throttle systems.

5.4.1.1. Flight Management Computer. The FMC is a sophisticated computer system that gathers aircraft position information from multiple onboard sensors and navigation aids including VOR, DME, TACAN, Inertial Reference Systems (IRS) and Inertial Navigation Systems (INS), Global Positioning System (GPS), and Air Data Computers. From this sensor data the FMC computes and continually updates the aircraft present position throughout the flight. Using this aircraft position information, navigation functions such as course and distance to a waypoint, desired track, groundspeed, and estimated time of arrival are computed and displayed on the CDU and other aircraft instruments. Navigation information may also be provided in the form of steering commands to autopilot and flight director systems. In addition, fuel flow information may be used by the FMC to calculate and update fuel consumption, specific range, and fuel overhead destination information.

5.4.1.2. Control Display Unit. The CDU serves as the aircrew's interface to the FMC and associated navigation sensors. The CDU normally consists of a display screen, data entry pad, and function and line select keys. The CDU allows menu-driven selection of various FMS modes, such as initialization, fuel planning, performance, and navigation. The pilot may input flight plan route, vertical profile and speed information, aircraft weight and fuel parameters, and certain waypoint data into the FMC. Data from the navigation database may be displayed and reviewed by the pilot on the CDU.

5.4.1.3. Navigation Database. An FMS normally contains an internal navigation database with either regional or worldwide coverage. The database typically includes information on navigation aids, airports, runways, waypoints, routes, airways, intersections, departures and arrivals, and instrument approaches. Aircrews may also store defined routes and waypoints in the database. Navigation databases require periodic updates, normally on a 28-day cycle, to ensure data is current.

Chapter 6

NAVIGATION AIDS

6.1. Precautions. Various types of navigation aids are in use today, each serving a special purpose. Although operating principles and cockpit displays will vary among navigation systems, there are several precautionary actions that must be taken to prevent in-flight use of erroneous navigation signals:

6.1.1. Identification. ***Check the identification of any navigation aid and monitor it during flight IAW Chapter 7 of this manual***.

6.1.2. Crosscheck Information. Use all suitable navigation equipment aboard the aircraft and crosscheck heading and bearing information.

6.1.3. Estimated Time of Arrival. Never overfly an estimated time of arrival (ETA) without a careful crosscheck of navigation aids and ground checkpoints.

6.1.4. Notices to Airmen. ***Check notices to airmen (NOTAM) and flight information publication (FLIP) before flight for possible malfunctions or limitations to navigation aids.***

6.1.5. Suspect Navigation Aid. Discontinue use of any suspect navigation aid and, if necessary, confirm aircraft position with radar (ground or airborne) or other equipment. Advise ATC of any problems receiving NAVAIDs--the problem may be the ground station and not your aircraft's equipment.

6.2. VHF Omni-Directional Range (VOR).

6.2.1. VOR Frequency. VORs operate within the 108.0 to 117.95 MHz, or very high frequency (VHF) and have a power output necessary to provide coverage within their assigned operational service volume. The equipment is subject to line-of-sight restriction, and its range varies proportionally to the altitude of the receiving equipment.

6.2.2. Voice Transmission. Most VORs are equipped for voice transmission. VORs without voice capability are indicated on enroute and sectional charts by underlining the VOR frequency or by the designation "VORW" in the IFR Supplement. Since a large portion of the frequencies available on the VOR control panel may overlap the VHF communication frequency band, you may use the VOR receiver as a VHF communications receiver.

6.2.3. Accuracy. The accuracy of course alignment of the VOR is excellent, being generally plus or minus 1°, but no more than 2.5°.

6.2.4. Identification. The only positive method of identifying a VOR is by its Morse code identification (either aural or alphanumeric display that meets the requirements of chapter 7) or by the recorded automatic voice identification. Voice identification consists of a voice announcement, "COUSHATTA VOR," alternating with the usual Morse code identification. During periods of maintenance, the facility may radiate a T-E-S-T code or the code may be removed.

6.3. Tactical Air Navigation (TACAN).

6.3.1. Principles of Operation. The theoretical and technical principles of operation of TACAN equipment are different from those of VOR; however, the end result, as far as the navigating pilot is concerned, is the same.

6.3.2. TACAN Ground Equipment. TACAN ground equipment consists of either a fixed or mobile transmitting unit. The airborne unit in conjunction with the ground unit reduces the transmitted signal to a visual presentation of both azimuth and distance information. TACAN operates in the ultra high frequency (UHF) band of frequencies. The system presently has a total of 252 channels available and is identified by two sets of channel numbers from 1 to 126, with suffixes "X" or "Y" for discrimination between the sets.

6.3.3. TACAN Malfunctions. Several forms of TACAN malfunctions can give false or erroneous information to the navigation display equipment:

6.3.3.1. Forty-Degree Azimuth Error Lock-On. Due to the nature of the TACAN signal, it is possible for the TACAN azimuth to lock on in multiples of 40° from the true bearing with no warning flag appearing. The pilot should crosscheck other navigation aids available to verify TACAN azimuth. Rechanneling the airborne receiver to deliberately cause unlock may correct the problem. Although some TACAN sets are designed to eliminate 40° lock-on error, the pilot should crosscheck the bearing with other available navigation aids.

6.3.3.2. Co-channel Interference. This occurs when the aircraft is in a position to receive TACAN signals from more than one ground station on the same channel, normally at high altitude. DME, azimuth, or identification from either ground station may be received.

6.3.3.3. False or Incorrect Lock-On. This is caused by misalignment or excessive wear of the airborne equipment channel selection mechanism. Rechanneling from the selected channel number and back preferably from the opposite direction than the original setting sometimes will correct this problem.

6.4. VHF Omni-Directional Range/Tactical Air Navigation (VORTAC).

6.4.1. VORTAC. A VORTAC is a facility consisting of two components, VOR and TACAN, which provides three individual services: VOR azimuth, TACAN azimuth, and TACAN distance (DME) at one site. Although consisting of more than one component, incorporating more than one operational frequency, and using more than one antenna system, a VORTAC is considered to be a unified navigation aid. Both components of a VORTAC operate simultaneously and provide the three services at all times.

6.4.2. Identification. Transmitted signals of VOR and TACAN are each identified by a three-letter code transmission and are interlocked so that pilots using VOR azimuth with TACAN distance can be assured that both signals being received are definitely from the same ground station. The frequencies of the VOR, TACAN, and DME at each VORTAC facility are "paired" in accordance with a national plan to simplify airborne operation. Frequency pairing information is published in the Flight Information Handbook.

6.5. Distance Measuring Equipment (DME).

6.5.1. Operation. In the operation of DME, paired pulses at a specific spacing are sent out from the aircraft and are received at the ground station. The ground station then transmits paired pulses back to the aircraft at the same pulse spacing but on a different frequency. The time required for the round trip of this signal exchange is measured in the airborne DME unit and is translated into distance in nautical miles from the aircraft to the ground station.

6.5.2. Line-Of-Sight Principle. Operating on the line-of-sight principle, DME furnishes distance information with a very high degree of accuracy. Reliable signals may be received at distances up to 199 NM at line-of-sight altitude with an accuracy of better than ½ mile or 3 percent of the distance, whichever is greater. Distance information received from DME equipment is slant range distance and not actual horizontal distance.

6.5.3. DME Frequencies. DME operates on frequencies in the UHF spectrum between 962 MHz and 1213 MHz. Aircraft equipped with TACAN equipment will receive distance information from a VORTAC automatically, while aircraft equipped with only a VOR receiver must have a separate DME airborne unit.

6.5.4. Facilities. VOR/DME, VORTAC, ILS/DME, and LOC/DME navigation facilities provide course and distance information from collocated components under a frequency-pairing plan. Aircraft receiving equipment that provides for automatic DME selection ensures reception of azimuth and distance information from a common source when designated VOR/DME, VORTAC, ILS/DME, and LOC/DME are selected.

6.5.5. Identification. VOR/DME, VORTAC, ILS/DME, and LOC/DME facilities are identified by synchronized identifications, which are transmitted on a time share basis. The DME or TACAN coded identification is transmitted one time for each three or four times that the VOR or localizer coded identification is transmitted. When either the VOR or the DME is inoperative, it is important to recognize which identifier is retained for the operative facility. A single coded identification with a repetition interval of approximately 30 seconds indicates that the DME is operative.

6.5.5.1. NOTE: DME unlocks can occur periodically due to ground station overload when more than 100 aircraft interrogations are received at the same time. This problem is most likely to occur at locations of heavy traffic (i.e. Chicago-O Hare).

6.6. Instrument Landing System (ILS).

6.6.1. Description.

6.6.1.1. Design. The ILS is designed to provide an approach path for exact alignment and descent of an aircraft on final approach to a runway.

6.6.1.2. Ground Equipment. The ground equipment consists of two highly directional transmitting systems, and along the approach, three (or fewer) marker beacons. The directional transmitters are known as the localizer and glide slope transmitters.

6.6.1.3. Signals. Both localizer and glide slope signals are received and displayed according to the aircraft control panel or flight director configuration.

6.6.1.4. The system may be divided functionally into three parts:

6.6.1.4.1. Guidance information: localizer, glide slope.

6.6.1.4.2. Range information: marker beacon, DME.

6.6.1.4.3. Visual information: approach lights, touchdown and centerline lights, runway lights.

6.6.1.4.4. Compass locators located at the OM or MM may be substituted for marker beacons. DME, when specified in the procedure, may be substituted for the OM.

6.6.2. Localizer (Figure 6.1). The localizer transmitter, operating on one of the 40 ILS channels within the frequency range of 108.10 MHz to 111.95 MHz, emits a signal that provides the pilot with course guidance to the runway centerline. The localizer signal is usable and accurate to a range of 18 NM from the localizer antenna unless otherwise stated on the IAP.

6.6.3. Glide Slope (Figure 6.1). The UHF glide slope transmitter, operating on one of the 40 ILS channels within the frequency range 329.15 MHz to 335.00 MHz radiates its signals primarily in the direction of the localizer front course. The glide slope signal is usable to a distance of 10 NM from the glide slope antenna (located near the approach end of the runway) unless otherwise stated on the IAP.

6.6.3.1. CAUTION: Spurious glide slope signals may exist in the area of the localizer back course that can cause the glide slope flag alarm to disappear and present unreliable glide slope information. Disregard all glide slope signal indications when flying a localizer back course approach unless a glide slope is specified on the instrument approach procedure.

6.6.4. Marker Beacons. A marker beacon light and (or) aural tone may be included in the cockpit display to indicate aircraft position along the localizer. The marker beacons are identified by continuous dashes for the outer marker, alternating dashes and dots for the middle marker, and continuous dots for the inner marker.

6.6.4.1. Compass locators located at the outer marker or middle marker may be substituted for marker beacons. DME, crossing radial, or radar, when specified in the procedure, may be substituted for the outer marker.

6.6.5. ILS System on Each End of Runway. Some locations have a complete ILS system installed on each end of a runway; on the approach end of Runway 04 and the approach end of Runway 22, for example. When this is the case, the ILS systems are not in service simultaneously. In most cases, each ILS will have its own frequency. Sometimes the frequency for both runways will be the same, however each runway will have its own unique Morse code identifier.

6.6.5.1. WARNING: It is extremely important to listen to the Morse code identifier or monitor the alphanumeric display IAW Chapter 7, especially when flying an ILS where the same frequency is used for two runways. If both ILSs are inadvertently left on, or the incorrect ILS is turned on, it is possible to receive back course indications and false glide slope indications.

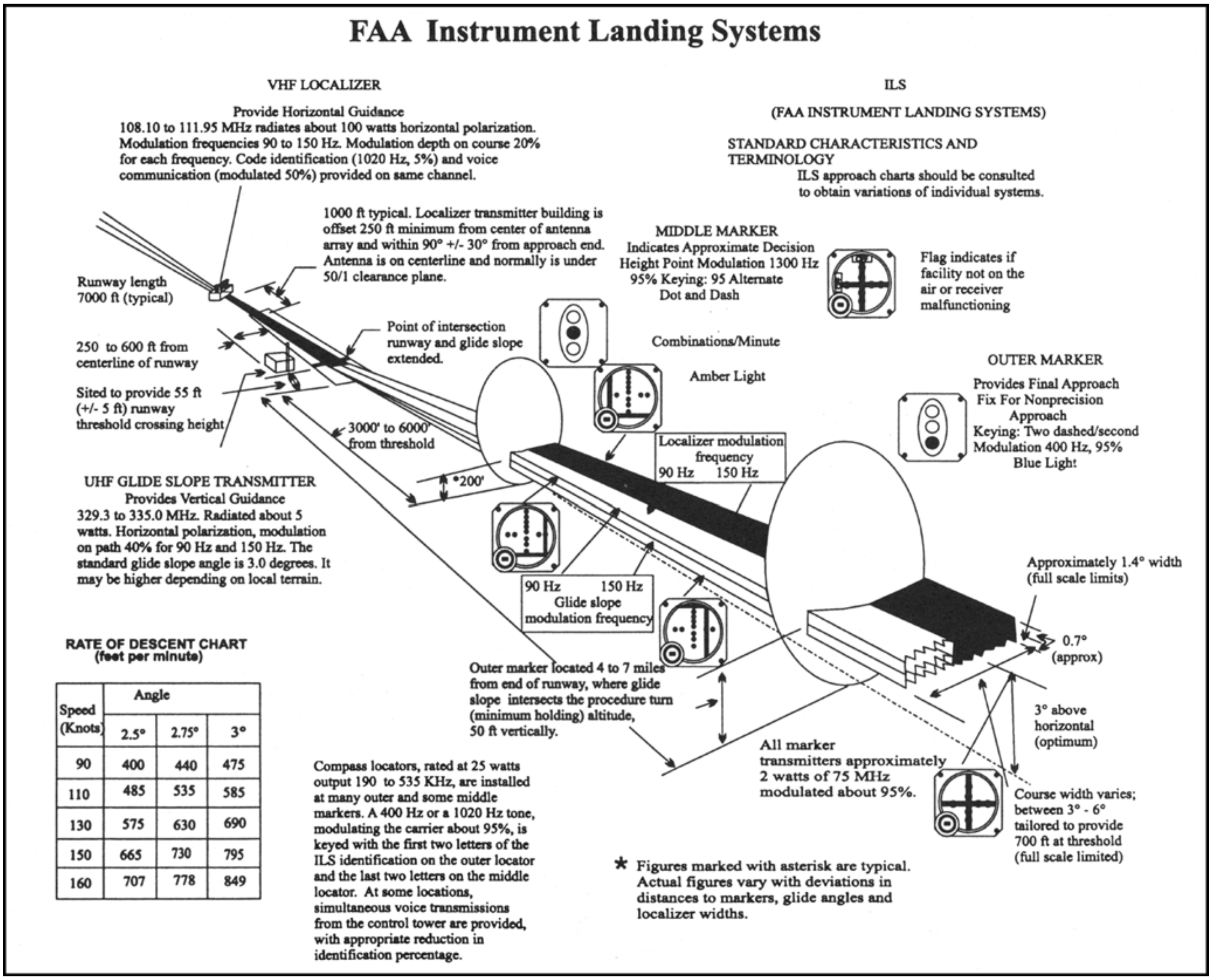
6.6.6. False Course Indications. False course indications may be received when the aircraft is not within the depicted area of coverage. Therefore, localizer course information received outside the area depicted in Figure 6.2 should be considered invalid unless the procedure is published otherwise (for example, localizer type directional aid or back course localizer). There is also a remote chance electromagnetic interference may cause false course indications within the depicted area of coverage. For these reasons, it is essential to confirm the localizer on course indication by reference to aircraft heading and any other available navigation aids, such as an ADF bearing pointer, before commencing final descent. Any abnormal indications experienced within 35 degrees of the published front course or back course centerline of an ILS localizer should be reported immediately to the appropriate ATC facility.

6.6.7. False Glideslope Indications. False glideslope indications may be received when the aircraft is not within the depicted area of coverage, or the glide slope power status is in alarm. There is also a chance that aircraft or vehicles parked in the ILS Critical Area may interfere with the glideslope signal. For these reasons, it is essential to confirm glideslope intercept altitudes and expected altitudes as depicted on the IAP. If indications are suspect, transition to localizer procedures or execute a missed approach.

6.6.8. ILS Facilities with Associated DME. ILS facilities sometimes have associated DME. These facilities are usually found at civilian fields. Some instrument approach procedures require TACAN or VOR associated DME on the initial segment and the ILS associated DME during the final portion of the approach. Pilots must exercise extreme caution to ensure the proper DME channel is tuned to preclude premature descents.

6.6.8.1. NOTE*:* Due to angular dispersion of the localizer and glide slope signals, the corrective inputs to return to "on course, on glide slope" become smaller as the aircraft approaches the runway threshold (Figure 6.2).

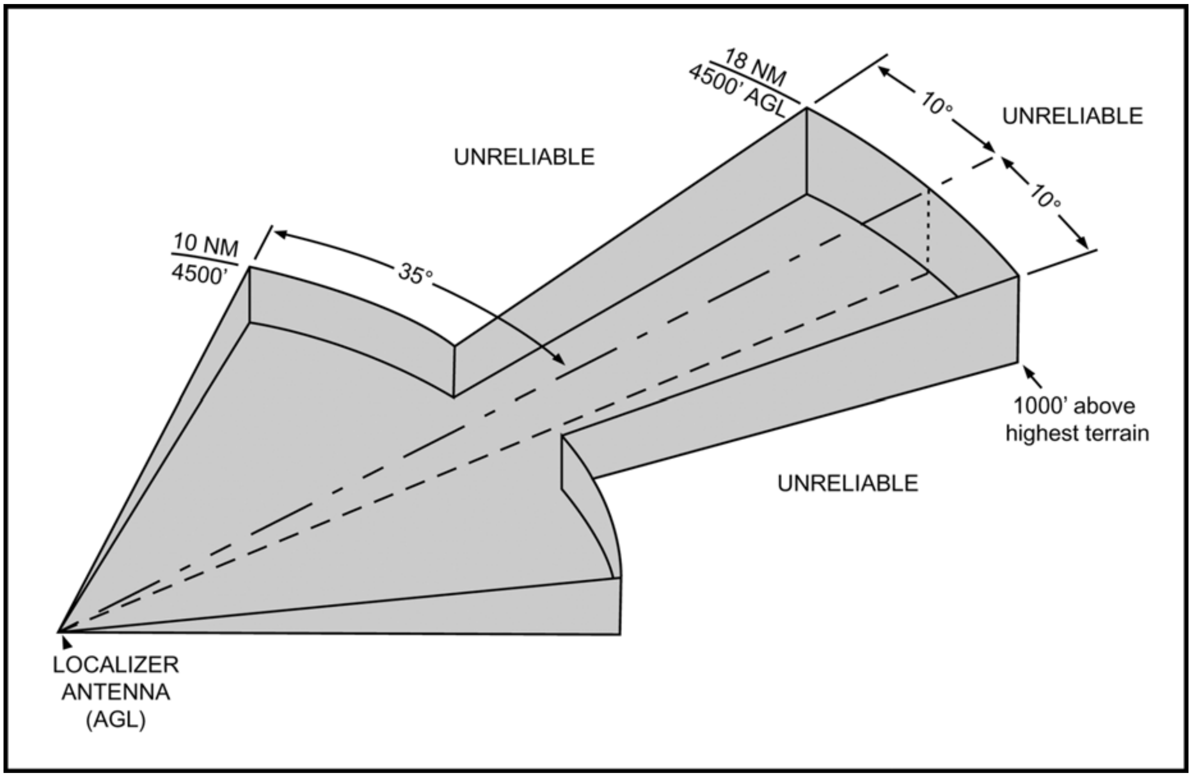
Figure 6.1. Standard ILS Characteristics and Terminology.



RATE OF DESCENT CHART (feet per minute)

Speed (Knots)	Angle 2.5°	2.75°	3°
90	400	440	475
110	485	535	585
130	575	630	690
150	665	730	795
160	707	778	849

Figure 6.2. Normal Localizer Signal Coverage.



6.7. Microwave Landing System (MLS).

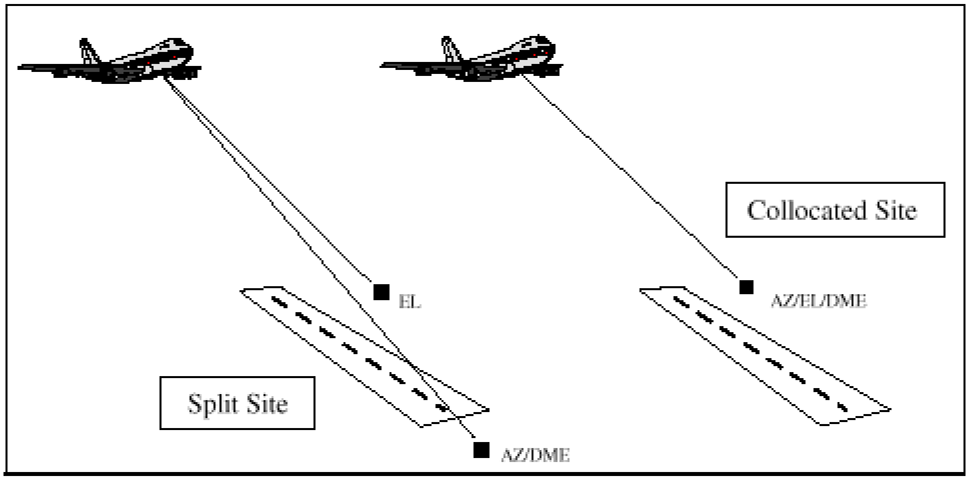
6.7.1. Description. The MLS provides precision navigation guidance for exact aircraft alignment and descent during an approach to a selected runway. It integrates azimuth (AZ), elevation angle (EL), and range (DME) information to provide precise aircraft positioning. The components of an MLS are similar to an ILS. Instead of a glide slope antenna, the MLS has an elevation station, and instead of a localizer antenna, it has an azimuth station. The MLS also has a precision DME (DME/P) transmitter. The DME/P signal is more accurate than traditional DME.

6.7.1.1. NOTE: An additional conventional-type DME source may be used to construct the instrument approach procedure; however, this DME is not considered to be a "system component."

6.7.2. Ground Equipment Location (Figure 6.3). MLS is normally installed in a configuration similar to ILS; however, it is possible, if necessary because of limited space, to install all of the components together. One example of this type of collocated configuration might be a hospital's heliport. In a standard airfield installation, the MLS azimuth transmitter is usually located between 1,000 and 1,500 feet beyond the departure end of the runway along the runway centerline. The elevation transmitter is normally located 400 feet from the runway centerline near the approach threshold. The DME, which provides range information, is collocated with the azimuth transmitter.

6.7.3. Displays. MLS displays are virtually identical to the ILS. Both lateral and vertical MLS guidance may be displayed on conventional course deviation indicators or incorporated into multipurpose cockpit displays. Range information can be displayed by conventional DME indicator or incorporated into multipurpose displays.

Figure 6.3. MLS Ground Facility Configurations.



6.7.3.1. NOTE: The USAF also has developed a Mobile Microwave Landing System (MMLS). MMLS components may be deployed in same configuration as a conventional MLS or the azimuth, elevation and DME transmitters may be collocated. MMLS operations are the same as the MLS unless otherwise noted in this manual or the aircraft tech order.

6.7.4. Approach Azimuth Guidance.

6.7.4.1. Azimuth Guidance. In addition to providing azimuth navigation guidance, the azimuth station also transmits basic data concerning the operation of the landing system and advisory data on the performance level of the ground equipment.

6.7.4.2. Azimuth Coverage Area (Figure 6.4). The limits of the azimuth coverage area are:

6.7.4.2.1. Laterally. Proportional coverage or clearance signal is normally ± 40° on either side of the runway. Actual coverage should be depicted on the instrument approach procedure. The coverage volume may be varied to eliminate multi-path effects caused by terrain or man-made obstructions.

6.7.4.2.2. Elevation. From the horizon (0°) up to an angle of 15° and up to at least 20,000 feet.

6.7.4.2.3. Range. To a distance of at least 20 NM (MMLS range is at least 15 NM).

Figure 6.4. Typical Azimuth Coverage Area

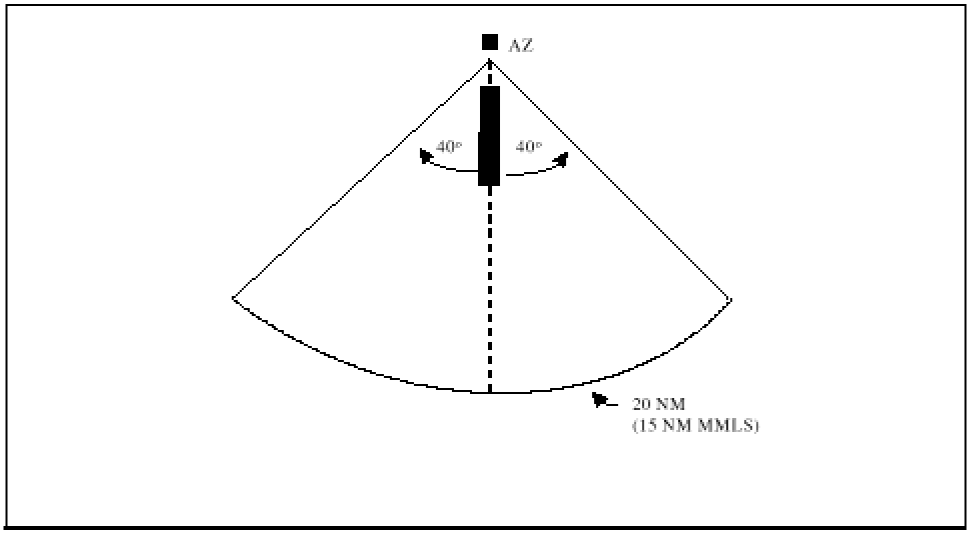
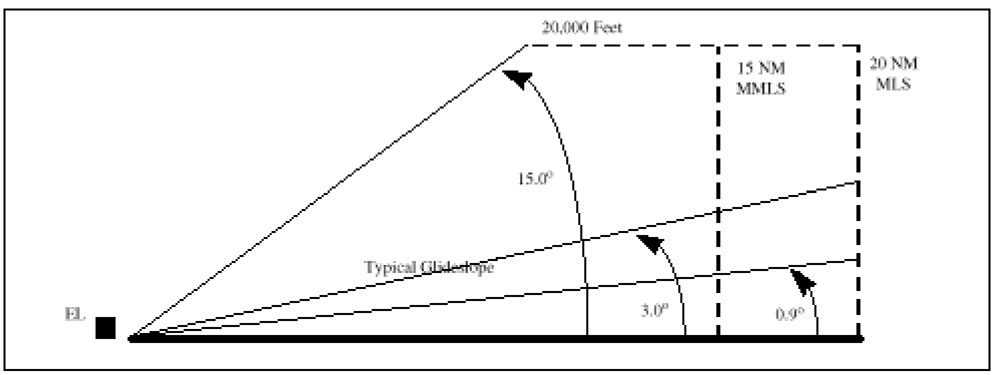


Figure 6.5. Elevation Coverage Area.



6.7.5. Elevation Guidance (Figure 6.5).

6.7.5.1. Elevation Station. The elevation station transmits its guidance signals on the same carrier frequency as the azimuth station.

6.7.5.2. Coverage. To a distance of at least 20 NM between 0.9 degrees and 15.0 degrees of elevation. (The MMLS range is at least 15 NM and the elevation is between 2.5 degrees and 15.0 degrees.)

6.7.6. MLS Precision Distance Measuring Equipment (DME/P). The MLS DME/P functions in the same way as the DME described in the TACAN section of this manual. DME/P accuracy within 7 NM of the station has been improved to be consistent with the accuracy provided by the MLS azimuth and elevation stations. The DME/P is an integral part of the MLS.

6.7.7. MLS Expansion Capabilities. The standard MLS configuration can be expanded by addition of one or more of the following functions:

6.7.7.1. Back Azimuth (BAZ). To provide lateral guidance for missed approach and departure navigation. (MMLS will not support back azimuth)

6.7.7.2. Auxiliary Data Transmissions. To provide additional data, including meteorological information, runway condition, and other supplementary information. This digitally transmitted data may be displayed on appropriately equipped aircraft.

6.7.7.3. Larger Coverage Area. Coverage area may be expanded up to 60 degrees for fixed-base MLS installations.

6.7.8. MLS Characteristics.

6.7.8.1. Accuracy. The MLS provides precision three-dimensional navigation guidance accurate enough for all approach and landing maneuvers.

6.7.8.2. Coverage. Precise navigation accuracy is provided throughout the coverage volumes.

6.7.8.3. Environment. The system has low susceptibility to interference from weather conditions and airport ground traffic.

6.7.8.4. Channels. MLS has 200 discrete channels. Normally, Air Force aircraft will use only even-numbered MLS channels. Even-numbered channels are paired with X- and Y-band DME stations; odd-numbered channels are paired with W- and Z-band DMEs.

6.7.8.5. Identification. MLS identification is via a four-letter system always beginning with the letter "M." The four-letter identifier is transmitted at least six times per minute by the approach azimuth (or BAZ) ground equipment. Some aircraft installations do not include the audible identification feature; in this case, observing the correct 4-letter identifier on the aircraft's avionics display can identify the MLS.

6.7.8.6. Data. The MLS transmits ground-air data messages associated with system operation including the MLS station identifier, glide path information, approach azimuth course, and AZ transmitter offset distance, if applicable.

6.7.8.7. Range Information. Continuous range information is provided to an accuracy of approximately 100 feet (within 7 NM of the station) if the aircraft's avionics includes DME/P capability. The range information is compatible with existing DME and TACAN avionics; however, the accuracy is downgraded to approximately 600 feet if using a standard DME receiver.

6.7.8.8. Operational Flexibility. The MLS can fulfill a variety of needs in the transition, approach, landing, missed approach and departure phases of flight. Some additional capabilities associated with MLS include curved and segmented approaches, selectable glide slope angles, accurate three-dimensional positioning of the aircraft in space, and the establishment of boundaries to ensure clearance from obstructions in the terminal area.

6.7.8.8.1. NOTE: While some of these capabilities are available to any MLS equipped aircraft, the more sophisticated capabilities, such as curved and segmented approaches, are dependent upon the capabilities of the aircraft's equipment. Refer to your aircraft flight manual for the specific capabilities of your MLS equipment.

6.7.9. Modes of Operation. There are two modes of operation for MLS approaches: automatic and manual.

6.7.9.1. Automatic Mode. The automatic mode of operation is the default mode and the preferred method of operation. When flying an MLS approach using the automatic mode, the approach's published azimuth and glide slope information is transmitted to your aircraft's MLS receiver.

6.7.9.1.1. See Chapter 14 for explanation of computed and non-computed MLS approaches.

6.7.9.2. Manual Mode. Some MLS receivers will also permit you to fly approaches in the manual mode. In the manual mode, you may change the azimuth and/or glide slope angle of the MLS approach.

6.7.9.2.1. WARNING: If operating in manual mode and the pilot selects a course and/or glide slope different from the published procedure, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance.

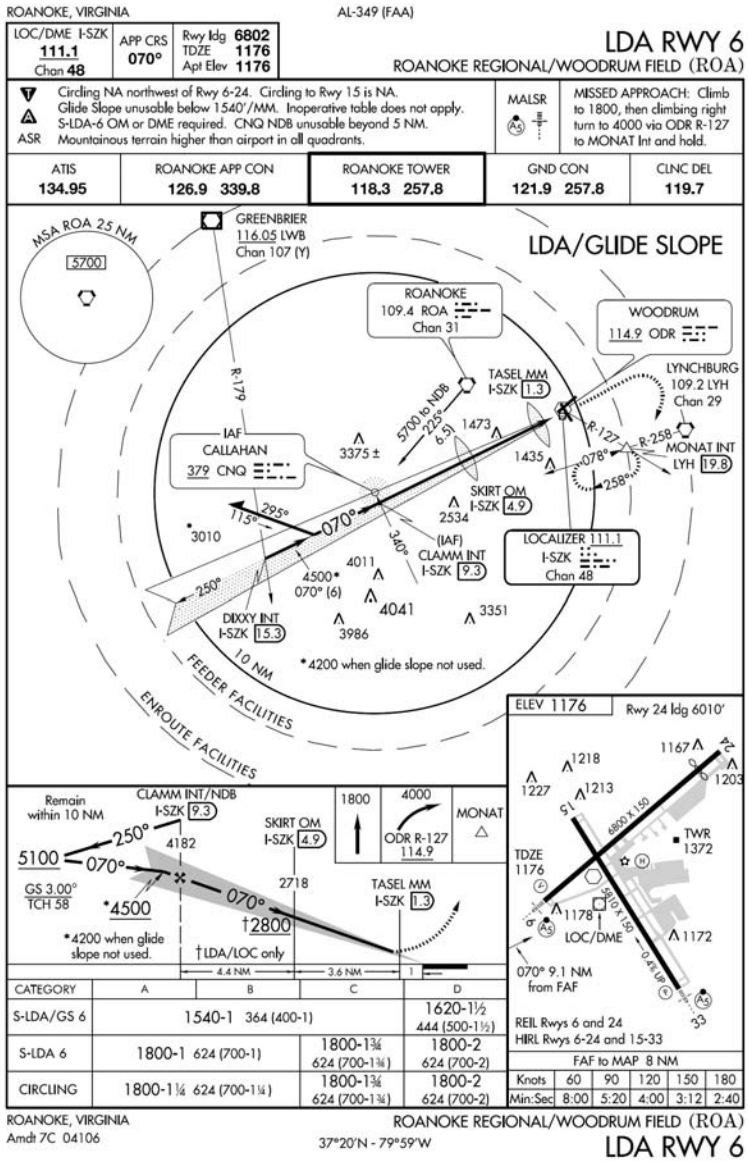
6.8. Marker Beacon (Figure 6.1). Marker beacons serve to identify a particular location in space on the approach to an instrument runway. This is done by means of a 75-MHz transmitter that transmits a directional signal to be received by aircraft flying overhead. These markers are generally used in conjunction with en route NAVAIDs and ILS as point designators.

6.9. Localizer Type Directional Aid (LDA). The LDA is of comparable utility and accuracy to a localizer but is not always aligned with the centerline of the runway. TERPS requires the Localizer (LOC) signal alignment within 3° of the runway alignment. If the alignment exceeds 3°, the LOC will be identified as an LDA. Once designated as an LDA, the maximum angle of convergence of the final approach course and the extended runway centerline is 30°**.** The signal accuracy of the LDA is the same as a LOC, however the LDA course alignment will be greater than 3°**,** not to exceed 30°. Straight-in minima can be published only where alignment conforms to the straight-in criteria specified in AFJMAN 11-226 (TERPS). Circling minima are published where this alignment exceeds straight-in criteria. The LDA is usually considered a non-precision approach; however, in some installations with a glide slope, a decision height will be published. If a decision height is published, it can be flown just like an ILS approach.

6.9.1. Localizer (LLZ). In International Civil Aviation Organization (ICAO) Procedures for Air Navigation Services-Aircraft Operations (PANS-OPS) abbreviates the localizer facility as LLZ. The accuracy of the signal generated by the LLZ is the same as a LOC. PANS-OPS normally requires the LLZ final approach track alignment to remain within 5° of the runway centerline. However, in certain cases, the alignment can exceed 5°. Where required, PANS-OPS allows an increase of the final approach track to 15° for categories C, D, and E. For aircraft categories A and B, the maximum angle formed by the final approach track and the runway centerline is 30°.

6.9.1.1. NOTE: Prior to flying a LDA or LLZ, compare the final approach course with the runway heading. The airdrome sketch should provide a visual indication of the angle formed between the final approach track and the runway centerline.

Figure 6.6. LDA With Glide Slope.



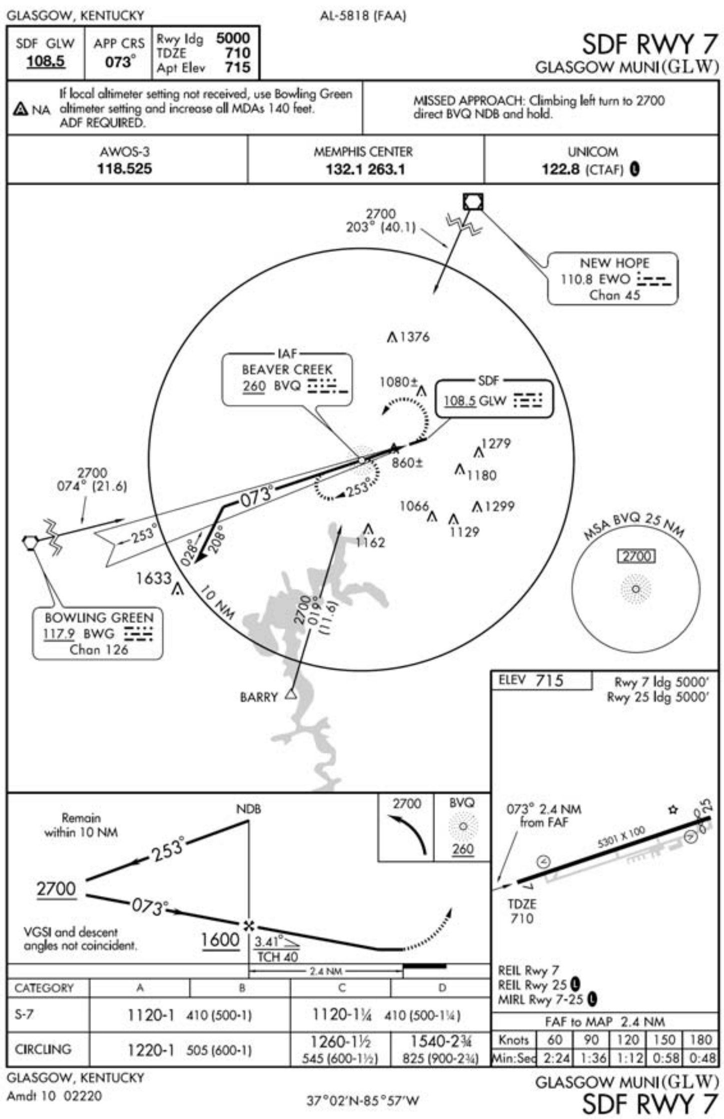
6.10. Simplified Directional Facility (SDF).

6.10.1. SDF. The SDF provides a final approach course that is similar to that of the ILS localizer and LDA. However, the SDF may have a wider course width of 6° or 12°. It does not provide glide slope information. A clear understanding of the ILS localizer and the additional factors listed below completely describe the operational characteristics and use of the SDF.

6.10.1.1. For the pilot, the approach techniques and procedures used in the performance of an SDF instrument approach are essentially identical to those used in executing a standard no glide slope localizer approach except that the SDF course may not be aligned with the runway and the course may be wider, resulting in less precision.

6.10.2. Frequencies. The SDF transmits signals within the range of 108.10 MHz to 111.95 MHz.

Figure 6.7. SDF Approach.



6.11. Nondirectional Radio Beacon (NDB).

6.11.1. Frequencies. NDB is a low, or medium, or ultra high frequency radio beacon that transmits nondirectional signals whereby an aircraft properly equipped can automatically determine and display bearing to any radio station within its frequency and sensitivity range. These facilities normally operate on frequencies between 190 and 1750 kHz or 275-287 MHz and transmit a continuous carrier keyed to provide identification except during voice transmission.

6.11.2. Compass Locator. When a radio beacon is used in conjunction with the ILS markers, it is called a "compass locator." Sometimes the low-powered NDB [i.e. compass locator] will be a stand alone NAVAID with limited range (usually less than 15 miles). These locators may be identified by an “L” and the use of the two-digit identifier.

6.11.3. Identification. Most radio beacons within the U.S. transmit a continuous three-letter identifier. A two-letter identifier is normally used in conjunction with an ILS. Some NDBs have only a one-letter identifier. Outside of the contiguous U.S., one, two, or three-letter identifiers are transmitted; for example, BB.

6.11.4. Voice Transmissions. Voice transmissions can be made on radio beacons unless the letter "W" (without voice) is included in the class designator (HW).

6.11.5. Disturbances. Radio beacons are subject to disturbances that may result in erroneous bearing information. Such disturbances result from intermittent or unpredictable signal propagation due to such factors as lightning, precipitation, static, etc. At night, radio beacons are vulnerable to interference from distant stations. Nearly all disturbances that affect the ADF bearing also affect the facility's identification. Noisy identification usually occurs when the ADF needle is erratic. Voice, music, or erroneous identification will usually be heard when a steady false bearing is being displayed.

6.11.5.1. WARNING: Since ADF receivers do not have a "flag" to warn the pilot when erroneous bearing information is being displayed, the pilot must continuously monitor the NDBs identification.

6.11.6. Control Panels. There are several different types of control panels currently installed in our operational aircraft. Refer to your aircraft technical manual for specific guidance pertaining to equipment operation and its limitations.

6.11.6.1. NOTE*:* ADF course intercept procedures are basically the same as those used in VOR/RMI-only procedures.

6.12. Global Positioning System (GPS).

6.12.1. GPS Capabilities.

6.12.1.1. Spaced Based System. GPS is a space based navigation system that has the capability to provide highly accurate three-dimensional position, velocity, and time to an infinite number of equipped users anywhere on or near the Earth (Figure 6.8). The typical GPS integrated system will provide: position, velocity, time, altitude, steering information, groundspeed and ground track error, heading, and variation. GPS also provides a constant monitor of system status and accuracy, and the built-in test circuitry provides self-tests that diagnose most system failures. The airborne GPS receiver may accept inputs from other aircraft systems, such as INS, altimeter, central air data computer (CADC), attitude gyro, and compass systems that improve GPS accuracy and reliability. GPS may also be integrated into a multi-sensor navigation system combining GPS information with other sources such as an Inertial Reference Unit (IRU) or DME/DME Area Navigation (RNAV) equipment.

6.12.1.2. Position Determination. GPS position determination is based on the concept of ranging and triangulation from a group of satellites in space acting as precise reference points. A GPS receiver measures distance from a satellite using the travel time of a radio signal. Each satellite transmits a specific code, called a coarse acquisition (C/A) code, which contains information on the satellite's position, the GPS system time, and the health and accuracy of the transmitted data. Knowing the speed at which the signal traveled (approximately 186,000 miles per second) and the exact broadcast time, the distance traveled by the signal can be computed from the arrival time. The distance derived from this method of computing distance is called a psuedo-range because it is not a direct measure of distance, but is based instead on timing. Psuedo-range is subject to several error sources including ionospheric and tropospheric delays and multipath (signal echoes and bounces). Using the calculated psuedo-range information supplied by the satellite, the GPS receiver mathematically determines its position by triangulation. The GPS receiver needs at least four satellites to yield a three-dimensional position and time solution. The GPS receiver can use data from any satellite that is above its mask angle (the lowest angle above the horizon at which a satellite is usable).

6.12.1.3. Levels Of Service. GPS provides two levels of service: Standard Positioning Service (SPS) and Precise Positioning Service (PPS). SPS is based on the C/A data and provides, to all users, a horizontal and vertical signal-in-space positioning accuracy standard of 13 meters and 22 meters, respectively, with a probability of 95 percent. PPS is based on an encrypted Precision (P) code transmitted over two frequencies (L1 and L2) as a P (Y) code which can only be received by military GPS receivers with a valid crypto key inserted and is accurate to within 9 meters.

6.12.1.3.1. CAUTION: Although these are the accuracy standards, there are many factors that influence the accuracy of the GPS signal (ex. atmospheric conditions, satellite geometry, receiver equipment, etc.) at any given time and place. At a specific time, users may experience lesser accuracy that those listed.

6.12.2. Description. The GPS is composed of three major segments: space, control, and user.

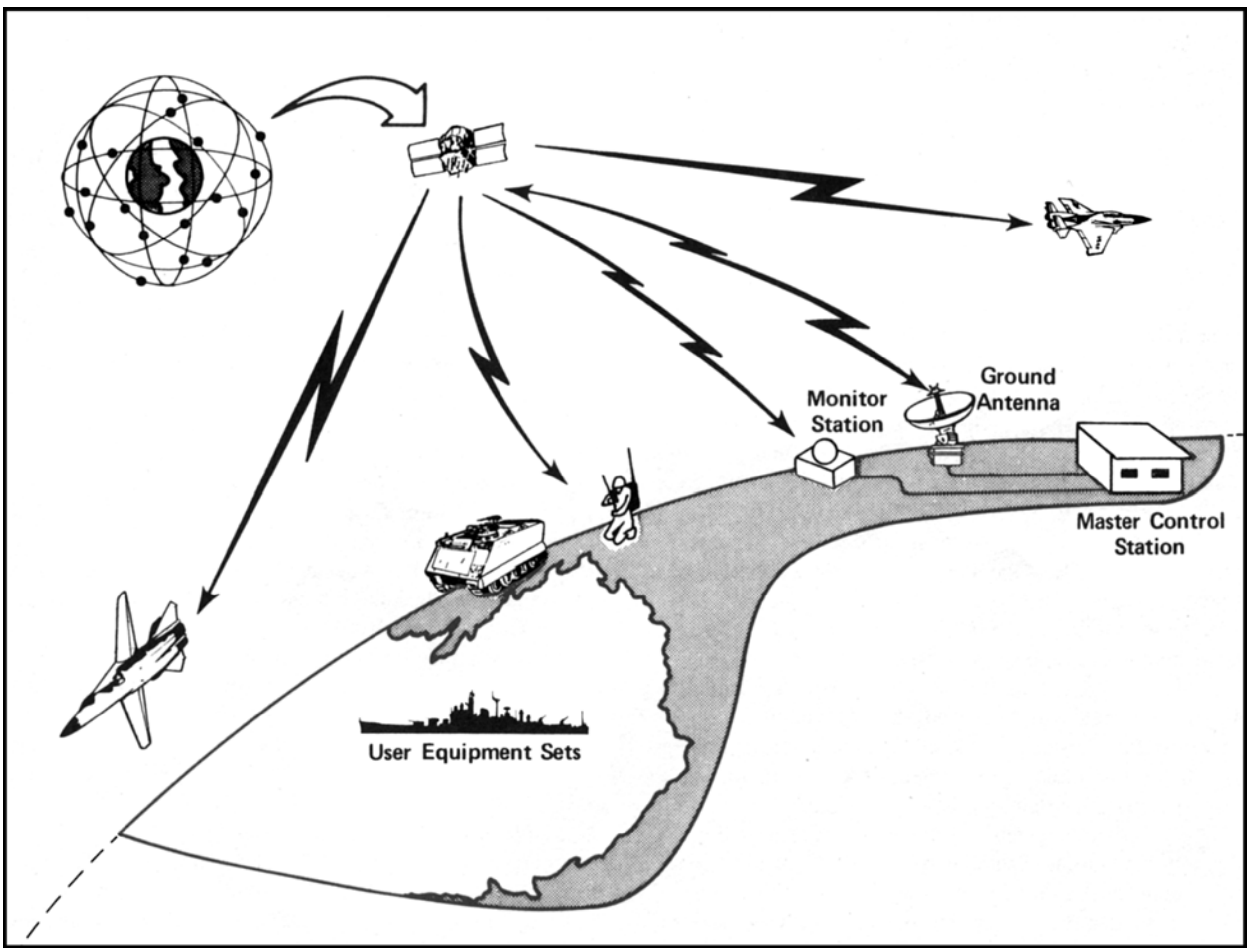
6.12.2.1. Space Segment. The GPS space segment is composed of 24 active satellites, which orbit at approximately 11,000 miles with an orbital period of 12 hours. Several spare satellites are also in orbit to replace older or malfunctioning satellites. Each satellite is uniquely identified by its own Satellite Vehicle Number (SVN), but is usually referred to by the Psuedo Random Noise (PRN) number assigned to its position in the GPS constellation. The presence of spare satellites in orbit results in PRN numbers greater than 24. The constellation consists of six orbital planes, spaced 60 degrees apart with an inclination of 55 degrees. It is designed so that between 5 and 8 satellites should be visible at any one time anywhere on earth.

6.12.2.2. Control Segment. The control segment consists of five monitor stations and four ground antennas located throughout the world. The monitor stations use a GPS receiver to passively track all satellites in view and accumulate ranging data from the satellite signals. The Master Control Station (MCS) processes data from the monitor stations in order to determine satellite clock and orbit states and update the navigation message of each satellite. This updated information is uploaded via ground antennas, which are also used for transmitting satellite control information and receiving health and control information.

6.12.2.3. User Segment (User Equipment - UE). The GPS user segment consists of a variety of configurations and integration architectures that include an antenna and receiver-processor to receive and compute navigation solutions to provide positioning, velocity, and precise timing to the user.

6.12.3. Signal Characteristics. Each satellite transmits three separate spectrum signals on two L-band frequencies, L1 (1575.42 MHz) and L2 (1227.6 MHz). L1 carries the P (Y) code and C/A code; L2 carries only the P (Y) code. The P (Y) code is normally encrypted and is also known as PPS, while C/A code is unencrypted and is known as the SPS. Only authorized users with cryptographic equipment and keys and specially equipped receivers may use PPS. The navigation data contained in the GPS signal are composed of satellite clock and ephemeris data for the transmitting satellite plus GPS constellation almanac data, GPS to UTC time offset information, and ionospheric propagation delay correction parameters for single frequency users. The entire navigation message repeats every 12.5 minutes. Within this 12.5 minutes, satellite clock and ephemeris data are sent 25 separate times so they repeat every 30 seconds.

Figure 6.8. GPS.



6.12.4. Integrated Systems. Although GPS is designed to replace some navigation equipment, the way it is integrated into the navigation system will depend on the mission of the aircraft. GPS can greatly enhance the performance of an INS. The INS in turn increases the usefulness of GPS equipment. INS has the ability to accurately measure changes in position and velocity over short periods of time using no external signal; however, errors are cumulative and increase with time. GPS can provide a continual position update that allows the INS to calculate error trends and improve its accuracy as time increases. The INS aids the GPS receiver by improving GPS anti-jam performance. When GPS is not available (due to mountain shadowing of satellites, jamming, or high dynamic maneuvers), this improved INS will provide the integrated navigation system with accurate position information until the satellites are in view or the jamming is over. An added advantage is that GPS provides an in-flight alignment capability for the INS.

6.12.4.1. Wide Area Augmentation System (WAAS). WAAS augments the basic GPS signal for IFR use from takeoff through Category I precision approach. This system improves the accuracy, availability, and integrity provided by GPS, thereby improving capacity and safety.

6.12.4.1.1. System Description. Unlike traditional ground-based navigation aids, the WAAS covers a more extensive service area. Wide-area ground reference stations (WRS) are linked to form a U.S. WAAS network. These precisely surveyed ground reference stations receive signals from GPS satellites and any errors in the signals are then determined. Each station in the network relays the data to a wide-area master station (WMS) where correction information for specific geographical areas is computed. A correction message is prepared and uplinked to a geostationary satellite (GEO) via a ground uplink station (GUS). The current WAAS site installation consists of 25 WRSs, 2 WMSs, 4 GUSs, and the required terrestrial communications to support the WAAS network. The message is then broadcast on the same frequency as GPS (L1, 1575.42 MHz) to WAAS receivers within the broadcast coverage area of the WAAS. The WAAS broadcast message improves the GPS 95 percent signal accuracy from 100 meters to approximately 7 meters.

6.12.4.1.2. Planned Expansion. Planned expansion of the U.S. ground-station network will include Canada, Iceland, Mexico, and Panama, and has the potential to expand to other countries as well. Additionally, Japan and Europe are building similar systems that are planned to be interoperable with the U.S. WAAS. The merging of these systems will create a worldwide seamless navigation capability similar to GPS, but with greater accuracy, availability and integrity.

6.13. Inertial Navigation System (INS).

6.13.1. Description. The INS is a primary source of groundspeed, attitude, heading, and navigation information. A basic system consists of acceleration sensors mounted on a gyro stabilized, gimbaled platform, a computer unit to process raw data and maintain present position, and a control display unit (CDU) for data input and monitoring. It allows the aircrew to selectively monitor a wide range of data, define a series of courses, and update present position. The INS operates solely by sensing the movement of the aircraft. Its accuracy is theoretically unlimited and affected only by technology and manufacturing precision. Since it neither transmits nor receives any signal, it is unaffected by electronic countermeasures or weather conditions. The INS can also supply data to many other aircraft systems.

6.13.2. Operation. Before an INS can be used, it must be aligned. During alignment, present position coordinates are inserted manually while the INS derives local level and true north. This operation must be completed before moving the aircraft. If alignment is lost in flight, navigation data may be lost, but, in some cases, attitude and heading information may still be used. Coordinate or radial and distance information describing points that define the route of flight are inserted as needed through the CDU. For complete operation procedures of any specific INS, consult the appropriate aircraft technical order.

Chapter 7

NAVIGATION TECHNIQUES AND PROCEDURES

7.1. Application. Instrument procedures are flown using a combination of the techniques described in this chapter (arc to radial, radial to arc, course intercepts, etc.). Individual aircraft flight manuals should provide proper procedures for using the navigation equipment installed. The following discussions apply to ground-based radio aids to navigation only. For a discussion on RNAV and GPS procedures, see paragraphs 7.11 and 7.12.

7.1.1. ***Where procedures depict a ground track, the pilot is expected to correct for known wind conditions. In general, the only time wind correction should not be applied is during radar vectors***. The following general procedures apply to all aircraft.

7.1.1.1. Unless otherwise authorized by ATC, no person may operate an aircraft within controlled airspace under IFR except as follows:

7.1.1.1.1. ***On a Federal airway, along the centerline of that airway.***

7.1.1.1.2***. On any other route, along the direct course between the navigational aids or fixes defining that route. However, this section does not prohibit maneuvering the aircraft to pass well clear of other air traffic or the maneuvering of the aircraft in VFR conditions to clear the intended flight path both before and during climb or descent.***

7.1.2. ***Tune***. Tune to or select the desired frequency or channel.

7.1.3. ***Identify***. Positively identify the selected station via an aural or visual signal. Through human error or equipment malfunction, it is possible that the station intended is not the one being received. This may occur as the result of failing to select the correct frequency or failure of the receiver to channelize to the new frequency. Insure you correctly interpret the Morse code letters being transmitted.

7.1.3.1. For aircraft with the capability to translate Morse code station identification into an alphanumeric visual display, it is acceptable to use the visual display as the sole means of identifying the station identification provided:

7.1.3.1.1. The alphanumeric visual display must always be in view of the pilot; and

7.1.3.1.2. Loss of the Morse code station identification will cause the alphanumeric visual display to immediately disappear, or a warning to be displayed.

7.1.3.1.2.1. WARNING: It is imperative that crews are cognizant of what station identification is being displayed. For example, if the station identification being displayed is from the DME portion of a VOR/DME station, then only the DME alphanumeric display may be used. The VOR azimuth station identification must still be identified aurally.

7.1.3.1.2.2. WARNING: Voice communication is possible on VOR, ILS, and

ADF frequencies. The only positive method of identifying a station is by its Morse code identifier (either aurally or alphanumeric display) or the recorded automatic voice identification, indicated by the word "VOR" following the station name. Listening to other voice transmissions by a Flight Service Station or other facility (ex. Transcribed Weather Broadcast (TWEB)) is not a reliable method of station identification and shall not be used. Consult FLIP documents to determine the availability of specific stations.

7.1.3.1.2.3. MAJCOMs will determine which aircraft can use this method for identifying NAVAIDS.

7.1.3.2. VOR. The station identification may be a repeated three-letter Morse code group, or a three-letter Morse code group alternating with a recorded voice identifier.

7.1.3.3. TACAN. The TACAN station transmits an aural three-letter Morse code identifier approximately every 35 seconds.

7.1.3.4. NDB/ADF. The nondirectional radio beacon transmits a repeated two or three-letter Morse code group depending on power output.

7.1.3.4.1. NOTE: The ground station portion of the nondirectional radio beacon is known as the Non-directional Beacon (NDB). The airborne receiver is known as the Automatic Direction Finder (ADF).

7.1.3.4.2**.** NOTE: When possible, use a non-directional radio beacon. Commercial broadcasting stations should be used with caution because some have highly directional radiation patterns. Additionally, they are not flight-checked for use in navigation. Positive identification of the commercial station being used is imperative.

7.1.3.5. ILS. The ILS localizer transmitter puts out a repeated four-letter Morse code group. In the US, the first letter of the identifier is always "I" to denote the facility as an ILS.

7.1.4. ***Monitor.*** Monitor station identification to ensure a reliable signal is being transmitted. Removal of identification serves as a warning to pilots that the facility is officially off the air for tune-up or repairs and may be unreliable even though intermittent or constant signals are received. ***The navigation signal must be considered unreliable when the station identifier is not being received.*** There are two methods for monitoring station identification (listed in no particular order).

7.1.4.1. The first method is the traditional aural Morse code identifier. All VOR, TACAN, VORTAC, NDB, and ILS transmitters transmit this. If this is the method selected to monitor the station, then it must be monitored while using it for navigation. Insure you correctly interpret the Morse code letters being transmitted.

7.1.4.2. The second method applies to aircraft with the capability to translate Morse code station identification into an alphanumeric visual display. For these aircraft it is acceptable to use the visual display as the sole means of monitoring the station identification provided:

7.1.4.2.1. The alphanumeric visual display must always be in view of the pilot; and

7.1.4.2.2. Loss of the Morse code station identification will immediately cause the alphanumeric visual display to disappear, or a warning to be displayed.

7.1.4.2.2.1. WARNING: It is imperative that crews are cognizant of what station identification is being displayed. For example, if the station identification being displayed is from the DME portion of a VOR/DME station, then only the DME alphanumeric display may be used. The VOR azimuth station identification must still be monitored aurally.

7.1.4.2.2.2. WARNING*:* Voice communication is possible on VOR, ILS, and ADF frequencies. The only positive method of identifying a station is by its Morse code identifier (either aurally or alphanumeric display) or the recorded automatic voice identification, indicated by the word "VOR" following the station name. Listening to other voice transmissions by a Flight Service Station or other facility (ex. (TWEB)) is not a reliable method of station identification and shall not be used. Consult FLIP documents to determine the availability of specific stations.

7.1.4.2.2.3. MAJCOMs will determine which aircraft can use this method to monitor NAVAIDS.

7.1.5. ***Select***. Select proper position for the navigation system switches.

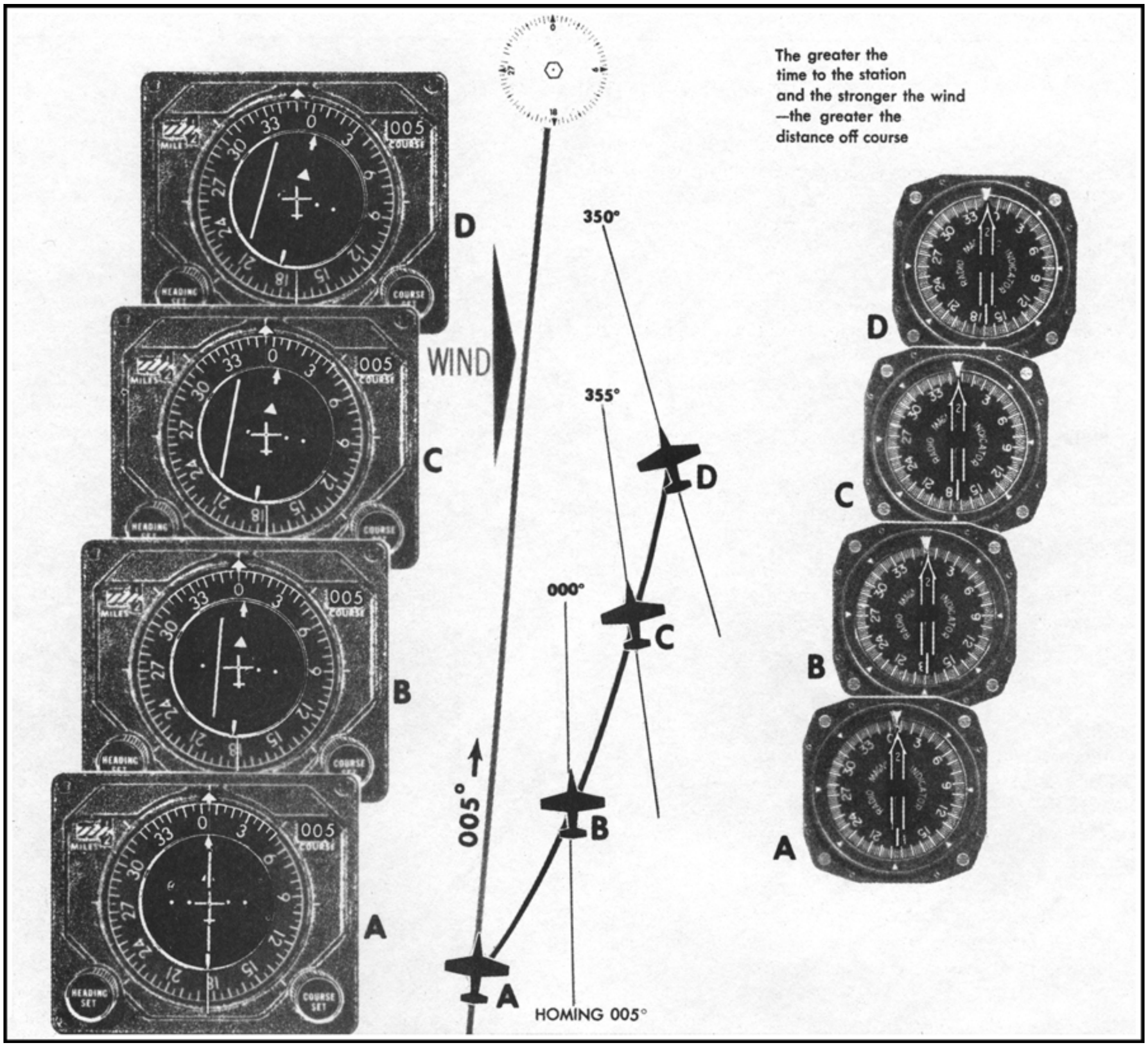
7.1.6. ***Set***. Set the selector switches to display the desired information on the navigation instruments.

7.1.7. ***Monitor***. Monitor the course warning flag (if installed) and, the aural or alphanumeric display continuously to ensure adequate signal reception strength.

7.1.8. ***Check***. Check the appropriate instrument indicators for proper operation.

7.2. Homing to a Station. ***Tune and identify the station***. Turn the aircraft in the shorter direction to place the head of the bearing pointer under the top index of the RMI/BDHI or upper lubber line of the HSI. Adjust aircraft heading, as necessary, to keep the bearing pointer under the top index or upper lubber line. Since homing does not incorporate wind drift correction, in a crosswind the aircraft follows a curved path to the station (Figure 7.1). Therefore, ***homing should be used only in the event maintaining course is not required***.

Figure 7.1. Curved Flight Path as a Result of Homing with a Crosswind.



7.3. Proceeding Direct to a Station (Figure 7.2).

7.3.1. Proceeding Direct. When proceeding direct to a station, the following applies:

7.3.1.1. ***Tune and Identify the Station***.

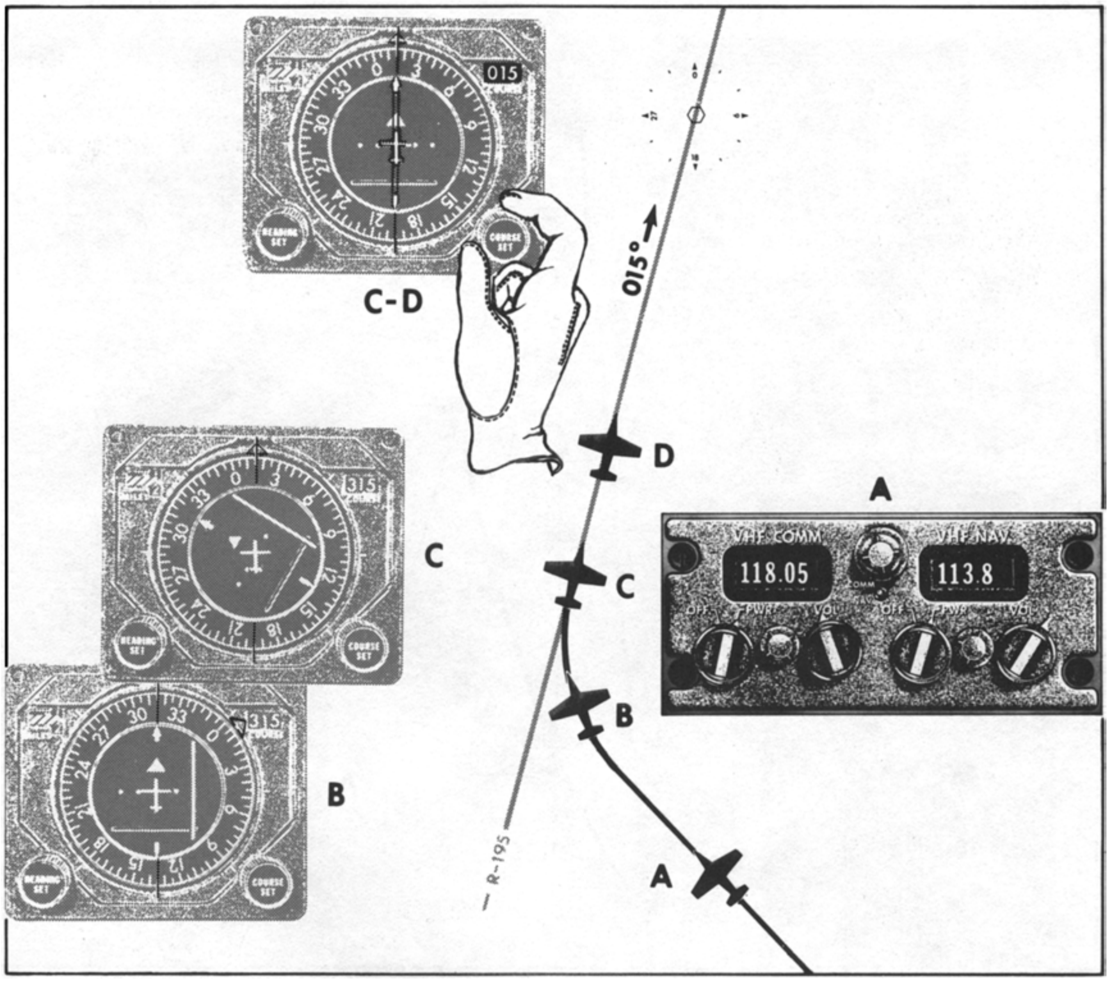
7.3.1.2. ***Turn***. Turn the aircraft in the shorter direction to place the head of the bearing pointer under the top index or upper lubber line.

7.3.1.3. ***Center the CDI***. Center the CDI with a TO indication (does not apply to RMI only).

7.3.1.4. ***Maintain Course***. Maintain the selected course to the station. (Correct for winds.)

7.3.1.5. Inoperative Procedures. If either the compass card or the bearing pointer is inoperative, a course indicator or HSI may be used to determine the bearing to the station by rotating the course set knob until the CDI centers and "TO" is read in the "TO-FROM" indicator. The magnetic bearing from the aircraft to the station then appears in the course selector window. Until verified by radar or other navigation equipment, consider this bearing information unreliable.

Figure 7.2. Proceeding Direct to Station.



7.4. Course Intercepts.

7.4.1. Successful Course Interception. Course interceptions are performed in many phases of instrument navigation. ***To ensure successful course interception, an intercept heading must be used that results in an angle or rate of intercept sufficient to complete a particular intercept problem***.

7.4.1.1. Intercept Heading. The intercept heading (aircraft heading) is the heading determined to solve an intercept problem. When selecting an intercept heading, the essential factor is the relationship between distance from the station and the number of degrees the aircraft is displaced from the course. Adjustments to the intercept heading may be necessary to achieve a more desirable rate of intercept.

7.4.1.1.1. A technique for determining intercept headings is:

7.4.1.1.1.1. Inbound: From the desired course, look in the shorter direction to the head of the bearing pointer. Continue beyond the head of the bearing pointer by 30 degrees or the number of degrees off course, whichever is less. This will give a recommended intercept angle of 30 degrees or less. Any heading beyond the bearing pointer, within 90° of the desired inbound course, is a no-wind intercept heading.

7.4.1.1.1.2. Outbound: From the tail of the bearing pointer, move in the shorter direction to the desired course. Continue beyond the course by 45 degrees, or the number of degrees off course, whichever is less. This will give the recommended intercept angle of 45 degrees or less. Any heading beyond the desired course, within 90°, is a no-wind intercept heading.

7.4.1.2. Angle of Intercept. The angle of intercept is the angular difference between the heading of the aircraft (intercept heading) and the desired course. The minimum acceptable angle of intercept for an inbound course interception must be greater than the number of degrees the aircraft is displaced from the desired course. The angle of intercept should not exceed 90°.

7.4.1.3. Rate of Intercept. The rate of intercept is determined by observing bearing pointer and CDI movement. The rate of intercept is a result of intercept angle, groundspeed, distance from the station, and if you are proceeding to or from the station.

7.4.1.4. Completing the Intercept.

7.4.1.4.1. Lead point. ***A lead point to roll out on the course must be determined*** because of turn radius of the aircraft. The lead point is determined by comparing bearing pointer or CDI movement with the time required to turn to course. Refer to AFMAN 11-217, Volume 3 *Supplemental Procedures*, for techniques to determine a lead point.

7.4.1.4.2. Rate of intercept. To determine the rate of intercept, monitor the bearing pointer or CDI movement.

7.4.1.4.3. Turn. The time required to make the turn to course is determined by the intercept angle and the aircraft turn rate.

7.4.1.4.4. Complete the intercept. Use the CDI, when available, for completing the course intercept.

7.4.1.4.5. Undershoot or Overshoot. If it is obvious that the selected lead point will result in undershooting the desired course, either reduce the angle of bank or roll out of the turn and resume the intercept. If the selected lead point results in an overshoot, continue the turn and roll out with a correction back to the course.

7.4.1.4.6. Maintain course. The aircraft is considered to be maintaining the course centerline when the CDI is centered or the bearing pointer points to the desired course. A correction for known winds should be applied when completing the turn to a course.

7.4.1.4.7. NOTE: ***Pilots should always attempt to fly as close to the course centerline as possible.*** TERPS design criteria will provide maximum obstacle clearance protection when the course centerline is maintained.

7.4.2. In-bound (CI and RMI; HSI) (Figure 7.3).

7.4.2.1. ***Tune and identify the station***.

7.4.2.2. ***Set inbound course***. Set the desired inbound course in the course selector window and check for a TO indication.

7.4.2.3. ***Turn***. Turn to an intercept heading.

7.4.2.3.1. CI and RMI. Turn in the shorter direction to place the heading pointer toward the CDI. Continue the turn to place the heading pointer in the top half of the instrument case. This precludes an intercept angle in excess of 90°. Roll out with the RMI/BDHI bearing pointer between the desired inbound course and top index. The angle of intercept must be greater than the number of degrees off course, not to exceed 90°. The intercept heading may be adjusted within these limits to achieve the most desirable rate of intercept. Displacing the bearing pointer approximately 30° from the top index will normally ensure a moderate rate of intercept.

Figure 7.3. Inbound Course Interceptions (CI and RMI; HSI).

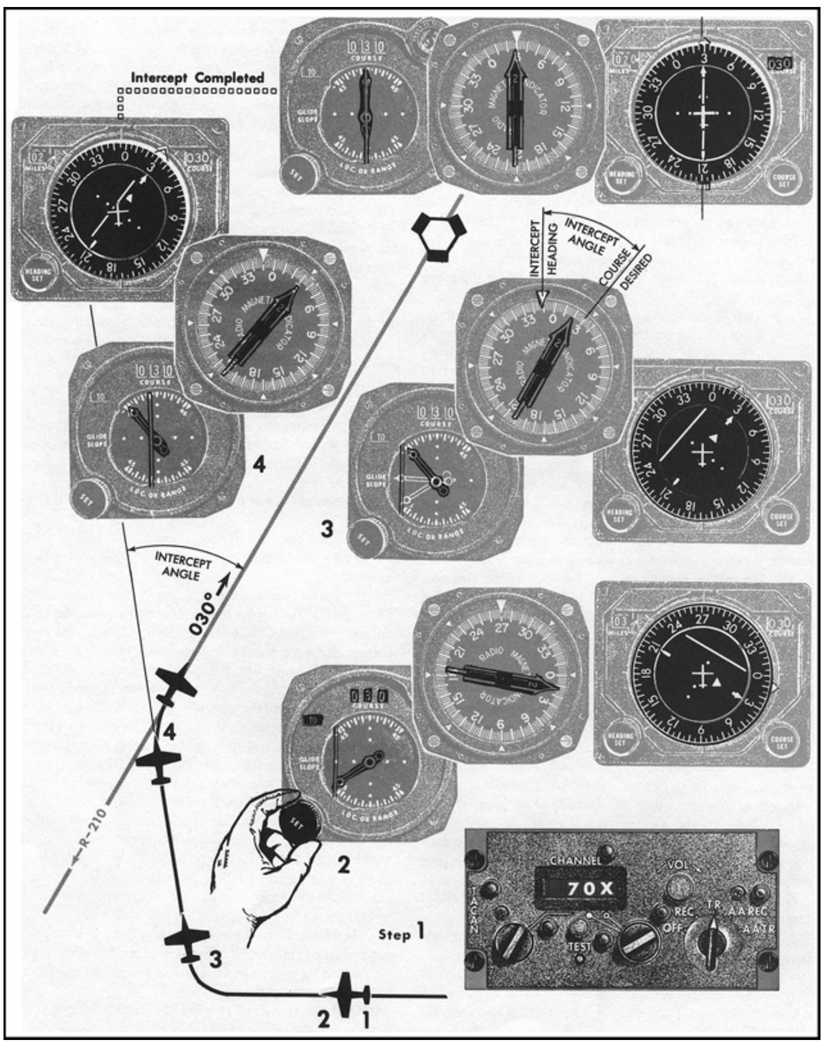
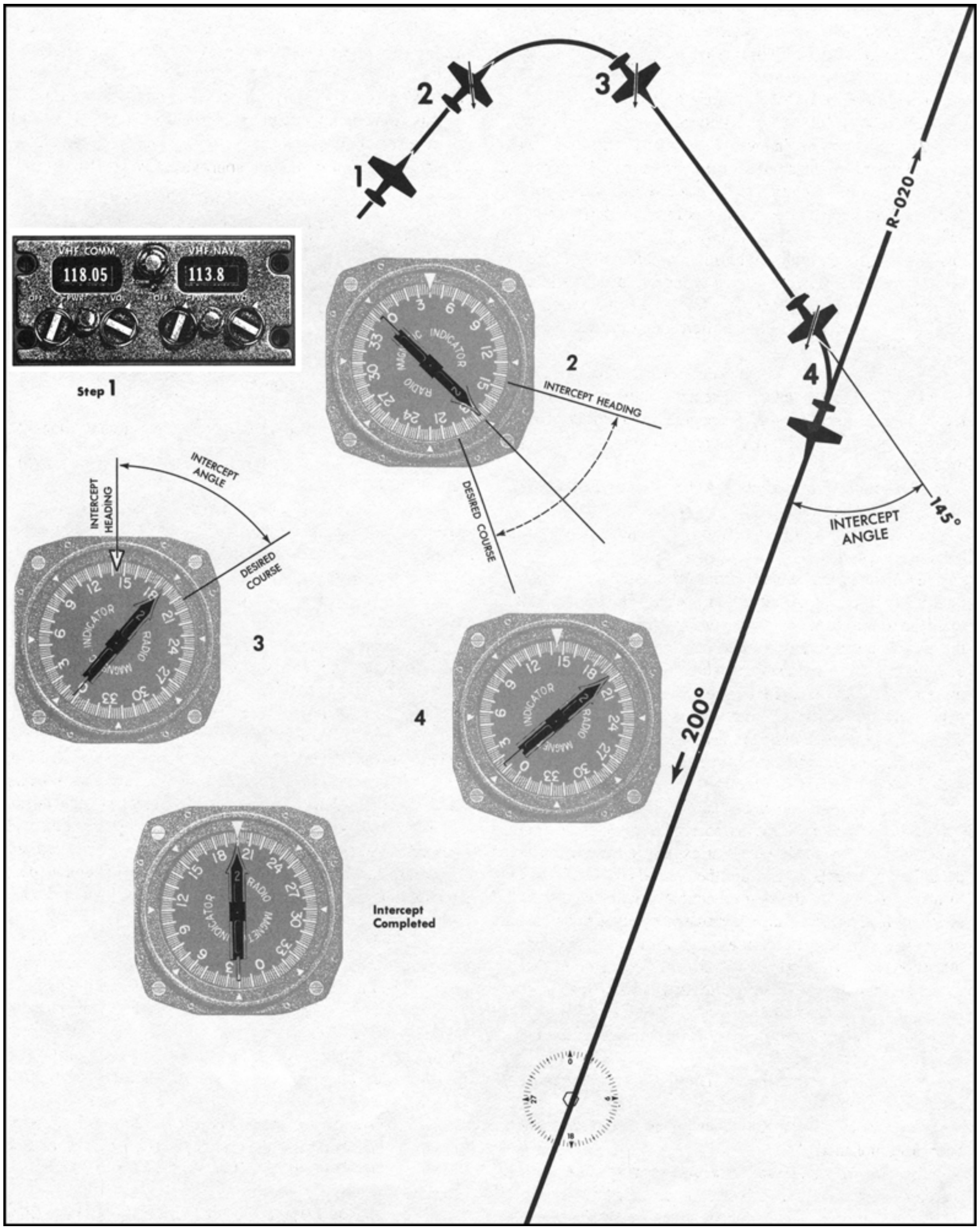


Figure 7.4. Inbound Course Interceptions (RMI Only).



7.4.2.3.2. HSI. Turn in the shorter direction toward the CDI. The shorter direction is displayed by the aircraft symbol and CDI relationship. Continue the turn to place the head of the course arrow in the top half of the instrument case. This precludes an intercept angle in excess of 90°. Roll out of the turn when the bearing pointer is between the upper lubber line and the head of the course arrow to establish an intercept heading. Displacing the bearing pointer 30° from the upper lubber line will normally ensure a moderate rate of intercept. The aircraft symbol will appear to be proceeding toward the CDI at an intercept angle equal to the angle formed between the upper lubber line and the head of the course arrow. The angle of intercept must be greater than the number of degrees off course, but not more than 90°.

7.4.2.4. ***Maintain intercept***. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on bearing pointer or CDI rate of movement and the time required to turn on course.

7.4.3. Inbound (RMI Only) (Figure 7.4).

7.4.3.1. ***Tune and identify***. Tune and identify the station.

7.4.3.2. ***Determine heading***. Determine an intercept heading. Locate the desired inbound course on the compass card. From the desired course, look in the shorter direction to the head of the bearing pointer. Any heading beyond the bearing pointer, within 90° of the desired inbound course, is a no-wind intercept heading. In many instances, an intercept heading selected 30° beyond the bearing pointer ensures a rate of intercept sufficient to solve the problem. An intercept angle is formed when the head of the bearing pointer is between the desired course and the top index on the RMI.

7.4.3.3. ***Turn***. Turn in the shorter direction to the intercept heading.

7.4.3.4. ***Maintain intercept***. Maintain the intercept heading until a lead point is reached, then complete the intercept. Lead point depends on bearing pointer rate of movement and the time required to turn on course.

7.4.4. Outbound -- Immediately After Station Passage (HSI, CI and RMI) (Figure 7.5).

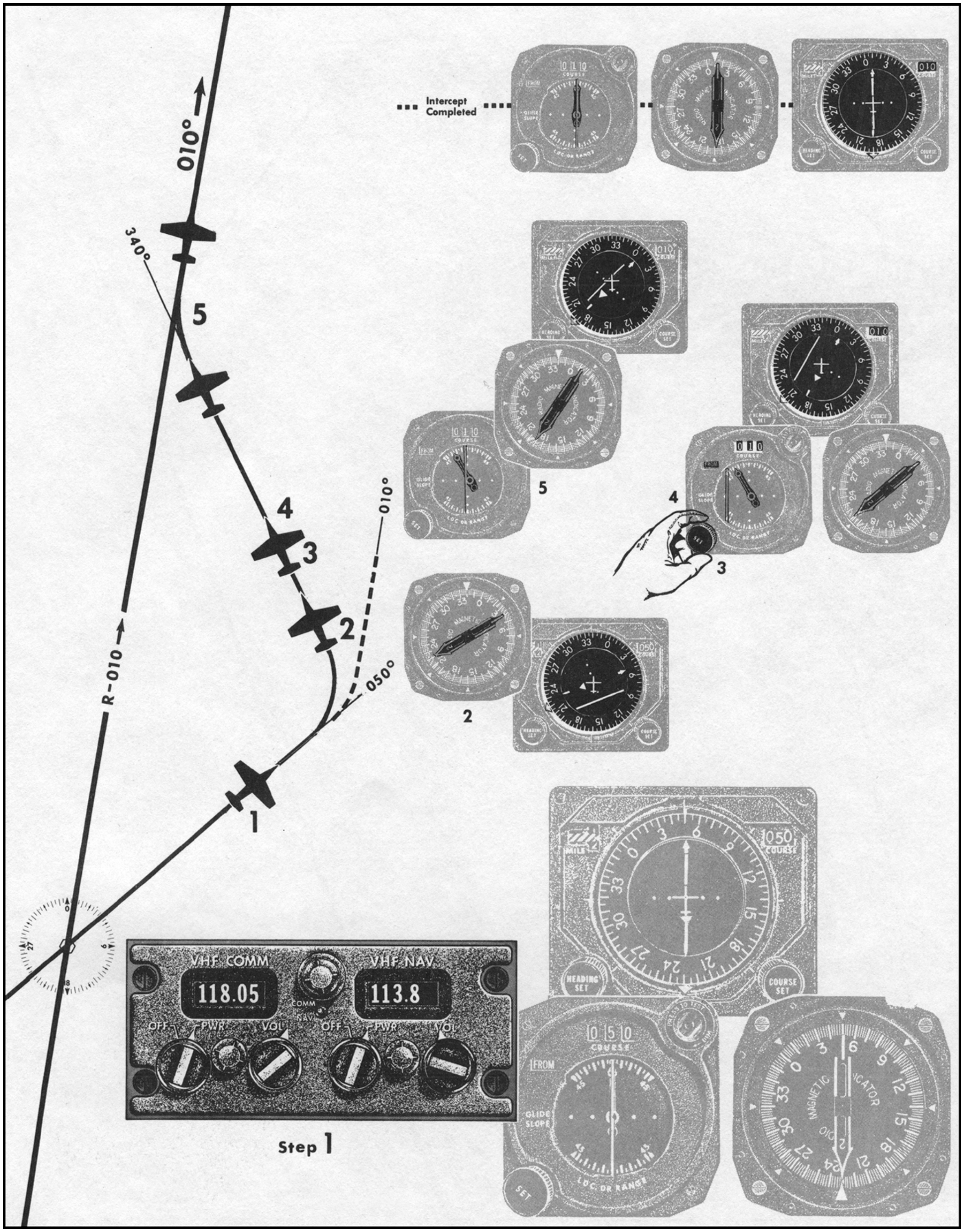
7.4.4.1. ***Tune and Identify***. Tune and identify the station. This should have already been accomplished.

7.4.4.2. ***Turn***. Turn in the shorter direction to a heading that will parallel or intercept the outbound course. Turning to parallel the desired outbound course is always acceptable. Continuing the turn to an intercept heading may be preferable when the bearing pointer is stabilized or when you know your position in relation to the desired course. The effect that airspeed, wind, and magnitude of turn will have on aircraft position during the turn to an intercept heading should be considered.

7.4.4.3. ***Set course***. Set the desired course in the course selector window and check for FROM indication.

7.4.4.4. ***Turn to Intercept***. Turn to an intercept heading if not previously accomplished. Determine the number of degrees off course as indicated by CDI displacement or angular difference between the tail of the bearing pointer and the desired course. If the initial turn was to parallel the desired course, turn toward the CDI to establish an intercept angle approximately equal to the number of degrees off course. Normally, to avoid overshooting, an intercept angle greater than 45° should not be used.

Figure 7.5. Outbound Course Interceptions-Immediately After Station Passage (HSI, CI and RMI).



7.4.4.5. ***Maintain***. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on bearing pointer or CDI rate of movement and the time required to turn on course.

7.4.5. Outbound -- Immediately After Station Passage (RMI Only) (Figure 7.6).

7.4.5.1. ***Tune and Identify***. Tune and identify the station. This should have already been accomplished.

7.4.5.2. ***Turn***. Turn in the shorter direction to a heading that will parallel or intercept the outbound course. Refer to paragraph 7.4.4 above (Outbound - Immediately After Station Passage (HSI and CI)).

7.4.5.2.1. Degrees Off Course. Determine the number of degrees off course. Note the angular difference between the tail of the bearing pointer and the desired course.

7.4.5.3. ***Intercept Heading***. Determine an intercept heading. Determine and turn to an intercept heading if a suitable intercept angle was not established during the initial turn. Look from the tail of the bearing pointer to the desired course. Any heading beyond the desired course is a no-wind intercept heading. Turn in this direction an amount approximately equal to the number of degrees off course. Normally, to avoid overshooting the course, do not use an intercept angle greater than 45°.

7.4.5.3.1. NOTE: On some aircraft, the RMI/BDHI bearing pointer does not have a tail. In this case, turn to the magnetic heading of the desired course. Continue on the outbound magnetic heading of the desired course until the bearing pointer stabilizes. Note the number of degrees the bearing pointer is off the tail of the aircraft. This is the number of degrees off course. Any heading change in the direction toward the head of the bearing pointer is a no-wind intercept heading. Turn in the direction of the head of the bearing pointer an amount approximately equal to the number of degrees off course. Normally, to avoid overshooting the course, do not use an intercept angle greater than 45°.

7.4.5.4. ***Maintain***. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on the bearing pointer rate of movement and the time required to turn on course.

7.4.6. Outbound-Away from the Station (HSI, CI and RMI) (Figure 7.7).

7.4.6.1. ***Tune and identify***. Tune and identify the station.

7.4.6.2. ***Set***. Set the desired outbound course in the course selector window.

7.4.6.3. ***Turn***. Turn to an intercept heading:

Figure 7.6. Outbound Course Interceptions-Immediately After Station Passage (RMI Only).

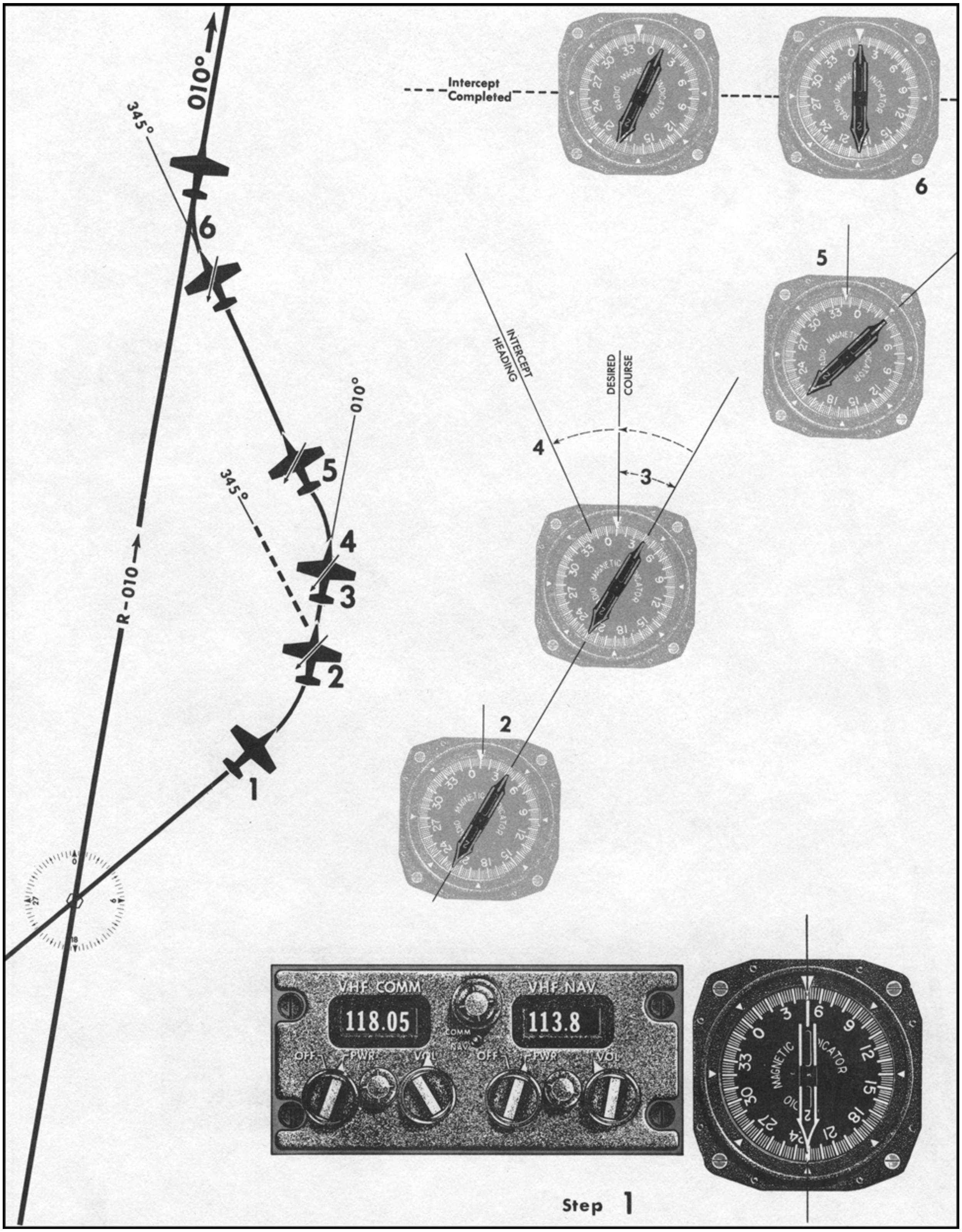
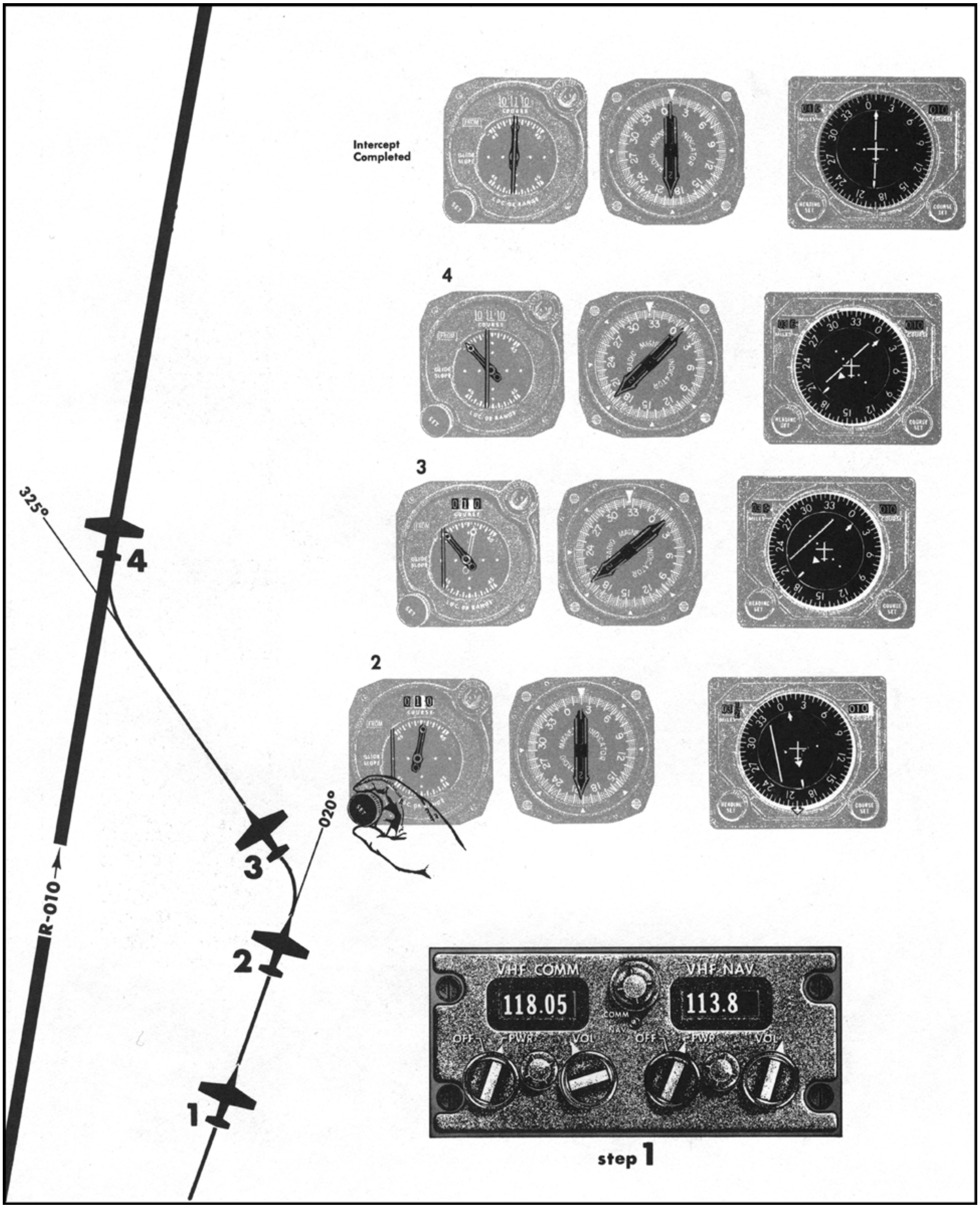


Figure 7.7. Outbound Course Interceptions-Away From the Station (HSI, CI and RMI).



7.4.6.3.1. CI. Turn in the shorter direction to place the heading pointer toward the CDI. Continue the turn to place the heading pointer in the top half of the instrument case and roll out on an intercept heading. This precludes an intercept angle in excess of 90°. Roll out of the turn on an intercept heading with a suitable intercept angle, normally 45°. A 45° intercept angle is established by rolling out with the desired course under the appropriate 45° index, or with the heading pointer displaced 45° from the top index and toward the CDI.

7.4.6.3.2. HSI. Turn in the shorter direction toward the CDI. Continue the turn until the head of the course arrow is in the top half of the instrument case. This precludes an intercept angle in excess of 90°. Roll out of the turn on an intercept heading with a suitable angle of intercept, normally 45°. A 45° intercept angle is established by rolling out with the head of the course arrow under the appropriate 45 ° index (aircraft symbol directed toward the CDI).

7.4.6.4. ***Maintain***. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on the bearing pointer or CDI rate of movement and the time required to turn on course.

7.4.7. Outbound-Away From the Station (RMI Only) (Figure 7.8).

7.4.7.1. ***Tune and identify***. Tune and identify the station.

7.4.7.2. ***Determine an intercept heading***. Look from the tail of the bearing pointer past the desired course and select an intercept heading. Any heading beyond the desired course, within 90°, is a no-wind intercept heading. A heading selected 45° beyond the desired course will normally ensure a moderate rate of intercept.

7.4.7.2.1. NOTE: On some aircraft, the RMI or BDHI bearing pointer does not have a tail. In this case, turn the shorter direction to the outbound magnetic heading of the desired course. Note the number of degrees the bearing pointer is off the tail of the aircraft. This is the number of degrees off course. Any heading change in the direction toward the head of the bearing pointer within 90° is a no-wind intercept heading. A turn in the direction of the head of the bearing pointer of 45° past the desired course will normally ensure a moderate rate of intercept.

7.4.7.3. ***Turn***. Turn in the shorter direction to the intercept heading.

7.4.7.4. ***Maintain***. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on the bearing pointer or CDI rate of movement and the time required to turn on course.

7.5. Maintaining Course (Figure 7.9). To maintain course, fly a heading estimated to keep the aircraft on the selected course. If the CDI or bearing pointer indicates a deviation from the desired course, return to course avoiding excessive intercept angles. After returning to course, again estimate the drift correction required to keep the CDI centered or the bearing pointer pointing to the desired course. (The CDI and bearing pointer may show a rapid movement from the on-course indication when close to the station. In this situation, avoid making large heading changes because actual course deviation is probably small due to proximity to the station).

Figure 7.8. Outbound Course Interceptions-Away From the Station (RMI Only).

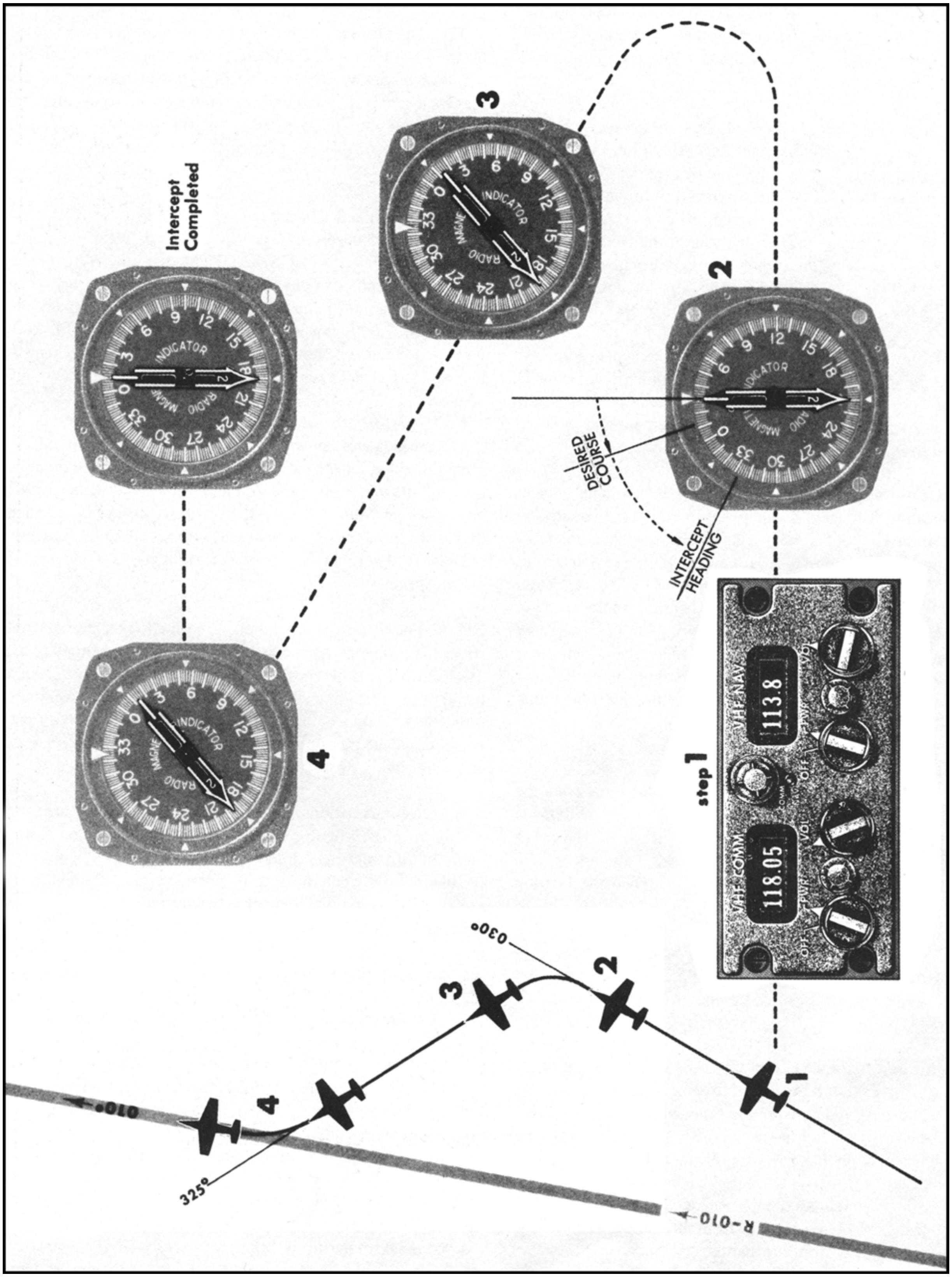
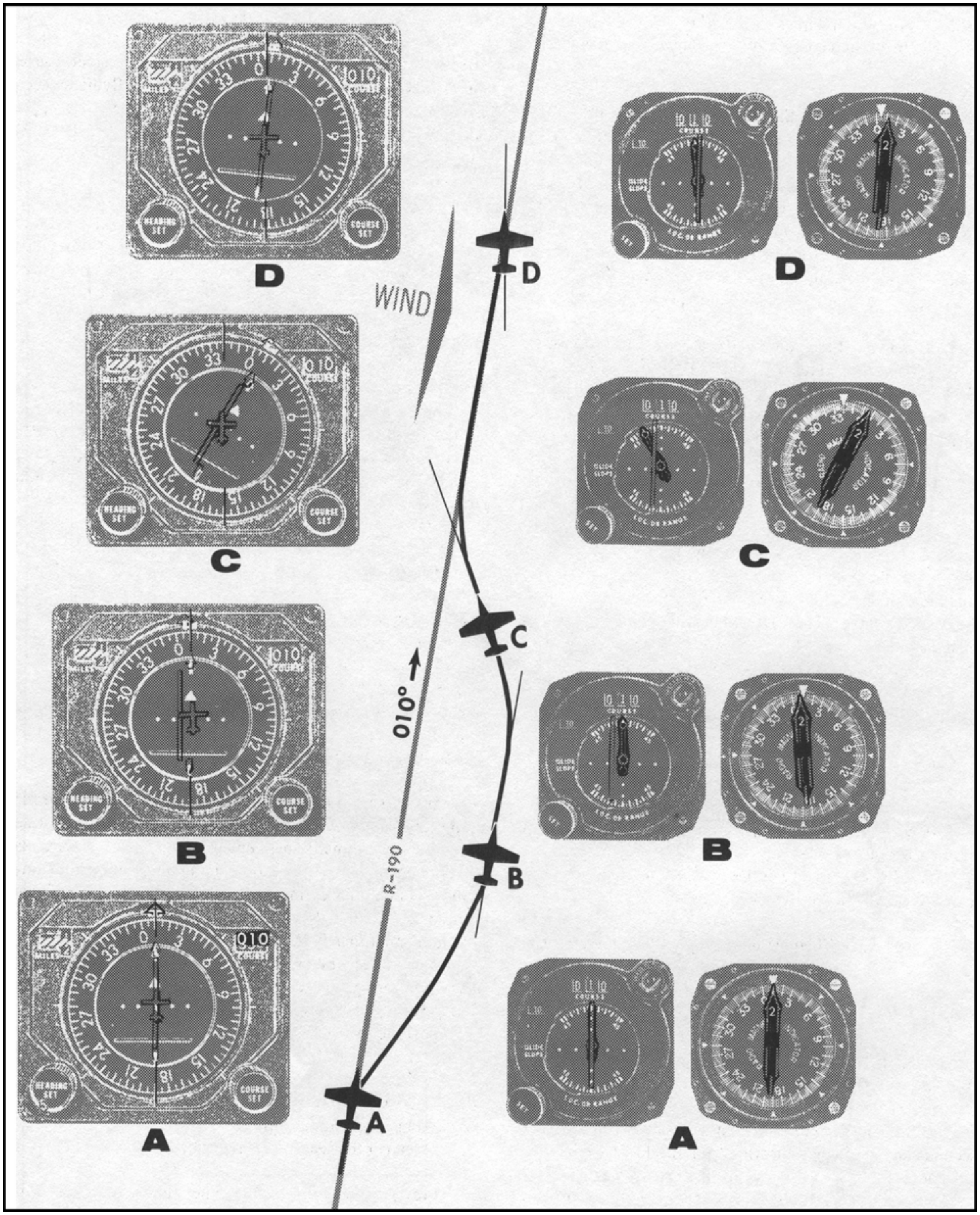


Figure 7.9. Maintaining Course.



7.6. Station Passage.

7.6.1. VOR and VOR/DME. Station passage occurs when the TO-FROM indicator makes the first positive change to FROM. For RMI/BDHI only, station passage is determined when the bearing pointer passes 90 degrees to the inbound course.

7.6.2. TACAN. Station passage is determined when the range indicator stops decreasing.

7.6.3. ADF. Station passage is determined when the bearing pointer passes 90° to the inbound course.

7.6.3.1. NOTE: When established in an NDB holding pattern, subsequent station passage may be determined by using the first definite move by the bearing pointer through 45° index on the RMI.

7.7. Time and Distance Check. To compute time and distance from a station, first turn the aircraft to place the bearing pointer on the nearest 90° index. Note the time and maintain heading. When the bearing pointer has moved 10°, note the elapsed time in seconds and apply the following formulas to determine time and distance:

7.7.1. Divide the elapsed time in seconds by the degrees of bearing change to obtain minutes from the station: 120 divided by 10 = 12 minutes from the station.

7.7.2**.** Multiply your groundspeed in nautical miles per minute by the minutes from the station.

7.7.2.1. NOTE: The accuracy of time and distance checks is governed by the existing wind, the degree of bearing change, and the accuracy of timing. The number of variables involved causes the result to be an approximation. However, by flying an accurate heading and checking the time and bearing closely, you can get a reasonable estimate of time and distance from the station.

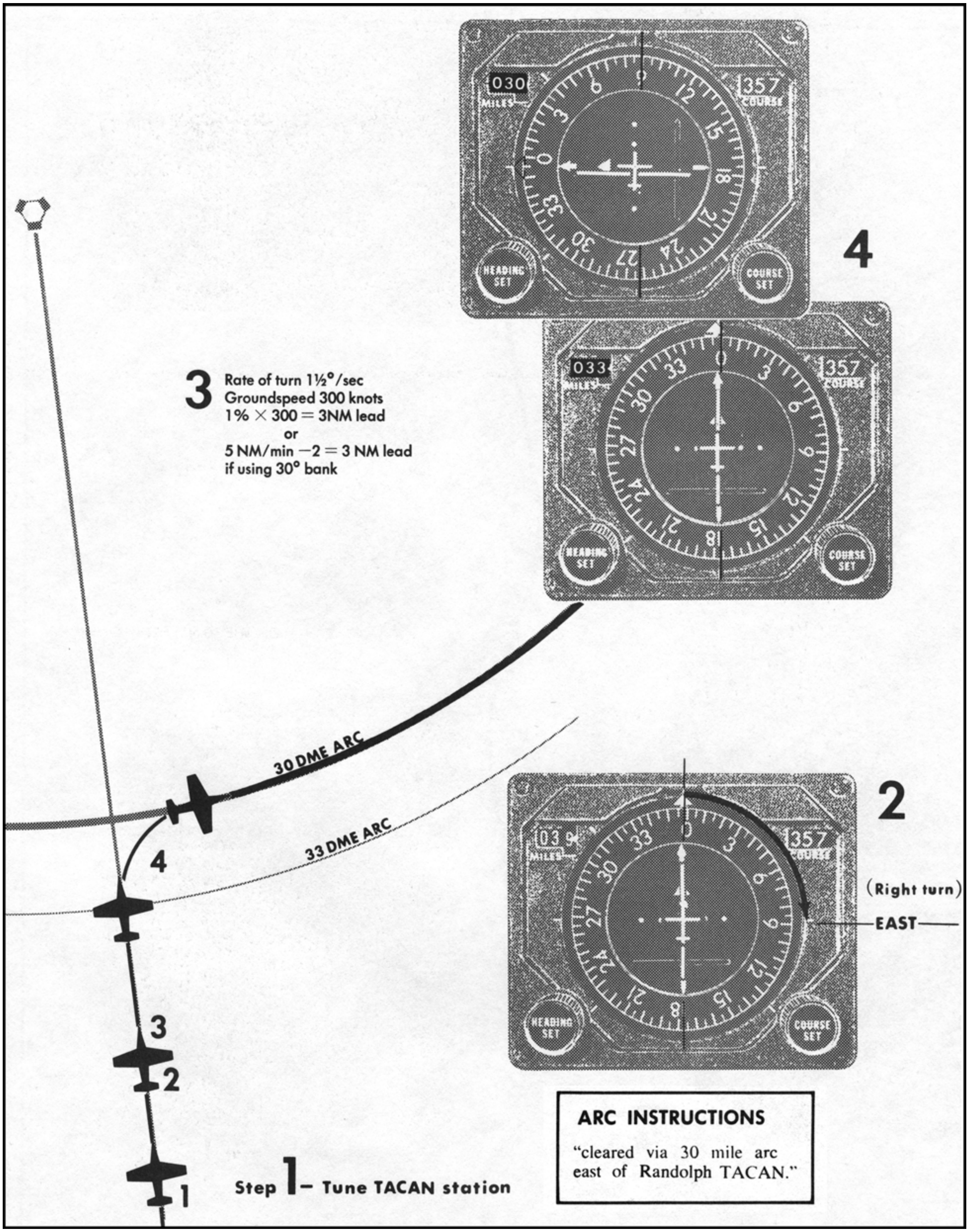
7.8. Groundspeed Check. Groundspeed checks are done to aid in calculating ETAs to fixes, which are useful for position reports, fuel computations and other mission timing problems.

7.8.1. Conditions. A groundspeed check can be made while maintaining a course to or from a TACAN/VORTAC station. As a guide, however, groundspeed checks should be performed only when the aircraft slant range distance is more than the aircraft altitude divided by 1,000. For example, if the aircraft is at FL 200, groundspeed checks should be performed when beyond 20 nautical miles. Checks made below 5,000 feet are accurate at any distance.

7.8.2. Begin Timing. To perform the groundspeed check, begin timing when the range indicator shows a whole number. After the predetermined time has elapsed, check the range indicator and note the distance flown. Apply the following formula to determine groundspeed: Multiply the distance flown times 60 and then divide the product by the elapsed time in minutes. For example, if you fly 12 NM in 2 minutes, then your groundspeed is 360 knots. ((12 NM x 60)/2 min = 360 knots)

7.8.2.1. NOTE: For precise computation, time for longer periods and solve the problems on a computer. To simplify computations, use a 2-minute time check and multiply the distance traveled by 30, a 3-minute time check, distance times 20; or a 6-minute time check, distance times 10. A rapid groundspeed check can be accomplished by timing the range indicator for 36 seconds and multiplying the distance traveled by 100.

Figure 7.10. Arc Interception From a Radial.



7.9. Arc Interceptions. TACAN and VOR/DME arcs are used during all phases of flight. An arc may be intercepted at any angle but it is normally intercepted from a radial. An arc may be intercepted when proceeding inbound or outbound on a radial. A radial may be intercepted either inbound or outbound from an arc. The angles of intercept (arc to radial or radial to arc) are approximately 90°. Because of the large intercept angles, the use of accurate lead points during the interception will aid in preventing excessive under or overshoots**.**

7.9.1. Arc Interception from a Radial (Figure 7.10).

7.9.1.1. ***Tune and Identify***. Tune the TACAN or VOR/DME equipment.

7.9.1.2. ***Direction***. Determine the direction of turn.

7.9.1.3. ***Lead Point***. Determine the lead point. Determine a lead point that will result in positioning the aircraft on or near the arc at the completion of the initial turn.

7.9.1.4. ***Turn***. When the lead point is reached, turn to intercept the arc.

7.9.1.4.1. ***Monitor***. Monitor the bearing pointer and range indicator during the turn, and roll out with the bearing pointer on or near the 90° index (wing-tip position).

7.9.1.4.2. ***Reference 90° index***. If the aircraft is positioned outside the arc, roll out with the bearing pointer above the 90° index; if inside the arc, roll out with the bearing pointer below the 90° index.

7.9.2. Radial Interception From an Arc (Figure 7.11).

7.9.2.1. ***Set***. Set the desired course in the course selector window.

7.9.2.2. ***Lead Point***. Determine the lead required in degrees. The interception of a radial from an arc is similar to any course interception except that the angle of interception will usually approximate 90°. The lead point for starting the turn to intercept the course will depend upon several variables. These are the rate of turn to be used, the angle of interception, and the rate of movement of the bearing pointer. The rate of movement of the bearing pointer is governed by the size of the arc being flown, aircraft true airspeed, wind direction and velocity.

7.9.2.3. ***Turn***. When the lead point is reached, turn to intercept the selected course. Monitor the course deviation indicator or bearing pointer during the turn and roll out on course or with a suitable correction to course.

7.9.3. Maintaining an Arc. Control aircraft heading to keep the bearing pointer on or near the 90° index (reference point) and the desired range in the range indicator. Some techniques for accomplishing this are:

7.9.3.1. Bank Angle. Establish a small bank angle that will result in a rate of turn that will keep the bearing pointer on the selected reference point. A reference point other than the 90° index must be used when operating in a crosswind. If the aircraft drifts toward the station, select a reference point below the 90° index. If the drift is away from the station, select a reference point above the 90° index. The selected reference point should be displaced from the 90° index an amount equal to the required drift correction. Monitor the range indicator to ensure the range remains constant. The angle of bank will depend upon the size of the arc, wind, and true airspeed (TAS). This technique is more suitable when flying a relatively small arc at a high airspeed.

7.9.3.2. Short Legs. Fly a series of short, straight legs to maintain the arc. To fly an arc in this manner, adjust the aircraft heading to place the bearing pointer 5° to 10° above the selected reference point. Maintain heading until the bearing pointer moves 5° to 10° below the reference point. The range should decrease slightly while the bearing pointer is above the reference point, and increase slightly when below the reference point. The arc is more closely maintained by flying shorter legs, controlling the heading to keep the bearing pointer nearer to the reference point. Adjust heading and reference point as necessary.

Figure 7.11. Radial Interception From an Arc.

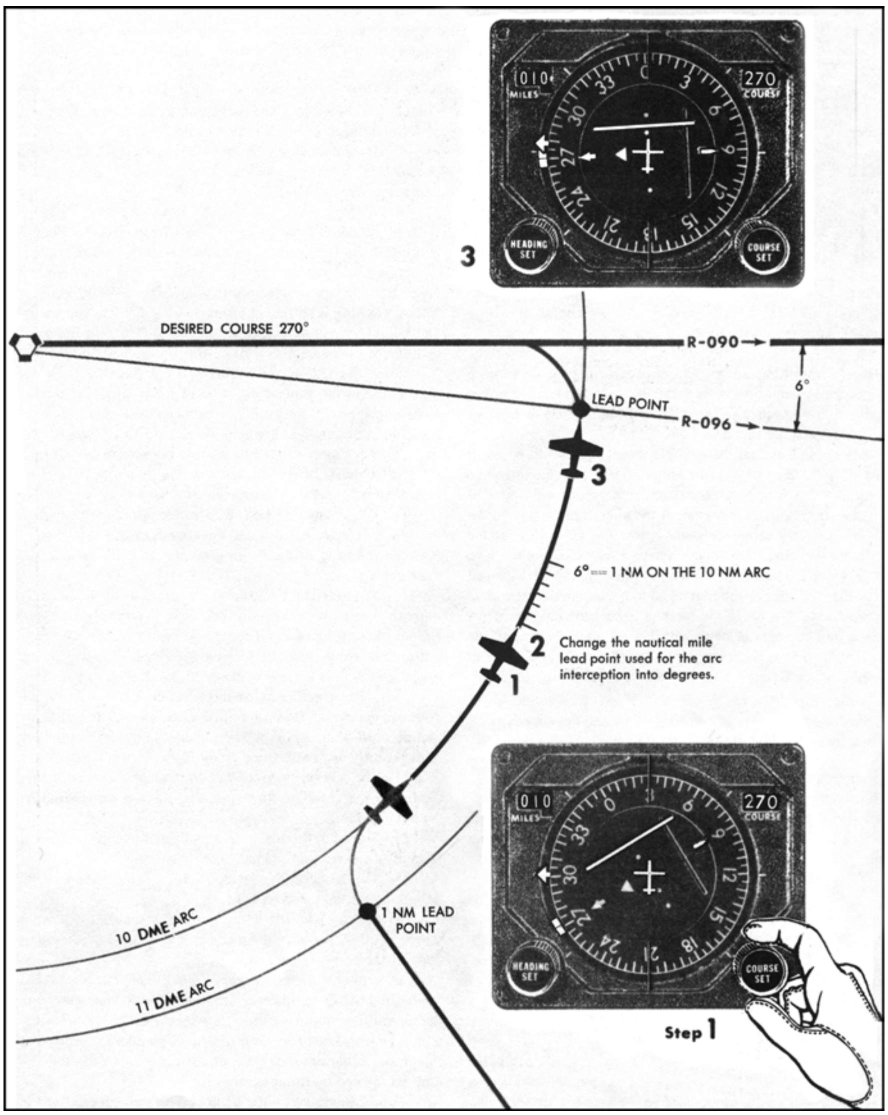
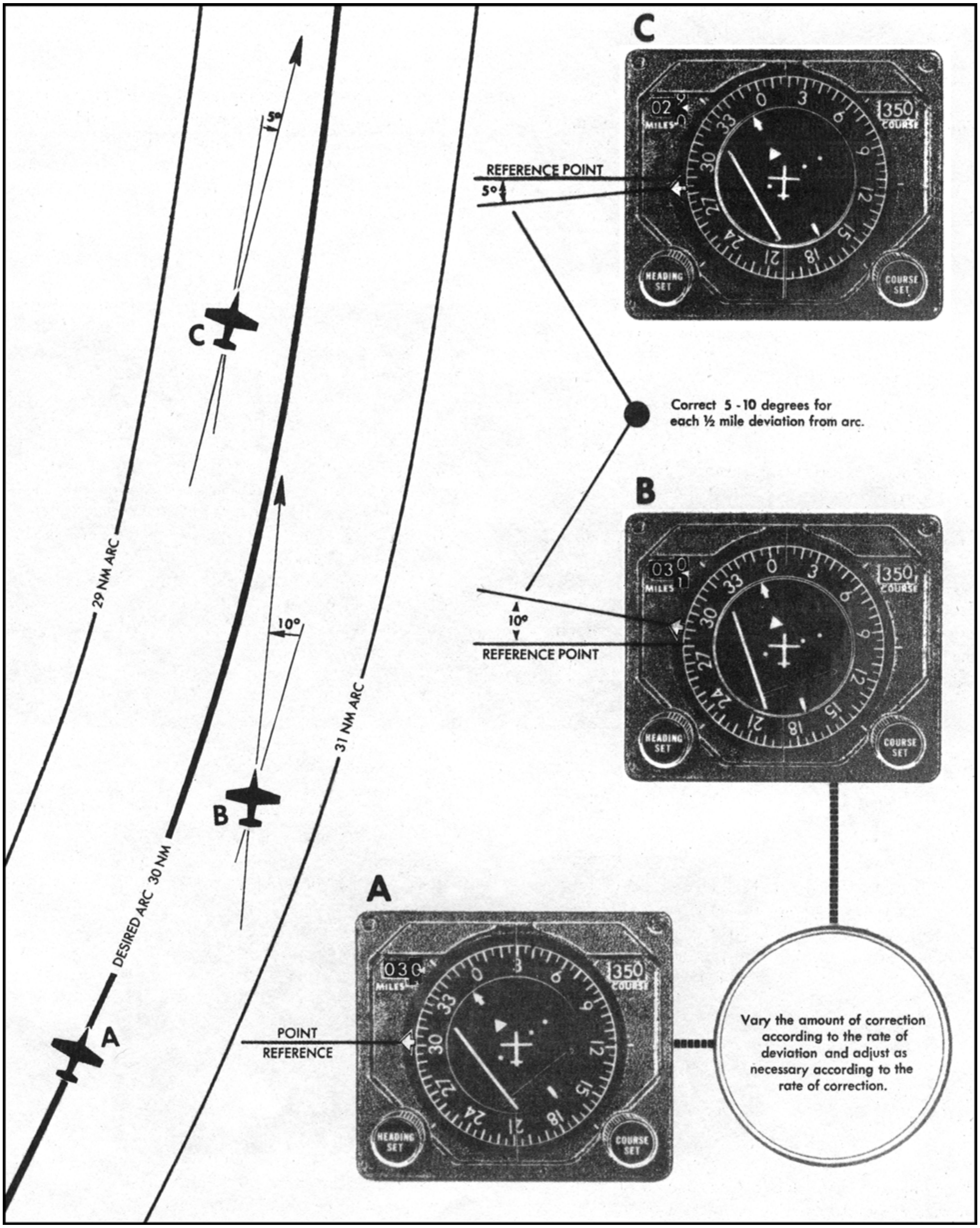


Figure 7.12. Correcting to Maintain an Arc.



7.9.3.3. Adjust. To correct to the arc, change aircraft heading to displace the bearing pointer as desired about the reference point (Figure 7.12). The size of the correction must be adequate to return the aircraft to the arc, and is dependent upon the magnitude and rate of deviation from the arc. The rate of deviation from or correction to an arc will vary with the size of the arc, whether the aircraft is inside or outside the arc, TAS of the aircraft, wind direction and velocity. A small arc has a relatively sharp curvature, and deviation to or from the arc can occur rapidly. Corrections from inside an arc are assisted by the curvature of the arc. Conversely, corrections from outside the arc for a like amount of deviation must necessarily be larger to offset the effect of arc curvature. The effects of aircraft TAS and wind are self-evident. These many variables make it impossible to use a consistent correction for a given deviation. The following technique may be used for determining the size correction to use:

7.9.3.3.1. Displace. Displace the bearing pointer 5° below the reference point for each one-half mile deviation to the inside of the arc, and 10° above the reference point for each one-half mile outside the arc.

7.9.3.3.2. Deviation. If the deviation is greater than the normal lead required for a 90° interception, consider using "arc interception" procedures rather than "correcting to the arc."

7.10. Proceeding Direct to a VOR/DME or TACAN Fix. To proceed direct from one fix to another is often required during departures, approaches, or when maneuvering in a terminal area. Bearing and range information from a VOR/DME or TACAN facility is sufficient for navigating direct to any fix within reception range. The following are some techniques to accomplish a fix-to-fix (Figure 7.13):

7.10.1. ***Tune***. Tune the TACAN or VOR/DME equipment (VOR and DME stations must be collocated).

7.10.2. ***Turn***. If not proceeding in the general direction of the desired fix, turn to a heading approximately halfway between the head of the bearing pointer and the radial on which the desired fix is located. The objective is to turn in the general direction of the desired fix rather than fly away from the fix while attempting to determine a precise heading.

7.10.2.1. HSI. When using an HSI, the desired radial should be set in the course selector window and the aircraft turned to a heading between the head of the bearing pointer and the head of the course arrow.

7.10.2.2. Initial Turn. The initial turn may be adjusted to roll out on a heading other than halfway between the bearing pointer and the desired fix and present location. If the range must be decreased, roll out on a heading closer to the bearing pointer. To increase the range, roll out on a heading closer to the desired radial.

7.10.3. ***Visualize***. Visualize the aircraft position and the desired fix on the compass card of an RMI or similar instrument. The following factors must be understood when visually establishing the aircraft position and the desired fix on the compass card.

7.10.3.1. Station Location. The station is located at the center of the compass card, and the compass rose simulates the radials around the station.

7.10.3.2. Aircraft Position. The aircraft position is visualized along the reciprocal (radial) of the bearing pointer.

7.10.3.3. Fix. The fix with the greater range is established at the outer edge of the compass card. The fix with the lesser range is visualized at a point that is proportional to the distance represented by the outer edge of the compass card.

7.10.4. ***Determine Heading***. Determine a precise heading from the aircraft position to the desired fix. Determine the heading to the fix by connecting the aircraft position to desired fix with an imaginary line. Establish another line in the same direction, parallel to the original line through the center of the compass card. This will establish a no-wind heading to the desired fix.

7.10.5. ***Adjust Heading***. Adjust aircraft heading as necessary and proceed to the fix.

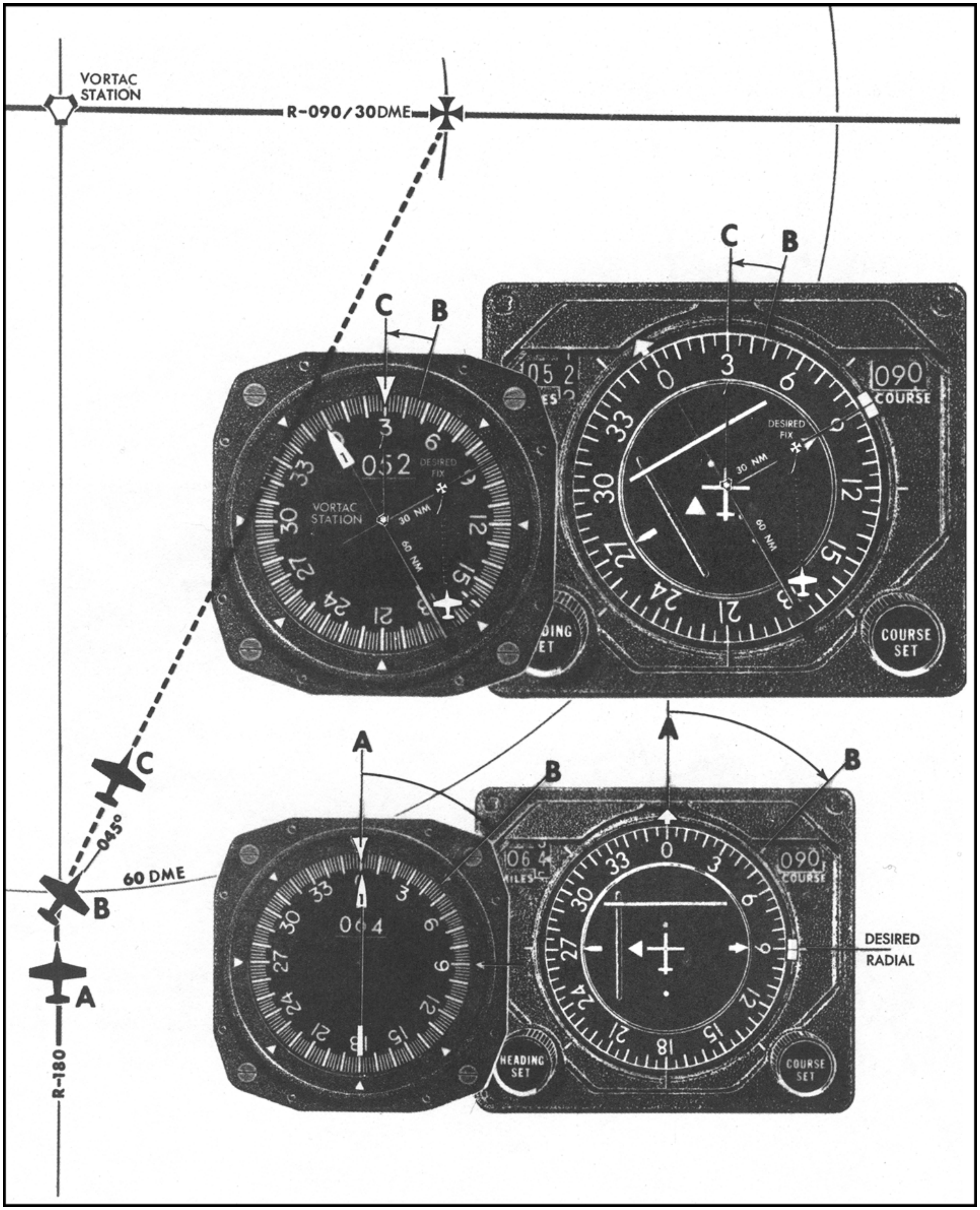
7.10.5.1. ***Drift. Apply any known wind drift correction.*** The effect of wind drift and any inaccuracy of the initial solution may be compensated for by repeating the previous steps while en route. As the aircraft approaches the desired fix, adjust the heading as necessary to intercept the arc or radial or to comply with route clearance beyond the fix.

7.10.5.2. Distance. The distance to the desired fix can be estimated since the distance between the aircraft position and the desired fix is proportionate to the distance established from the center to outer edge of the compass card.

7.10.6. ***Update***. Update heading continuously enroute to refine your solution and correct for winds.

7.10.6.1. NOTE: The same problem can be easily and more accurately solved on the CPU/26A computer. This is done on the wind face by imagining that the center grommet is the station and applying the same basic techniques as in 7.10.3 though 7.10.5 above.

Figure 7.13. Proceeding Direct to a DME Fix.



7.11. Area Navigation.

7.11.1. Definitions.

7.11.1.1. RNAV. A method of navigation permitting aircraft operations on any desired course within the coverage and capabilities of the aircraft onboard navigation equipment.

7.11.1.2. Aircraft RNAV Equipment. Any of the various types and (or) combinations of onboard equipment required to file and fly RNAV. These include INS, TACAN/VOR/DME-based FMS, Integrated/Embedded GPS, or Loran-C.

7.11.1.3. RNAV Waypoint. A predetermined geographical position used for route or instrument procedure definition normally defined in terms of latitude and longitude coordinates or radial/distance relative to a ground based navigation facility.

7.11.1.4. Designated RNAV Route. Permanent, published and charted airway routes based on area navigation equipment, they are available for use by aircraft with RNAV capability.

7.11.1.5. Random RNAV Routes. A direct route flown between any two points using RNAV equipment without reference to airways or jet routes.

7.11.1.6. Required Navigation Performance (RNP). A statement of the aircraft navigation performance necessary for operation within a defined airspace.

7.11.1.7. Required Navigation Performance Type (RNP Type). A value stating the actual position of the aircraft for at least 95 percent of the total flying time from the intended position of that aircraft. The value is a must remain within value and is typically expressed as a distance in (longitudinal and lateral) nautical miles (e.g., RNP-5 airspace requires an aircraft to be within 5 miles of its intended position 95 percent of the time). In addition to accuracy, many RNP applications also impose additional functional requirements. ***Aircrew must ensure compliance with training, certification, and equipment requirements prior to flying any RNAV procedure.***

7.11.2. RNAV Capability. An aircraft must have equipment capable of displaying a course from a given point (waypoint) to a clearance limit while also providing a continuously updated aircraft position with reference to that course line. An aircraft FMS, INS, LORAN, or integrated GPS navigation system providing course guidance to the aircrew meets this requirement. Mission enhancement GPS systems do not meet this requirement.

7.11.3. RNAV Restrictions.

7.11.3.1. En Route. RNAV aircraft must be able to navigate on the intended RNP Type route or within the RNP Type airspace using their onboard navigation equipment. MAJCOMS provide operational approval for each type of RNP airspace/procedure. Operational approval ensures that RNAV equipment meets accuracy and functional requirements, and that appropriate crew training and procedures are in place. While airspace requirements vary between regions, in some cases backup equipment (VOR/DME, TACAN, etc.) may be required to allow reversion to an alternate means of navigation should RNAV equipment fail.

7.11.3.2. Terminal. RNAV in the terminal area consists of both approach and departure procedures. RNAV equipment may be used as the sole source of navigation information for instrument approaches in suitably equipped and certified aircraft. RNAV approaches must only be retrieved from an aircraft database and not be manually entered. MAJCOMs certify the capabilities of their aircraft in accordance with civil standards as outlined in various Technical Standard Order's (TSO) and Advisory Circular's (AC).

7.11.4. Aircrew Responsibilities. Although RNAV routes (including random routes) may be filed at any time, aircrews should have alternate routing and contingency actions planned. ATC considers radar coverage capability and compatibility with traffic flow and volume prior to assigning random RNAV routes. Although ATC provides radar separation on RNAV routes in the national airspace system (NAS), navigation and collision avoidance on any RNAV route remains the responsibility of the aircrew. Aircrews must consider the limits of RNAV equipment certification prior to accepting clearance for RNAV routes or RNP airspace. Aircrews should also take advantage of opportunities to update the navigation system while en route. In addition, crews should monitor RNAV equipment performance and be prepared to return to an alternate means of navigation should equipment malfunction require.

7.12. Navigation using GPS. The ICAO has adopted "Global Navigation Satellite System (GNSS)" as an umbrella term to identify any satellite navigation system where the user performs onboard position determination from satellite information. Currently there are only two GNSS systems that are recognized by the International Frequency Registration Board (IFRB): the GPS developed by the United States and the Global Orbiting Navigation Satellite System (GLONASS) now under development by the Federation of Russia.

7.12.1. Aviation GPS Requirements for IFR navigation. In order to be used for IFR navigation, GPS equipment must meet minimum functional requirements, and comply with approved standards for accuracy, integrity, availability, and continuity. Compliance with FAA TSOs and ACs are the primary means of ensuring these standards are met. AFI 11-202Volume 3, *General Flight Rules*, lists FAA TSOs and ACs applicable to GPS User Equipment (UE).

7.12.2. ***Properly certified GPS equipment may be used as a primary means of IFR navigation in remote/oceanic areas, and may be used as a supplemental means of IFR navigation for domestic enroute, terminal, and some instrument approach operations. Except in remote/oceanic areas, aircraft using GPS for IFR navigation must be equipped with an approved and operational alternate means of navigation appropriate to the flight (INS, VOR, TAC, etc.).***

7.12.2.1. NOTE. Some countries do not allow the use of GPS (either SPS or PPS) for IFR navigation in their sovereign airspace. ***Consult the appropriate FLIP Area Planning (AP) document for details***.

7.12.2.2. NOTE. IFR navigation using PPS GPS. ***Without host nation approval, PPS may not be used for IFR navigation in civil airspace, including the US National Airspace System (NAS).*** For discussion on GPS PPS, see Chapter 6.

7.12.2.3. Training. This manual provides general guidance for GPS operations. Procedures vary between different equipment manufacturers and between different models within a single manufacturer. ***Aircrews must follow specific GPS procedures as described in the aircraft flight manual.***

7.12.2.4. Flight planning. ***File appropriate equipment suffix listed in FLIP General Planning (GP), Chapter 4.***

7.12.2.5. Conventional vs. GPS Navigational Database Information. There may be slight differences between the heading information portrayed on navigational charts and the GPS navigation display. All magnetic tracks defined by a VOR radial are determined by the application of magnetic variation at the VOR. GPS equipment may apply the magnetic variation at the current position, resulting in small differences in the displayed course. Additionally, due to the use of great circle courses, the bearing to the next waypoint and the course from the last waypoint (if available) may not be exactly 180 degrees apart when long distances are involved. In any event, the resulting ground track should be the same. Distance information may also vary since GPS distances are along track values, while DME measures slant range distance. For a complete discussion of database issues, see paragraph 7.13.

7.12.2.6. Receiver Autonomous Integrity Monitor (RAIM). The GPS receiver verifies the integrity (usability) of the signals received from the GPS constellation through RAIM to determine if a satellite is providing corrupted information. RAIM gives the pilot an indication of the reliability of the GPS navigation solution. Without RAIM capability, the pilot has no assurance of the accuracy of the GPS position. ***RAIM (or equivalent integrity method) is required for use of GPS in IFR navigation***. At least one satellite, in addition to those required for navigation, must be in view for the receiver to perform the RAIM function. Therefore, RAIM requires at least 5 satellites in view.

7.12.2.6.1. NOTE: Barometric aiding is accomplished by use of a non-satellite input (approved aircraft barometric altimetry system). Baro-aiding only requires 4 satellites in view. Baro-aiding requires a current altimeter setting entered in accordance with the aircraft flight manual.

7.12.2.6.2. NOTE: The term "RAIM" describes one particular method of integrity monitoring, however, receivers and navigation systems may employ alternate integrity monitoring algorithms as long as these methods provide a level of protection equivalent to RAIM. For sake of simplicity, this document will use the term RAIM to refer to all acceptable integrity monitoring methods. The procedures and guidance discussed are applicable to all approved integrity monitoring algorithms.

7.12.2.6.3. RAIM outages may occur due to an insufficient number of satellites or due to unsuitable satellite geometry that causes the error in the position solution to become too large. Loss of satellite reception and RAIM warnings may occur due to aircraft dynamics (changes in pitch or bank angle). Antenna location on the aircraft, satellite position relative to the horizon, and aircraft attitude may affect reception of one or more satellites.

7.12.2.6.3.1. RAIM Alerts. There are two types of RAIM alerts. One type indicates that not enough satellites are in view (or in an insufficient geometry) to provide RAIM. The other type indicates that the RAIM monitor has detected a potential error that exceeds the limits (enroute, terminal, or approach) for the current phase of flight. Without RAIM capability, the pilot has no assurance of GPS positional accuracy.

7.12.2.6.3.2. Predictive RAIM. This is the process where the GPS receiver predicts whether RAIM will be available at a particular location at a time in the future. To effectively check predictive RAIM, aircraft avionics must allow deselection of satellites based on NOTAM information. ***Predictive RAIM must be checked prior to flight or flight segment where GPS is required.***

7.12.2.6.3.2.1. The requirement for a predictive RAIM check only applies to those aircraft that are not approved for RNP RNAV operations as indicated by appropriate statements in the aircraft flight manual. ***Prior to flying RNP RNAV procedures, aircrew must ensure that the appropriate level of RNP will be available to fly a given procedure.*** This may or may not require a predictive RAIM check. Details on methods to confirm RNP RNAV availability are detailed in the aircraft flight manual.

7.12.2.6.3.2.2. ***If the required level of RAIM (e.g., enroute, terminal or approach) is not available, another type of navigation and approach system must be used, another destination selected, or the trip delayed until RAIM is predicted to be available***.

7.12.2.6.3.2.3. Pilots should recheck the RAIM prediction for the destination during the flight. This may provide early indications that an unscheduled satellite outage has occurred since takeoff.

7.12.2.6.3.2.4. ***The predictive RAIM check must be accomplished prior to the intended GPS operation, including both GPS departures and approaches, and may be accomplished either by onboard GPS equipment or via a ground system.*** The predictive RAIM algorithm should take into account satellites that are NOTAMed out of service between the time of the predictive RAIM check and the flight segment over which GPS is required. Prior to deselecting satellites for predictive RAIM purposes, aircrew should ensure that deselecting would also affect use of the satellite in the active navigation solution. Some systems only allow deselecting from the active navigation solution and do not allow deselecting for predictive RAIM purposes.

7.12.2.6.3.2.5. GPS NOTAMs may be obtained by typing "KGPS" from the military NOTAM website. Note that the NOTAM web site refers to satellites using the PRN, not the SVN. Most, if not all, GPS avionics use the PRN to identify satellites to be deselected. For information on the correlation between a particular PRN and SVN, consult the GPS Support Center web site.

7.12.2.6.3.2.6. Predictive RAIM information may be obtained from either aircraft or ground based systems. For operations in the US NAS, predictive RAIM information for individual destinations may be obtained by contacting an FAA Flight Service Station. For operations within Europe, predictive RAIM information may be obtained at the AUGUR web site (http://augur.ecacnav.com/). Additionally, the military also provides airfield-specific GPS RAIM NOTAMs for nonprecision approach procedures at military airfields. The RAIM outages are listed as M-series NOTAMs and may be obtained for up to 24 hours from the time of request. However, this list currently covers 320 military-use airfields and may not include your intended destination.

7.12.2.7. Fault Detection and Exclusion (FDE). FDE allows GPS equipment to automatically detect and exclude faulty satellites from the navigation solution. FDE requires a minimum of 6 satellites in view (or 5 satellites with baro-aiding). Past experience indicates that without FDE, or the ability to manually determine which satellite is faulty and exclude it from the navigation solution; satellite failure can lead to significant GPS position errors (in excess of 100 nm). ***FDE is required for use of GPS as a primary means of navigation in remote/oceanic areas.***

7.12.3. GPS in Lieu of ADF and DME. GPS equipment certified for IFR operations IAW AFI 11-202 Volume 3, *General Flight Rules*, may be used in place of ADF and/or DME equipment for en route and terminal operations, except for use as the principal instrument approach navigation source, as listed below (U.S. National Airspace (NAS) only):

7.12.3.1. Determining the aircraft position over a DME fix.

7.12.3.2. GPS satisfies the requirement for DME at and above 24,000 feet mean sea level (MSL) (FL 240).

7.12.3.3. Flying a DME arc.

7.12.3.4. Navigating to/from an NDB/compass locator.

7.12.3.5. Determining the aircraft position over an NDB/compass locator.

7.12.3.6. Determining the aircraft position over a fix defined by an NDB/compass locator bearing crossing a VOR/LOC course.

7.12.3.7. Holding over an NDB/compass locator.

7.12.3.8. Procedures for Using GPS in Lieu of ADF and DME***. In order to use GPS in place of ADF or DME use the procedures listed below. In all cases, RAIM must be available and operational, and any fixes used for navigation must be retrieved from a current, approved database.***

7.12.3.8.1. Determining position over a DME fix:

7.12.3.8.1.1. If the fix is identified by a five-letter name that is contained in the GPS airborne database, ***select either named fix as the active GPS waypoint (WP) or the facility establishing the DME fix as the active GPS WP.***

7.12.3.8.1.1.1. NOTE: The charted DME facility that establishes the DME fix is the only acceptable facility to use as an active WP. If this facility is not in the airborne database, do not use the facility WP for this operation. If the named fix is selected as the active GPS WP, consider yourself over the fix when the GPS system indicates you are at the active WP.

7.12.3.8.1.2. If the fix is identified by a five-letter name, which is not contained in the GPS airborne database, or if the fix is not named, select the facility establishing the DME fix or another named DME fix as the active GPS WP. If selecting the DME providing facility as the active GPS WP, ***consider yourself over the fix when the GPS distance from the active WP equals the charted DME value and you are on the appropriate bearing and course.***

7.12.3.8.1.2.1. NOTE: Until all DME sources are in the database, pilots may use a named DME fix as the active waypoint in lieu of using the DME source. If using this method the named DME fix must be on the same course and based on the same underlying DME source. Pilots should be extremely careful to ensure correct distance measurements are used when utilizing this method. Pilots should review distances for DME fixing during preflight preparation.

7.12.3.8.2. Flying a DME arc:

7.12.3.8.2.1. ***Select the DME facility from the airborne database as the active WP***. If this facility is not in your database, do not perform this operation.

7.12.3.8.2.1.1. Use GPS distance to the WP in lieu of DME.

7.12.3.8.3. Select CDI terminal sensitivity (+- 1 nm) if in the terminal area. Determining position over an NDB/compass locator

7.12.3.8.3.1. ***Select the charted NDB/compass locator from database as active WP***. If facility is not in the airborne database, do not use a facility WP for this operation.

7.12.3.8.3.2. Select CDI terminal sensitivity (+- 1 nm) if in the terminal area

7.12.3.8.3.3. ***You are over the NDB/compass locator when the GPS system indicates you are over the active WP***.

7.12.3.8.4. Determining position over a fix made up of an NDB/compass locator bearing crossing a VOR/LOC course.

7.12.3.8.4.1. A fix made up by a crossing NDB/compass locator bearing will be identified by a five-letter fix name. Select either the named fix, or the NDB/compass locator facility providing the crossing bearing to establish the fix as the active GPS WP. If the facility is not in your airborne database, do not use a facility WP for this operation.

7.12.3.8.4.2. If using the named fix, fix passage is when indicated by the GPS system as you fly the prescribed track from the non-GPS navigation source.

7.12.3.8.4.3. If using the NDB/Compass locator as the active GPS WP, fix passage occurs when the GPS bearing to the active WP is the same as the charted NDB/Compass locator bearing for the fix as you fly the prescribed track from the non-GPS navigation source.

7.12.3.8.5. Holding over an NDB/Compass locator**.**

7.12.3.8.5.1. ***Select CDI terminal sensitivity (+- 1 nm) if in the terminal area.***

7.12.3.8.5.2. ***Select the NDB/compass locator as the active WP. Fix must be retrieved from a current approved database***.

7.12.3.8.5.3. ***Program holding pattern IAW the flight manual***.

7.12.3.8.5.4. ***Hold using approved procedures***.

7.12.4. GPS In Lieu Of A Named Intersection. GPS equipment certified for IFR terminal area operations IAW AFI 11-202 Volume 3, *General Flight Rules*, may be used to identify a named intersection for en route and terminal operations, except for use as the principal instrument approach navigation source (U.S. National Airspace only):

7.12.4.1. Determining position over a named intersection.

7.12.4.1.1.1. Select the charted named intersection from database as active WP. Named waypoints must be retrieved from the database; waypoint data may not be entered manually or modified in any way.

7.12.4.1.1.2. You are over the named fix when the GPS system indicates you are over the active WP.

7.12.5. GPS Terminal Area Restrictions

7.12.5.1. Definition of Terminal Area Procedures. The FAA does not define the dividing line between terminal area procedures and other types of RNAV procedures (DP, STARS, etc.). In some areas, for example where terrain is a factor, transitioning to terminal area accuracy would be appropriate from the beginning of the STAR. In other areas, for example in eastern Kansas where the terrain is relatively flat, terminal accuracy would not be required until on the approach. To preclude confusion, the USAF has adopted the following as procedure. ***Terminal Area Procedures and Restrictions as described below apply when on any segment of a published instrument approach procedure or Level 1 departure procedure.*** See paragraph 9.13 for a definition of Level 1 departure procedure.

7.12.5.1.1. ***Equipment must meet the requirements of AFI 11-202 Volume 3 General Flight Rules and have an operational RAIM capability.***

7.12.5.1.2. ***All waypoints, fixes, facility locations must be retrieved from a current aircraft database.*** Users may not alter terminal procedures retrieved from the equipment database.

7.12.5.1.3. Pilots must ***double check all waypoint names, sequence, course, distance, and altitude information from the database against information listed***

on the paper copy of the terminal procedure (to include the missed approach) as discussed in the section 7.13 of this AFMAN.

7.12.5.1.4. ***CDI must be set to terminal sensitivity (+- 1 nm) or confirmed the receiver has automatically set it.***

7.12.5.1.5. ***A predictive RAIM check must be accomplished prior to commencing the approach.*** If RAIM outages are predicted or occur, the flight must rely on other approved equipment; otherwise the flight must be rerouted, delayed, or canceled.

7.12.5.1.6. ***Comply with alternate requirements IAW AFI 11-202 Volume 3 General Flight Rules.***

7.13. Data Base Issues for RNAV and GPS Navigation. GPS and other RNAV procedures rely on data extracted from the aircraft navigation database. The potential for serious navigation errors is created by inherent properties of database creation and its use by aircrew and aircraft systems. In order to mitigate these potential errors crews must be familiar with database issues and required procedures.

7.13.1. Aircraft use navigation databases provided by either National Geospatial-Intelligence Agency (NGA) (i.e. DAFIF) or a commercial vendor (i.e. Jeppesen). These databases contain a worldwide list of airports, navigation aids, waypoints, and instrument procedures. Outside the US NAS, this data is provided by host nations, and is not necessarily quality-checked by database providers during database creation. Navigation data may be filtered and tailored to meet individual aircraft requirements. Jeppesen tailors their data to meet customer specifications, while DAFIF data is filtered and formatted by outside contractors. Updated navigation data is published on a 28-day cycle.

7.13.1.1. Database Requirements. In order to use GPS for the terminal area, ***all procedures (DP, Standard Terminal Arrival (STAR), IAP) must be retrieved in their entirety from a current, approved navigation database.*** Only those approaches included in the receiver database are authorized, and must display as full approaches (not advisory approaches which would not allow pilot to "arm" the approach).

7.13.1.1.1. Manual Data Base Manipulation. ***Users may not alter terminal procedures retrieved from the equipment database.*** However, this requirement does not prevent the storage of "user-defined" data. This requirement also does not preclude aircrew from complying with ATC instructions by proceeding direct to a point on a STAR/DP or by receiving ATC vectors onto course.

7.13.1.1.1.1. NOTE: This "user-defined" data cannot be part of a terminal procedure, to include IAF or feeder fixes.

7.13.2. Database related errors have occurred at all stages of database development and use. Host nations have provided inaccurate data; database providers have introduced errors during database creation and aircraft specific tailoring; aircrew have selected incorrect waypoint/procedure data; finally, aircraft flight management systems/navigation computers have flown instrument procedures in a manner that does not match the charted procedure.

7.13.3. ***A paper copy of the applicable instrument procedure (IAP, SID, STAR) must***

always be available and crosschecked in the terminal environment.

7.13.3.1. Data Base Procedures.

7.13.3.1.1. Prior to flight, crews must check navigation database validity. If the database has expired, the crew:

7.13.3.1.1.1. ***May continue a mission with an expired database if the database information required for the flight can be verified with current flip.***

7.13.3.1.1.2. ***Shall get the database updated at the first opportunity.***

7.13.3.1.1.3. ***May not use the database to fly procedures that require terminal or better accuracy (i.e. terminal or approach).***

7.13.4. Defining Airways

7.13.4.1. Conventional (Overlay) Airways. Appropriately certified RNAV equipment may be used to fly conventional airways (e.g. FAA J /V routes). These routes may be either retrieved from the aircraft database or constructed by manually entering waypoints.

7.13.4.1.1. If within aircraft capabilities, conventional airways should be retrieved from the aircraft database using the airway identifier.

7.13.4.1.2. If airways cannot be retrieved from the database using the airway identifier, conventional airways may be constructed by manual entry of associated waypoints/NAVAIDS. These waypoints/NAVAIDS should be retrieved from the database by waypoint name if possible. Entry of all airway waypoints is not required. At a minimum, all compulsory waypoints, all NAVAIDS, and any waypoint associated with a change in course must be entered. If airways are entered manually, waypoint sequence must be verified by another crewmember on multi-crew aircraft.

7.13.4.2. RNAV Airways. RNAV airways should be retrieved in their entirety from the database using the airway identifier. If entered manually, aircrew must ensure that all waypoints are entered and flyby/flyover attributes are correctly entered.

7.13.5. RNAV Terminal Area Operations.

7.13.5.1. Some databases may not contain all transitions or departures from all runways. Terminal area and instrument approach procedures must be retrieved in their entirety from the navigation database. These procedures may not be modified or entered manually.

7.13.5.2. ***Prior to commencing a terminal area or instrument approach procedure, crews must confirm waypoint name, sequence, course, distance, and altitude information match charted information (to include the missed approach segment). Waypoint type (flyby vs. flyover) should also be confirmed if this information is available***.

7.13.5.3. ***In the event of differences between the terminal procedure chart or approach chart and database, the published approach chart, supplemented by***

NOTAMs, holds precedence and the database may not be used to fly terminal area or instrument approach procedures except as noted below.

7.13.5.3.1. In some cases, waypoints in the navigation database may differ from the charted instrument procedure. The differences listed below are acceptable and do not preclude use of the database procedure.

7.13.5.3.1.1. Step down fixes depicted on the approach chart may not be contained in the aircraft database. Pilots are responsible for ensuring compliance with applicable step down fixes regardless of whether or not they are in the aircraft database.

7.13.5.3.1.2. The database may contain some waypoints (capture fixes, and a point in lieu of a FAF for non-FAF overlay approaches) that are not depicted on the approach chart.

7.13.5.3.2. For GPS overlay approaches, certain unnamed points and fixes appearing on a chart are assigned a database identifier.

7.13.5.3.2.1. NOTE: These database identifiers should not be used for pilot/controller communications or on flight plans.

7.13.5.3.3. Small differences may exist in distances between waypoints. Differences less than 0.3nm are acceptable for GPS overlay approaches. For stand-alone GPS and RNAV approaches, the maximum allowable difference is 0.1nm. If distance information varies by more than these tolerances, the procedure shall not be flown.

7.13.5.3.4. Computation of the GPS final approach course is based on the station magnetic variation retrieved from the aircraft magnetic variation database. Many aircraft have a non-updateable magnetic variation database, thus will be almost guaranteed to be different from actual magnetic variation. This will cause a difference between the displayed GPS final approach course and the charted final approach course in the IAP. The discrepancy between displayed and charted magnetic variation will depend on discrepancy between aircraft magnetic variation database (age of database) vs. magnetic variation upon which charted approach course is based (date of magnetic variation survey). Variation between charted final approach course in the IAP and the final approach course computed by the aircraft should be no more than 5 degrees. ***If the two differ by more than 5 degrees, the procedure is not authorized.***

7.13.5.4. ***Underlying traditional navigational aids must be monitored if available for RNAV and GPS terminal area and instrument approach overlay operations. In the event of discrepancy between RNAV and underlying navigation aids, crews must revert to using underlying ground-based navigation aids***.

7.13.5.5. Crews must be knowledgeable of system limitations and be ready to manually intervene with RNAV or GPS equipment if necessary. Certain segments of a missed approach, DP, or SID may require some manual intervention by the pilot, especially when radar vectored to a course or required to intercept a specific course to a waypoint.

7.13.5.6. Due to aircraft specific limitations, on some occasions aircraft may not fly a database procedure as indicated on the chart, even though the procedure is correctly coded in the database. This is especially true of missed approach and DP operations that have closely spaced waypoints or require turns initiated at an associated altitude. Crews must carefully monitor aircraft performance to ensure adherence to the charted procedure.

7.13.6. Charting Standards. WGS-84 is the worldwide standard for coding database information. The use of this common reference system is required to ensure accurate navigation. Although most nations have signed up to the WGS-84 standard, there is no means of ensuring compliance, and not all data from foreign nations is developed IAW WGS-84. A number of database discrepancies have been reported in foreign airspace. Aircrews must monitor underlying ground based navigation aids when available. In the event of discrepancy between RNAV/GPS information and the underlying navigation aids, crews must revert to using underlying ground-based navigation data.

7.13.7. Database NOTAMs. Both Jeppesen and NGA (DAFIF) have established procedures for informing crews of known database problems. Crews must check database NOTAMs prior to flight for information on any planned RNAV or GPS procedures.

7.13.7.1. NGA (DAFIF) database NOTAMs associated with a particular airfield are class “W” NOTAMs and may be obtained by entering an airfield identifier in the Joint Chiefs of Staff (JCS) NOTAM web site. DAFIF NOTAMs not associated with a particular airfield (airway NOTAMs, etc.) may be obtained by consulting flip change notices via the DAFIF NOTAMs link on the JCS NOTAM web site.. The Jeppesen NOTAM page contains information on airfield specific procedures at the top of the page and has links to regional information at the bottom of the page. Jeppesen database NOTAMs may be accessed through the links section of the JCS NOTAM web site.

Chapter 8

PLANNING AN INSTRUMENT FLIGHT

8.1. Altimeter Setting Procedures. ***Accomplish the following procedures at an altimeter checkpoint if practical:*** (Altimeter checkpoints are required at all USAF bases if the takeoff end of the runway varies more than 25 feet from the official field elevation.)

8.1.1. Procedure. ***Set the reported altimeter setting on the barometric scale. Compare the indicated altitude to the elevation of a known checkpoint. The maximum allowable error is 75 feet. If the altimeter error exceeds 75 feet, the instrument is out of tolerance for flight***. No further corrections are necessary if the altimeter is within tolerance.

8.1.2. Off-Scale Altimeter Settings. Figures 8.1 and 8.2 give a sampling of possible altimeter settings and their resulting correction factors.

8.1.2.1. WARNING: Most altimeters will only accommodate altimeter settings from 28.10 inches to 31.00 inches. Attempting to adjust an altimeter outside this range may cause internal damage to the instrument. At some higher latitude locations, extremely high and low pressures occasionally occur outside this range. When this occurs, a correction may be made to all depicted approach altitudes (DH, MDA, FAF, intermediate altitudes) using a ratio of 10 feet for every .01-inch difference between the actual altimeter setting and the lower or upper limit set in the altimeter. ***If the actual altimeter setting is greater than 31.00 inches, the correction factor will be subtracted from all depicted approach altitudes. If the actual altimeter setting is less than 28.10 inches, the correction factor will be added to all depicted approach altitudes.***

Table 8.1. Altimeter Correction Factor: Actual Altimeter Setting Exceeds Altimeter Upper Limit.

ACTUAL ALSTG	VALUE SET IN ALTIMETER	DIFFERENCE	CORRECTION (- Feet)
31.01	31.00	.01	10
31.02	31.00	.02	20
31.03	31.00	.03	30
31.04	31.00	.04	40
31.05	31.00	.05	50
31.06	31.00	.06	60
31.07	31.00	.07	70
31.08	31.00	.08	80
31.09	31.00	.09	90
31.10	31.00	.10	100
31.20	31.00	.20	200
31.30	31.00	.30	300
31.40	31.00	.40	400
31.50	31.00	.50	500
32.00	31.00	1.00	1,000

Table 8.2. Altimeter Correction Factor: Actual Altimeter Setting Less than Altimeter Lower Limit.

ACTUAL ALSTG	VALUE SET IN ALTIMETER	DIFFERENCE	CORRECTION (+ Feet)
28.09	28.10	.01	10
28.08	28.10	.02	20
28.07	28.10	.03	30
28.06	28.10	.04	40
28.05	28.10	.05	50
28.04	28.10	.06	60
28.03	28.10	.07	70
28.02	28.10	.08	80
28.01	28.10	.09	90
28.00	28.10	.10	100
27.90	28.10	.20	200
27.80	28.10	.30	300
27.70	28.10	.40	400
27.60	28.10	.50	500
27.10	28.10	1.00	1,000

8.1.3. Corrections to Approach Altitudes. To illustrate how these corrections are applied, consider the two approach plate excerpts (Figures 8.1 and 8.2).

Figure 8.1. Example 1-Off-Scale Altimeter.

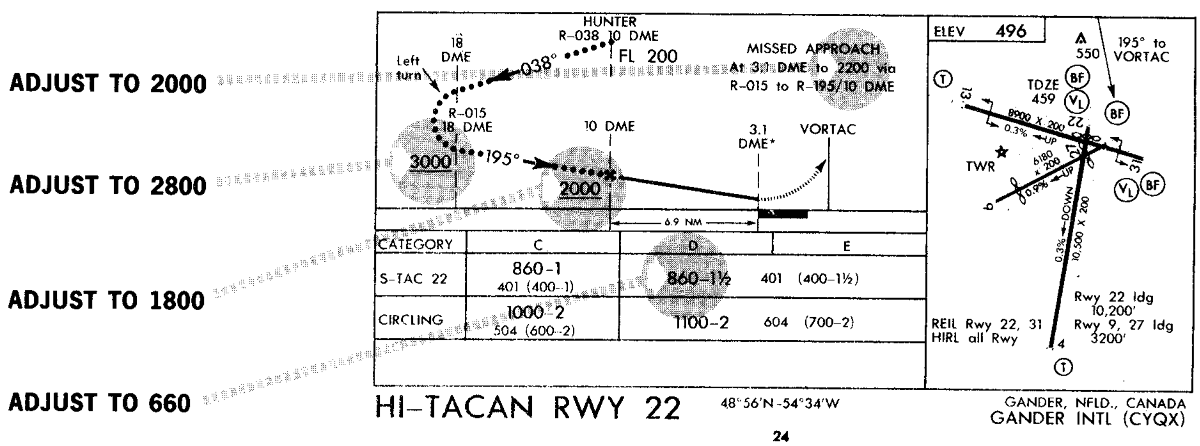
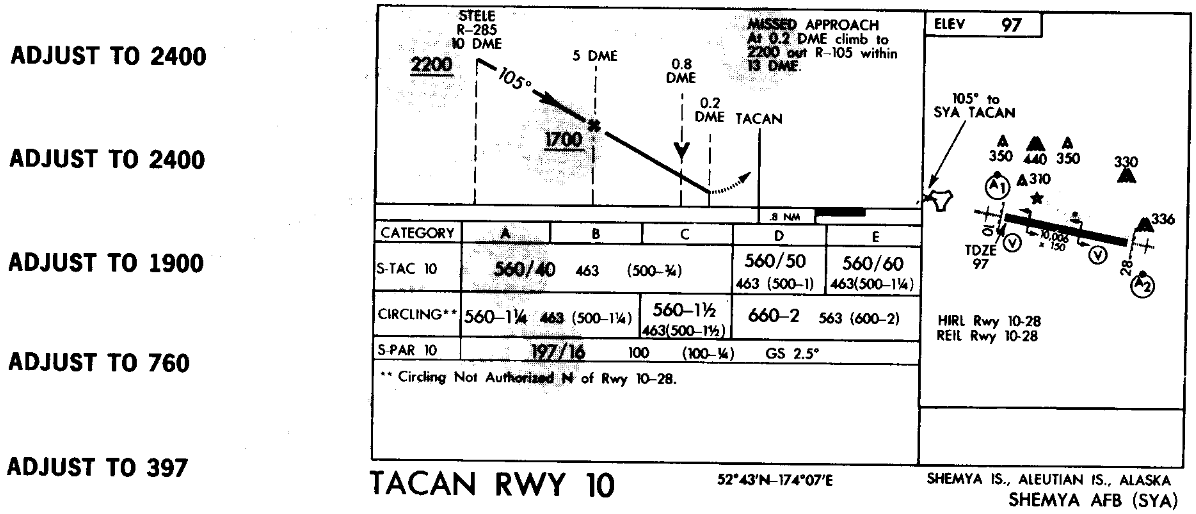


Figure 8.2. Example 2 - Off-scale Altimeter Settings.



8.1.3.1. Subtracting Corrections. In example one (Figure 8.1), you have been cleared to fly the HI-TACAN RWY 22 at Gander INTL. The local altimeter setting is 31.20 inches. Your altimeter's maximum range is 31.00 inches. First, determine the difference between the actual ALSTG (31.20) and the value set in your altimeter (31.00). Take this result (.20) and multiply by 1,000. This will give you your correction factor (200 ft). Because the altimeter setting exceeds the altimeter's maximum range, the correction (200 ft) will be subtracted from all approach altitudes. These corrections are indicated on the approach.

8.1.3.2. Adding Corrections. In example two (Figure 8.2), you have been cleared to fly the TACAN RWY 10 at Shemya AFB. The local altimeter setting is 27.90 inches. Your altimeter's minimum range is 28.10 inches. First, determine the difference between the actual ALSTG (27.90) and the value set in your altimeter (28.10). Take this result (.20) and multiply by 1,000. This will give you your correction factor (200 ft). Because the altimeter setting is less than the altimeter's minimum range, the correction (200 ft) will be added to all approach altitudes. These corrections are indicated on the approach.

8.1.3.2.1. NOTE: Because high pressure is usually associated with fair weather (VMC), the use of correction factors where the actual altimeter setting exceeds the altimeter upper limit does not present a serious problem. On the other hand, low ceilings and visibilities are often associated with extremely low pressure (low altimeter settings). Aircraft that must execute an actual instrument approach (IMC) under these conditions should consider this situation an emergency. It is further recommended that all available approach and navigation aids (radar altimeters, Ground Controlled Approach (GCA) monitored approach, etc.) be used to determine aircraft position and altitude.

8.1.4. Cold Weather Altimeter Corrections. Pressure altimeters are calibrated to indicate true altitude under International Standard Atmospheric (ISA) conditions. Any deviation from these standard conditions will result in an erroneous reading on the altimeter. This error becomes important when considering obstacle clearances in temperatures lower than standard since the aircraft's altitude is below the figure indicated by the altimeter. The error is proportional to the difference between actual and ISA temperature and the height of the aircraft above the altimeter setting source. The amount of error is approximately 4 feet per thousand feet for each degree Celsius of difference. Corrections will only be made for DHs, MDAs, and other altitudes inside, but not including, the FAF. The same correction made to DHs and MDAs can be applied to other altitudes inside the FAF. ***For the current cold weather altimeter correction procedure, you must refer to the Flight Information Handbook (FIH).*** The guidance found in paragraph 8.1.4.1 is provided as an example of how to accomplish the procedure found in the FIH.

8.1.4.1. To ensure adequate obstacle clearance the values derived from the chart below will be:

8.1.4.1.1. Added to the published DH or MDA and step-down fixes inside the FAF whenever the outside air temperature is less than 0° Celsius

8.1.4.1.2. Added to ALL altitudes in the procedure in Designated Mountainous Regions whenever the outside air temperature is 0° Celsius or less

8.1.4.1.3. Added to ALL altitudes in the procedure whenever the outside air temperature is -30° Celsius or less, or procedure turn, intermediate approach altitude Heights Above Touchdown (HAT)/Heights Above Aerodrome (HAA) are 3000 feet or more above the altimeter setting source.

Table 8.3. Temperature Correction Chart.

(Feet)

(This chart is not authorized for use in flight. For the current chart and procedure, see the FIH)

TEMP °C														
0	0	20	20	20	20	40	40	40	40	60	80	140	180	220
-10	20	20	40	40	40	60	80	80	80	120	160	260	340	420
-20	20	40	40	60	80	80	100	120	120	180	240	380	500	620
-30	40	40	60	80	100	120	140	140	160	240	320	500	660	820
-40	40	60	80	100	120	140	160	180	200	300	400	620	820	1020
-50	40	80	100	120	140	180	200	220	240	360	480	740	980	1220
	200	300	400	500	600	700	800	900	1000	1500	2000	3000	4000	5000

8.1.4.1.3.1. Example: Published MDA 1180' MSL

HAT 402
Temp -30° C
Correction 60'
MDA to use: 1180 + 60 = 1240' MSL

8.1.4.1.3.1.1. NOTE: Pilots should advise ATC of corrections in excess of 80 feet.

8.2. U.S. NOTAM System (USNS). ***You must check applicable NOTAMs for each flight.*** Thorough preflight planning is the key to successful flight operations. For flight planning purposes, Notice to Airmen (NOTAM) information is available from the U.S. NOTAM System (USNS) via the DoD Internet NOTAM Distribution System (DINS). To fully understand where and how to get all available NOTAM information, it is important to understand the USNS.

8.2.1. Defense Internet NOTAM System. DINS is composed of a large central data management system deriving information from the US Consolidated NOTAM Office at the FAA Air Traffic Control System Command Center (ATCSCC) located at Herndon, VA. Real-time NOTAM information is maintained and made available through the internet. Coverage includes all military airfields and virtually all domestic, international, and Flight Data Center (FDC) NOTAMs. If not covered by DINS, the airfield does not transmit NOTAM data to the USNS. A plain language notice in red font is displayed advising the user of that fact. In such a case, you must contact the desired location directly for NOTAM information.

8.2.2. NOTAMs - Definition. NOTAM is defined in AFJMAN 11-208 (DoD Notice to Airmen (NOTAM) System), as an unclassified notice containing information concerning the establishment of, condition of, or change in an aeronautical facility, service, procedures or hazards; the timely knowledge of which is essential for safe flight operations.

8.2.2.1. NOTAM abbreviations are explained in the FIH and the Notices to Airmen Publication (NTAP). NOTAM abbreviations for DINS can be found in the FIH and FAAO 7930.2 *Notice to Airmen (NOTAMS).*

8.2.3. NOTAMs – Types. There are many different types of NOTAMs.

8.2.3.1. Military Flight Safety NOTAMS. These NOTAMs contain flight safety related information about individual military aerodromes: runway closures, NAVAID outages, frequency changes, runway lighting, etc.

8.2.3.2. FDC NOTAMs. The most important thing to know about FDC NOTAMs is that they are regulatory. FDC NOTAMs contain important information such as amendments to published approaches, chart changes and Temporary Flight Restrictions (TFR). FDC NOTAMs are broken down into the following categories: General FDC NOTAMs, Air Route Traffic Control Center (ARTCC) FDC NOTAMs, Airports, Facilities & Procedural FDC NOTAMs, and Special Notices

8.2.3.2.1. General FDC NOTAMs. These FDC NOTAMs apply to all aircraft, regardless of departure, destination or route of flight. General FDC NOTAMs contain information including, but not limited to changes to U.S. Government flight information publications, hostile airspace advisories, special FAA regulations, changes to standard operating procedures in U.S. airspace, and any other general information which might affect flight operations.

8.2.3.2.2. ARTCC FDC NOTAMs. These FDC NOTAMs only apply to aircraft flying through the associated ARTCC. These NOTAMs are identified by the three-letter center identifier beginning with a “Z” (ZHU – Houston Center). ARTCC FDC NOTAMs may include, but are not limited to, changes to published minimum altitudes and routings, in-flight hazards and advisories, special use airspace activity and airspace changes/restrictions.

8.2.3.2.3. Airports, Facilities & Procedural FDC NOTAMs. These NOTAMs cover civilian and some joint-use fields and include, but are not limited to, changes to local procedures, changes/revisions/amendments to published instrument approach and departure procedures, and changes/revisions to minimum altitudes.

8.2.3.2.4. Special Notices. These NOTAMs are FDC NOTAMs that normally specify special FAA regulations dealing with current events and issues of national security.

8.2.3.3. Attention Notices. Attention Notices are general notices that apply to military pilots. They are broken down into the following groups with the associated abbreviation; All (ATTA), Europe (ATTE), North America (ATTN), Caribbean and South America (ATTC) and Pacific (ATTP).

8.2.3.4. Civilian “D” (Distant) Series NOTAMs. These NOTAMs are the civilian equivalent of a Military Flight Safety NOTAM. They contain information about individual civilian aerodromes: runway closures, NAVAID outages, frequency changes, runway lighting, etc.

8.2.3.5. Civilian “L” (Local) Series NOTAMs. These NOTAMs are equivalent to a military airfield advisory. L Series NOTAMs contain information that doesn’t require wide dissemination and will not prevent the use of an airfield’s runways. The information may, however, affect the use of other parts of an airfield. These NOTAMs are found by calling the local Flight Service Station (FSS) governing the field.

8.2.3.6. Notices to Airman Publication. NTAP is available on the internet via a link from DINS. If you do not have internet access, ask Base Operations for the hard copy. This book consists of four parts.

8.2.3.6.1. Part 1 contains FDC NOTAMs and NOTAMs that meet the criteria of "D" NOTAMs and are expected to remain in effect for an extended period of time.

8.2.3.6.2. Part 2 contains revisions to Minimum En Route IFR altitudes and changeover points as well as other information regarding a wide geographic area or not suited for Part 1.

8.2.3.6.3. Part 3 contains significant international NOTAMs including Foreign

Notices, Department of State Advisories, and Overland/Oceanic Airspace Notices.

8.2.3.6.4. Part 4 contains graphical notices of items that will impact flight operations in the following areas: General Information, Special Military Operations, Major Sporting and Entertainment Events, Northeast United States, Southeast United States, East Central United States, South Central United States, Southwest United States, Northwest United States, Alaska/Hawaii and Special Airshow Section.

8.2.3.7**.** GPS NOTAMs. There are three types of GPS NOTAMs – satellite outage NOTAMs, RAIM availability NOTAMs and GPS jamming NOTAMs. Satellite outage NOTAMs are accessed through the DINS web page by entering the 4-letter identifier "KGPS". When entered, this identifier will provide information on satellite outages. Out of service satellites will be identified by their PRN. RAIM availability NOTAMs maybe obtained by entering the 4-letter ICAO airfield identifier on the NOTAM home page for selected military airfields. Additionally, information on planned GPS jamming operations for the US NAS is listed in the appropriate center NOTAMs. In areas of predicted jamming, aircraft may not plan to use GPS to fly instrument procedures, however, if GPS is available it may be used. ***Both types of GPS NOTAMs must be retrieved for all flights that will use GPS***.

8.3. DoD Internet NOTAM Distribution System (https://www.notams.jcs.mil or backup https://www.notams.faa.gov). DINS provides real time NOTAM data validated by the U.S. NOTAM System (USNS), which includes domestic, international, military and FDC NOTAMs. DINS undergoes frequent changes to improve the content and format of information provided. The information is broken down into multiple pages including the Home Page/United States NOTAM Office, FDC NOTAMs, TFRs, Special Notices, ARTCC NOTAMs, Radius/Flight Path Search, the North Atlantic and Pacific Track Systems, Reduced Vertical Separation Minima (RVSM), European Theater, FM Immunity, and ICAO Search/Listing. DINS will provide a plain language notice, highlighted in red, when a requested location is not in the U.S. NOTAM System. If the requested location is not covered, it does not transmit NOTAM information for the USNS. You must contact the requested location to receive NOTAM information.

8.3.1. Home Page/United States NOTAM Office Page. Input the four-letter ICAO identifiers for the airfields you want to check NOTAMs for. You can enter up to 50 ICAO identifiers at any one time. You may also enter Flight Information Region (FIR) identifiers, Military Operations Areas (MOA) names, special use airspace identifiers and ARTCC identifiers to check their NOTAMs as well as KFDC and KGPS to check FDC and GPS NOTAMs respectively. ***GPS NOTAMs must be retrieved prior to flight where GPS will be used***. Click the "View NOTAMs" button to view the current NOTAMs for your selections. NOTAMs are displayed in plain language text with the tracking number unless "raw" format is selected. When raw format is selected, NOTAMs are presented in the international, machine-readable, ICAO code format with multiple report fields, NOTAM series and NOTAM tracking numbers displayed.

8.3.2. FDC TFRs, Special Notices & ARTCC NOTAMs Page (Applies to CONUS only). This page offers the flexibility for the user to extract TFRs from the FDC NOTAMs and the various ARTCC area NOTAMs by clicking on the "TFR Only" button and then selecting the ARTCC(s) of interest.

8.3.2.1. NOTE: If you are interested in all ARTCC TFRs click on the "All ARTCC TFRs" button. You can use the optional ARTCC Special Notices checkbox to add FDC Special Notices with your TFR request.

8.3.3. Radius/Flight Path Search. The radius search page allows the user to input a ICAO identifier or latitude/longitude and receive NOTAMS within a specified radius of that location. The NOTAMs listed include surrounding airports and NAVAIDs, ARTCCs, Upper Information Regions (UIR), and FIRs. The flight path search page allows the user to input ICAO identifiers for the departure and arrival fields as well as several enroute locations. The user can select to receive airports and NAVAIDs, ARTCCs, UIRs, and FIRs within a specified nautical mile buffer in addition to FDC NOTAMs. Special Use Airspace NOTAMs are also available with the radius and flight path search pages.

8.3.3.1. NOTE: Local NOTAMs are not displayed on these pages. You must check for Local NOTAMs from the DINS home page for military airfields or the local FSS for civilian fields.

8.3.4. Track Systems. This section provides aircrews with daily message traffic regarding the North Atlantic Track System (NATS) and Pacific Tracks. Other parts of the organized track system will be added in the future.

8.3.5. Reduced Vertical Separation Minimums. FIRs and controlling ATC Centers break out RVSM NOTAMs. They will be displayed alphabetically by their respective ICAO identifier. Aircrews are encouraged to frequently check the FAA RVSM website at http://www.faa.gov/ats/ato/rvsm1.htm for the latest news. Note that there could be as many as 90 active RVSM notices, and it may take approximately 15 to 20 seconds to retrieve the data.

8.3.6. European Theater. This page provides data from the US Army Flight Operations Detachment Europe (AFOD) and contains NOTAMs on airfields, airspace, navigation/communications, special notices and updates throughout the European theatre. This page also covers FM immunity information for Europe, Africa, and the Middle East areas of operation. It also contains Bird Activity NOTAMs (BIRDTAMS) issued by the German Military Geophysical Office.

8.3.6.1. FM Immunity. This page refers crews to the current source(s) of FM Immunity information. Listed countries require FM immune receivers unless otherwise noted in the individual country entry. Countries not listing any information are assumed to have implemented ICAO Annex 10 requirements for FM Immunity.

8.3.6.2. EUCARF Page. NOTAMs concerning operations and airspace controlled by the European Central Airspace Reservation Facility (EUCARF) can be obtained through this page. Information will include airspace, refueling tracks and Altitude Reservations (ALTRV) currently reserved through EUCARF.

8.3.7. ICAO Search/Listing Pages. The search page allows a user to search the DINS database for an ICAO airport and country by inputting the ICAO identifier. The Listing Page provides a geographic listing of all sites covered by DINS, allowing the user to find the four-letter identifier of the desired airfield by selecting the country (and state in the

Continental United States (CONUS)) to determine if an airfield is covered by DINS and the USNS. Special Use Airspace identifiers are listed at the bottom of each states listing on the Listing Page.

8.3.8. Jeppesen Notices and Alerts. This link allows a user to view the current Jeppesen NAVDATA alerts and notices that pertain to their products. Aircrews must check these NOTAMS when using Jeppesen products.

8.3.9. SNOWTAM. The DINS system displays SNOWTAM NOTAMs for select OCONUS locations. A SNOWTAM is originated and issued whenever the presence, removal or significant changes in hazardous conditions occur due to snow, slush, ice or water contaminants. The legend for decoding SNOWTAM codes is in FLIP General Planning.

8.3.10. Air Traffic Control System Command Center (ATCSCC). From the "Links" page, click on ATCSCC to obtain information on traffic management programs in the US. The direct link is http://www.fly.faa.gov/flyfaa/usmap.jsp. This site details delays, gate holds, ground stops, and other traffic management programs in effect for the major civil airports. Even if your destination or departure point is not one of these airports, traffic management programs can still affect your flight if you are in a terminal area in close proximity to an airport experiencing a delay. Traffic management programs do apply to military aircraft.

8.3.11. The FAA NOTAM Distribution System. Unlike DINS, which allows pilots to check their own NOTAMs, the FAA NOTAM Distribution System is based on a verbal briefing system. To obtain a verbal briefing, contact a FSS. The easiest way to accomplish this is to call 1-800-WXBRIEF. The FSS Briefer will provide you with NOTAM D information for any field you request. NOTAM L information must be requested from the servicing FSS or directly from the airfield. FSSs maintain a file of FDC NOTAMs affecting conditions within 400 miles of their facility. FDC information concerning conditions more than 400 miles away from the FSS, or that is already published in the NTAP, is given only on request. The Flight Service Station briefer assumes you have looked at the appropriate sections of the NTAP. They will not brief the information contained in the NTAP unless specifically requested.

8.3.11.1. A FSS will not brief Military Safety NOTAMS unless specifically requested. FSS do not have the capability to brief the Military "L" series NOTAMS. If you request Military Safety NOTAMS from a FSS briefer, there is sometimes a significant delay in obtaining them.

8.3.12. DINS Web Page Limitations. It is important to understand that the DINS web page, while updating on a real-time basis, does not auto-refresh the information. This means that while the page is current up to the minute when it is originally accessed, no further updates are received unless the page is "refreshed" by clicking VIEW—REFRESH, or by reentering the selected ICAO identifiers and clicking on "view notices." New NOTAMs will contain a tracking number and should be sorted in increasing numerical order (oldest to newest). Use caution as various numbering formats are used depending on the type of NOTAM being displayed. The newest NOTAMs may not necessarily be at the bottom of the complete list of NOTAMs for a particular ICAO location. ***You must recheck the NOTAM web site prior to all flights to ensure you have***

the latest NOTAMs.

8.3.12.1. Most aircrews use DINS as the primary means to obtain NOTAM information. Occasionally, due to internet outages or lack of facilities at austere locations, internet access may not be available. In these cases, ***aircrews must use any means available to obtain NOTAMs prior to all flights*** (telephone, fax, HF radio, etc.).

8.3.13. The Airfield Suitability and Restrictions Report (ASRR). This publication is helpful in pre-mission planning and consists of two parts. Part One provides basic airfield and suitability information; Part Two provides airfield restrictions and other information for select airfields. ASRR information is available via the worldwide web address: https://www.afd.scott.af.mil.

8.3.14. Navigation Options in the National Airspace System. There are two methods of navigating in the National Airspace System: on airways and off airways. Specific procedures for filing are found in FLIP GP unless noted otherwise.

8.3.15. On Airways. Two fixed route systems are established for air navigation purposes. They are the VOR and L/MF system, and the jet route system. To the extent possible, these route systems are aligned in an overlying manner to facilitate transition between each.

8.3.15.1. ***Unless otherwise authorized by ATC, pilots are required to adhere to the centerline of airways or routes being flown.*** Special attention must be given to this requirement during course changes. Turns that begin at or after fix passage may exceed airway or route boundaries. Consequently, the FAA expects pilots to lead turns and take other actions considered necessary during course changes to adhere as closely as possible to the airways or route being flown. USAF pilots should attempt to adhere to course centerline whenever possible.

8.3.15.1.1. VOR and L/MF Airway System. The VOR and L/MF Airway System consist of airways designated from 1,200 feet above the surface (or in some instances higher) up to but not including 18,000 feet Mean Sea Level (MSL). These airways are depicted on En Route Low Altitude Charts.

8.3.15.1.2. VOR Airways. Except in Alaska and coastal North Carolina, the VOR airways are based solely on VOR or VORTAC navigation aids and are identified by a "V" (Victor) followed by the airway number (e.g., V12). Segments of VOR airways in Alaska and North Carolina (V290) are based on L/MF navigation aids and charted in brown instead of black on en route charts.

8.3.15.1.3. L/MF Airways. The L/MF airways (colored airways) are based solely on L/MF navigation aids and are depicted in brown on aeronautical charts and are identified by color name and number (e.g., Amber One). Green and Red airways are plotted east and west. Amber and Blue airways are plotted north and south. Except for G13 in North Carolina, the colored airway system exists only in Alaska.

8.3.15.1.4. Jet Routes. The Jet Route system consists of jet routes established in Class A airspace. These routes are depicted on En Route High Altitude Charts. Jet routes are depicted in black on aeronautical charts and are identified by a "J"

(Jet) followed by the airway number (e.g., J12). Jet routes, as VOR airways, are based solely on VOR or VORTAC navigation facilities (except in Alaska). Segments of jet routes in Alaska are based on L/MF navigation aids and are charted in brown instead of black on en route charts.

8.3.16. RNAV Routes. RNAV is a method of navigation permitting aircraft operations on any desired course within the coverage and capabilities of the aircraft onboard navigation equipment.

8.3.16.1. Designated RNAV Routes. Permanent published and charted airway routes based on area navigation equipment are available for use by aircraft with RNAV capability. Refer to the FAA NTAP web site, section 4 for a description of equipment requirements for RNAV Jet routes in the US NAS.

8.3.16.1.1. RVAV routes are designated in blue on US enroute charts.

8.3.16.2. Required Equipment for RNAV. FAA AC 90-45, *Approval of Area Navigation Systems for Use in the US National Airspace System*, outlines the RNAV equipment specifications for certification within the NAS. The major types of appropriate equipment are:

8.3.16.2.1. VORTAC-Referenced or Course Line Computer (CLC) Systems. These systems account for the greatest number of RNAV units in use. In the military, most FMS units use the functions of a VOR, VOR/DME, DME, or TACAN station to update an onboard navigation computer. With any of these systems, the aircraft must remain within the service range of the navigation station.

8.3.16.2.2. INS Systems. INS units are self-contained and require no information from external references. They provide aircraft position and navigation information in response to signals resulting from inertial effects on components within the system.

8.3.16.2.3. MLS/RNAV. MLS/RNAV equipment provides area navigation with reference to an MLS ground facility. The aircraft must remain within the service range of the navigation station.

8.3.16.2.4. LORAN-C. LORAN-C is a long-range radio navigation system of ground waves transmitted at low frequency to provide the user position information at ranges of up to 600 to 1,200 nautical miles from the navigation station at both en route and approach altitudes. The usable signal coverage varies through many environmental and physical characteristics and must be monitored by the aircrew during flight.

8.3.16.2.5. GPS. GPS is a space-based radio positioning, navigation, and time-transfer system. The system provides highly accurate position and velocity information, and precise time, on a nearly continuous global basis, to properly equipped users. The system is unaffected by weather, and provides a worldwide common grid reference system. GPS navigation equipment must be approved in accordance with the requirements specified in FAA TSO, AC and Notices pertaining to the intended operations (e.g., enroute, oceanic, terminal, non-precision, and precision approach). ***Operate GPS equipment IAW AFI 11-202***

Volume 3 General Flight Rules.

8.3.17. Off Airways (Direct). There are several methods pilots can use to fly off of the airway system, otherwise known as "direct" flight.

8.3.17.1. NAVAID to NAVAID. ***Aircraft may file along a direct course between NAVAIDs as long as the aircraft does not exceed the limitations of the NAVAIDs being used to define the course***. For example, an "L" class VORTAC is only usable below 18,000 feet MSL and within 40 nautical miles of the station. NAVAID limitations can be found in the front of the FLIP IFR Supplement.

8.3.17.2. Degree-Distance Route Definition for Military Operations. Degree-distance route definition is a military-only privilege that allows certain aircraft to exceed the NAVAID limitations imposed by NAVAID to NAVAID filing restrictions. The specific procedures for filing and using degree-distance route definition are published in FAAH 7110.65, *Air Traffic Control*. The use of degree-distance criteria is limited to aircraft performing specialized military missions.

8.3.17.3. Random RNAV Routes. Random RNAV routes are direct routes flown between any two points, based on aircraft onboard RNAV capability and defined in terms of latitude/longitude coordinates, degree-distance fixes, or offsets from established routes/airways at a specified distance and direction. Radar monitoring by ATC is required on all random RNAV routes within the National Airspace System. Factors ATC will consider in approving random RNAV routes include the capability to provide radar monitoring and compatibility with traffic volume and flow. ATC will radar monitor each flight; however, navigation on the random RNAV route is the responsibility of the pilot.

8.3.17.4. National Route Program (NRP). An FAA program designed to make air travel easier and more cost efficient by taking advantage of emerging technologies. Aircraft flying under the NRP will fly normal departure and arrival routes within 200 nautical miles of the departure and destination airports and direct routes of their choice in between. The equipment required to participate in the NRP is the same as the equipment required for RNAV. The NRP may eventually allow “free flight” route operations throughout the continental U.S. at FL 290 and above. Specific procedures and restrictions can be found in FLIP General Planning.

8.3.17.5. Navigation Reference System. The Navigation Reference System (NRS) is a system of waypoints developed for use within the United States for flight planning and navigation without reference to ground based navigation aids. The waypoints are located in a grid pattern along defined latitude and longitude lines. The initial use of the NRS will be in the high altitude environment in conjunction with the High Altitude Redesign initiative. The waypoints are intended for use by aircraft capable of point-to-point navigation. The naming convention for NRS waypoints is defined by a five-character sequence which reference the ICAO FIR, airspace subsets of the FIR and coding for increments of latitude and longitude.

8.4. Planning for En Route. Preflight planning of the en route portion should be adequate to ensure a safe and efficient flight. As a minimum, aircrews should review:

8.4.1. Route. The intended route of flight (to include preferred routing located in AP/1) using current flight publications.

8.4.2. En route NOTAMs.

8.4.3. En route weather.

8.4.4. FLIP products. The appropriate FLIP products to ensure compliance with any special procedures that may apply.

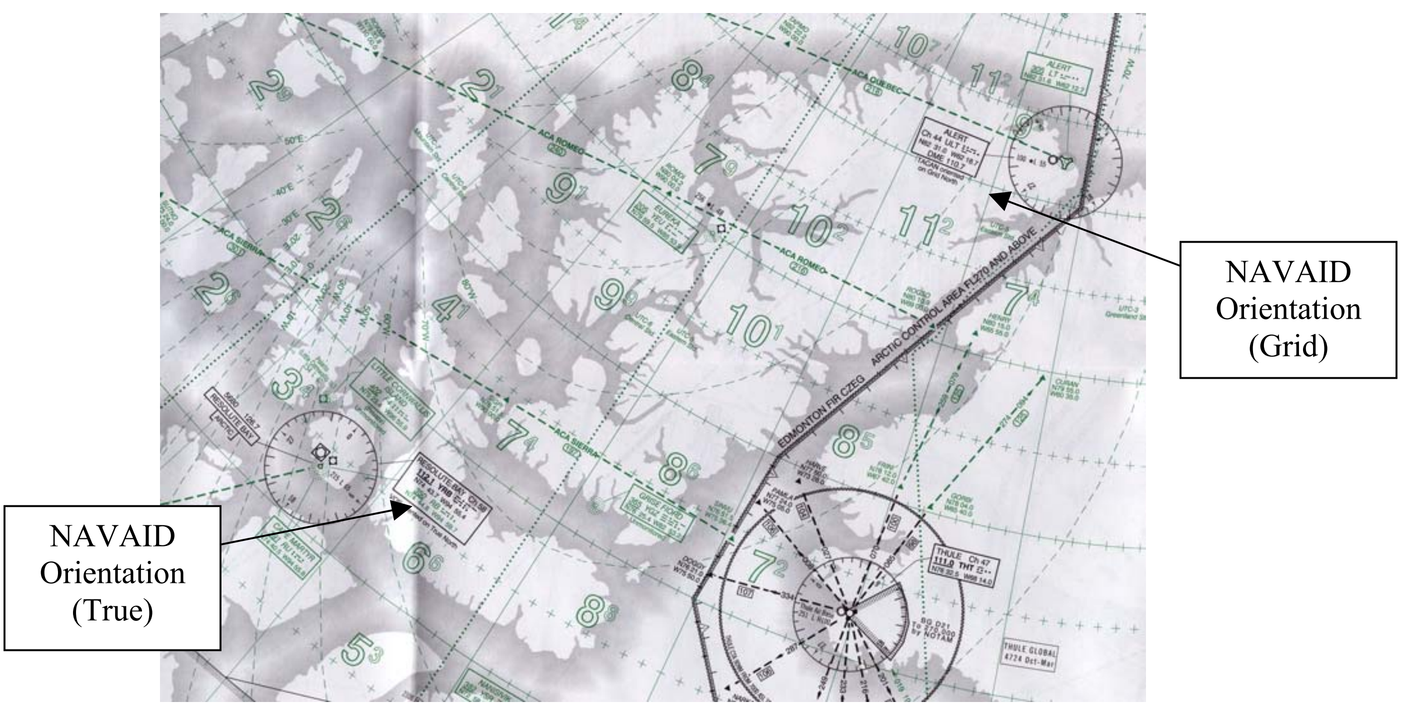
8.4.5. Diversion fields. Emergency diversion fields and approaches.

8.4.6. Compliance. Comply with the jet route or airway system as published on the FLIP en route charts and air traffic clearances. You must also ensure your aircraft is equipped and authorized to operate in the airspace along your route of flight. For example, only aircraft certified through their MAJCOM for RNP-5 may operate in the European Basic RNAV (BRNAV) structure. Consult your MAJCOM and Mission Design Series (MDS)-specific guidance if you have any doubts concerning your aircraft's capabilities.

8.4.7. Enroute Navigation in High Latitudes. Enroute navigation in higher latitude regions may be based on reference to true or grid north instead of the customary reference to magnetic north. Procedures vary greatly between aircraft type and avionics capabilities. Thorough mission planning, including review of applicable aircraft/avionics specific procedures and limitations, is essential to accurate navigation at higher latitudes.

8.4.7.1. When flying at higher latitudes, review the enroute charts carefully to ensure you are cognizant of the heading source required by the instrument procedures in the airspace you are transiting, and the orientation reference of the NAVAID. This is annotated on the enroute chart as shown in Figure 8.3.

Figure 8.3. Enroute Charts for Navigation in Higher Latitudes.



8.4.7.2. Normally, navigation north of 70°North latitude or south of 60°South latitude is conducted with reference to true north or grid north. Specific procedures vary greatly depending on aircraft type, avionics capabilities, and crew complement. Unless otherwise annotated, where there is a reference to true north, the text also applies in southern latitudes and applies to navigation with reference to grid north/south.

8.4.7.2.1. There are areas officially designated Areas of Magnetic Unreliability (AMU). ***Aircraft capable of displaying only magnetic heading are prohibited from operating in designated AMUs. For areas north of 70°North and south of 60° South that are not officially designated as AMUs, MAJCOMs will determine the highest allowable latitude for aircraft capable of displaying only magnetic heading.***

8.4.7.2.1.1. NOTE: Although partly south of 70° North, the entire Canadian Northern and Arctic Control Areas and areas of Northern Domestic Airspace are designated as AMUs.

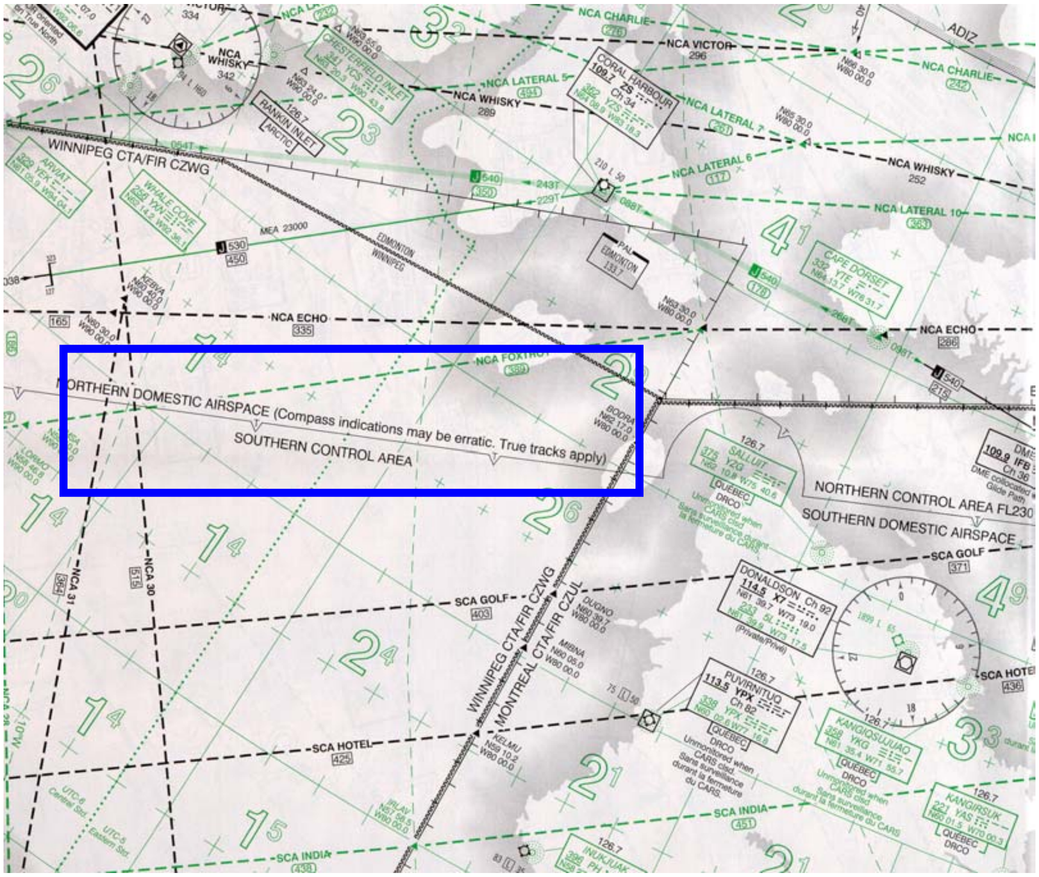
8.4.7.2.2. ***MAJCOMs must provide aircraft-specific operational approval prior to enroute and terminal area operations using navigation aids oriented to true or grid***.

8.4.7.2.2.1. Operational approval shall be based on development of aircraft specific procedures and training. As a minimum, procedures and training should address: identification of areas where reference to true or grid north is required, procedures for displaying true or grid heading reference, procedures for verifying magnetic variation information from the aircraft navigation computer, procedures for inputting manual magnetic variation information, procedures for returning to automatic magnetic variation computation, minimum equipment requirements, and emergency procedures in the event of true or grid navigation equipment failure while operating in the AMU.

8.4.7.3. ***Aircraft navigation displays must be set to display true north prior to flying true headings or courses***. ***Suitably equipped aircraft may also use grid reference if applicable.***

8.4.7.4. ***Outside of designated AMUs, aircraft unable to display true or grid heading may use navigation aids oriented to true north for enroute navigation provided procedures listed below are followed***.

Figure 8.4. Canadian Northern Control Area Boundaries (Areas South of 70°N Where True Tracks Apply).



8.4.7.4.1. Enroute navigation using approved RNAV equipment backed up by display of VOR/TAC/NDB data is recommended.

8.4.7.4.1.1. Depending on system architecture, aircraft navigation computers (flight management systems) automatically provide magnetic variation information. Accuracy of this magnetic variation depends on the period of time since the last magnetic variation update. Some systems contain magnetic variation information that cannot be updated. Also, some navigation systems provide magnetic variation information for only a limited portion of the globe. Thus, when true or grid heading information cannot be displayed, aircraft magnetic variation information must be verified with current aeronautical charts prior to use of RNAV equipment to fly true or grid courses. For navigation using FMS or other RNAV system, procedures and system limitations vary widely among aircraft and avionics installations. ***Consult your aircraft flight manual and MAJCOM directives for specific FMS and RNAV procedures for navigation where reference to true or grid north is required.***

8.4.7.5. For navigation using VOR or TACAN, if the NAVAID is oriented to true north, use the following procedures for enroute navigation:

8.4.7.5.1. NOTE: Only VORs and TACANs can be oriented to true north. NDBs cannot be oriented to true north. ADF needles always display relative bearing to the station.

8.4.7.5.2. ***If your aircraft allows selection of true north as a heading reference, select true north.*** No additional corrections are required for courses or headings.

8.4.7.5.3. ***If your aircraft does not allow selection of true north as a heading reference, use the following procedures***:

8.4.7.5.3.1. VOR and TACAN courses do not require correction for magnetic variation.

8.4.7.5.3.1.1. The desired true course must be set into the CDI. The aircraft CDI will indicate deviations left and right of the desired true course. However, with magnetic heading displayed, the bearing pointer will not point to the station, but will instead indicate true bearing to the station. In other words, when established on course, the CDI will be centered on the desired true course, but the bearing pointer will indicate true bearing to the station and will be displaced from aircraft no-wind heading by the amount of station magnetic variation. For example, the Thule magnetic variation is approximately 60 degrees west. When proceeding inbound on the Thule 180 degree radial true (360 course), the aircraft no wind heading will be 060, while the bearing pointer will point to 360. Be aware that this discrepancy between aircraft heading and desired course may make flight director guidance unreliable.

8.4.7.5.3.2. All headings require corrections for magnetic variation.

8.4.7.6. For navigation using NDB, use the following procedures:

8.4.7.6.1. NOTE: Only VORs and TACANs can be oriented to true north. NDBs cannot be oriented to true north. ADF needles always display relative bearing to the station.

8.4.7.6.2. ***If your aircraft allows selection of true north as a heading reference, select true north. No additional corrections are required for relative bearings.***

8.4.7.6.3. ***If your aircraft does not allow selection of true north as a heading reference, all relative bearings require correction for magnetic variation.***

8.4.7.6.3.1. ***Crews should compute and fly the appropriate magnetic course by correcting the desired true course for the magnetic variation at the current aircraft location. Use the magnetic variation at your current location. This correction should be updated at least every 5° of magnetic variation or every 30 nm, whichever occurs first.***

8.4.8. Minimum Altitudes.

8.4.8.1. Altitude Clearances. Ensure altitude clearances received en route do not conflict with minimum en route altitudes (MEA), minimum obstruction clearance altitudes (MOCA), minimum reception altitudes (MRA), or minimum crossing altitudes (MCA) shown on en route charts.

8.4.8.2. Controlled Airspace. In controlled airspace, the air traffic controller will assign altitudes that provide obstacle clearance. You should use all available navigation aids to remain position-oriented and immediately query the controller if there is any uncertainty of the obstacle clearance provided by the assigned altitude**.** When flying via published routing (a route with minimum altitudes depicted), compliance with the minimum altitude published on the routing ensures obstacle clearance. ***If a published minimum altitude is not available, aircrews must determine minimum altitudes in accordance with AFI 11-202 Volume 3, General Flight Rules.***

8.4.8.3. Uncontrolled Airspace. ***In uncontrolled airspace, you must ensure the altitudes flown will provide obstacle clearance during all phases of flight.***

8.4.8.4. Radio Failure. In case of radio failure, you are responsible for minimum altitude selection. ***Comply with published radio failure procedures in the FIH.***

8.5. Planning the Approach. Preparation for flying an instrument approach begins with a study of the approach depiction during preflight planning. The end result of an approach--a landing or a missed approach--can be directly dependent upon the pilot's familiarity with the approach depiction.

8.5.1. Aircraft Categories and Instrument Approach Procedures Selection.

8.5.1.1. Category. Aircraft approach category is based on 1.3 times the stalling speed in the landing configuration at maximum certificated gross landing weight. ***An aircraft can fly an IAP only for its own category or higher, unless otherwise authorized by AF Instruction or MAJCOM directives***. If it is necessary to maneuver at speeds in excess of the upper limit of a speed range for a category, the minimums for the next higher category should be used. The categories are as follows:

8.5.1.1.1. Category A - Speed less than 91 knots.

8.5.1.1.2. Category B - Speed 91 knots or more but less than 121 knots.

8.5.1.1.3. Category C - Speed 121 knots or more but less than 141 knots.

8.5.1.1.4. Category D - Speed 141 knots or more but less than 166 knots.

8.5.1.1.5. Category E - Speed 166 knots or more.

8.5.1.1.5.1. NOTE: If MAJCOMs allow aircraft to fly an IAP using a lower category, the MAJCOM must publish procedures to ensure that aircraft do not exceed TERPS airspace for the IAP being flown to include circling and missed approach.

8.5.1.2. IAP chart. ***A current copy of the appropriate IAP chart must be available in the aircraft for the departure base, destination, and all planned alternates.***

8.5.1.2.1. Approved sources for IAP charts used in aircraft include printed FLIP distributed by NGA, National Aeronautical Charting Office (NACO), or other source authorized by your MAJCOM (for example, Jeppesen).

8.5.1.2.1.1. ***Do not print an IAP from DAFIF and then fly that digital version.*** Until the DAFIF is certified for terminal IFR use in your weapon system, always use the IAP distributed via printed FLIP.

8.5.1.2.1.2. IAPs downloaded from the NGA website in PDF format are identical to those in the printed NGA approach books. Effective dates are printed on the bottom of each downloaded page. The responsibility for ensuring the current version of an IAP is onboard lies with the pilot.

8.5.1.2.1.3. If you print an IAP from the JEPPVIEW CD distributed by Jeppesen (or another equivalent commercial product), ***ensure the CD is current and you are a licensed user of that CD***. If you do not know the license arrangement with Jeppesen (or other commercial vendor), do not use the IAP. The vendors and USAF take copyright violations very seriously. It is the responsibility of each pilot to ensure not only currency of IAPs prior to use, but also compliance with copyright and licensing agreements. These agreements may vary from Wing to Wing.

8.5.1.2.1.4. ***Do not fly Host Nation IAPs unless properly trained and the procedure(s) are approved by your MAJCOM TERPS***.

8.5.1.2.2. Low altitude IAP charts normally depict instrument approaches for categories A, B, C, and D aircraft. High altitude IAP charts depict instrument approaches for category C, D, and E aircraft. When an operational requirement exists, the low altitude IAP charts may depict category E procedures.

8.5.1.2.2.1. NOTE: If there is a discrepancy between stand-alone GPS approach charts and the database onboard the aircraft, the chart takes precedence.

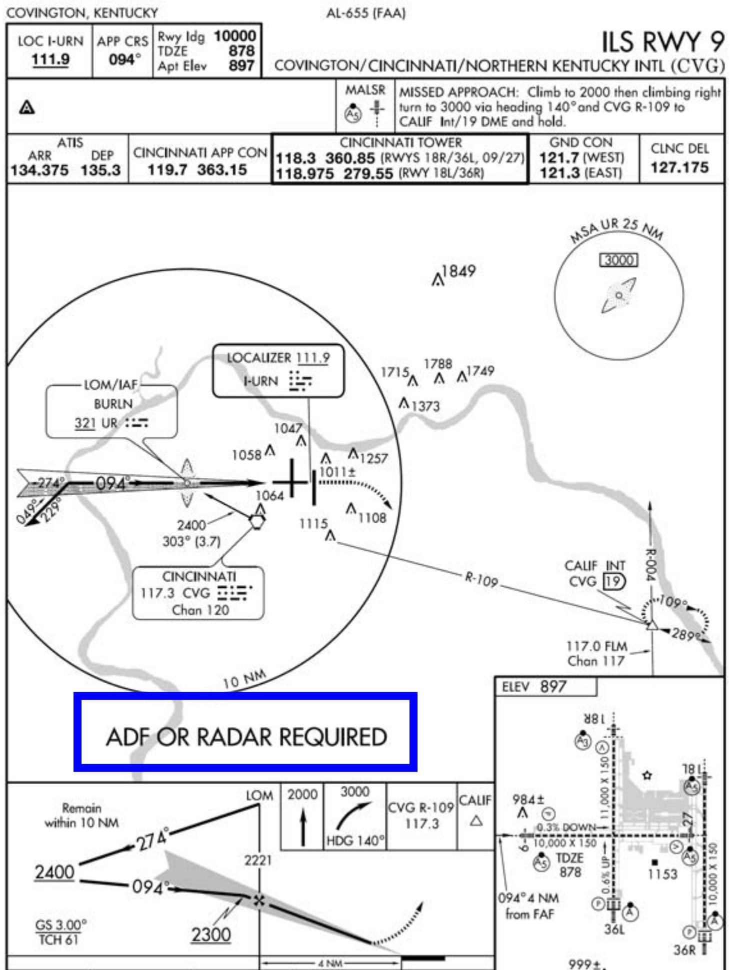
8.5.1.2.2.2. NOTE: Consult the Terminal Change Notice (TCN) to ensure the approach selected is current.

8.5.1.3. Navigation Equipment Compatibility. ***Ensure the approach you select is compatible with the navigation equipment installed and operating on your aircraft, including the missed approach instructions.***

8.5.1.3.1. Exception: ***If there is a requirement to execute an approach procedure with incompatible missed approach instructions, ATC may be able to issue alternate missed approach instructions.*** Request alternate missed approach instructions prior to accepting approach clearance.

8.5.1.3.1.1. NOTE: This requirement for alternate missed approach instructions does not preclude practice approaches if the field is VFR according to AFI 11-202 Volume 3, *General Flight Rules*.

Figure 8.5. Equipment Requirements for IAP.

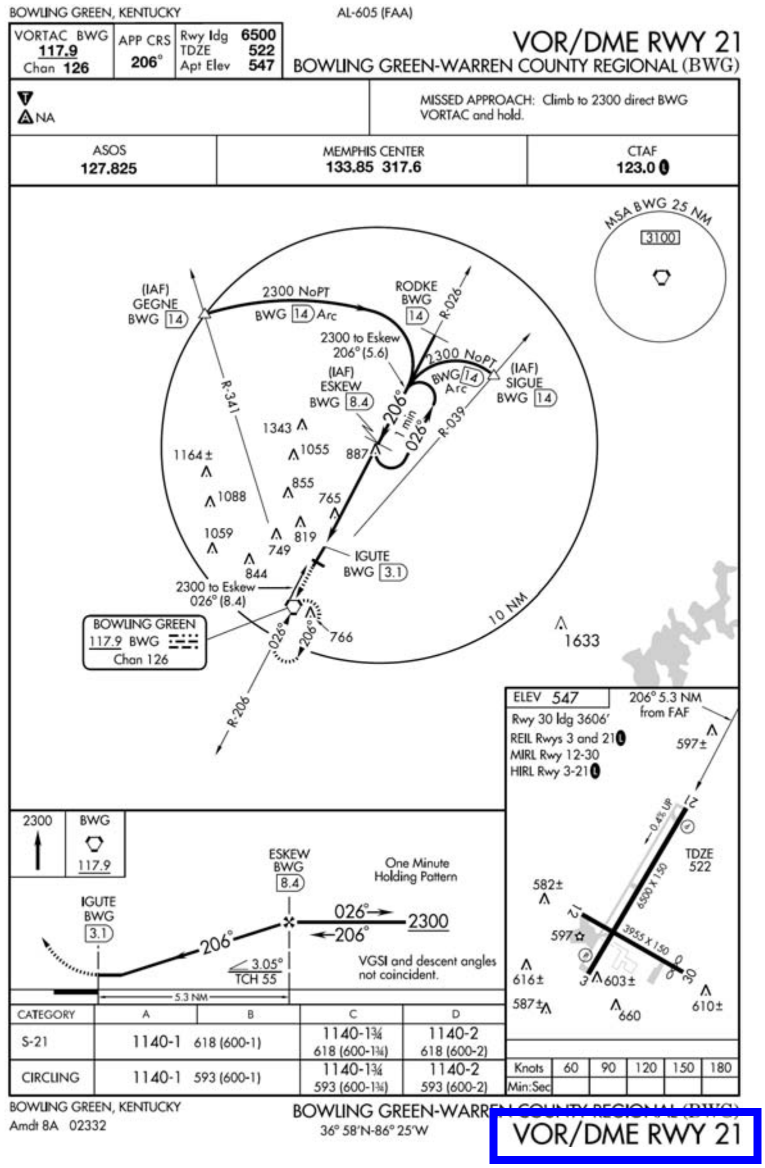


CATEGORY	A	B	C	D
S-ILS 9	1078/24 200 (200-½)			
S-LOC 9	1220/24 342 (400-½)			1220/40 342 (400-¾)
CIRCLING	1460-1 563 (600-1)		1460-1½ 563 (600-1½)	1560-2 663 (700-2)

Knots	60	90	120	150	180
Min:Sec	4:00	2:40	2:00	1:36	1:20

8.5.1.3.2. Straight-in approaches. The types of navigation aids that provide final approach guidance and the runway to which the final approach courses are aligned identify straight-in approaches. A slash (/) indicates that more than one type of equipment may be required to execute the final approach (VOR/DME, ILS/DME, etc.). Be aware that additional equipment may be required to execute the other portions of the procedure.

Figure 8.6. IAP With "/" in Title.



8.5.1.3.2.1. Where more than one approach using the same final approach guidance is developed to the same runway, each runway/navigational aid combination will be identified with an alphabetical suffix beginning at the end of the alphabet; e.g. ILS Z RWY 28L (first procedure), ILS Y RWY 28L (second procedure), ILS X RWY 28L (third procedure), etc. Suffixes will be used in reverse alphabetical order, beginning with "Z."

Figure 8.7. More Than One Approach With Same Final Approach Guidance.

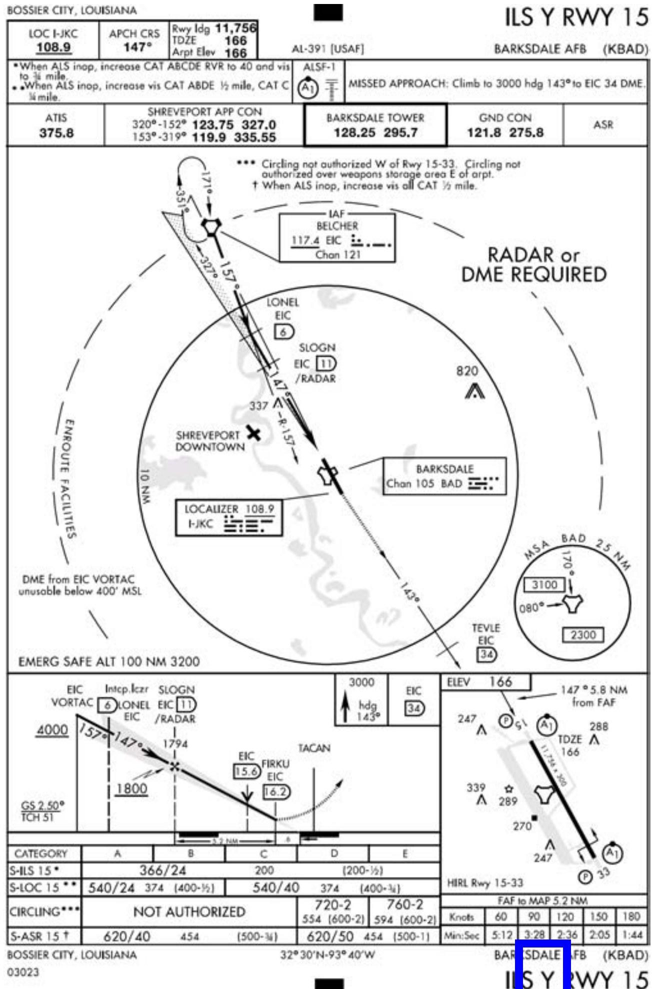
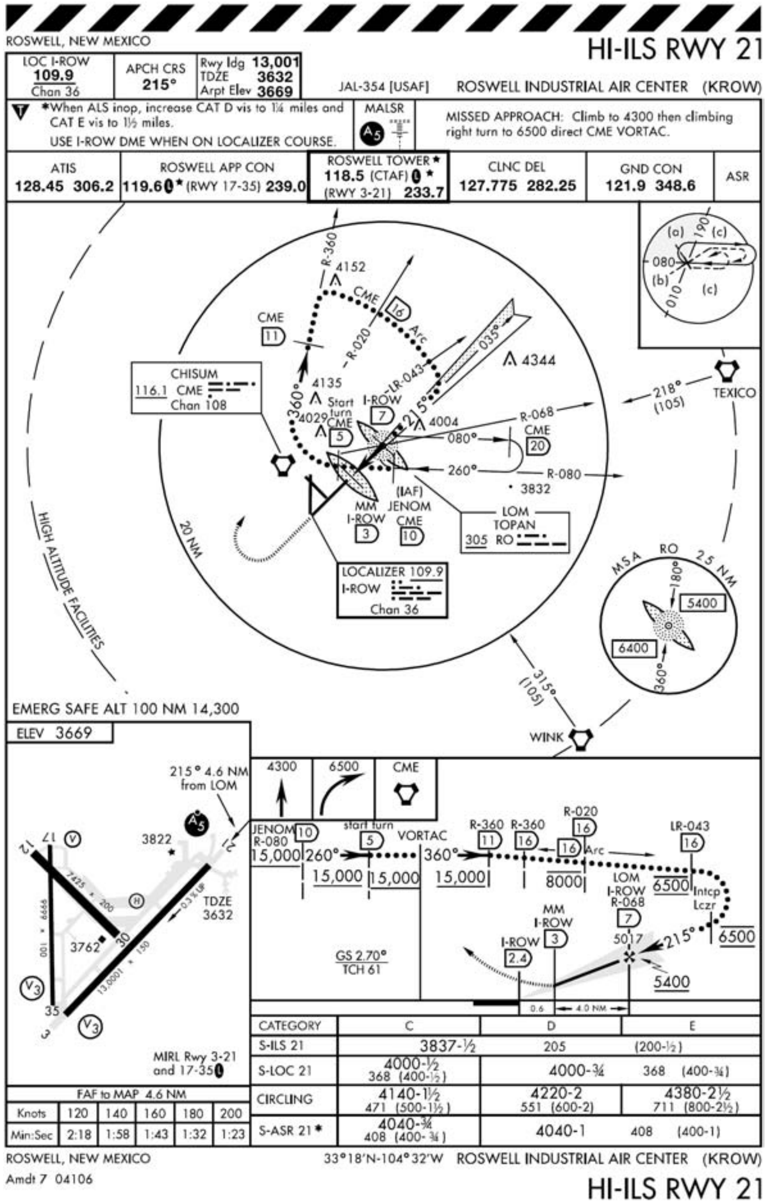


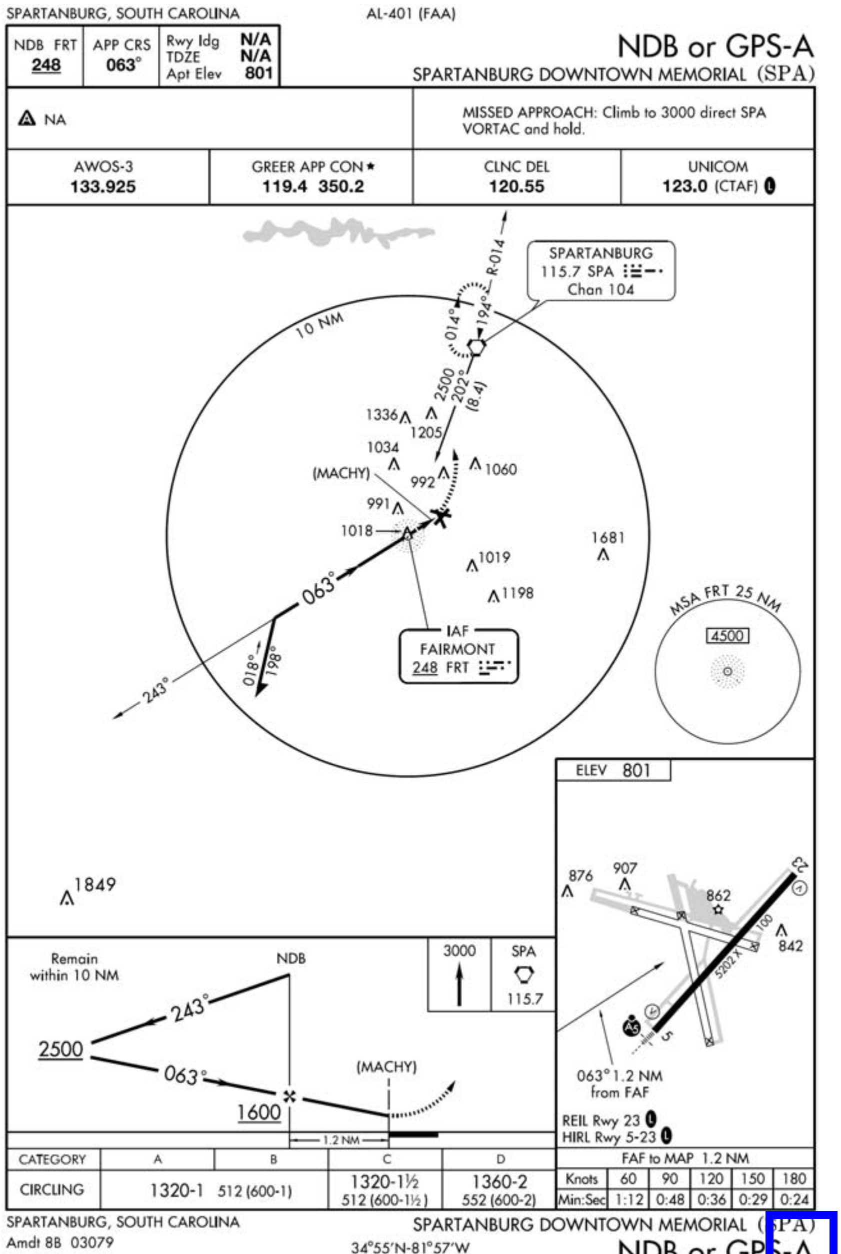
Figure 8.8. ILS Approach.



8.5.1.3.3. VOR approaches. Some VOR approaches are approved for use by TACAN equipped aircraft. These will be designated by the term "(TAC)" printed adjacent to the name of the procedure, for example, VOR-A (TAC).

8.5.1.3.4. Circling approaches. When the name of the approach is followed by a letter such as A, B, C, etc., the approach is designed for circling minimums only. Circling approaches are designated VOR-A, TACAN-B, NDB-C, etc. Circling approach designators will begin at the beginning of the alphabet.

Figure 8.9. Circling Approach.



8.5.1.4. Radar Minimums. Radar minimums by aircraft category may be found in a separate section in the IAP book.

8.5.2. True Approach Procedures.

8.5.2.1. Selected instrument approach procedures in higher latitude regions may be based on reference to true or grid north/south instead of the customary reference to magnetic north/south. Procedures vary greatly between aircraft type and avionics capabilities. Thorough mission planning, including review of applicable aircraft/avionics specific procedures and limitations, is essential to safely flying an instrument approach at higher latitudes.

8.5.2.1.1. When flying at higher latitudes, review the IAP carefully to ensure you are cognizant of the heading source required by instrument procedures and the orientation reference of the NAVAID. This is annotated on the IAP as shown in Figures 8.10 and 8.11.

8.5.2.1.1.1. NOTE: At airfields with true or grid approaches, the runway direction number will also be based on reference to true or grid, as appropriate.

8.5.2.1.2. ***Unless otherwise restricted by this AFMAN, the aircraft flight manual or MAJCOM directives, USAF aircrews are authorized to fly true or grid approaches.***

8.5.2.1.3. ***Except as noted below, aircraft must possess a true or grid heading source, and be able to display true or grid heading on appropriate navigation displays in order to fly terminal area true or grid instrument procedures in night or IMC.***

8.5.2.1.4. ***Aircraft without a true or grid heading source may fly true or grid RNAV (GPS) approaches and true or grid RNAV departure procedures in night or IMC providing the RNAV procedure provides all required magnetic course information***.

8.5.2.1.5. For terminal area procedures referenced to true north, use the following procedures:

8.5.2.1.5.1. NOTE: This section covers general true approach procedures, your flight manual and/or MAJCOM may have additional procedures or limitations.

8.5.2.1.5.2. Radar vectors should be provided with reference to true north. If in doubt, query the controller.

8.5.2.1.5.3. Orientation of an IAP to true north will be indicated by inclusion of the word "true" in the procedure title.

8.5.2.1.5.4. Select true as a heading source IAW with your aircraft flight manual and MAJCOM directives.

8.5.2.1.5.4.1. NOTE: ADF needles always display relative bearing to the station. Localizer signals emanate along a fixed path along the final approach course. CDIs always indicate position relative to the final approach course regardless of what is dialed into the CSW.

8.5.2.1.5.5. Select the published true final approach course as appropriate for the type of approach and aircraft equipment. For aircraft capable of displaying true heading, no further corrections to headings, courses or bearings are required.

8.5.2.1.6. ***For aircraft not capable of displaying true north, instrument approaches in night or IMC are not authorized***. ***If your aircraft does not allow selection of true north as a heading reference, use the following procedures when flying a true approach (Day, VMC Only)***:

8.5.2.1.6.1. WARNING: In certain areas, magnetic heading indications may be unreliable or erratic. ***If magnetic heading indications are suspect, do not commence the approach. If already established on the approach and magnetic heading indications are suspect, execute a missed approach.***

8.5.2.1.6.2. WARNING: Flight director commands and CDI deflection may be grossly inaccurate on aircraft without a true heading source even with proper set-up of courses, bearings, and headings.

8.5.2.1.6.3. VOR and TACAN approaches. VOR and TACAN final approach courses do not require correction for magnetic variation. ***Dial in the true final approach course as depicted on the IAP***. Although the CDI will be centered when on course, the bearing pointer will point to the true bearing to the station. ***When selecting a heading to fly to intercept/maintain the course, corrections for magnetic variation are required***. ***Use the magnetic variation at the NAVAID the approach is based upon***.

8.5.2.1.6.4. NDB Approaches. NDBs cannot be oriented to true north. ADF needles always display relative bearing to the station. ***Corrections for magnetic variation must be applied to the published bearing(s). When selecting a heading to fly to intercept/maintain the published bearing, corrections for magnetic variation are also required. Use the magnetic variation at the NAVAID the approach is based upon***.

8.5.2.1.6.5. ILS and Localizer Approaches (includes LDA, SDF, and LOC BC). Localizer signals emanate along a fixed path along the final approach course and cannot be oriented on true north. CDIs always indicate position relative to the final approach course regardless of what is dialed into the CSW. However, selection of the correct final approach course is critical to insuring consistent cockpit indications of position relative to the final approach course. ***When selecting a course to dial in, corrections for magnetic variation must be applied to the published front course*** to insure consistent cockpit indications while on final approach. ***When selecting a heading to fly to intercept/maintain the published final approach course, corrections for magnetic variation are also required***. ***Use the magnetic variation at the airport***.

Figure 8.10. True VOR Approach.

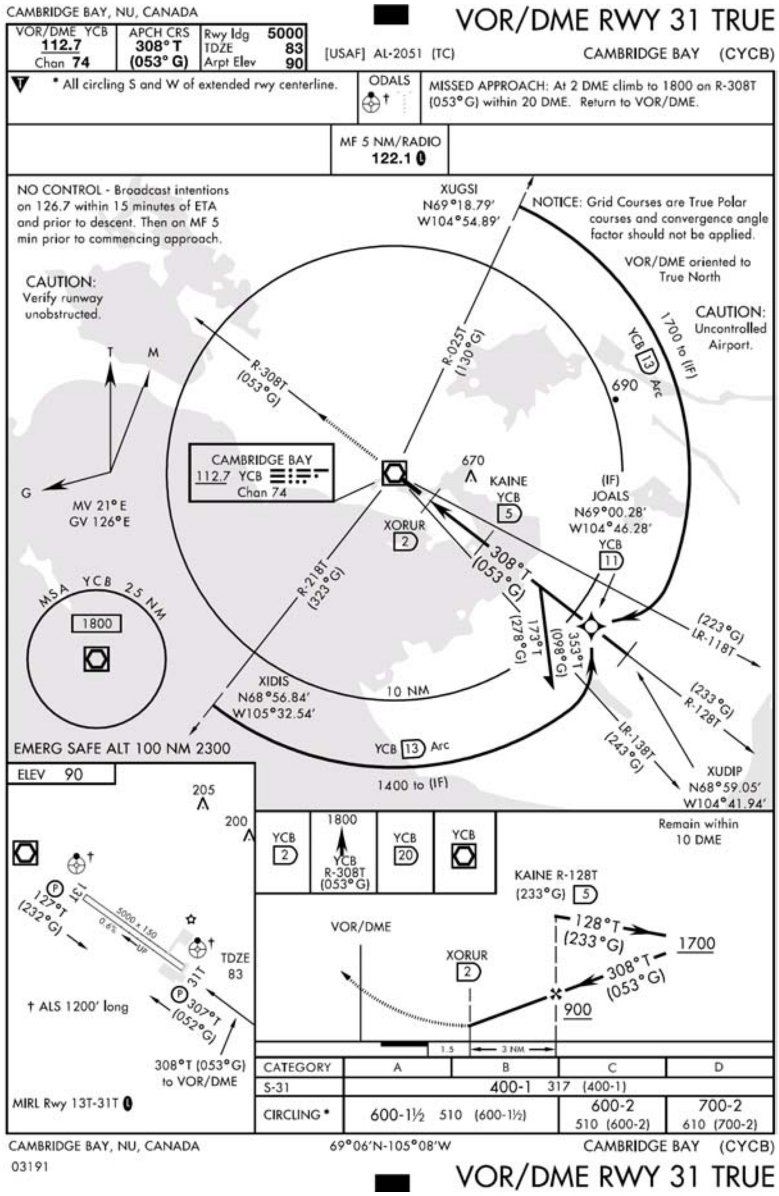
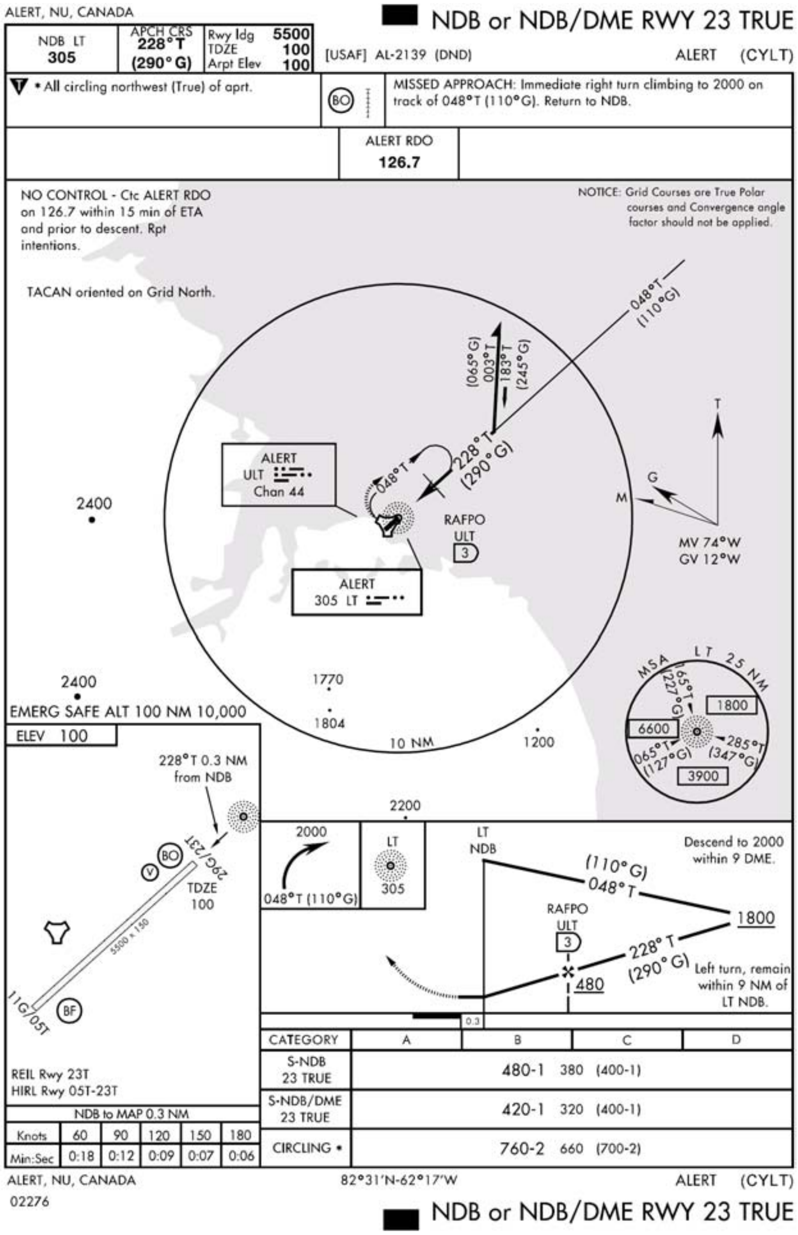


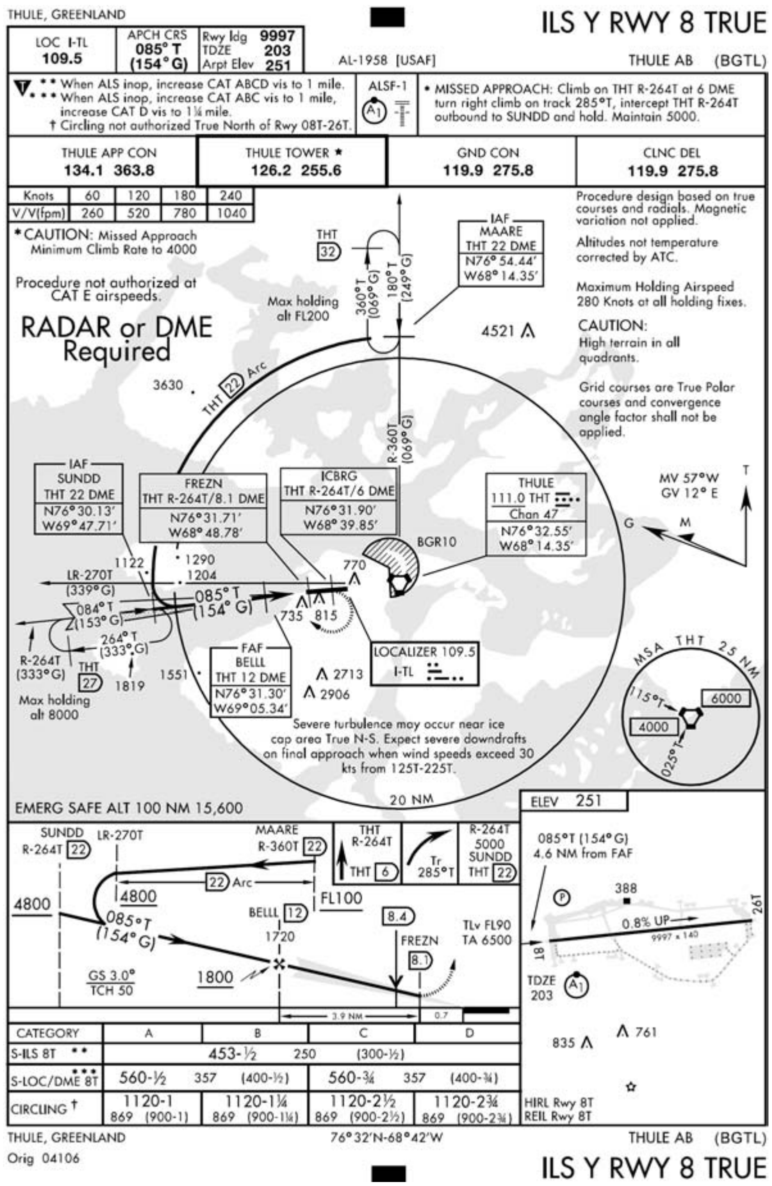
Figure 8.11. True NDB Approach.



CATEGORY	A	B	C	D
S-NDB 23 TRUE	480-1 380 (400-1)			
S-NDB/DME 23 TRUE	420-1 320 (400-1)			
CIRCLING •	760-2 660 (700-2)			

NDB to MAP 0.3 NM					
Knots	60	90	120	150	180
Min:Sec	0:18	0:12	0:09	0:07	0:06

Figure 8.12. True ILS Approach.



8.5.2.1.6.6. PAR, ASR, and Radar Vectors. When being radar vectored in the vicinity of an airport using true north as a heading reference, all vectors will be issued in true headings. ***If your aircraft does not allow selection of true north as a heading reference, corrections for magnetic variation are required.***

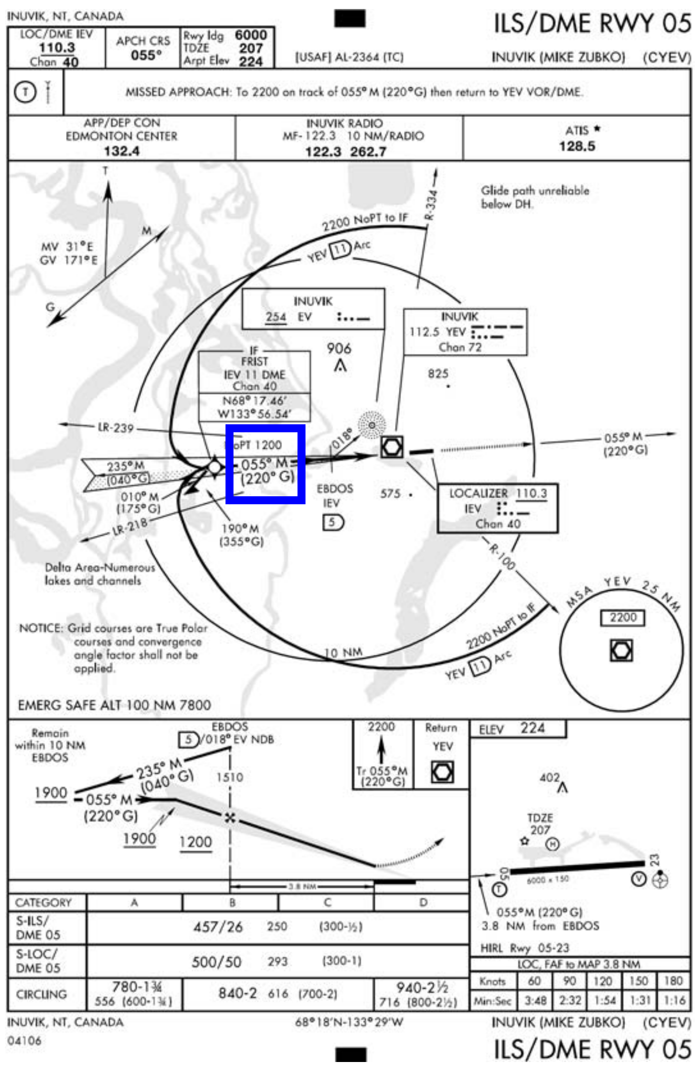
8.5.3. Grid Approach Procedures. In some cases a NAVAID may be oriented on grid north, or a grid final approach course may be published alongside a magnetic or true final approach course. ***Use the following general procedures to fly a grid approach.*** Consult your aircraft flight manual and MAJCOM directives for specific equipment, procedures, and crew complement to fly grid.

8.5.3.1. ***The heading reference of the primary means of navigation on final approach, the heading reference of the NAVAID the approach is based on, and the orientation of the runway direction number should all be the same***.

8.5.3.1.1.1. NOTE: The NAVAID the approach is based on and the runway direction number normally will use the same heading reference.

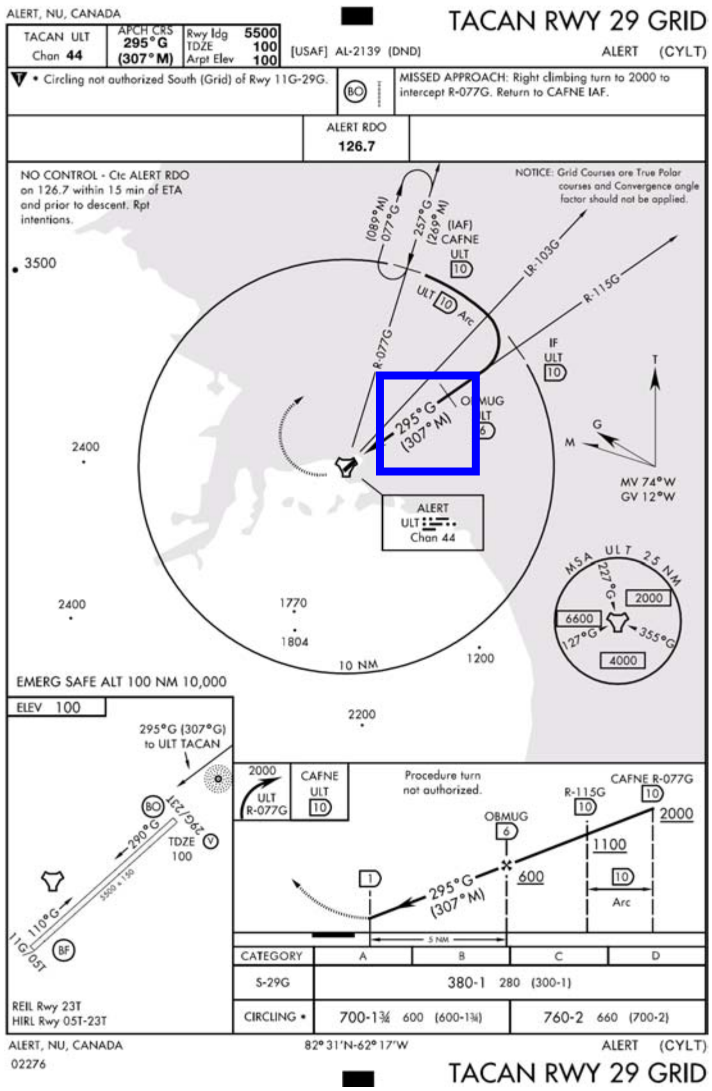
8.5.3.1.2. ***When a final approach course using another heading reference is published on the IAP in parenthesis, this is provided for situational awareness, and is not to be used as the primary means of navigation on final approach.*** Use the grid course IAW with the aircraft flight manual and MAJCOM directives.

Figure 8.13. Magnetic Heading Reference With Grid Course.



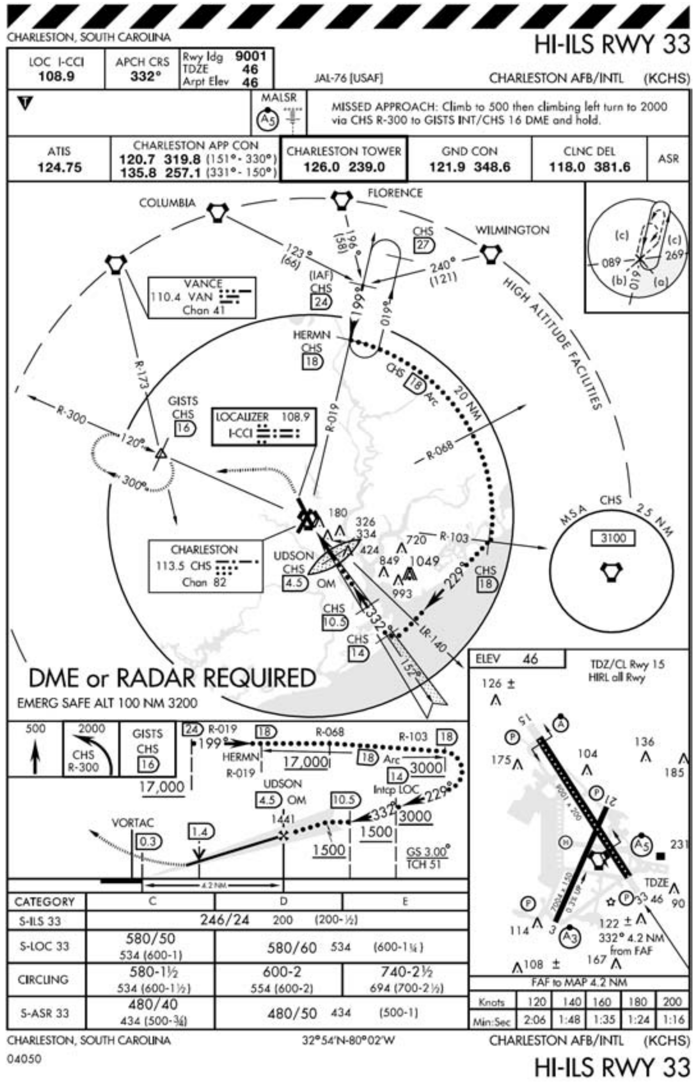
8.5.3.1.3. If the NAVAID and runway direction number are oriented on grid north, then grid is the primary means of navigation along final approach. Use aircraft flight manual procedures and MAJCOM directives to fly a grid approach. ***If a magnetic or true final approach course is published alongside the grid course it should only be used as a situational awareness tool, not the primary means of navigation.***

Figure 8.14. Grid Approach.



8.5.4. Reviewing an IAP (Figure 8.15). Prior to departure, you should become familiar with all aspects of the IAP so that during the recovery you can concentrate on flying the maneuver rather than trying to fly and interpret it simultaneously. Here are some important areas to consider and techniques to use:

Figure 8.15. Review of the IAP.



8.5.4.1. Plan View.

8.5.4.1.1. Ground Track. Note the general ground track of the approach, the NAVAIDs that provide the course guidance, and the NAVAID location. (The NAVAIDs that appear in the name of an IAP are the NAVAIDs that provide the final approach guidance. Other types of NAVAIDs may be required to accomplish the approach and missed approach.)

8.5.4.1.2. Initial Approach Fix. Note the location of the IAF you plan to use as well as the NAVAID used to define the fix. Sometimes the IAF is displayed on the IAP by name only, and the NAVAID and radial/DME that defines the point is not listed. In this case, refer to the appropriate en route and terminal charts for the area to determine the NAVAID and the radial/DME that defines the IAF.

8.5.4.1.3. Holding Pattern. Note the location of the holding pattern and its relation to the IAF. It is extremely important that you review the altitude of the holding pattern at the IAF and determine if your aircraft can meet the holding speed restrictions associated with that altitude. If you are unable to comply with that holding speed, coordinate with ATC prior to arriving at the IAF and entering holding. You could exit TERPS protected airspace if you fly faster than the holding pattern design speed.

8.5.4.1.4. Plan the Approach. Mentally fly the approach from the IAF to the MAP and determine the lead points for radial, course, or arc interceptions. Identify the point where the aircraft should be configured for landing.

8.5.4.1.5. Missed Approach. Review the missed approach departure instructions and determine if your aircraft can comply with the required climb gradient if one is published. It is extremely important to review the Missed Approach holding pattern and determine if your aircraft can meet the holding speed restrictions associated with that altitude. If you are unable to comply with the holding speed, coordinate with ATC prior to arriving at the IAF and commencing the approach. If you lose communications and subsequently execute the published missed approach procedures, you could exit TERPS protected airspace if you fly faster than the missed approach holding pattern was designed for. Even when in radio contact, waiting to notify ATC of your requirement for alternate missed approach instructions, it may be too late for ATC to react and you could still exit protected airspace.

8.5.4.1.6. Published Routings. Terminal routings from en route or feeder facilities normally provide a course and range from the en route structure to the IAF but may take the aircraft to a point other than the IAF if operational circumstances so require (Low altitude feeder routes provide minimum altitudes).

8.5.4.1.7. Minimum Safe/Sector Altitudes. Minimum Safe Altitudes consist of minimum sector altitudes and emergency safe altitudes. When more than one Minimum Safe Altitude is required, it is referred to as a Minimum Sector Altitude. A minimum safe altitude is the minimum altitude that provides at least 1000 feet of obstacle clearance for emergency use within a specified distance from the navigation facility upon which the procedure is based (for example VORTAC, VOR, TACAN, NDB, or locator beacon at OM or MM). The minimum sector altitude provides the 1000 feet of obstacle clearance within 25 NM of the facility. An emergency safe altitude is normally developed only for military procedures and will provide 1000 feet of obstacle clearance (2000 feet in designated mountainous areas) within 100 NM of the facility. If it is not clear on which facility the altitude is based, a note should state the facility that is used. Minimum safe altitudes do not guarantee NAVAID reception.

8.5.4.1.8. Scale. The inner ring gives a scale presentation of the approach that is normally within a 10 NM radius for low altitude approaches and 20 NM for high altitude approaches. However, it should be noted that the radius of the rings may differ. Some, but not necessarily all, obstacles are depicted. This inner ring is normally necessary for better portrayal of the IAP. On IAPs with a single ring, the entire plan view is to scale. Instrument approach procedure plan views can use up to three rings to show the approach information needed for the IAP. The addition of outer or middle rings indicates that only approach information inside the inner ring is to scale.

8.5.4.2. Profile View.

8.5.4.2.1. Altitude Restrictions. Note the altitude restrictions. Minimum, maximum, mandatory, and recommended altitudes normally precede the fix or facility to which they apply. If this is not feasible, an arrow will indicate exactly where the altitude applies. In some cases altitude restrictions are published in the plan view and not in the profile view. This is often the case with multiple IAFs where it is not feasible to show all the routings in the profile view.

8.5.4.2.2. Descent Gradients. Consider the descent gradient. For a low altitude IAP, the initial descent gradient will not exceed 500 ft/nm (approximately 5°); and for a high altitude approach, the maximum allowable initial gradient is 1,000 ft/nm (approximately 10°).

8.5.4.3. Landing Minimums. Review the landing minimums for your aircraft category to see how low you can descend on the approach and to determine if the forecast weather conditions will permit use of the IAP.

8.5.4.3.1. NOTE: The minimums published in FLIP must be the lowest possible minimums in accordance with TERPS criteria; however, MAJCOMs may establish higher minimums for their pilots. The visibility values determine whether a straight-in approach may be flown. These values are based on all approach lighting being operational. When approach lighting is inoperative, the visibility minimums will normally be one-half mile higher. If a circling approach is to be flown, the weather must be at or above both the published ceiling and visibility.

8.5.4.3.2. NOTE: There may be situations when you are required to fly a circling approach which does not have a ceiling requirement published. In this case, ***the required ceiling will be the HAA plus 100 feet rounded up to the next one hundred foot value***. For example, if the HAA is 757 feet, add 100 feet to get 857 feet and then round up to the nearest one hundred foot value, which would be 900 feet. Your ceiling for the approach must be at or above 900 feet.

8.5.4.4. Aerodrome Sketch.

8.5.4.4.1. Field elevation. Check the field elevation. This is the highest point on any usable landing surface.

8.5.4.4.2. Touchdown zone elevation (TDZE). Note the touchdown zone elevation. This is the highest point in the first 3,000 feet of the landing runway.

8.5.4.4.3. Runway. Observe the runway dimensions and layout.

8.5.4.4.4. Lighting systems. Check the types of approach lighting systems available.

8.5.4.4.5. Navigation facility location. Note the direction and distance of the runways from the navigation facility.

8.5.4.4.6. Obstructions. Check the location of prominent obstructions.

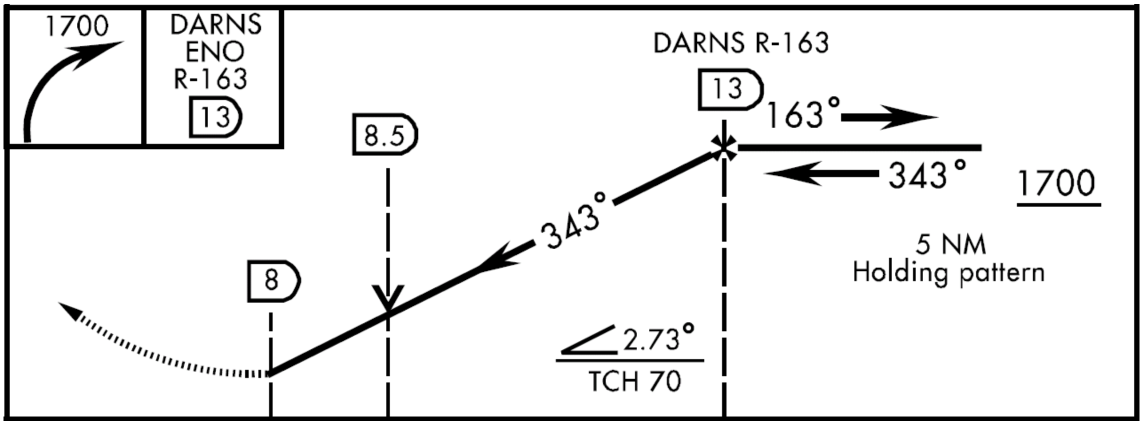
8.5.4.4.7. Final Approach Direction. The arrow shows the direction the final approach brings you in relation to the runway. This information can help you know where to look for the runway. It is also useful in determining how much maneuvering may be required to align the aircraft with the runway. A straight-in approach may bring your aircraft to the runway as much as 30 degrees off of the runway centerline and still be considered a straight-in approach.

8.5.4.5. Additional Information. Look carefully for notes on the IAP. Notes are used to identify either nonstandard IAP criteria or to emphasize areas essential for the safe completion of the approach.

8.5.4.6. Visual Descent Point (VDP). The VDP is a defined point on the final approach course of a non-precision straight-in approach procedure from which a normal descent (approximately 3°) from the MDA to the runway touchdown point may be commenced, provided visual reference with the runway environment is established. The VDP is normally identified by DME and is computed for the non-precision approach with the lowest MDA on the IAP. A 75 MHz marker may be used on those procedures where DME cannot be implemented. VDPs are not a mandatory part of the procedure, but are intended to provide additional guidance where they are implemented. A visual approach slope indicator (VASI) lighting system is normally available at locations where VDPs are established. Where VASI is installed, the VDP and VASI glide paths are normally coincident. If VASI is not installed, the descent is computed from the MDA to the runway threshold. On multi-facility approaches, the depicted VDP will be for the lowest MDA published. Therefore, on an approach with a higher MDA, the published VDP will not be correct and must be computed by the pilot. No special technique is required to fly a procedure with a VDP; however, to be assured of the proper obstacle clearance, the pilot should not descend below the MDA before reaching the VDP and acquiring the necessary visual reference with the runway environment. The VDP is identified on the profile view of the approach chart by the symbol "V" (Figure 8.16).

8.5.4.6.1. In some cases a published VDP may be absent from an IAP due to an obstacle that penetrates a 20:1 surface. In addition, there was a period of time where the FAA did not place any emphasis on publishing VDPs on IAPs. As a result, many IAPs were designed without published VDPs. The problem is that when a IAP is published without a VDP, there is no way for the pilot to know if it is due to an obstacle penetration, or because the TERPS specialist just did not publish it. If performing a non-precision approach to an unfamiliar field at night (or very low visibility) without a published VDP, and no visual or "normal" electronic glide path guidance to that runway is available, use caution when departing the MDA, as there could potentially be an obstacle penetrating the 20:1 surface. See Chapter 15, Visual Glide Slope Indicators (VGSI) for more information on obstacles in the 20:1 surface.

Figure 8.16. Visual Descent Point (VDP).



8.5.4.7. Alternate minimums. Some civil and foreign approaches may have ▲ or ▲ NA in the remarks. The ▲ tells civilian pilots that the alternate minimums for the approach are non-standard and they must look in the front of the IAP book for new alternate minimums. Since Air Force alternate minimums are published in AFI 11-202 Volume 3, *General Flight Rules*, Air Force pilots may disregard the weather minimums listed under the ▲. The ▲ NA does apply to USAF aircrews and has very serious implications. ***The ▲ NA tells civilian and military pilots that the specific approach cannot be used to qualify the field as an alternate*** either because of lack of weather reporting facilities and/or the lack of capability to monitor the NAVAID. Without weather reporting facilities at the airport a pilot will not be able to get a specific forecast for that airport as required by AFI 11-202 Volume 3, *General Flight Rules*. The lack of monitoring capability of the navigation facilities is a bigger problem. Without a monitoring capability the pilot won't get any advance warning if the NAVAID is not operating. This means if the NAVAID goes off the air, there is no one to issue a NOTAM to inform the pilot of the situation before an attempt is made to identify and use the NAVAID.

8.5.5. Reviewing a Radar Approach. Depictions of radar approaches are not normally included in flight publications, but some important aspects of the approach are available.

8.5.5.1. IAP. It is helpful to review a published IAP for the airfield. In addition to helping you prepare for a backup approach in the event of radio failure, the IAP provides:

8.5.5.1.1. NAVAIDs. NAVAID frequencies and locations for position orientation and, in some cases, additional voice reception capability.

8.5.5.1.2. Altitudes. Minimum safe altitudes in the terminal area.

8.5.5.1.3. Stepdown altitudes. A stepdown altitude between the nonprecision FAF and MAP that may alert you to the possibility of a stepdown on an airport surveillance radar (ASR) approach to the same runway.

8.5.5.1.4. Radar minimums. Depiction of radar minimums and the glide slope angle. Normally the precision approach radar (PAR) glide slope will coincide with the ILS glide slope.

8.5.5.1.5. Airport sketch. The airport sketch and all the information associated with it.

8.5.5.2. Operating hours. The IAP books contain complete radar minimums. The IFR Supplement contains time periods when the aerodrome and its NAVAIDs are operational. It also indicates when NAVAIDs will be off the air for NO-NOTAM preventive maintenance, as well as other items unique to the particular operation of the airfield.

8.5.6. Reviewing RNAV (GPS) IAPs. The following section highlights elements of RNAV (GPS) IAPs that differ from IAPs based on conventional NAVAIDs.

8.5.6.1. Equipment requirements. The "TERMS/LANDING MINIMUMS DATA" (Section A) of the U.S. Government Terminal Procedures books provide a description of the aircraft equipment requirements for RNAV (GPS) IAPs. More detailed information can be obtained via the AFFSA web page. Pilots are responsible for ensuring that the aircraft is suitably equipped for the level of minimums used. Be aware that very few RNAV (GPS) IAPs may be flown using DME/DME RNAV systems. Note that the "(GPS)" in the approach title does not indicate the approach may be flown in aircraft with any GPS equipment. ***GPS equipped aircraft must meet the equipment requirements described above.***

8.5.6.1.1. ***Use of LNAV/VNAV DA requires certified VNAV functionality or WAAS on the aircraft. Use of GLS minimums requires WAAS equipment on the aircraft.***

8.5.6.2. Procedure name. Where multiple RNAV procedures exist to the same runway, subsequent RNAV procedure titles will be followed by the suffix X, Y, or Z (e.g., "RNAV (GPS) Z RWY 22"). ATC clearance for the RNAV procedure will authorize the pilot to use any landing minimums for which the pilot and/or aircraft is capable and authorized.

8.5.6.3. Chart Terminology.

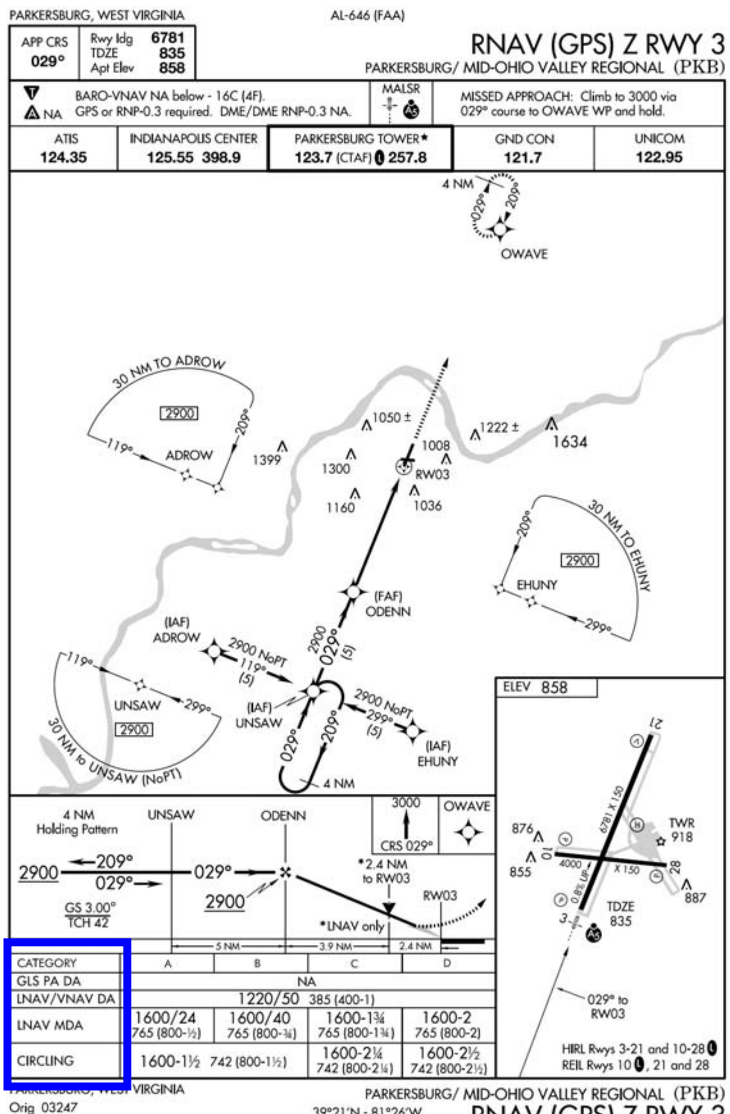
8.5.6.3.1. Decision Altitude (DA). DA replaces the term Decision Height (DH) as a step towards harmonization with ICAO terminology. The published descent profile is flown to the DA, where a missed approach will be initiated if visual references for landing are not established. Obstacle clearance criteria accounts for a momentary descent below DA while transitioning to the missed approach.

8.5.6.3.2. Minimum Descent Altitude (MDA). MDA carries the same meaning as in conventional IAPs, and is associated with LNAV minimums. Obstacle clearance is based on no descent below MDA. ***Thus, if vertical guidance is used down to LNAV minimums, pilots must ensure that the descent is broken in time to level off at MDA if visual references for landing are not established***.

8.5.6.3.3. LPV. LPV minimums are based on augmented GPS systems (WAAS) providing near ILS accuracy. "LPV" is not an acronym, but the title of a set of approach minima associated with specific performance criteria. LPV can also be referred to as GNSS Landing System (GLS). LPV minima can be as low as a DA(H) of 250 feet above the ground, with visibility as low as 1/2 mile.

8.5.6.3.4. Minimums: RNAV instrument approach procedure charts incorporate all types of approaches using Area Navigation systems, both ground and satellite based. The approach charts may contain as many as four lines of approach minimums: Lateral Navigation (LNAV); LNAV/Vertical Navigation (VNAV) (LNAV/VNAV); GNSS Landing System (GLS), also known as LPV; and Circling. The minima are dependent on the navigational equipment capability as outlined in the Terms/Landing Minima Data section at the front of the approach plate book. Typically, the approach chart will indicate the equipment required for the approach, i.e. GPS or RNP-.03 Required.

Figure 8.17. RNAV (GPS) Approach Minimums.



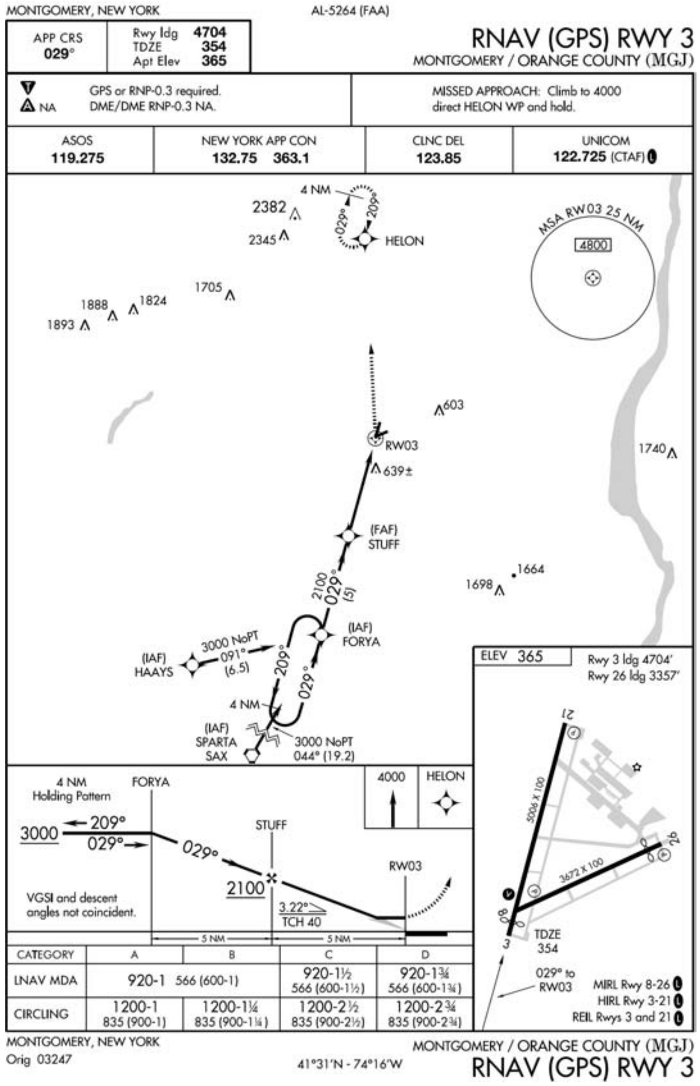
8.5.6.3.4.1. LNAV. These minimums are for LNAV (lateral) –only guidance. Because vertical guidance is not provided, the procedure minimum altitude will be published as a MDA. With an approved VNAV system, VNAV guidance may be used if provided by the RNAV system as long as the aircraft is level prior to MDA.

8.5.6.3.4.2. LNAV/VNAV. LNAV/VNAV minimums are based on lateral and vertical guidance to the published DA.

8.5.6.3.4.2.1. NOTE: Barometric VNAV (BARO-VNAV) systems compute a vertical path based on aircraft barometric altimetry systems. This vertical path may be greatly affected by non-standard temperatures, incorrect or rapidly changing altimeter settings, and altimeter error. Pilots should closely monitor compliance with step down fix altitude constraints and ***may not use Baro-VNAV guidance for reference below the published DA***. Also note that deviations from the VNAV path are often linear as opposed to angular, i.e. one dot deviation represents a fixed number of feet from the vertical path, regardless of distance to the runway waypoint.

8.5.6.3.4.3. LPV minimums. LPV minimums may support precision approach minimums as low as 200' HAT and 1/2 statute mile (SM) visibility. Pilots will be informed that the notation “LPV PA” or “GLS” on the first line of minimums in U.S. Government Terminal Procedure Publication charts satisfies all the requirements of the precision system. Pilots will be informed that the precision system requirements are not met by the notation "LPV" without the letters "PA" on the first line of minimums. In this latter case, since the landing environment does not support the low visibility operations, minimums no lower than 300' HAT and 3/4 SM visibility will be published. LPV minimums are published as a Decision Altitude (DA).

Figure 8.18. RNAV (GPS) Chart Symbology.



8.5.7. Chart Symbology

8.5.7.1. Descent Angle. The RNAV (GPS) IAP format provides descent angle to the hundredth of a degree (e.g., 3.00°), with a range from 2.75° to 3.5°. The angle is provided in the graphically depicted descent profile. The optimum RNAV (GPS) descent angle is 3.00°.

8.5.7.1.1. For RNP and WAAS approaches just now being fielded, the minimum descent angle is still 2.75°. However, the maximum angle is based on aircraft category as shown in the table below.

Table 8.4. Maximum Descent Angle for RNP and WAAS Approaches.

Aircraft Category	Maximum Descent Angle
CAT A (less 80 kts)	6.4 Degrees
CAT A 81-90 kts	5.7 Degrees
CAT B	4.2 Degrees
CAT C	3.6 Degrees
CAT D and E	3.1 Degrees

8.5.7.2. Threshold Crossing Height (TCH). The concept of TCH is the same as in conventional IAPs. On RNAV (GPS) IAPs, TCH refers to the point where the descent angle crosses above the threshold. Unless required by larger type aircraft, the typical TCH will be 30-50 feet.

8.5.7.3. VDP. The VDP on an RNAV (GPS) IAP only pertains to aircraft using LNAV minimums (not LNAV/VNAV or LPV). The VDP will be accompanied by the notation "*LNAV only."

8.5.7.4. Missed Approach Symbology. In addition to a textual description of the missed approach procedure in the "pilot briefing" at the top of the IAP, missed approach instructions will be graphically depicted in the profile view. Up to four icons will be shown. These icons are intended only for quick reference and may not depict the full missed approach procedure.

8.5.7.5. Waypoints. Two types of waypoints appear in RNAV procedures – "fly-over" and "fly-by" waypoints. "Fly-by" waypoints will be depicted using the standard WP symbol. Turn anticipation is allowed for fly-by waypoints. Fly-over waypoints are indicated by the standard waypoint symbol enclosed in a circle. For a fly-over WP, turn anticipation is not allowed. No turn may be accomplished until the aircraft passes over the waypoint. Note: A "Fly By" vertical waypoint is a WP for which an aircraft may initiate a vertical rate change and depart the specified vertical path to the active WP prior to reaching that WP, in order to asymptotically capture the next vertical path. A "Fly Over" vertical waypoint is a WP for which an aircraft must stay on the defined vertical path until passing the active WP, and may not initiate the necessary vertical rate change to capture the next vertical path until after passing the active WP. Hence, after passing the active WP, as the next WP becomes active, and if there is a vertical path change, then the aircraft must re-adjust vertical rate to re-capture the vertical path after having already overshot the first opportunity for an asymptotic capture of that new path.

8.5.7.6. Approach waypoints, except for the MAWP and the missed approach holding waypoint (MAHWP), are normally fly-by waypoints. Overlay approach charts and some early stand alone GPS approach charts may not reflect this convention.

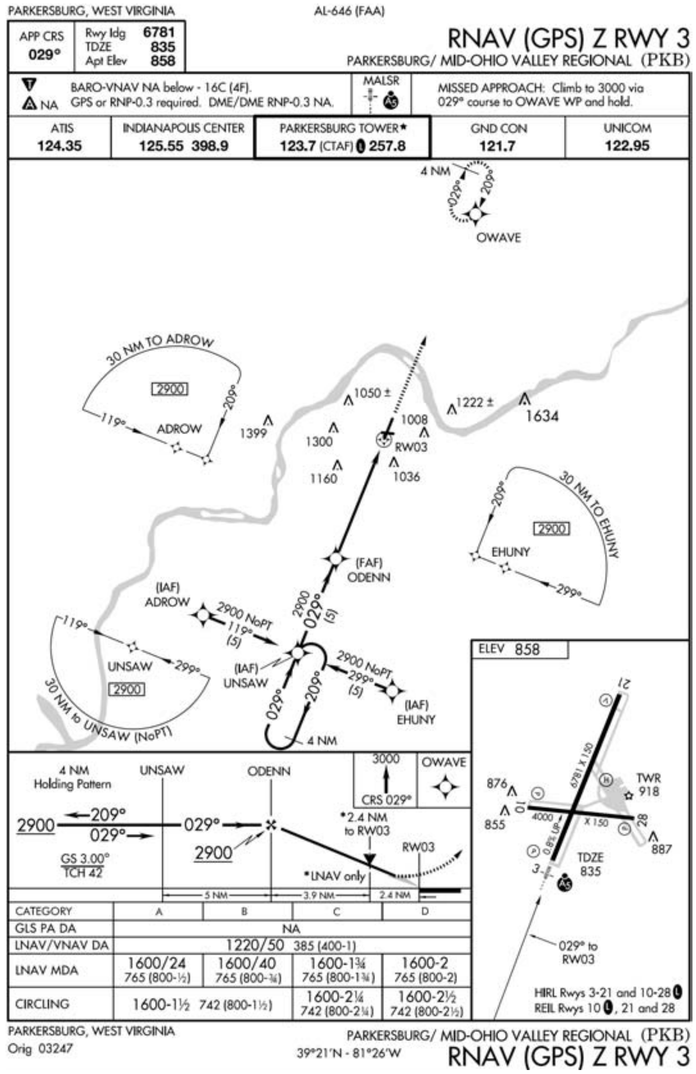
8.5.7.7. Pilots may see terminal 5 letter waypoints outside the U.S. The first 2 letters are airport ID, third letter is cardinal direction from airfield and the fourth/fifth positions are sequential numbers. Approach waypoints may use 4 or 5 alphanumeric characters, where first 3 characters represent runway designation (e.g., 24L, where C/L/R is optional), the fourth character is G for waypoint-type code and last digit is for uniqueness (e.g., 24LG2).

8.5.7.8. Pilot Briefing Area. The pilot briefing consolidates, in one location, pertinent information needed to conduct the approach. It includes final approach course, runway/airport data, procedure restrictions, approach light data, missed approach text, WAAS and BARO-VNAV information, and various NAVAID/ATC radio frequencies.

8.5.7.8.1. Cold Temperature Limitations. The upper left hand area of the pilot briefing lists the airport temperature below which BARO-VNAV will not be authorized to LNAV/VNAV minimums. ***Cold weather corrections should still be applied to all barometrically derived approach minimums and step-down altitudes, whether Baro-VNAV is used or not.*** (Use of barometric VNAV DA is not authorized with a remote altimeter setting.)

8.5.7.9. Terminal Arrival Areas (TAA). The standard TAA consists of three areas defined by the extension of the IAF legs and the intermediate segment course. These areas are called the straight-in, left-base, and right-base areas. TAA area lateral boundaries are identified by magnetic courses TO the IF (IAF). The straight-in area can be further divided into pie-shaped sectors with the boundaries identified by magnetic courses TO the IF (IAF), and may contain stepdown sections defined by arcs based on RNAV distances (DME or along track distance (ATD)) from the IF (IAF). The right/left-base areas can only be subdivided using arcs based on RNAV distances from the IAFs for those areas. Minimum MSL altitudes are charted within each of these defined areas/subdivisions that provide at least 1,000 feet of obstacle clearance, or more as necessary in mountainous areas.

Figure 8.19. Terminal Arrival Area (TAA).

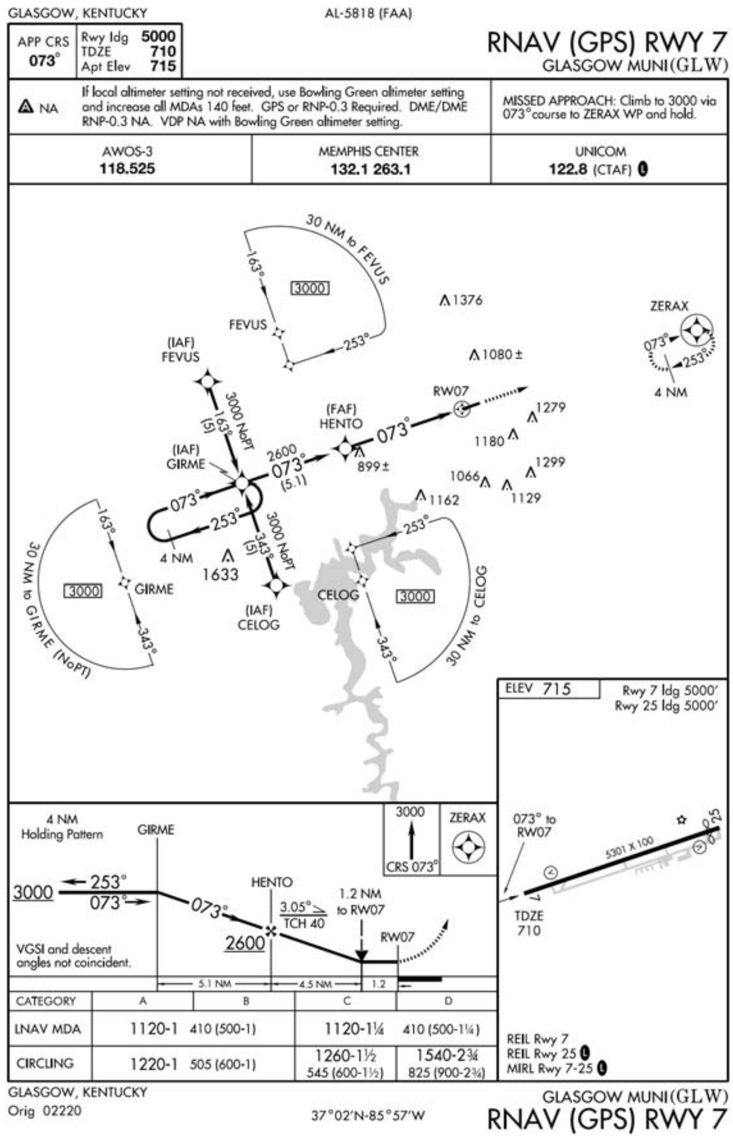


8.5.8. Reviewing GPS instrument approaches. There are two types of GPS instrument approaches: "Stand Alone" and overlay approaches.

8.5.8.1. AFI 11-202 Volume 3, *General Flight Rules*, lists specific equipment requirements for GPS stand-alone and overlay instrument approaches.

8.5.8.2. RNAV (GPS) "Stand-Alone" Approaches. RNAV (GPS) "stand-alone" approaches are constructed specifically for use by RNAV and/or GPS equipped aircraft and are not based on ground based NAVAIDS. RNAV (GPS) stand-alone approaches are identified by the absence of other NAVAIDS in the approach title, for example GPS RWY 35 or RNAV (GPS) RWY 35. ***RNAV (GPS) approaches are authorized in IMC for appropriately equipped and certified USAF aircraft***.

Figure 8.20. Stand Alone GPS Approach.

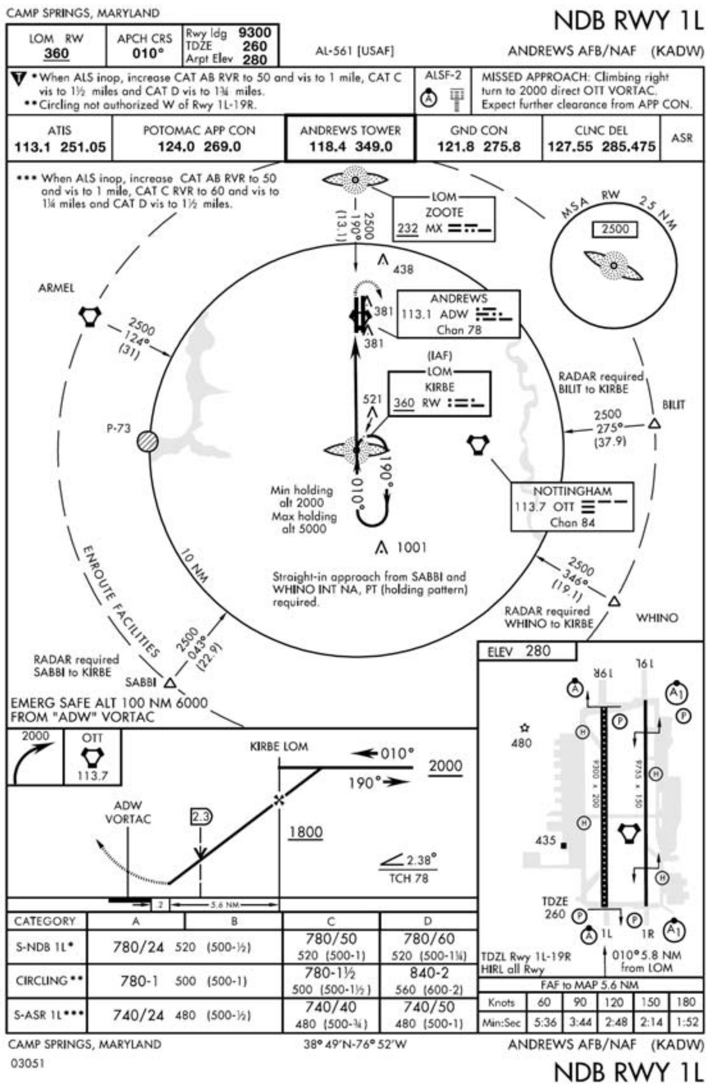


8.5.8.3. GPS Overlay Approaches. GPS overlay approaches are those where the pilot is allowed to use GPS equipment to fly existing VOR, VOR/DME, NDB, NDB/DME, TACAN, and RNAV precision approach procedures. There are two different types of overlay approaches; those where "or GPS" is included in the title and those where "or GPS" is NOT included in the title. Approaches must be flown in accordance with the Aircraft Flight Manual and the procedure depicted on the appropriate instrument approach chart.

8.5.8.3.1. Overlay approaches where "GPS" is NOT included in the title of the procedure but are retrievable from the aircraft database. (Example: your GPS avionics equipment allows you to retrieve and arm an approach titled "VOR RWY 35") ***USAF aircraft are NOT authorized to use RNAV/GPS equipment in IMC to fly overlay approaches without "or GPS" included in the title. However, USAF crews may enhance situation awareness by loading the***

approach so that it is displayed on the aircraft moving map display. Primary course guidance must be provided by the underlying traditional navigational aid in IMC (TAC, VOR, NDB, etc.).

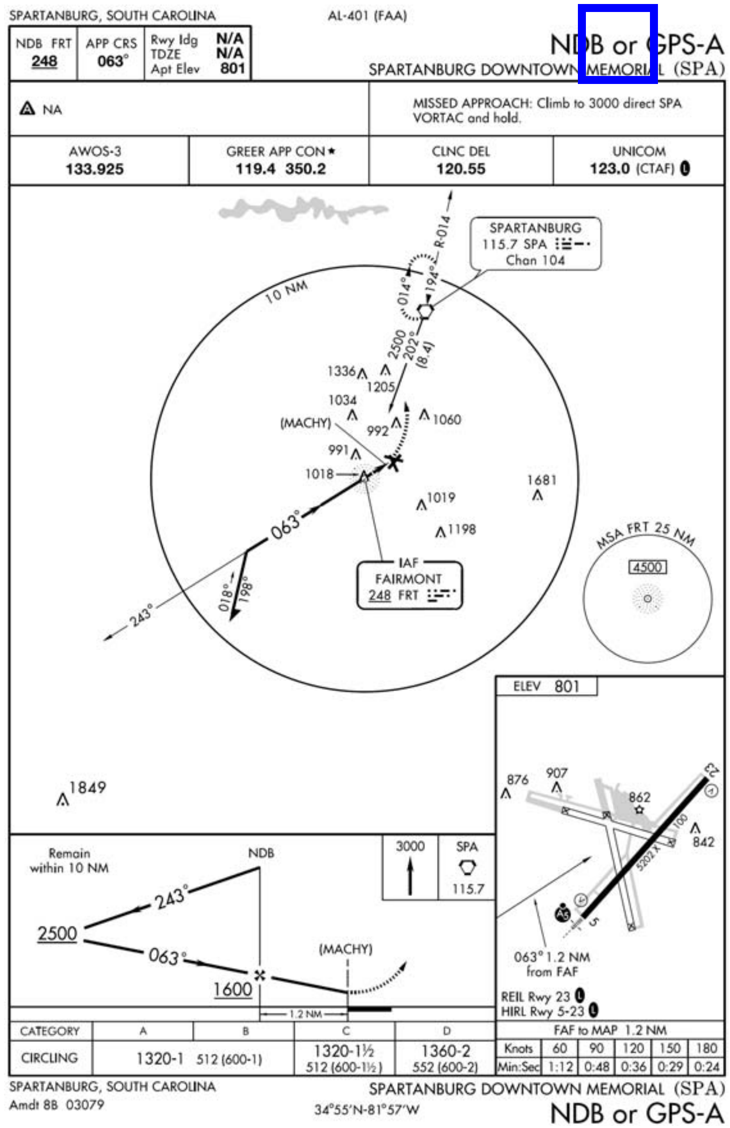
Figure 8.21. GPS Overlay Approach Where GPS is NOT in Title of Approach (Not Authorized in IMC for USAF Aircraft).



8.5.8.3.2. Overlay approaches where "or GPS" IS included in the title of the procedure and are retrievable from the database (e.g., "VOR or GPS RWY 35"). (Note: Non-U.S. overlay approaches may include "(GPS)" in the approach title**.)** ***Properly certified USAF aircraft may fly these overlay approaches in IMC in the U.S. NAS. These overlay approaches may not be flown outside the U.S. due to potential discrepancies in database information. Underlying ground-based NAVAIDS must be operational and associated aircraft avionics must be installed, operational, turned on and monitored. In the case of a discrepancy between GPS and traditional data, pilots must revert to using the traditional NAVAID.***

8.5.8.3.2.1. NOTE: When retrieving an "or GPS" overlay approach from the navigation database, it will be titled in the database by the title of the conventional NAVAID. For example: VOR or GPS Rwy 5 will be titled in the aircraft database as "VOR Rwy 5". The title on the published IAP chart determines the type of overlay, not how it is named in the aircraft database.

Figure 8.22. Overlay Approach "or GPS".



8.5.8.3.3. Procedures Without a Final Approach Fix. Procedures without a FAF and without a stepdown fix have a Sensor FAF waypoint coded in the database at least 4 NM Actual Track Distance (ATD) to the MAP waypoint. The MAP, in this case, is always located at the NAVAID facility. A Sensor FAF is a final approach waypoint created and added to the database sequence of waypoints to support GPS navigation of an FAA or DoD published, no-FAF, nonprecision instrument approach procedure. The coded name or Sensor FAF appears in the waypoint sequence. If a stepdown fix exists on the published procedure and it is greater than 2 NM to the MAP, the stepdown fix is coded in the database as the Sensor FAF waypoint for the waypoint sequence. If a stepdown fix distance is 2 NM or less to the MAP, a Sensor FAF waypoint is coded at least 4 NM to the MAP.

8.5.8.3.4. Non-Codable Approach Procedures. Certain nonprecision instrument approaches may present an irresolvable coding situation relating to database or equipment interface constraints. An approach may be determined to be not codable or not flyable by the regulatory agency having jurisdiction, by the database coding agency, or by the manufacturer of the navigation equipment. In addition, some procedures may present a potential safety hazard to normal piloting techniques using GPS equipment. These procedures will not be included in navigation databases. Approach procedures that are omitted from the database cannot be legally flown using GPS navigation equipment.

8.5.9. Relationship of Avionics Displayed Waypoints to Charted Data. The GPS Approach Overlay Program waypoints contained in the database represent the waypoints, fixes, NAVAIDs, and other points portrayed on a published approach procedure beginning at the initial approach fix. Certain unnamed points and fixes appearing on a chart are assigned a database identifier. Although there currently is no requirement to provide these database identifiers, most charting agencies are publishing them at their discretion. Database identifiers should not be used for pilot/controller communications or on flight plans.

8.6. Instrument Cockpit Check. Before flight, accomplish a thorough instrument cockpit check. You should check the applicable items listed below (unless your flight manual or command directives dictate otherwise):

8.6.1. Publications. Ensure appropriate, up-to-date publications obtained from an authorized source are in the aircraft.

8.6.1.1. If you are authorized to carry Jeppesen products, ensure you have Book 1 (summary, notices, legend information, etc.) and ALL the pages for the appropriate airport. Important information is contained on the back of the airfield diagram page. Radio out procedures are often contained on a different page from the IAP you are using. Without Book 1 and all the pages for the airport, you may miss crucial information.

8.6.1.2. ***Host nation FLIP documents, enroute charts, IAPs, etc, will not be used without MAJCOM approval IAW AFI 11-202 Volume 3, General Flight Rules.***

8.6.2. Pitot Heat. Check for proper operation.

8.6.3. Attitude Indicators.

8.6.3.1. Erect. Ensure it is erect and that the bank pointer is aligned vertically with the zero bank index. Check your flight manual for tolerance limits.

8.6.3.2. Flags. Ensure the warning flags are not visible.

8.6.3.3. Alignment. Check the pitch trim knob alignment and ensure it is within limits, then set the miniature aircraft or horizon bar for takeoff.

8.6.4. Magnetic Compass. Check the accuracy of heading information.

8.6.5. Clock. Ensure the clock is running and the correct time is set.

8.6.6. VVI. Ensure the pointer is at zero. If the indicator does not return to zero, adjust it with a small screwdriver or use the ground indication as the zero position in flight.

8.6.7. Altimeters.

8.6.7.1. Current setting. Set current altimeter setting on barometric scale.

8.6.7.2. Known elevation. Check the altimeter at a known elevation and note any error in feet. If the error exceeds 75 feet, the instrument is out of tolerance for flight.

8.6.7.3. Check pointers. Ensure the 10,000/1000/100 counter-drum-pointers indicate approximate field elevation. Check and ensure the low altitude warning symbol is in view.

8.6.7.4. Modes. Check both reset and standby modes on AIMS altimeter and set in accordance with the flight manual or command directives.

8.6.7.4.1. NOTE: Helicopter rotor operation may affect altimeter indications. Check individual helicopter flight manual for altimeter limitations if published.

8.6.8. Turn and Slip Indicator.

8.6.8.1. Turn needle. Check and ensure the turn needle indicates proper direction of turn.

8.6.8.2. Ball. Check the ball for freedom of movement in the glass tube.

8.6.9. Heading Indicators.

8.6.9.1. Accuracy. Check the accuracy of heading information. In lieu of guidance in aircraft technical orders the aircraft's primary heading indicator should be within approximately 5 degrees of a known heading (i.e., runway heading or designated ground checkpoint).

8.6.9.2. Indicators. Ensure the heading indicators indicate correct movement in turns.

8.6.9.3. Set. Set adjustable heading indicators to the desired heading.

8.6.9.4. Bank steering. For flight director systems, check the bank steering bar for proper commands in the heading mode.

8.6.10. Airspeed and Mach Indicators.

8.6.10.1. Set. Set the airspeed or command mach markers as desired or as directed in the flight manual.

8.6.10.2. Indicators. Check the pointers or rotating airspeed scale for proper indications.

8.6.11. Airspeed Mach Indicator (AMI).

8.6.11.1. Airspeed Warning Flag. Ensure it is out of view.

8.6.11.2. Command Airspeed Marker. Set the marker as desired; that is, decision, rotation, climb speed, etc.

8.6.12. Altitude Vertical Velocity Indicator (AVVI).

8.6.12.1. Vertical Velocity. Check for a zero indication.

8.6.12.2. Altimeter. Make the same check as for conventional altimeter. Ensure the altimeter warning flag is out of view.

8.6.12.3. Command Altitude Marker. Set the command altitude marker as desired; that is, first anticipated level off, emergency return DH/MDA, etc.

8.6.12.3.1. WARNING: The command airspeed or altitude slewing switches should not be placed in the side detent position for takeoff due to the possibility of misreading those instruments.

8.6.13. Navigation Equipment and Instruments.

8.6.13.1. Tune and identify.

8.6.13.2. Pointers. Ensure the bearing pointers point to the station.

8.6.13.3. Flags. Check and ensure the range warning flag on the range indicator is out of view and the distance indicated is within one-half mile or 3 percent of the distance to the facility, whichever is greater.

8.6.13.4. Course set knob. Rotate the course set knob and check for proper CDI displacement.

8.6.13.5. To-from. Rotate the course set knob and check that the TO-FROM indication changes when the selected course is approximately 90° to the bearing pointer.

8.6.13.6. Designated checkpoints. When checking the VOR/TACAN at a designated ground checkpoint, the allowable CDI error is ±4° and the CDI and bearing pointer should agree within the tolerances specified for the aircraft.

8.6.13.7. Dual systems. If the aircraft has dual VOR or dual TACAN receivers, the systems are considered reliable for instrument flight if they check within ±4° of each other. However, if the VOR/TACAN is also checked at a designated ground checkpoint, the equipment must meet the requirement in the above bullet.

8.6.13.7.1. NOTE: The self-test mode incorporated into some VOR/TACAN/ILS sets provides an operational test of the set. The self-test does not, however, provide a test of the aircraft antennas. If the VOR/TACAN set self-test function checks within the aircraft's flight manual tolerances and the VOR/TACAN station identifier is received, the requirements of the paragraph above are satisfied.

8.6.13.8. VOR Test Facility (VOT). VOT is an FAA facility that transmits a test signal for either a ground or airborne operational test of VOR equipment.

8.6.13.8.1. When using a VOT on the ground, allowable error is ±4 degrees. When using an airborne VOT, allowable error is ±6 degrees.

8.6.13.8.2. Airborne checks using a VOT are limited to those areas/altitudes specifically authorized.

8.6.13.8.3. VOT frequencies are listed in the NAVAIDS section of the Enroute Supplement entry for each airport and on the air/ground voice communications panels on the Enroute Low Altitude charts and Area charts.

8.6.13.8.4. When using a VOT to test VOR equipment, accomplish the following procedures:

8.6.13.8.4.1. Tune the appropriate VOT frequency on your VOR receiver.

8.6.13.8.4.2. With the CDI centered, the Omni Bearing Selector (OBS) should read 0 degrees with a "from" indication; or the OBS should read 180 degrees with a "to" indication. The RMI will indicate 180 degrees regardless of OBS setting.

8.6.13.8.4.3. Identify the VOT station by listening for a series of dots or a continuous tone.

8.6.13.9. Other equipment. Check all other flight and navigation instruments and equipment for proper operation and accurate information.

8.6.13.10. GPS Navigation Database: Ensure the GPS navigation database is current. See AFI 11-202, Volume 3, *General Flight Rules* for current database restrictions.

8.7. IFR Flight in Uncontrolled Airspace.

8.7.1. Uncontrolled airspace is that airspace not otherwise designated as controlled airspace. There is little uncontrolled airspace within the CONUS. However, once outside the CONUS, there can be significant areas of uncontrolled, or Class G, airspace.

8.7.1.1. FAA controllers will only assign an IFR route through Class G airspace when requested by the pilot.

8.7.1.2. For IFR flights in Class G airspace outside the CONUS, consult the appropriate FLIP AP volume, NOTAMs, and local procedures for any specific instructions unique to each theater, area, country, or airport.

8.7.2. IFR operations are permitted in uncontrolled airspace. While operating under IFR on an IFR flight plan, there is no requirement to maintain VMC or VFR cloud clearances. All normal IFR equipment requirements and rules apply to include minimum altitude and flight levels.

8.7.2.1. IAW AFI 11-202 Volume 3, *General Flight Rules*, the pilot in command is the clearance authority for IFR flights in uncontrolled airspace.

8.7.2.2. While operating in VMC, pilots are solely responsible to see and avoid other traffic, terrain, and obstacles.

8.7.2.3. While operating under IFR in Class G airspace, pilots must strictly maintain the correct altitude for the direction of flight.

8.7.3. Air traffic control only provides separation between aircraft in controlled airspace. Therefore, caution should be exercised when operating in IMC under IFR in uncontrolled airspace.

8.8. Instrument Approaches to Uncontrolled Airports.

8.8.1. ***Instrument approaches to uncontrolled airports are authorized for USAF aircrews unless otherwise restricted by MAJCOM***. For VFR procedures at uncontrolled airports, see AFMAN 11-217 Volume 2 *Visual Flight Procedures*.

8.8.2. All operations at uncontrolled airports require additional vigilance on the part of the aircrew. Conducting instrument approaches at uncontrolled airports are especially challenging as the ground track of the instrument approach may not coincide with the ground tracks of the VFR traffic pattern, the instrument approach may not terminate at the active runway, altitudes may not coincide with the prevailing traffic patterns, and not all VFR pilots are familiar with the instrument approach procedures at the airport. Aircrews must thoroughly brief reporting procedures and crew coordination procedures prior to accomplishing an instrument approach at an uncontrolled airport.

8.8.2.1. A critical point to remember is that any person on the ground providing traffic advisories at a non-towered airport is only providing advisories. Personnel on the ground are not air traffic controllers. Pilots operating at uncontrolled airports are responsible for their own traffic avoidance, sequencing, and separation.

8.8.2.2. Pilots conducting actual or practice instrument approaches at uncontrolled airports must be especially vigilant for traffic departing in the opposite direction.

8.8.3. Common Traffic Advisory Frequency (CTAF). The CTAF is a frequency designed for the purpose of carrying out airport advisory practices while operating to or from an airport without an operating control tower. The CTAF may be a UNICOM, MULTICOM, FSS, or tower frequency and is identified on the approach plate.

8.8.3.1. A UNICOM is a non-governmental communication facility, which may provide airport information. The frequency will be published on the approach plate as "UNICOM". Many times these radios are located in the airport office or at a fixed base operator (FBO).

8.8.3.2. A MULTICOM is a mobile service not open to public correspondence used to provide communications essential to conduct the activities being performed by or directed from private aircraft. Where there is no tower, FSS, or UNICOM station on the airport, use MULTICOM frequency 122.9.

8.8.3.3. A FSS physically located on an airport may provide airport advisory service (AAS) at an airport that does not have a control tower or where a tower is operated on a part-time basis and the tower is not in operation.

8.8.3.4. When a control tower is not operational 24 hours a day, the CTAF frequency will normally be the same as the tower frequency listed on the approach plate and will be annotated, "TOWER (CTAF)."

8.8.4. There are two ways for pilots to communicate their intentions and obtain airport/traffic information when operating at an airport that does not have an operating tower: by communicating with an FSS that is providing airport advisories on a CTAF or by making a self-announced broadcast on the CTAF.

8.8.4.1. A FSS provides pilots with wind direction and velocity, favored or designated runway, altimeter setting, known traffic, NOTAMs, airport taxi routes, airport traffic pattern, and instrument approach procedures information. Pilots may receive some or all of these elements depending on the current traffic situation. Some airport managers have specified that under certain wind or other conditions, designated runways are used. Therefore, pilots should advise the FSS of the runway they intend to use. It is important to note that not all aircraft in the vicinity of an airport may be in communication with the FSS.

8.8.4.2. "Self-announce" is a procedure whereby pilots broadcast their position, intended flight activity or ground operation on the designated CTAF. This procedure is used primarily at airports that do not have a control tower or an FSS on the airport. The self-announce procedure should also be used when a pilot is unable to communicate with the local FSS on the designated CTAF.

8.8.5. Communication at Uncontrolled Airports.

8.8.5.1. Aircraft operating on an IFR flight plan, landing at an uncontrolled airport will be advised to “Change to advisory frequency”, when direct ATC communications are no longer required. When directed, pilots should expeditiously change to the CTAF frequency, as the ATC facility will not have runway in use or airport traffic information.

8.8.5.2. Inbound aircraft should initiate contact approximately 10 miles from the airport and continue to monitor the appropriate frequency until after landing and clear of the movement area.

8.8.5.2.1. NOTE: If your aircraft only has one radio capable of transmitting on the ATC and CTAF frequency, do not leave the assigned ATC frequency until instructed to do so.

8.8.5.3. Inbounds should report altitude, aircraft type, and location relative to the airport; should indicate whether landing or over flight; and should request airport advisory (if UNICOM or FSS).

8.8.5.4. Make position reports at the following locations on the approach.

8.8.5.4.1. When departing the final approach fix inbound;

8.8.5.4.2. When established on the final approach segment or immediately upon being released by ATC;

8.8.5.4.3. Upon completion or termination of the approach; and

8.8.5.4.4. Upon executing the missed approach procedure.

8.8.5.4.5. When exiting the active runway.

8.8.5.4.5.1. NOTE: It is important to remember that most VFR pilots operating in the vicinity of the airport will not be familiar with fix names. Location should be referred to in the simplest terms the average VFR pilot will understand. For example, use the terminology “5 miles south” instead of “Kirby Intersection”.

8.8.5.5. When self-announcing your position, insure you use the following format:

8.8.5.5.1. Name of the airport, followed by the word “traffic.”

8.8.5.5.2. Your call sign.

8.8.5.5.3. Your aircraft type in terms the average VFR pilot will understand.

8.8.5.5.4. Your location in terms the average VFR pilot will understand.

8.8.5.5.5. Your intentions.

8.8.5.5.6. Repeat the name of the airport.

8.8.5.5.6.1. Example: "Shenandoah traffic, Track 66, white Learjet, 5 miles south on the straight-in ILS Runway 5, touch and go, Shenandoah."

8.9. Flyability Checks.

8.9.1. Instrument procedure flyability checks are flown to ensure procedures are safe, practical, and consistent with good operating procedures before general use. They may be accomplished in lieu of or in addition to an official flight check. Whenever possible, ***flyability checks should be conducted by instructor/evaluator pilots***. Flyability checks are NOT official flight inspections ("flight checks"), but shall include the entire procedure including the missed approach segment and all holding patterns. ***Prior to accomplishing a flyability check, pilots will review applicable portions of AFI 11-230, Instrument Procedure.***

8.10. Procedure and Database Problem Reporting.

8.10.1. Despite the best quality control measures, it is still possible for aircrews to discover errors in databases, instrument procedures, charts, etc. If you discover a discrepancy or a discrepancy between two sources (ex. procedure pulled from aircraft database differs from paper IAP), report the discrepancy to your unit Standardization/Evaluation function. They, in turn, should report the details to the source of the database or procedure. All sources of databases, instrument procedures, charts, etc. have established procedures for reporting errors. Procedures and points of contact vary by vendor and organization and are located in the documentation that comes with the particular product.

Chapter 9

IFR DEPARTURE PROCEDURES

9.1. Introduction. Arriving at an airport is usually the focus of most of our attention; however, in many cases, departing an airport under IFR is a more hazardous operation. When planning a mission, aircrews must ensure they cannot only arrive safely, but also depart safely. ***This planning must be accomplished prior to arrival at the destination.*** Arriving aircraft have several advantages over departing aircraft.

9.1.1. Performance. Mainly due to fuel consumption enroute, arriving aircraft are typically lightweight and thus have a higher performance capability. Departing aircraft are much more performance-limited and may have difficulty achieving the minimum required climb gradient.

9.1.2. Established Routing. Clearly established routing is almost always available to arriving aircraft. Normally, there will be several published instrument approach procedures to choose from that will provide a safe route to the airport of intended landing. A departing aircraft, on the other hand, may be faced with an extensive array of IFR departure procedures with little or no accurate information about obstacles in the terminal area. Some, but not all obstacle data may be depicted on individual IAPs or published departure procedures and routings.

9.2. Planning an Instrument Departure. Prior to departure, consideration must be given to terrain and/or obstacles on or in the vicinity of the airport. Pilots must use all available sources to select the most appropriate departure method, which will ensure proper terrain and/or obstacle clearance. Consideration must be given to degraded climb performance and the actions required in the event of loss of thrust during the departure.

9.2.1. Except for diverse departures, instrument departure procedures are preplanned IFR procedures that provide obstruction clearance from the terminal area to the appropriate en route structure. If an airport has an instrument approach procedure, then it has also been assessed for an instrument departure. The primary purpose of instrument departure procedures is to provide obstacle clearance protection information to pilots. At busier airports, a secondary purpose is to increase efficiency and reduce departure delays.

9.2.2. Published departure procedures must meet the same requirements as approach procedures. Approval of non-DOD/NACO departure procedures is IAW AFI 11-202, Volume 3 *General Flight Rules*.

9.3. Obstacle Clearance Surface (OCS). In order to assess the airport for instrument departures, the TERPS specialist looks for obstacles along an obstacle identification surface (OCS) on a 40:1 slope from at or above the departure end of the runway. The 40:1 slope is equivalent to a 2.5% gradient or 152 feet per nautical mile. TERPS also requires a certain amount of required obstacle clearance (ROC). Historically, the standard ROC has been 48 feet per nautical mile (ft/nm), which when added to the standard OCS of 152 ft/nm equates to the standard minimum climb gradient of 200 ft/nm. The FAA has recently changed the ROC from a standard 48 ft/nm to a formula based on 24% of the climb gradient required to clear the obstacle. This transition will take a number of years for all FAA designed procedures. During the transition there is no way for aircrews to know which criteria were used to calculate the ROC for a particular FAA procedure; however, there will always be at least 48 feet per nautical mile ROC (24% of 200 ft/nm = 48 ft/nm). If it provides an operational advantage, the USAF will use 48 feet per nautical mile of ROC on USAF-designed procedures. On USAF procedures, if 48 feet per nautical mile ROC will be less than the FAA criteria, the procedure will note "Not For Civil Use." If no obstacles penetrate the OCS, then the required climb gradient is standard: 200 feet per nautical mile. If an obstacle penetrates the OCS then a higher gradient is required and will be published on the procedure. ***On all IFR departures, USAF aircraft are required to meet or exceed 200 feet per nautical mile or the published climb gradient; whichever is higher, with all engines operating***. ***See AFI 11-202 Volume 3, General Flight Rules, for engine out performance requirements.***

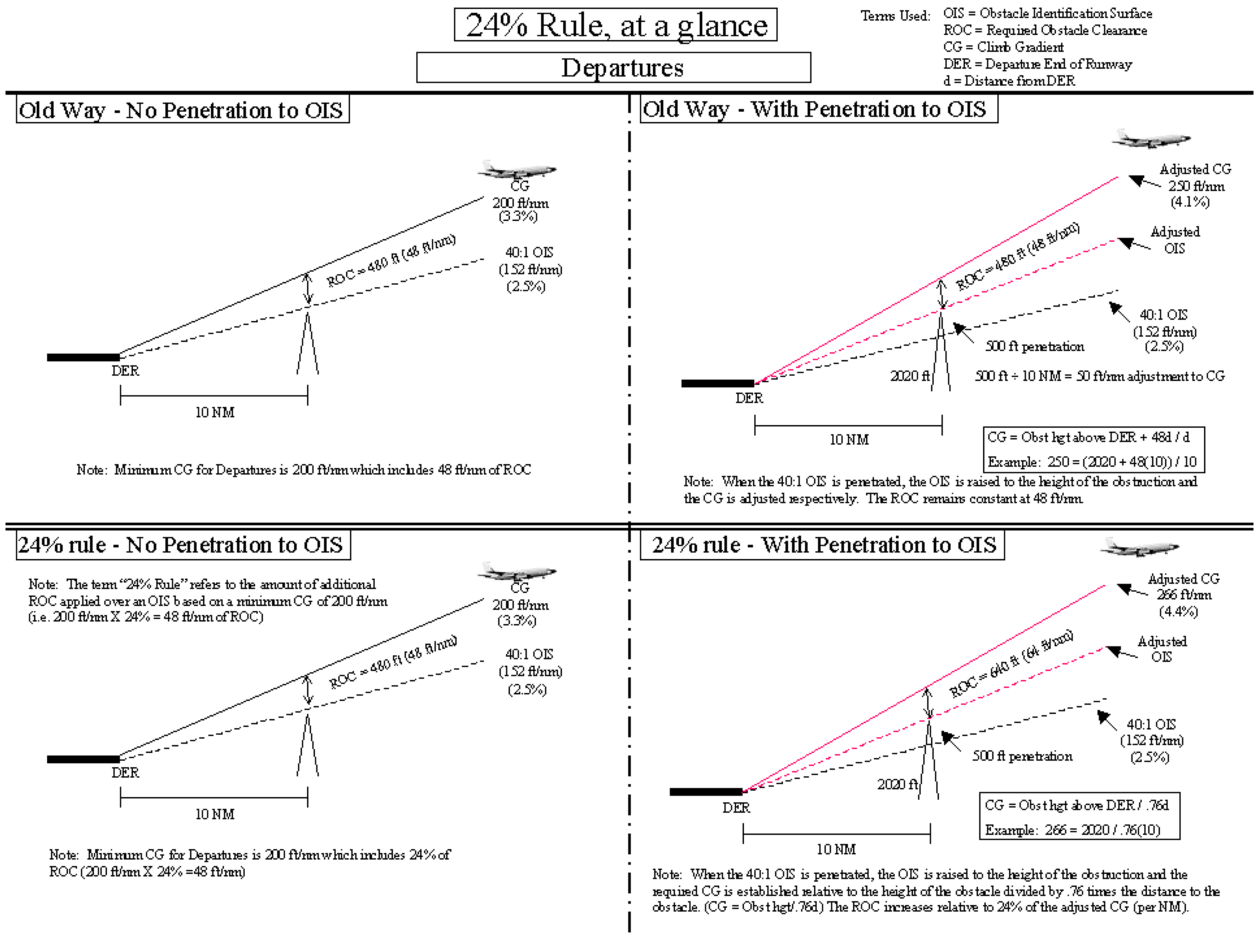
9.3.1. NOTE: ***In the absence of a Special Departure Procedure (SDP), if your MAJCOM allows the use of zero feet obstacle clearance to compute engine-out performance data, the only acceptable technique to compute the required engine-out climb gradient is to subtract 48 feet/nm from the published climb gradient. This applies regardless of whether the procedure was created using the 24% rule or the conventional 48 feet/nm.*** Under the 24% rule, the ROC will always be greater than or equal to 48 feet/nm.

9.3.1.1. NOTE: ***If the airport has a Special Departure Procedure (SDP) for your type aircraft, you are required to use the SDP for engine-out performance planning.***

9.3.2. NOTE: The ICAO does not recognize the new FAA ROC formula and uses the conventional 48 feet per nautical mile ROC.

9.3.3. NOTE: When the TERPS specialist looks for obstacles, many different sources are used in order to obtain the best available data to build an obstacle database. Some of the sources include civil engineering tabs (surveys), various high-resolution maps and charts, and even products obtained from satellite imagery. Needless to say, the TERPS specialist's obstacle data is much more complete than any data an aircrew could ever obtain. ***The limited data available to the aircrew (aeronautical charts, FLIP, ASRR, etc.) is not adequate to plan an instrument departure***; it is not complete nor does it provide sufficient detail. Therefore, ***USAF aircrews are not allowed to use raw obstacle data to construct their own departure procedures. Aircrews shall not use the "prominent obstacles" depicted on a Standard Instrument Departure (SID) to recompute the required climb gradient. Published instrument departure procedures must be flown as published. The published climb gradient or 200 ft/nm, whichever is higher, must be used as the basis for all computations. For VFR departure procedures, see AFMAN 11-217 Volume 2, Visual Flight Procedures.***

Figure 9.1. Obstacle Identification Surface.



9.4. "Runway End Crossing Height" or "Screen Height." "Runway End Crossing Height" or "Screen Height" is the required altitude (AGL) at the end of the runway (usually depicted as the Departure End of the Runway (DER)). The OCS slope begins at the runway end crossing height. Therefore, an accurate determination of the proper height is crucial because if you do not make the runway end crossing height, you will be operating below the OCS. There is a great deal of variation in runway end crossing height depending on location of the airport, who designed the procedure, terrain, obstacles and other factors. ***Under no circumstances may a USAF aircrew plan to depart a runway without complying with the runway end crossing height restriction.*** See Table 9.1 below for summary of Runway End Crossing Heights.

9.4.1. Runway End Crossing Heights (FAA and US Army (USA)). If obstacles penetrate the OCS, TERPS allows a runway end crossing height of up to 35 feet. There is no way to know if the FAAs TERPS specialist raised the OCS or not; therefore, ***in the United States on FAA, Army or any other procedures not designed by the USAF or US Navy (USN), you must always plan to cross the departure end of the runway at or above 35 feet unless an appropriate authority (i.e., MAJCOM TERPS Office) has determined a lower crossing restriction is permissible.***

9.4.1.1. There is no provision for a runway end crossing height greater than 35 feet. If raising the runway end crossing height to 35 feet does not eliminate all penetrations of the 40:1 OCS, then the procedure developer will raise the required climb gradient above 200 ft/nm.

9.4.2. Runway End Crossing Heights (USAF/USN). USAF and USN procedures always try to begin the OCS at zero feet at the DER, but may raise the OCS up to 35 feet in order to clear obstacles (Figure 9.2). Unlike the FAA/USA, when a USAF or USN TERPS specialist raises the OCS, the actual height will be published on the procedure. ***In the United States, if the USAF or USN designs the procedure, cross the departure end of the runway above 0 feet only when a higher altitude is published***.

9.4.2.1. NOTE: At civil/joint-use fields, the FAA can develop procedures for the USAF or USN when requested. When this occurs, the procedure developer will be annotated as "USAF" or "USN" on the procedure, misleading the pilot into thinking the screen height is 0 feet, when in fact, it could be up to 35 feet. Therefore, ***when departing civil/joint use airports within the US, always plan to cross the departure end of the runway at or above 35 feet unless a higher altitude is published or an appropriate authority (i.e., MAJCOM TERPS Office) has determined a lower crossing restriction is permissible.***

9.4.3. Runway End Crossing Heights (ICAO). Runway end crossing heights are clearly identified in the United States; however, as soon as you leave the U.S., it becomes very difficult to determine what runway end crossing height applies (if any) because it is difficult for the aircrew to identify what type of TERPS criteria (if any) were used to construct the procedure. Consequently, ***when outside the US, use the table below to determine the appropriate runway end crossing height. Plan to cross the departure end of the runway at or above the altitude shown below unless a different altitude is published or an appropriate authority (i.e., MAJCOM TERPS Office) has determined a different crossing restriction is permissible***. ***Consult FLIP AP to determine if there are any exceptions to this for each country you will transit***.

Table 9.1. Runway End Crossing Heights.

COUNTRY/REGION	TERPS CRITERIA *NORMALLY* USED	*NORMAL* RUNWAY END CROSSING HEIGHT
CONUS (FAA/USA)	FAA TERPS	35 feet
CONUS (USAF/USN)	DoD TERPS	0 feet (or as published)
CONUS (Civil/Joint-Use)	FAA TERPS or DoD TERPS	35 feet
Canada	Canadian TERPS (GPH-209 or TP-308)	35 feet
NATO Countries (except US and Canada) Military Airports	NATO APATC-1	35 feet
NATO Countries (except US and Canada) Civil Airports	PANS-OPS	16 feet or as published
Other ICAO Nations	Various or None	16 feet or as published

Figure 9.2. Runway End Crossing Heights.

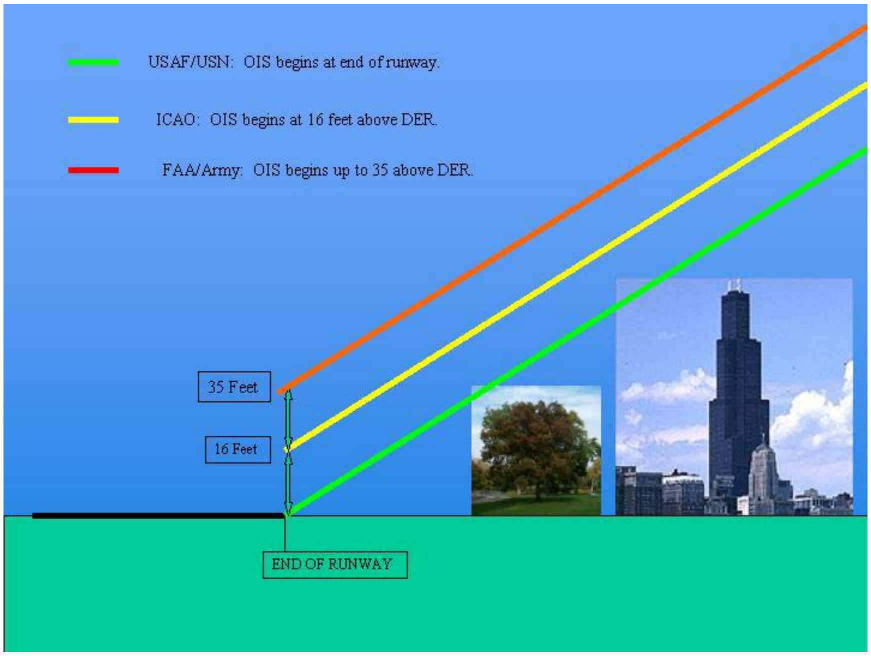
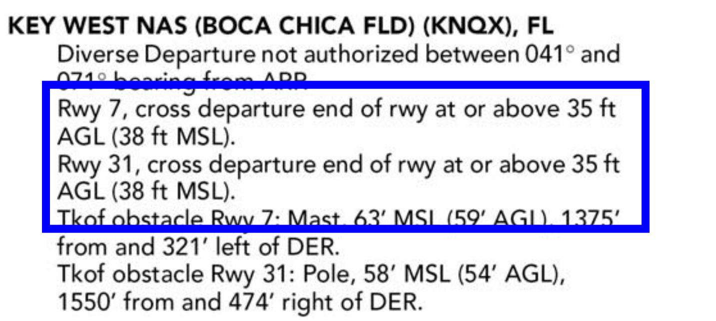


Figure 9.3. Specific Runway End Crossing Height.



KEY WEST NAS (BOCA CHICA FLD) (KNQX), FL

Diverse Departure not authorized between 041° and 071° bearing from ARP.

Rwy 7, cross departure end of rwy at or above 35 ft AGL (38 ft MSL).

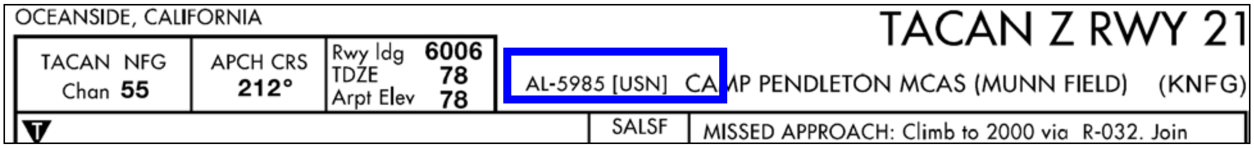
Rwy 31, cross departure end of rwy at or above 35 ft AGL (38 ft MSL).

Tkof obstacle Rwy 7: Mast, 63′ MSL (59′ AGL), 1375′ from and 321′ left of DER.

Tkof obstacle Rwy 31: Pole, 58′ MSL (54′ AGL), 1550′ from and 474′ right of DER.

9.4.4. Who 'Produced' the Procedure? At the top of each instrument approach procedure is an airport reference number, as seen in Figure 9.4. This number is unique to each airport and is simply a record-keeping notation for the publisher. The producer of the procedure is annotated in parenthesis to the right of the airport reference number as shown in Figure 9.4. When the airport reference number has parenthetical information on both the left and the right, the parenthetical info on the left indicates who requested the procedure be published in FLIP, and the parenthetical information on the right shows who produced the procedure.

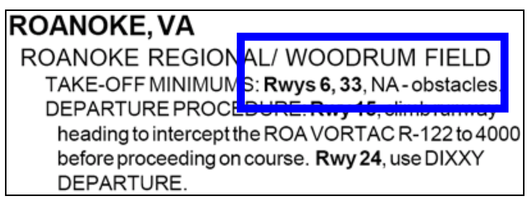
Figure 9.4. Who Produced The Procedure?



9.5. Instrument Departure Procedures. Except for Diverse Departures, Instrument Departure Procedures are preplanned IFR procedures that provide obstruction clearance from the terminal area to the appropriate enroute structure. Normal IFR departure methods are designed for all engines operating. The following discussion pertains to normal IFR departures. ***See paragraph 9.15 for a discussion of engine-out performance considerations.***

9.5.1. Methods to Avoid Obstacles. If any obstacles penetrate the 40:1 OCS, then the TERPS specialist must provide notification to the pilot, as well as establish a method to avoid the obstacles, or publish the low close-in obstacles. When designing an IFR departure procedure, methods used by the TERPS specialist are: publish obstacles location, non-standard takeoff weather minimums, climb gradients, specific routing, or a combination of several methods. In some cases, IFR departures are not authorized from specific runways. ***It is the responsibility of the Pilot In Command (PIC) to thoroughly review the published instrument departure procedures in order to determine the appropriate method to be used***.

Figure 9.5. IFR Departure Not Authorized.



9.5.1.1. NOTE: Knowing the proper terminology for departures is important. In the late 1990's, the FAA started to remove the term Standard Instrument Departure (SID) from its publications in an attempt to standardize processing and terminology. After re-evaluating the use of the term SID worldwide, the FAA harmonized with ICAO and reverted back to using the term SID. The FAA is using the terms SID and Obstacle Departure Procedure (ODP) in the United States to describe preplanned published departure routings. The information in the front of the IAP book is titled "Takeoff Minimums and (Obstacle) Departure Procedures. This section includes non-standard weather minimums, low close-in obstacles, ODPs, and climb gradients. ODPs, are printed either textually or graphically and are referred to as a "Textual ODP" and "Graphic ODP"; and SIDs are always printed graphically. ODPs are developed to provide obstruction clearance/avoidance. SIDs also provide obstruction clearance information but are designed primarily to reduce pilot/controller workload and to facilitate traffic flow. Thus, a SID may not provide the most optimal route for obstacle avoidance.

9.5.2. NOTE: Occasionally, a departure procedure will be published specifying a maximum speed or different routings or restrictions based on aircraft category. ***On***

procedures that specify an aircraft category for different aspects of the procedure, use the aircraft approach category to determine which procedure(s) to apply.

9.5.3. Basic Rules for all IFR Departures. No matter what method of IFR departure is used, these basic rules always apply:

9.5.3.1. ***Delay all turns until at least 400 feet above the departure end of the runway elevation unless an early turn is specifically required by the departure procedure***, with the annotation of "immediate" or "as soon as practical".

9.5.3.2. ***Climb at a minimum of 200 feet per nautical mile unless a higher gradient is published. Air Force aircraft must always meet or exceed the published climb gradient for the runway used with all engines operating.***

9.6. Methods of IFR Departures (All Engines Operating). There are six authorized methods for departing IFR with all engines operating:

9.6.1. Obstacle Departure Procedures (ODP); Textual or Graphic

9.6.2. Standard Instrument Departure Procedures (SID)

9.6.3. Specific ATC Departure Instructions (including radar vectors)

9.6.4. Diverse Departures

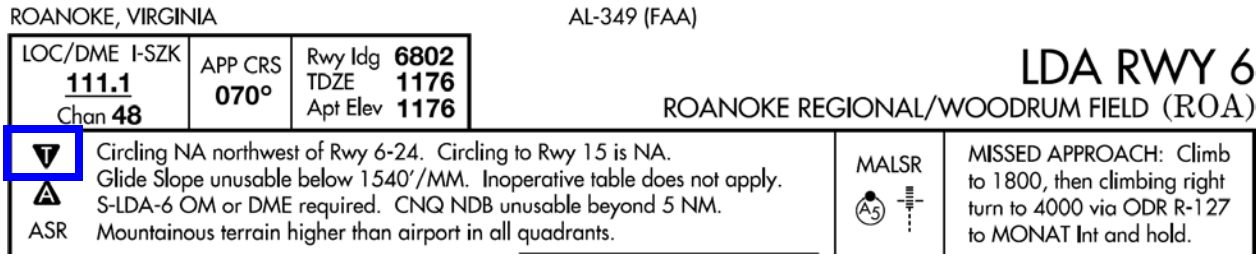
9.6.5. Visual Climb Over the Airport (VCOA)

9.6.6. Special MAJCOM Certification (authorized airports, aircrews and aircraft only)

9.6.7. If unable to depart IFR using any of the above listed methods, a VFR climb to the IFR MEA or a VFR departure are authorized IAW AFI 11-202 Volume 3 *General Flight Rules* if allowed by your MAJCOM. A VFR climb to the IFR MEA or a VFR departure are to be used only as a last resort when the mission priority justifies the increased risk (not applicable to planned VFR training or operational flights where the majority of the flight is to be conducted under VFR).

9.7. Obstacle Departure Procedures (ODP). If any obstacles penetrate the 40:1 OCS, the TERPS specialist must notify the pilot and provide a procedure to depart under IFR. The TERPS specialist may fulfill this requirement using one of the following methods or a combination of one of the following methods: publication of location of obstacles, non-standard takeoff weather minimum, minimum climb gradient, or specific routing. On U.S. Government charts (DoD FLIP, NACO), the notification is provided by the placement of a special symbol on all of the IAPs and SIDs for the airport. The symbol is a white "T" on a black inverted triangle (▼). From now on, we'll refer to this "T" symbol as the "Trouble T" because it usually means trouble for departing aircraft. The presence of the "Trouble T" means you must consult the separate listing in the front of the approach plate titled, "IFR Takeoff Minimums and (Obstacle) Departure Procedures."

Figure 9.6. "Trouble T".



9.7.1. FAA Takeoff Weather Minimums. The FAA's "standard" takeoff weather minimums for commercial operations are defined in Federal Aviation Regulations (FAR) 91.175 as one statute mile visibility for aircraft with two engines or less and one-half statute mile for aircraft with more than two engines. ***USAF aircraft will not use FAA takeoff weather minimums. USAF aircraft shall use takeoff weather minimums IAW AFI 11-202, Volume 3, General Flight Rules***.

9.7.1.1. Non-Standard Takeoff Weather Minimums. When obstacles penetrate the 40:1 OCS, non-standard takeoff weather minimums are provided for commercial civil pilots to "see-and-avoid" obstacles during departure. "See-and-avoid" is for pilots who are flying aircraft that are not capable of meeting the minimum climb gradient, and/or climb out at a very slow airspeed with a minimal deck angle (i.e., small, single-engine general aviation aircraft). ***USAF aircraft may only use non-standard weather minimums for takeoff if aircraft performance with <u>one engine inoperative</u> will allow the aircraft to be at the non-standard ceiling requirement by the end of the runway and comply with published climb gradient requirements thereafter. USAF aircraft are not authorized to create their own "see-and-avoid" weather minimums in lieu of meeting the required minimum climb gradient.***

9.7.1.1.1. NOTE: TERPS does not allow a climb gradient in excess of 500 ft/nm without a waiver. Normally, waivers will be granted for climb gradients up to 750 ft/nm. In many cases, the procedure designer will publish only non-standard takeoff weather minimums due to a climb gradient in excess of 750 ft/nm or a gradient unrealistic for the majority of aircraft that use that particular airport. The presence of only non-standard weather minimums is a signal to the aircrew that there are significant obstacles around the airport.

9.7.1.1.2. NOTE: Non-standard takeoff weather minimums are valuable as a situational awareness tool for crews. Non-standard weather minimums are determined by taking the controlling obstacle height plus a ROC, and rounding up to the nearest MSL altitude and the distance from the DER rounded up to the nearest half mile. Therefore, if 1700-2 is the non-standard weather minimum, this tells the crew there is an obstacle somewhat under 1700 feet AGL within 1.5-2 statute miles of the DER. The maximum visibility allowed for non-standard weather minimums is 3 sm. Consequently, the presence of a visibility minimum of 3 sm indicates the obstacle could be greater or less than 3 sm from the DER. As with other obstacle information, ***this is a situational awareness tool and shall***

not be used to compute a required climb gradient. There could be other significant obstacles at lower altitude, closer to the DER. Non-standard takeoff weather minimums only represent the controlling obstacle. This information also does not tell the crew what the obstacle is or precisely where it is.

Figure 9.7. Non-Standard Weather Minimums.

ORANGEBURG, SC
ORANGEBURG MUNI
TAKE-OFF MINIMUMS: **Rwys 5, 31** 500-1.

9.7.2. Minimum Climb Gradient. The TERPS specialist may also provide a minimum climb gradient for use with the FAAs "standard" takeoff weather minimums. This is the type of IFR departure procedure most commonly used by USAF aircraft. Typically, the non-standard takeoff weather minimums will have an asterisk (*) leading you to a note which will say something like, "Or standard with minimum climb gradient of 300 ft/NM to 700 feet." ***USAF aircraft are authorized to depart IFR using the minimum climb gradient***. When using this type of IFR departure, substitute your MAJCOM-directed takeoff weather minimums in place of the word "standard." ***USAF aircraft must always meet or exceed the published climb gradient with all engines operating for the runway used.***

Figure 9.8. Climb Gradient In Lieu of Non-Standard Weather Minimums.

SIMMONS AAF (KFBG)
FORT BRAGG, NC
. . . . .Rwy 27, 900-1*
* Standard with minimum climb of 250/NM to 1000.

9.7.3. Specific Routing. A third method used by the TERPS specialist is to provide a specific route of flight, which will take the aircraft away from the obstacle. You must be careful when using this type of IFR departure. Make sure no requirement exists to use non-standard takeoff weather minimums in order to execute the procedure. This situation could indicate more than one obstacle along the departure path and would not be allowed unless you comply with paragraph 9.7.1.1.

Figure 9.9. Obstacle Departure Procedure (ODP).

ROANOKE, VA
ROANOKE REGIONAL/ WOODRUM FIELD
TAKE-OFF MINIMUMS: **Rwys 6, 33**, NA - obstacles.
DEPARTURE PROCEDURE: **Rwy 15**, climb runway heading to intercept the ROA VORTAC R-122 to 4000 before proceeding on course. **Rwy 24**, use DIXXY DEPARTURE.

9.7.4. Combination of All Three Methods. Some IFR Departure Procedures use a combination of all three methods. Make sure that if the procedure requires the use of non-standard takeoff weather minimums, the aircraft performance with one engine inoperative will allow the aircraft to be at the non-standard ceiling minimum by the end of the runway.

Figure 9.10. Combination of Methods.

RICHMOND, VA
CHESTERFIELD COUNTY
TAKE-OFF MINIMUMS: **Rwy 15**, 800-1 or std. with a min. climb of 280' per NM to 1200. **Rwy 33**, 1200-1, or std. with a min. climb of 220' per NM to 1700.
DEPARTURE PROCEDURE: **Rwy 15,** climb runway heading to 1200' before proceeding on course. **Rwy 33**, climb runway heading to 1700' before proceeding on course.
NOTE: **Rwy 15**, 18' AGL pole 1315' from departure end of runway, 304' left of centerline. **Rwy 33**, 84' AGL tree 2399' from departure end of runway, 84' left of centerline.

9.7.5. For airports outside the US, the separate listing will be titled "IFR Takeoff Minimums and Departure Procedures" in DoD/NACO FLIP. Commercial or foreign government products may differ in title and format.

9.7.6. Because the US government does not produce them, Jeppesen charts do not use the "Trouble T" symbol. Instead, they publish IFR takeoff minimums and departure procedures on the back of the airfield diagram page. When using Jeppesen products, you must have the airfield diagram page – not just the approach charts. Without the airfield diagram page, you will have no way of identifying the proper method to plan your IFR departure.

9.7.7. ***The non-standard weather minimums and minimum climb gradients published in the front of the approach book also apply to SIDs and radar vector departures unless different minimums are specified on the SID***. See paragraph 9.8.4.1.2.4.

9.7.8. Low Close-In Obstacles. A low close-in obstacle is one that would require a climb gradient in excess of 200 ft/nm that terminates at or below 200 feet above the departure end of the runway. These are very close to the runway and typically would create a very large climb gradient. Instead of publishing a climb gradient, the TERPS specialist will publish a NOTE informing you of the height and location of the obstacles (this information can also appear in NOTAMS). If there are additional obstacles that require a climb gradient above 200 feet above the departure end of the runway, then there will be a published climb gradient as well. The published climb gradient will not provide clearance over low close-in obstacles, only the more distant ones. ***Therefore, in addition to complying with the published climb gradient, you must also ensure you can vertically clear applicable obstacles along the planned departure path published in this type of NOTE.***

Figure 9.11. Low Close-in Obstacles.

QUANTICO MCAF (TURNER FIELD) (NYG)
QUANTICO, VA
. . . . . Rwy 2, 400-1*
Or standard with minimum climb of 410'/NM to 500.
TAKE-OFF OBSTACLES: Rwy 2: 78' AGL smokestack 2305' from departure end of rwy, 406' left of centerline; 75' AGL trees 4069' from departure end of rwy, 809' left of centerline; 75' AGL trees 5758' from departure end of rwy, 502' right of centerline; 75' AGL trees 8466' from departure end of rwy, 904' right of centerline. Rwy 20: 11' AGL traverse way 81' from departure end of rwy.

9.7.9. How to Fly an IFR Departure Procedure

9.7.9.1. "Will ATC Clear Me for an ODP?" In most situations, ATC will not specifically clear you for an ODP. ***If you are "cleared as filed" and ATC does not issue you further instructions (by assigning a SID), then you are expected to fly the published ODP for the runway used.***

9.7.9.1.1. CAUTION: Use caution when assigned a heading on departure. Issuance of a heading for departure is not a radar vector. A radar vector is only issued when you are in radar contact at or above the minimum vectoring altitude (MVA) or are in a Diverse Vector Area (DVA). See paragraph 9.9.4.3.

9.7.9.1.2. NOTE: If you are departing an airport, and pilot compliance with the ODP is necessary for traffic separation, then ATC may include the ODP in your ATC clearance. The verbiage will be, "Depart via the Vandenberg Runway 32 Departure Procedure."

9.7.9.2. "How Do I File an ODP?" Refer to FLIP General Planning for the most up-to-date guidance on filing. Some ODPs are named and those with graphical depictions will look very similar to a SID and may even have a coded identifier like a SID. In these cases, file it like a SID. You can put a note in the remarks, "Will depart via (airport)(runway) via textual ODP". If you are in doubt as to whether the controller expects you to fly the ODP, query the controller.

9.7.10. SIDs Instead of ODP. There are some airports that will provide obstacle clearance via a SID instead of establishing an ODP. You will be notified via NOTAM or by a statement in the front of the book under the section titled, "IFR Takeoff Minimums and (Obstacle) Departure Procedures." The statement will say, "RWY XX, use published SID for obstacle avoidance."

9.8. Standard Instrument Departures (SIDs). A SID is an ATC coded departure procedure that has been established at certain airports to simplify clearance delivery procedures. SIDs are preplanned IFR departure procedures printed for pilot use in graphic and/or textual form. SIDs are supposed to be simple, easy to understand, and (if possible) limited to one page. A heavy black line depicts the actual SID; thin black lines represent transition routings. The departure route description should be complete enough that the pilot can fly the SID with only the textual description.

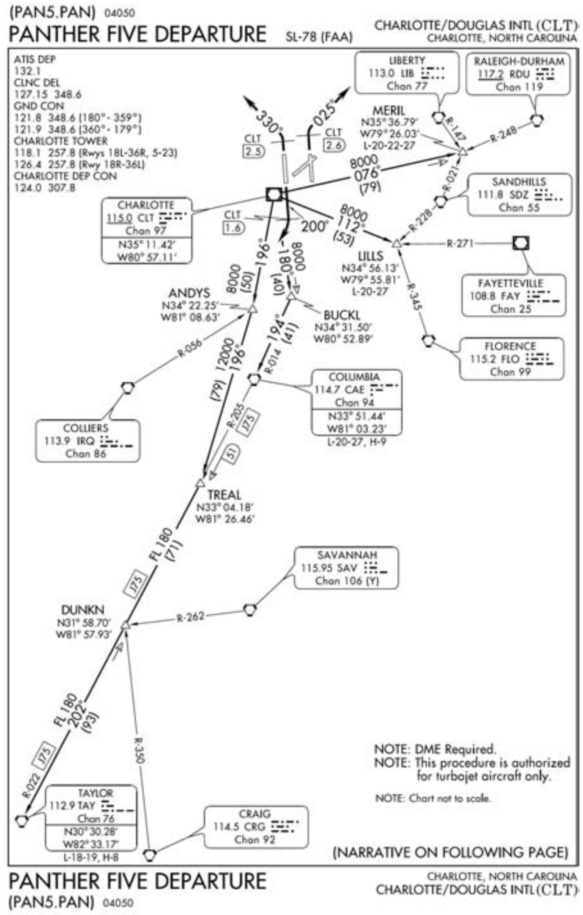
9.8.1. SIDs Are Optimized for ATC. A SID is an ATC procedure. Although a SID will keep an aircraft away from obstacles along the route of flight, it may not provide the lowest possible climb gradient. It will strike a balance between obstacle avoidance and airspace considerations.

9.8.2. Using SIDs. Pilots operating from locations where SIDs exist can expect an ATC clearance containing a SID***. In order to use a SID, the pilot must possess at least the textual description of the SID procedure***. Controllers may omit the departure control frequency if a SID clearance is issued and the departure control frequency is published on the SID***. ATC must be immediately advised if the pilot does not possess a charted SID or a preprinted SID description or, for any other reason, does not wish to use a SID***. Notification may be accomplished by filing "NO SID" in the remarks section of the filed flight plan or by the less desirable method of verbally advising ATC.

9.8.3. SID Depictions. SIDs are usually depicted in one of two basic forms – Pilot Nav or Vector SIDs.

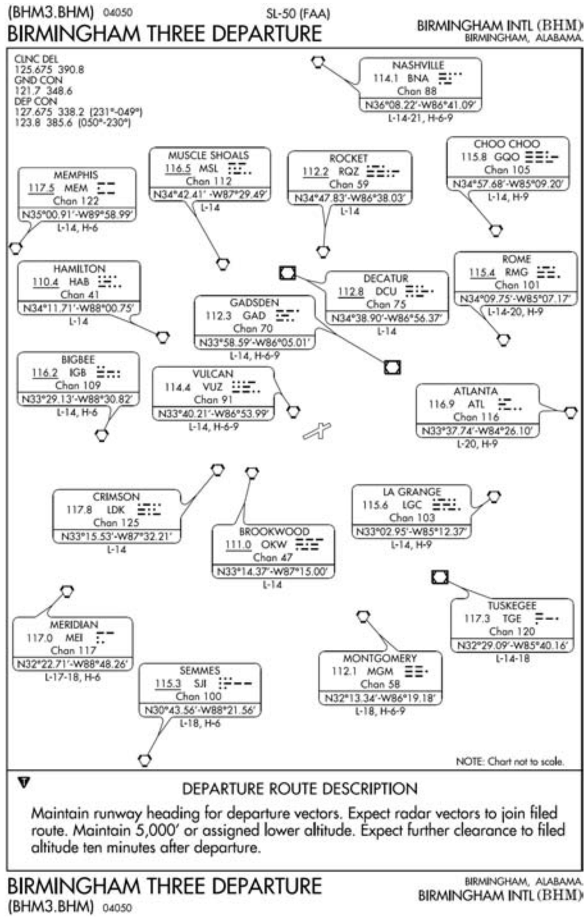
9.8.3.1. Pilot Navigation (Pilot NAV) SIDs. The pilot is primarily responsible for navigation on the SID route. They are established for airports when terrain and safety related factors indicate the necessity for a pilot NAV SID. Some Pilot NAV SIDs may contain vector instructions which pilots are expected to comply with until instructions are received to resume normal navigation on the filed/assigned route or SID procedure. Some Pilot NAV SIDs also require you to fly the ODP first, especially those that begin in uncontrolled airspace.

Figure 9.12. Pilot-Nav SID.



9.8.3.2. Vector SIDs. Vector SIDs are established where ATC will provide radar navigational guidance to a filed/assigned route or to a fix depicted on the SID. On a vector SID, flying the ODP first may be required. This usually occurs in locations where the ODP states something similar to "Fly runway heading to xxx prior to making any turns."

Figure 9.13. Vector SID.

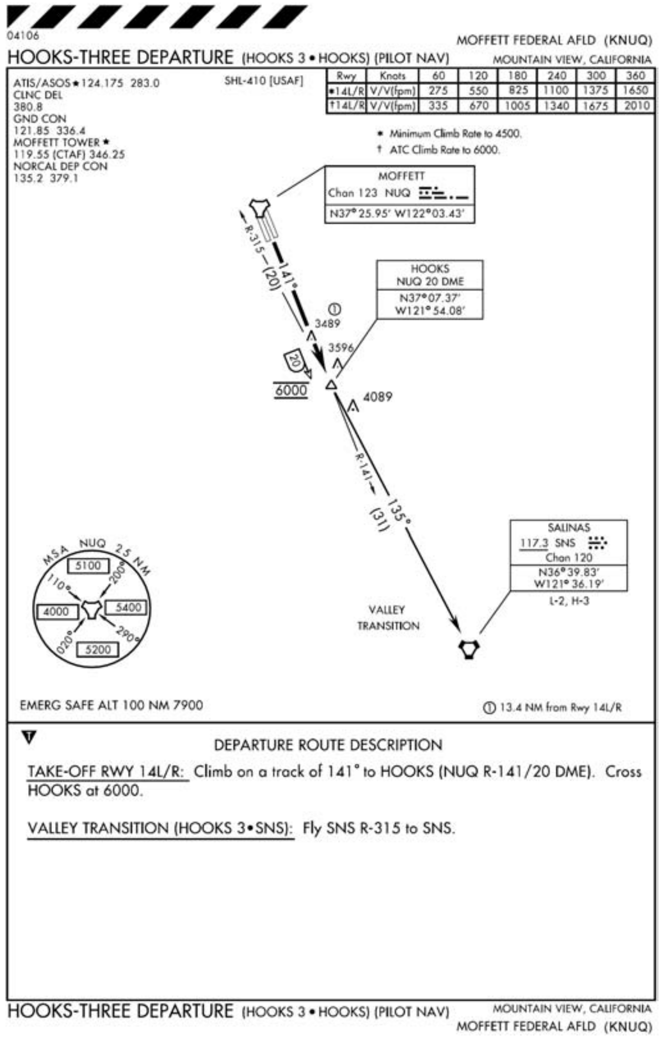


9.8.4. Different Types of SIDs. SIDs are very common everywhere we fly. Even though SIDs seem about the same the world over, there are some very important differences that you must be aware of in order to fly them safely.

9.8.4.1. Domestic SIDs. In the United States, all SIDs are developed using U.S. TERPS criteria. Even so, there is a big difference between how military SIDs and civil SIDs are depicted. It's important to understand what each format provides (or does not provide) for you.

9.8.4.1.1. Military SIDs. Generally speaking, military SIDs provide you with more information than civil SIDs. (The phrase "military SIDs" applies to USAF/USN SIDs in the CONUS. Army SIDs are produced by the FAA in the CONUS and should be treated as civil SIDs.).

Figure 9.14. Military SID.



9.8.4.1.1.1. Obstacles Are Charted. On a military SID, "prominent" obstacles (not all obstacles) that might create a hazard if departure procedures are not executed precisely, shall be shown in their exact geographic location. When portrayal of several obstacles would create clutter, only the highest of the group must be shown.

9.8.4.1.1.2. ATC Climb Gradients Identified. Military SIDs identify and publish ATC climb gradients that exceed 200 feet per nautical mile. ATC climb gradients are for crossing restrictions or other airspace considerations.

9.8.4.1.1.3. Obstacle Climb Gradients. Military SIDs identify and publish minimum climb gradients that exceed 200 feet per nautical mile, which will ensure proper obstacle clearance.

9.8.4.1.1.3.1. CAUTION: Although military SIDs may try to depict information about the "controlling obstacle," that information is <u>not</u> provided to assist you in creating your own departure. For example, you may not take the obstacle height and distance from the SID and determine a "new" climb gradient for the SID. To do so may expose you to other obstacles that are not depicted. ***USAF aircraft must meet the published climb gradient or 200 feet per nm, whichever is higher, with all engines operating – not a new gradient that you have calculated.***

9.8.4.1.1.3.2. Climb Gradient Table. Military SIDs provide information about both obstacle and ATC climb gradients. Typically, all climb gradient information is placed in a climb gradient table published on the SID. An asterisk generally denotes a minimum climb gradient (*) and a "dagger" (†) symbol generally denotes an ATC climb gradient. It is important to understand how to properly use the information presented in the climb gradient table.

9.8.4.1.1.3.3. Climb Rate vs. Climb Gradient. The unit of measurement used actually describes climb rates in feet per minute (like VVI). Because the table's climb rate is based on feet per minute, it assumes a constant groundspeed. During climbout, you rarely hold a constant groundspeed (affected by TAS, winds, acceleration, pilot technique, etc.), so the climb rates in feet per minute are actually not very useful. Instead of a "climb rate," what you really need to know is the required "climb gradient" expressed in feet per nautical mile or percent gradient. The table provides the information you need, but you need to know how to pick it out.

9.8.4.1.1.3.4. CAUTION: Flying the VVI values represented in the climb gradient table does not guarantee obstacle clearance. In order to properly ensure obstacle clearance, you must compare your aircraft's climb performance to the required climb gradient (not the climb rate).

9.8.4.1.1.4. Determining the Climb Gradient in Feet Per Nautical Mile. By applying the "60-1 Rule" (described in AFMAN 11-217, Volume 3, *Supplemental Information*.), the number that appears in the "60 knot" block of the climb gradient table is the required gradient in feet per nautical mile. If there is no "60" block, just divide the "120" block by two or divide the "180" block by three, etc.

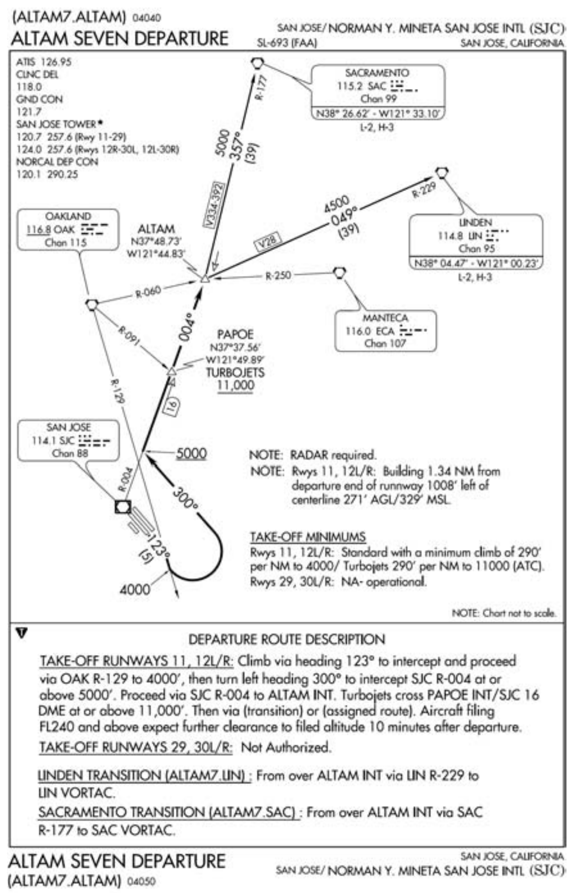
9.8.4.1.1.4.1. Conversions. With your climb gradient in feet per nautical mile, you can now convert to other units of measurement in order to assess your aircraft's required performance. Here are some of the common conversions:

9.8.4.1.1.4.2. Feet Per Nautical Mile to Percent Gradient. To convert feet per nautical mile to percent gradient, divide the gradient in feet per nautical mile by 60 to convert to percent gradient. For example, if your required climb gradient is 300 ft/NM, divide by 60 to convert to percent gradient. In this case, 300 divided by sixty equals five, so your required climb gradient is 5%. Just reverse the process to convert percent gradient to feet per nautical mile.

9.8.4.1.1.4.3. Feet Per Minute to Percent Gradient. If you are using a chart with a "100 knot" groundspeed block, you can take the feet per minute value in the "100 knot" column and divide it by 100 to calculate the required climb gradient in percent gradient. For example, if the climb rate in the "100 knot" column is 600 feet per minute, then divide by 100 to convert the climb rate to percent gradient. In this case, 600 feet per minute equates to a 6% climb gradient. To convert to feet per nautical mile, multiply by 60 to determine the required climb gradient in feet per nautical mile. In this case, the answer is 360 feet per nautical mile.

9.8.4.1.2. Civil SIDs. Although civil SIDs (FAA and CONUS Army procedures) in the United States are constructed using the same TERPS criteria as military SIDs, the information presented is significantly different. It is important to be aware of the differences.

Figure 9.15. Civil SID.



9.8.4.1.2.1. No Obstacles Are Identified or Depicted. Although many obstacles may be present, civil SIDs do not provide any obstacle information to the pilot.

9.8.4.1.2.2. ATC Climb Gradients. Civil SIDs also do not normally identify ATC climb gradients in any way; it is up to the pilot to recognize and compute any ATC climb gradients.

9.8.4.1.2.3. Obstacle Climb Gradients. On civil SIDs, minimum climb gradients required for obstacle clearance will be depicted in one of two ways: depicted on the SID or included in the IFR Departure Procedures.

9.8.4.1.2.3.1. Climb Gradient Depicted On the SID. At some airports, the minimum climb gradient will be published on the SID. Although a "Trouble T" is depicted on the SID, ***the climb gradient published on the SID itself takes precedence over the climb gradient contained in the IFR Departure Procedure***.

9.8.4.1.2.4. Climb Gradient Included in the ODP. In other situations, there will be no climb gradient published on the SID; however, the SID chart will depict a "Trouble T." In these cases, you must refer to the ODPs in the front of the approach book to determine the minimum climb gradient for the runway used. ***When no climb gradient is specified on the SID, you must comply with the gradient published with the ODP for that runway***.

9.8.4.1.3. SID Crossing Restrictions. On a civil SID, the only reason a climb gradient is normally published is when it is required for obstacle clearance. It is also important to realize that crossing restrictions on SIDs may be established for traffic separation or obstacle clearance. The problem is that you will not be able to tell the difference just by looking at the SID. If you are ever in doubt about making a SID crossing restriction, notify ATC immediately. When no gradient is specified, the pilot is expected to climb at least 200 feet per nautical mile to MEA unless required to level off by a crossing restriction.

9.8.5. How to Fly a SID.

9.8.5.1. "Will ATC Clear Me To Fly a SID?" If ATC wants you to fly a SID, the name of the SID will be included in your clearance. The controller will state the SID name, the current number and the SID transition name after the phrase "Cleared to (destination) airport" and prior to the phrase, "then as filed," for ALL departure clearances when the SID or SID transition is to be flown. Controllers may omit the departure control frequency if a SID has or will be assigned and the departure control frequency is published on the SID.

9.8.5.2. "How Do I File a SID?" Select a SID and/or SID transition routing that is appropriate for your desired route of flight. File a SID IAW FLIP GP.

9.8.5.3. SID Altitudes. In your initial clearance, ATC will provide you with an altitude to climb and maintain. In some cases, your initial altitude will be published on the SID. In some cases, the altitude issued with your IFR clearance on the ground may be higher than restriction(s) on the SID. In these cases, you must comply with the SID restrictions as you climb to the assigned altitude.

9.8.5.4. Amended Clearances. ATC may change your altitude clearance at any time after receiving your initial clearance. The important point to remember is that the last ATC clearance has precedence over the previous ATC clearance. When the route or altitude in a previously issued clearance is amended, the controller will restate applicable altitude restrictions. If the altitude to maintain is changed or restated, whether prior to departure or while airborne, and, previously issued altitude restrictions are omitted, those altitude restrictions are canceled, including SID/DP/STAR altitude restrictions.

9.8.5.4.1. An Example. ATC initially gives you the following clearance: “Track 32, cross Ollis intersection at or above 3,000; Gordonsville VOR at or above 12,000; maintain FL 200.” Shortly after departure, the controller changes the altitude to be maintained to FL240. If the controller wants you to continue to comply with the previously issued altitude restrictions, he will restate them like this: “Track 32, amend your altitude. Cross Ollis at or above three thousand; cross Gordonsville at or above one two thousand; maintain flight level two four zero.” If he wants you to climb unrestricted to FL 240 and disregard the previously issued altitude restrictions, he will issue the following clearance: “Track 32, climb and maintain flight level two four zero."

9.8.5.4.1.1. CAUTION: It is important to understand the different types of altitude restrictions that may be depicted on SIDs. Although you may be able to disregard ATC altitude restrictions after receiving an amended clearance, some altitude restrictions are depicted due to terrain and/or obstacles. Obviously, these types of restrictions can never be disregarded. If there is any question about your new clearance and/or the applicable altitude restrictions, query the controller.

9.8.5.5 Restrictions Not Depicted On the SID. If it is necessary for the controller to assign a crossing altitude that differs from the SID altitude, the controller should repeat the changed altitude for emphasis. If you are radar vectored or cleared off an assigned SID, you may consider the SID canceled unless the controller adds “Expect to resume SID.” If ATC reinstates the SID and wishes any restrictions associated with the SID to still apply, the controller will state: “Comply with restrictions.”

9.8.5.5.1. CAUTION: When pilots and controllers discuss changes to SIDs, the potential for miscommunication is high. If there is any question about your clearance, query the controller.

9.9. Specific ATC Departure Instructions. Specific ATC departure instructions include a heading to fly and an altitude. Although a heading in normally associated with radar vectors, there are some situations when ATC’s departure instructions do not meet the strict definition of a “radar vector.” For example, prior to departure, tower may issue you the following clearance, “Track 32, on departure, turn right heading 360, climb and maintain 5,000 feet.” In this case, technically, this instruction is not a “radar vector” because it is not “navigational guidance based on the use of radar.” Even so, if you are operating in a radar environment, you are expected to associate departure headings with radar vectors to your planned route of flight. Although not as common as the example above, there are situations when ATC may give you specific departure instructions even when radar is not available.

9.9.1. NOTE: ***Except in a DVA, you should fly the ODP prior to the radar vector***. You must carefully review all aspects of FLIP to determine the appropriate actions. This is mainly apparent at airports with a “Trouble T” that states something similar to this, “All Departures climb to 1600 prior to any turns.” However, if there is any doubt, query ATC.

9.9.2. The first thing you need to know about a radar departure is what the term, “radar contact" means. In plain English, it means the controller sees your aircraft's radar return on his scope and he has positively identified you. It's also important to understand what "radar contact" does not mean – it does not mean the controller now has responsibility for your terrain/obstacle clearance. Specifically, here's what the AIM says: "The term 'radar contact,' when used by the controller during departure, should not be interpreted as relieving pilots of their responsibility to maintain appropriate terrain and obstruction clearance." AIM goes on to say that "Terrain/obstruction clearance is not provided by ATC until the controller begins to provide navigational guidance in the form of radar vectors." Even this statement is a little misleading; ATC is never solely responsible for your terrain/obstruction clearance. A better way to describe this relationship would be to say, "ATC does not begin to share responsibility for terrain/obstacle clearance until the controller begins to provide navigational guidance."

9.9.2.1. NOTE: When told to "fly runway heading," the Pilot-Controller Glossary says, "When cleared to "fly or maintain runway heading," pilots are expected to fly or maintain the heading that corresponds with the extended centerline of the departure runway. Drift correction shall not be applied; e.g., Runway 4, actual magnetic heading of the runway centerline 044, fly 044". This becomes a concern in a strong crosswind, as other factors such as downwind engine loss and/or using little of the runway prior to liftoff can cause the aircraft to drift out of the TERPS assessed airspace.

9.9.3. Lack of Specific ATC Departure Instructions. It is equally important to understand what you must do when you do not have any specific ATC departure instructions. ***Unless cleared otherwise by ATC (via a SID or radar vector, for example), you must fly the ODP established for the runway you select***. If the airport meets diverse departure criteria, you may depart using a diverse departure.

9.9.4. Minimum Climb Gradients. When receiving specific ATC departure instructions, it is sometimes difficult to determine the minimum climb gradient. If there is no SID or IFR Departure Procedure published for the runway used, then 200 feet per nautical mile should be sufficient to provide obstacle clearance. ***If the runway used has a minimum climb gradient published (either by SID, IFR Departure Procedure, or by notification from ATC), then you are required to meet or exceed the published climb gradient even when executing a radar departure.***

9.9.4.1. When a diverse departure is not authorized, it indicates penetration of the 40:1 OCS and there should be a SID or IFR Departure Procedures published for that airport. However, this is not always the case in DoD FLIP. There are cases where a commercial or host nation procedure will contain a climb gradient not annotated in DoD FLIP. Consequently, where diverse departures are not authorized, absence of a SID or IFR Departure Procedures does NOT indicate a radar departure with a 200 ft per nm climb gradient is appropriate. Therefore, ***if there is no SID or IFR Departure Procedure AND diverse departures are NOT authorized, a MAJCOM TERPS review is required prior to departing that airport to determine if there is a required climb gradient.***

9.9.4.2. If there are different climb gradients published for a SID and DP that serve the same runway, then the departure ground tracks are different. Since pilots have no way of knowing in advance what radar vectors they will receive, ***aircrews must plan to meet or exceed the highest of the climb gradients published for that runway with all engines operating unless they can determine a lower climb gradient is permissible (i.e., MAJCOM TERPS Office).***

9.9.4.3. When departing using radar vectors, it is important to understand some limitations. These limitations drive the USAF to using the conservative guidance for radar vector climb gradients above.

9.9.4.3.1. ATC may assume responsibility for obstacle clearance by vectoring an aircraft prior to the minimum vectoring altitude (MVA) by using a Diverse Vector Area (DVA). The DVA has been assessed (i.e., TERPS) for departures that do not follow a specific ground track. ATC may also vector aircraft off a previously assigned SID or DP. ATC controllers may not issue vectors to an aircraft prior to reaching the MVA unless there is a DVA for that airport. When a DVA is developed, the standard climb gradient required is 200 ft per nm. ATC controllers in the US are required to issue the climb gradient for the DVA in the IFR clearance to the aircrew if it is greater than 200 ft/nm.

9.9.4.3.2. MVAs and DVAs are not published outside of local directives. Aircrews have no readily accessible method of ascertaining if there is a DVA for that airport or the required climb gradient. Simple issuance of radar vectors on departure does not imply the existence of a DVA.

9.9.4.3.3. Bottom line: When departing via radar vectors, an aircrew does not know until airborne what specific ground track they will end up following. Therefore, the crew does not know what the required climb gradient will be until after airborne. The intent of AFI 11-202 Volume 3 *General Flight Rules*, and this AFMAN is that aircrews will accomplish departure planning prior to takeoff, to include determination of required climb gradients. Therefore, when departing using specific ATC departure instructions, because aircrews do not know which ground track they will fly until after airborne, they must plan to meet the highest climb gradient unless they can positively determine (i.e., MAJCOM TERPS review) a lower climb gradient is permissible, as stated in paragraph 9.9.4.2.

9.9.5. How to Fly Specific ATC Departure Instructions.

9.9.5.1. Generally specific ATC departure instructions will be issued with your IFR clearance. They are not published procedures for you to file.

9.10. Diverse Departure.

9.10.1. Diverse Departure. If no obstacles penetrate the 40:1 OCS for a particular runway, then a minimum climb gradient of 200 feet per nautical mile will ensure proper obstacle clearance. In this case, a "diverse departure" will ensure obstacle clearance. A diverse departure means the pilot may execute a turn in any direction from the runway and remain clear of obstacles. ***To fly a diverse departure, track runway centerline until 400 feet above the departure end of the runway elevation before executing any turns. Maintain a minimum climb gradient of 200 feet per nautical mile until reaching a minimum IFR altitude.***

9.10.1.1. NOTE: There are airports around the world where the diverse departure assessment has not been properly completed. At these airports, a diverse departure may not be authorized for certain runways. You will be notified via NOTAM, or in the case of DoD/NACO FLIP books, by a statement in the front of the book under the section titled, "IFR Takeoff Minimums and (Obstacle) Departure Procedures." The statement will say, "Diverse Departure Not Authorized." Commercial or foreign government products may not follow this convention.

Figure 9.16. Diverse Departure Not Authorized.

OCEANA NAS (KNTU)
VIRGINIA BEACH, VA
Diverse Departure not Authorized.

Figure 9.17. Diverse Departure Authorized (Runway 10 Only).

HUNTER AAF (KSVN) AMDT 2 03191
SAVANNAH, GA
. . . . Rwy 28, 300-1*
* Or standard with minimum climb of 340/NM to 400.
Rwy 28, climbing left turn hdg 230° to 1700 before proceeding on course.

9.10.2. How to Fly a Diverse Departure.

9.10.2.1. "Will ATC Clear Me for a Diverse Departure?" ATC will not specifically "clear" you for a diverse departure. If you are "cleared as filed," there is no minimum published climb gradient or "Trouble T" for the departure runway, and ATC does not issue you further instructions (by providing radar vectors or assigning a SID), then ATC expects you to execute a diverse departure. See Figure 9.17 for an example of a runway where a diverse departure is authorized. If a diverse departure is not authorized for your runway, you must choose another departure method.

9.10.2.1.1. WARNING: By definition, diverse departures are only authorized when there are no penetrations of the 40:1 OCS and nothing is written for that runway in the front of the IAP book. Therefore, if there is a minimum climb gradient specified above 200 feet/nm for the departure runway, then a diverse departure is not authorized for that runway. Do not be confused by the "cleared as filed" terminology. If you are "cleared as filed" in a location with a climb gradient above 200 feet/nm (or other annotations in the front of the IAP book such as an ODP), and ATC does not issue you further instructions (by assigning a SID), then you are expected to fly the published ODP for the runway used then proceed to your first filed point. This is an ODP, not a diverse departure.

9.10.2.2. How Do I File a Diverse Departure? There is no special annotation for filing a diverse departure. Simply file your first point on the route of flight. When you are "cleared as filed" and ATC does not issue specific departure instructions (radar vectors or SID), then make a turn to your first filed point after reaching 400 feet above the departure end of the runway elevation.

9.11. Visual Climb Over Airport (VCOA).

9.11.1. VCOA is a method for pilots to depart the airport where aircraft performance does not meet the specified climb gradient. VCOAs are developed only when the obstacle(s) are more than 3 sm from the DER and require more than a 200 ft/nm climb gradient. ***USAF aircrews are authorized to depart IFR using a published VCOA.***

9.11.1.1. VCOAs will be annotated in the front of the IAP book with the other ODPs and will include the verbiage, "climb in visual conditions." A VCOA will specify an altitude to climb to and may specify a direction of flight and/or a routing.

9.11.1.2. The standard airspeed for development of a VCOA is 250 KIAS unless otherwise annotated on the procedure. Designed bank angle is 23°. 30° of bank is recommended when flying the VCOA.

9.11.1.3. The radius of the visual climb area evaluated for obstacles is called the visual climb area (VCA). Use Table 9.2 below to determine the radius of the VCA based on the "climb to" altitude specified in the procedure. For altitudes between those listed, use the next lower altitude. For example, if the "climb to" altitude is 4500, use the 2000' column.

9.11.1.3.1. All values used in calculating the visual climb area for VCOA are measured from the airport reference point (ARP), which is normally the geographic center of the airport.

Table 9.2. Radius of Visual Climb Area from Airport Reference Point.

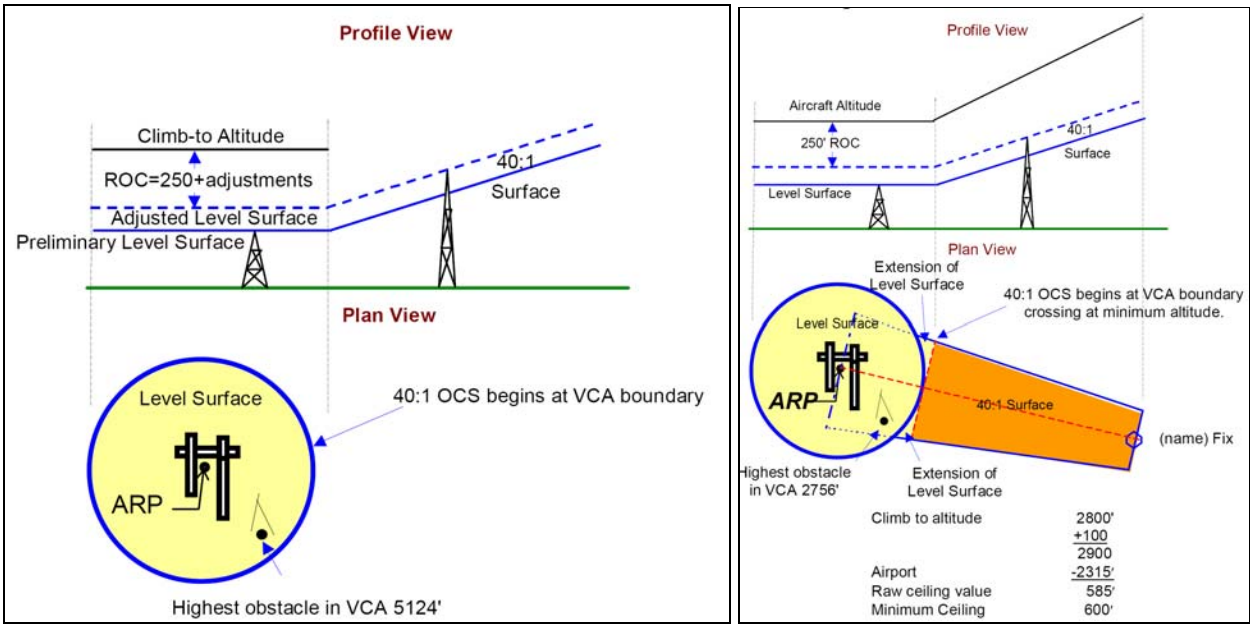
SPEED KIAS	2,000 FEET	5,000 FEET	10,000 FEET
90	2.0	2.0	2.0
120	2.0	2.0	2.0
180	2.0	2.0	2.5
210	2.1	2.5	3.2
250	2.8	3.4	4.2
310	4.2	4.9	6.0
350	5.2	6.0	7.3

9.11.1.3.1.1. NOTE: Speeds in Table 9.2 include 30-knot tailwinds up to 2000 MSL, 45-knot tailwinds up to 5000 MSL, and 60-knot tailwinds at 10,000 MSL.

9.11.2. The height of the VCA is determined by identifying the highest obstacle within the VCA. The TERPS specialist will then identify a 40:1 OCS from the edge of the VCA up to the IFR MEA. If this 40:1 surface is penetrated, the height of the VCA will be raised above that obstacle(s). The "climb to" altitude will be determined by adding a ROC to the highest obstacle and rounding up to the next 100-foot increment.

9.11.2.1. If there are numerous significant obstacles penetrating the 40:1 surface that would cause the VCA to be raised to an unacceptably high altitude, the TERPS specialist can also publish a minimum climb gradient in conjunction with the "climb to" altitude. This climb gradient only applies outside the VCA.

Figure 9.18. Determination of "Climb To" Altitude.



9.11.3. A VCOA will have weather minimums associated with it. These are the minimum requirements to execute the procedure. In the IAP, these minimums will be annotated as "takeoff minimums". Do not confuse these with non-standard takeoff weather discussed elsewhere in this chapter. VCOA weather minimums do apply to USAF aircrews. You can easily distinguish between the two, as a VCOA will always have the text "climb in visual conditions" associated with the weather minimum. ***In order to execute a VCOA, the weather must be at or above the published takeoff minimums for the procedure.*** These weather minimums apply only to the VCOA and not to other procedures at the airport.

9.11.3.1. The ceiling minimum associated with a VCOA will be the 100-foot increment above the "climb to" altitude. Visibility minimums are determined based on aircraft speed and the height of the "climb to" altitude.

9.11.4. Obstacles inside the VCA must be avoided visually. Remember the TERPS specialist does not look for obstacles below the 40:1 OCS. Obstacles outside the VCA will be avoided by maintaining a 200 ft/nm rate of climb from the edge of the VCA to the IFR MEA or by following the published routing at 200 ft/nm and/or higher published climb gradient to the IFR MEA.

9.11.5. VCOAs are typically published in locations where airspace and ATC considerations will allow a spiraling departure over the airport. Some locations may have other departures in addition to the VCOA and/or other ATC and airspace considerations that may limit the practical use of the VCOA.

9.11.6. How to File a VCOA. VCOAs do not have names or coded identifiers to file. There is no special annotation for filing a VCOA. Simply file your first point on the route of flight. A technique is to put a statement in the remarks section of your flight plan that you intend to depart via the VCOA.

9.11.7. How to Fly a VCOA. When you are "cleared as filed", fly the VCOA as published unless there are other procedures (i.e., SID and/or ODP) for that runway. If there are other procedures for that runway, query the controller to clarify which procedure is expected.

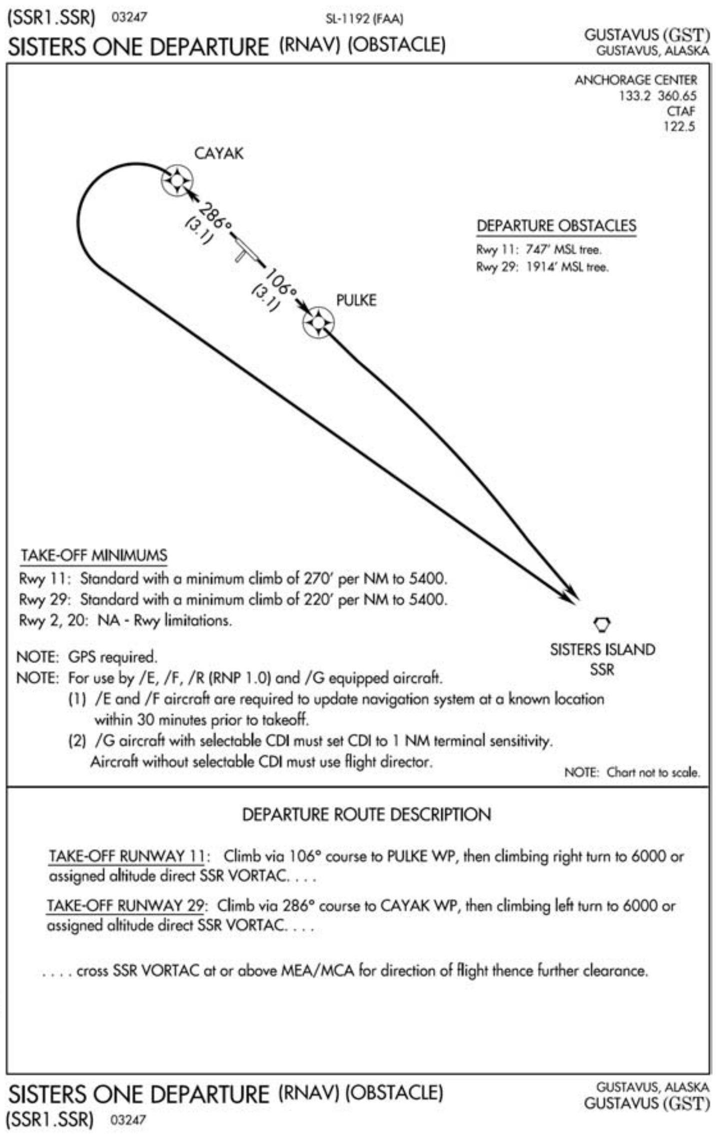
Figure 9.19. VCOA Example.

GUSTAVUS, AK

GUSTAVUS

TAKE-OFF MINIMUMS: **Rwy 2,** 1500-2½ for climb in visual conditions. **Rwy 11,** std. with a min. climb of 260' per NM to 1200 or 1500-2½ for climb in visual conditions. **Rwy 20,** std. with a min. climb of 290' per NM to 1400 or 1500-2½ for climb in visual conditions.

DEPARTURE PROCEDURE: **Rwy 2,** climb in visual conditions to cross departure end of Runway 11 eastbound at or above 1500, then climb to 5500 via SSR VORTAC R-288 (287° bearing from EEF NDB) to SSR VORTAC/EEF NDB. **Rwy 11,** climb via SSR VORTAC R-288 to SSR VORTAC, or via 287° bearing from EEF NDB to EEF NDB, or climb in visual conditions to cross departure end of Runway 11 eastbound at or above 1500, then climb to 5500 via SSR VORTAC R-288 (287° bearing from EEF NDB) to SSR VORTAC/EEF NDB. **Rwy 20,** left turn via 155° heading and SSR VORTAC R-280 (282° bearing from EEF NDB) inbound to SSR VORTAC/EEF NDB, or climb in visual conditions to cross departure end of Runway 11 eastbound at or above 1500, then climb to 5500 via SSR VORTAC R-288 (287° bearing from EEF NDB) to SSR VORTAC/EEF NDB. **Rwy 29,** left turn via 195° heading and SSR VORTAC R-280 (282° bearing from EEF NDB) inbound to SSR VORTAC/EEF NDB. **All aircraft** maintain 5500.



9.11.8. Example of VCOA.

9.11.8.1. Gustavus AK is an example of a VCOA at an airport that also has an ODP. A brief review of the ODP shows the required climb gradients are 220 or 270 ft/nm and require RNAV equipment that meets the specified standards. The VCOA provides a viable alternative for aircraft that cannot meet the climb gradient and/or are not suitably equipped to fly the Sisters One Departure.

9.11.8.2. The VCOA for Gustavus has two sections. The first part details the takeoff minimums and the second details the routing and required climb altitudes.

9.11.8.2.1. Takeoff Minimums. The takeoff minimums do apply to USAF aircrews where they state "climb in visual conditions." For runway 2, you must have weather equal or greater than 1500-2½ to use the VCOA. On runway 11 and 20 you can either do the VCOA with weather equal or greater than 1500-2½; or have a climb gradient of 260 or 290 ft/nm to the altitude specified; and comply with your MAJCOM takeoff minimums if they are more restrictive. Runway 29 does not include any weather minimums, but does have a procedure listed in this section; therefore, use your MAJCOM takeoff minimums for runway 29.

9.11.8.2.2. Departure Procedure. Follow the procedure specified for the runway of departure. For example, for runway 2 the procedures states, "…cross departure end of runway 11 eastbound at or above 1500, then climb via…" After departure on runway 2, execute a climbing turn over the airport to cross the departure end of runway 11 eastbound at or above 1500 feet. Multiple spiraling turns are authorized as long as you remain within the VCA. Because no airspeed is annotated on the procedure, fly a maximum of 250 KIAS using a minimum of 23°. 30° of bank is recommended.

9.12. Special MAJCOM Certification (SMC) (authorized airports, aircrews and aircraft only).

9.12.1. MAJCOMS may elect to develop procedures at specific airports that will allow aircrews to depart using non-standard weather minimums when no other options for IFR departures are possible. These are procedures developed by MAJCOMS in conjunction with MAJCOM TERPS. These procedures are airport, aircraft and aircrew specific; require specific authorization by MAJCOM; and require specialized training.

9.12.1.1. These procedures will only be developed at airports that have only non-standard weather minimums and cannot be used in lieu of meeting a published climb gradient. For example, in Figure 9.20 below, a MAJCOM can elect to develop a procedure at Orangeburg SC, but may not develop one at Ft. Bragg, since there is a climb gradient available.

Figure 9.20. Special MAJCOM Certification (SMC).

ORANGEBURG, SC
ORANGEBURG MUNI
TAKE-OFF MINIMUMS: **Rwys 5, 31,** 500-1.

SIMMONS AAF (KFBG)
FORT BRAGG, NC
. . . . .Rwy 27, 900-1*
* Standard with minimum climb of 250/NM to 1000.

9.13. VFR Departures.

9.13.1. If there are no other IFR departure options, crews may depart VFR as a last resort. This discussion does not apply to training or operational missions where all or most of the mission is planned as a VFR flight. See AFMAN 11-217 Volume 2, *VFR Flight Procedures*, for a discussion of VFR departures where all or most of the mission is planned as a VFR flight. The following discussion is intended for those cases where the flight is planned and authorized for IFR but there is either no authorized IFR departure method for that airport or the aircraft cannot comply with any authorized IFR departure method(s) for any reason (ex. aircraft equipment). Departing VFR and later obtaining an IFR clearance can present serious hazards and inconvenience if not accomplished with a thorough knowledge of obstacles, airspace, and air traffic control in the area.

9.13.1.1. When departing VFR, an ATC clearance is not required unless departing from an airport within Class B airspace. Comply with communication, transponder, and other requirements detailed in AFMAN 11-217 Volume 2, *VFR Flight Procedures*.

9.13.1.1.1. It can be difficult or impossible to obtain an IFR clearance after airborne if the controller's workload is high (especially when in Class B or C airspace). Insure you are thoroughly familiar with the air traffic control and airspace environment prior to departing VFR, or you could be forced to maintain VFR for an extended distance along your planned routing.

9.13.1.2. When departing VFR, you are solely responsible for terrain, obstacle, traffic, and wake turbulence avoidance.

9.13.1.2.1. If you subsequently receive your IFR clearance but are below the IFR MEA for your area, you are responsible for terrain and obstruction clearance until reaching the MEA, even though you are now on an IFR clearance.

9.13.1.2.2. Although a VFR departure relieves you of the responsibility to maintain IFR minimum climb gradients IAW AFI 11-202 Volume 3, *General Flight Rules*, you must still conduct a thorough study of terrain and obstacles. Do not discount the IFR climb gradients and obstacle information when departing VFR, as these are providing valuable information about obstacles that will affect your departure regardless of what type of flight plan you use for departure.

9.13.1.3. A viable option when electing to depart VFR is to depart on an IFR clearance and climb VFR to the IFR MEA. When doing this procedure you are on an IFR clearance and may even be assigned the same routing as an IFR departure, but you are solely responsible for terrain, obstruction, traffic, and wake turbulence avoidance until reaching a specified altitude. When climbing VFR to the specified altitude, you must also maintain VFR cloud clearances and have basic VFR weather minimums for takeoff IAW AFI 11-202 Volume 3, *General Flight Rules*.

9.13.1.3.1. To file for a VFR climb to the IFR altitude, consult FLIP GP for the most current guidance. In general, this procedure simply requires a remark on the flight plan stating that you request a VFR climb.

9.13.1.4. ***When departing VFR, you must maintain VFR cloud clearances until obtaining an IFR clearance or reaching the IFR MEA***.

9.14. RNAV Departure Procedures. RNAV Departure Procedures take advantage of the ability of RNAV systems to fly accurate and repeatable ground tracks.

9.14.1. Levels of service. There are two different types of RNAV Departure Procedures under development – level 1 and level 2. Level 1 Departure Procedures are based on RNP 1.0 criteria. Level 2 RNAV Departure Procedures are based on RNP 2.0 criteria. Specific equipage requirements will be listed on the RNAV DP.

9.14.1.1. Leg types. RNAV Departure Procedures contain three different leg types, Direct to Fix (DF), Heading to Altitude (VA), and Track to Fix (TF).

9.14.1.2. Waypoint types. RNAV DPs may contain both Flyover and Flyby waypoints.

9.14.1.2.1. A fly-by waypoint is used when an aircraft should begin a turn to the next course prior to reaching the waypoint separating the two route segments.

9.14.1.2.2. Fly-over waypoints are used when the aircraft must fly over the point prior to starting a turn. Fly-over waypoints are normally depicted as a circled waypoint symbol.

9.14.1.3. Flying RNAV Departure Procedures. In order to fly RNAV DPs, the following conditions must be met:

9.14.1.3.1. ***Aircraft equipment must meet requirements specified on the DP.***

9.14.1.3.2. ***Aircraft RNAV system must meet appropriate certification standards as addressed in AFI 11-202 Volume 3 General Flight Rules.***

9.14.1.3.3. ***Procedure must be retrieved in its entirety from a current, approved navigation database. Waypoint and waypoint type (e.g., flyby, flyover) may not be modified.***

9.14.1.3.4. ***Pilots must double check all waypoint names, waypoint type (flyby vs. flyover), altitude, and airspeed information from the database against information listed on the paper copy of the terminal procedure. Should differences between the approach chart and database arise, the published approach chart, supplemented by NOTAMs, holds precedence. Users may not alter terminal procedures retrieved from the equipment database.***

9.14.1.3.5. ***If GPS is used, RAIM must be available to execute the procedure. Terminal (or better) RAIM must be available.***

9.14.1.3.6. ***CDI sensitivity must be set at terminal (+/-1nm) or confirmed the receiver has automatically set it.*** For FMS equipped aircraft without the capability of manually setting the CDI the departure must be flown with a flight director.

9.14.1.3.7. ***System must either provide RAIM alerts based on terminal criteria, or pilot must be able to monitor navigation performance (Actual Navigation Performance).***

9.14.1.3.7.1. NOTE: Terminal RAIM for departure may not be available unless the waypoints are part of the active flight plan.

9.14.1.3.7.2. NOTE: Actual Navigation Performance (ANP) is a technical term that describes the navigation accuracy of the system. Other terms synonymous with ANP are Figure of Merit, Estimation of Position Uncertainty, or Quality Factor.

9.14.1.3.8. ***Underlying NAVAIDS must be monitored if available.***

9.14.1.3.9. There are conventional DPs (RNAV and/or GPS does not appear in title of procedure) published in FLIP that are retrievable from selected aircraft navigation databases. ***USAF aircrews are authorized to fly these procedures as an "overlay" in IMC provided it is retrieved from the database and underlying NAVAIDS are installed, operational, tuned, and monitored.***

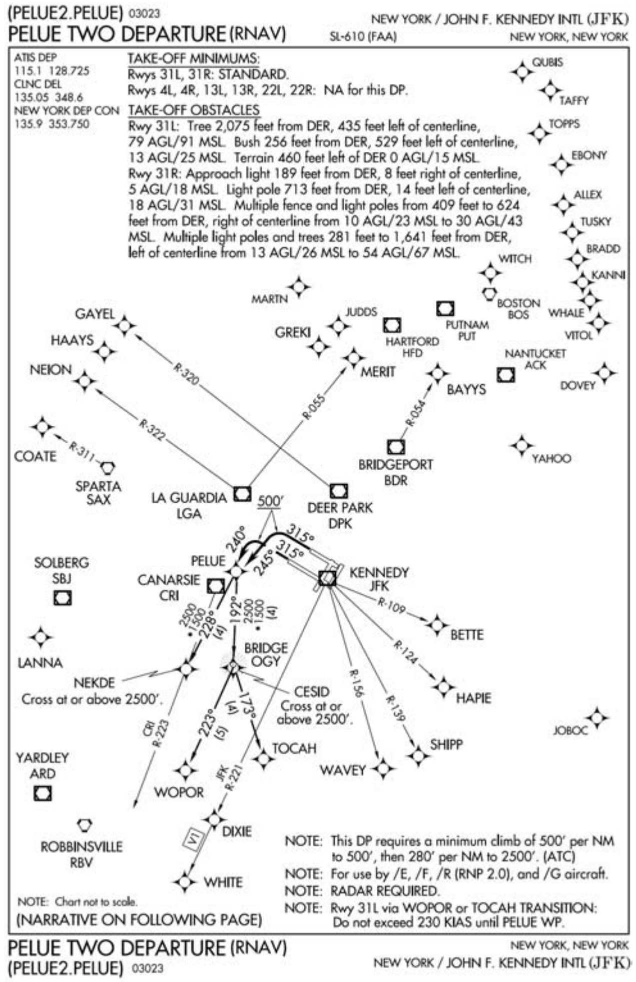
9.14.1.3.9.1. Aircrews must verify the information in the database with the published DP. The maximum allowable difference between the database course(s) and published course(s) is ±5°.

9.14.1.3.9.2. In some cases, because of the software programming, there can be tracking inaccuracies when flying non-RNAV/FMS DPs using an FMS. These tracking inaccuracies have resulted in less-than-required air traffic control separation and air traffic control intervention to prevent a possible Controlled Flight Into Terrain (CFIT) accident. Non-RNAV/FMS procedures often require navigational tracking over all the specified fixes. Many FMS databases code the points in these procedures as Fly-by waypoints, instead of Fly-over waypoints. Unlike an RNAV DP, which will specify on the printed FLIP which waypoints are Fly-by and which are Fly-over, a conventional DP will not make this distinction. Consequently, the FMS will lead the turn on these points. This turn anticipation could result in a turn being started miles prior to the expected turn point depending on the amount of required track change, wind, and true airspeed. When verifying waypoints prior to flying a non-RNAV/FMS DP using an FMS, aircrews must determine how the points are coded (Fly-by vs. Fly-over) in their database. If there are large course changes coded as Fly-by waypoints, the aircrew must be prepared to manually intervene to ensure the aircraft tracks the procedure as published to remain within protected airspace. This is permissible, as this is not altering the waypoints retrieved from the database; it is insuring the navigation system properly executes the procedure.

9.14.1.4. Certain segments of a DP may require some manual intervention by the pilot, especially when radar vectored to a course or required to intercept a specific course to a waypoint. This is permissible, as this is not altering the waypoints retrieved from the database; it is insuring the navigation system properly executes the procedure. The database also may not contain all of the transitions or departures from all runways and some GPS receivers do not contain DPs in the database.

9.14.1.4.1. Helicopter-only GPS departure procedures are to be flown at 70 knots or less since turning areas and segment lengths are based on this speed.

Figure 9.21. RNAV DP.



9.15. Engine-Out Performance Requirements for IFR Departures.

9.15.1. USAF aircrews flying multi-engine aircraft are required to ensure terrain and obstacle clearance in the event of engine failure on takeoff. ***Plan one-engine inoperative climb performance on departure IAW AFI 11-202 Volume 3, General Flight Rules and MAJCOM directives.*** The following information is provided to assist aircrews in safely complying with engine-out performance planning requirements.

9.15.2. Engine Inoperative Performance Considerations. There are several considerations for computing obstacle clearance to comply with AFI 11-202 Volume 3 *General Flight Rules* requirements. Some are difficult to quantify in actual operational practice. Normal IFR departure procedures add a safety factor in the form of the ROC to ensure obstacle clearance when conditions are less than ideal. Any reduction in ROC for engine-out performance computations will reduce that safety margin should an aircrew experience an engine loss or loss of thrust on takeoff or departure.

9.15.2.1. Turning Performance. With one engine inoperative, turning performance must be accounted for in computing aircraft capability to clear obstacles. Special

Departure Procedures (SDP) take turning performance into account.

9.15.2.2. Meteorological Conditions. Rapidly changing meteorological conditions (updrafts, downdrafts, tailwinds, headwinds, temperature changes, etc.) are not accounted for in engine inoperative performance calculations. Although aircrews receive weather updates prior to and during departure, there could be significant differences between actual conditions at the aircraft location, depending on the aircraft proximity to the location of the weather observation. These differences as well as rapid changes cannot always be predicted or compensated for in a timely manner. Aircrews should be cognizant of this in departure planning, especially where obstacle clearance is marginal.

9.15.3. The following methods are authorized for computing engine-out climb performance on departure. Methods may not be combined. These are in priority order.

9.15.3.1. Meet or exceed the published climb gradient, or 200 ft/nm (whichever is higher) for the selected departure, with one-engine inoperative, or;

9.15.3.2. Special Departure Procedure (SDP) (if available), or;

9.15.3.3. Vertically clear all obstacles along the planned departure path with one engine inoperative, or;

9.15.3.4. Use "Limiting Takeoff Runway Available (TORA) to Reduce Climb Gradient" procedure in TERPS (MAJCOM TERPS only), or;

9.15.3.5. Depart VFR or climb in VFR to an IFR MEA IAW AFI 11-202 Volume 3, *General Flight Rules*, and paragraph 9.13 (not applicable to planned VFR training or operational flights where the majority of the flight is to be conducted under VFR).

9.15.4. Published Climb Gradient. The safest and simplest method to ensure obstruction clearance in the event of engine loss is to plan to meet or exceed the published climb gradient or 200 ft/nm (whichever is higher) with one engine inoperative. This method ensures obstacle clearance provided the published procedures are flown.

9.15.5. Special Departure Procedures (SDP). SDPs are published procedures that provide escape routing from normal ATC departure routing in the event of an engine loss or similar performance degradation. SDPs are commercially produced under a contract with the USAF and are available on the internet. Web site address, user name, and password information are supplied to aircrews that have completed appropriate training in the use of SDPs.

9.15.5.1. SDPs are developed using extensive terrain and obstacle databases from conventional sources as well as those not normally available to aircrews. With one engine inoperative, an SDP will provide between 0-60 feet of clearance over obstacle(s) depending on MDS flight manual performance data.

9.15.5.1.1. For military derivative aircraft, obstacle clearance provided with one engine inoperative will normally be 0 feet.

9.15.5.1.2. For civil derivative aircraft, obstacle clearance provided with one engine inoperative will be between 0-60 feet depending on MDS.

9.15.5.2. SDPs do not provide standard ATC departure routing; they are for emergencies that arise after the aircraft is committed to takeoff or already airborne on their normal cleared departure. ***Do not file or plan to fly an SDP as your normal all engines operating IFR departure routing***.

9.15.5.2.1. SDP routings may differ significantly from normal ATC IFR departure routings due to terrain or other obstacles. Whereas SIDs and ODPs may include routing optimized for ATC as well as obstacles, SDPs are optimized for emergency escape routing that will provide the lowest required climb gradient and do not take airspace or ATC considerations into account. Therefore, SDP routing can diverge significantly from normal IFR departure routing. ATC may not even know of SDP existence and query the aircrew on their routing after loss of an engine if they immediately turn in the direction of their SDP.

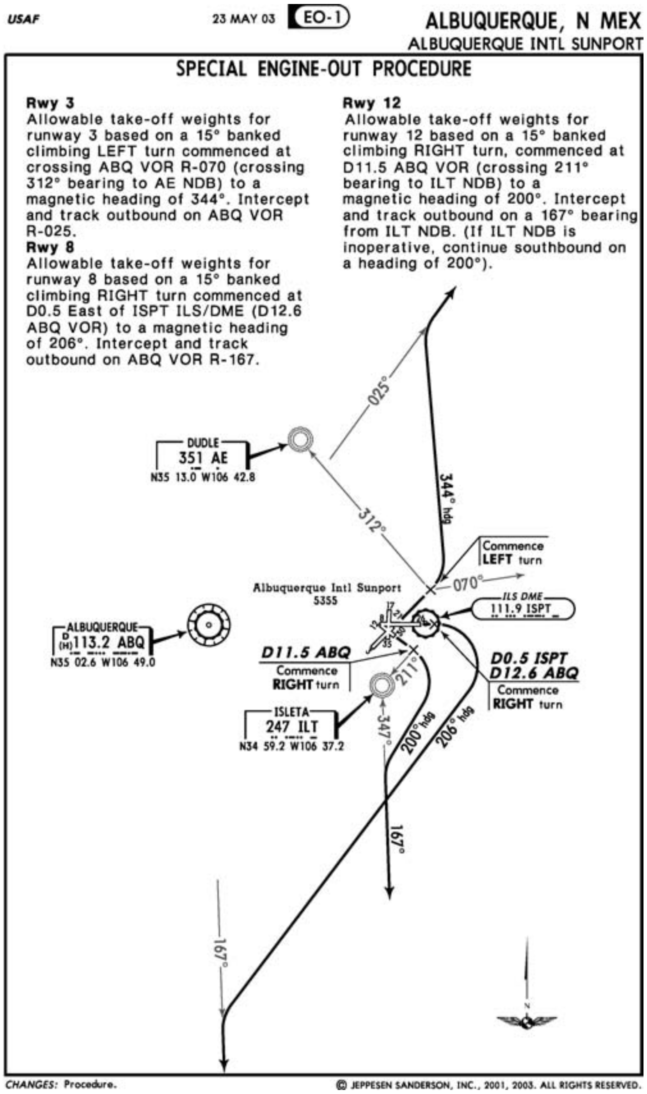
9.15.5.2.1.1. SDP routings will not avoid special use airspace.

9.15.5.2.1.2. The first consideration in development of an SDP is for a straight out escape routing. If this does not provide the optimum climb gradient due to terrain and/or obstacles, then a turning departure will be developed. SDPs that incorporate turning departures will account for performance degradation in the turns IAW the aircraft flight manual. If the aircraft flight manual does not provide turning performance information, an appropriate aerodynamically calculated degradation factor will be developed and applied.

9.15.5.2.1.3. In addition to meeting the requirements of the SDP with one engine inoperative, you must also meet the published climb gradient for the normal IFR departure with all engines operating. There are rare cases when the all engines operating normal IFR departure will be your limiting factor for departure planning due to divergence or other factors.

9.15.5.2.1.4. When an aircrew plans to use an SDP as their escape maneuver in the event of engine loss or loss of thrust, thorough planning of the transition from the normal departure routing to the SDP is critical. In about 10% of cases, the SDP routing is divergent from the normal IFR departure routing. In the case of a divergent SDP, crews must carefully consider the terrain and obstacles between the normal IFR departure routing and the SDP routing to determine the best course of action in the event of an engine failure after liftoff. SDP routings and performance data are predicated on losing an engine at the most critical time, which is at go-no go speed (V1, S1, Go, etc.). Therefore, if you lose an engine after liftoff, you may have sufficient engine-out performance to remain on the normal IFR routing. Crews must be cognizant of the point at which it is better to remain on the normal IFR routing, rather than transition to the divergent SDP. SDPs do not provide for obstacle clearance between the normal IFR routing and the SDP in divergent situations. ***Escape and transition procedures are a key crew coordination item and must be briefed and understood by all crewmembers prior to departure***.

Figure 9.22. Special Departure Procedure.



--KABQ-- FLAPS 15 --ABQ--
ELEV. 5355 FT ALBUQUERQUE INT'L
MAX TEMP 43C C-32 ALBUQUERQUE,NEW MEX.
PW-2040 ENG TAKE OFF PERFORMANCE VAR 11 E
A/C PACKS ON

ANALYSIS COMPLIES WITH STC ST01053WI-D

RUNWAY NO		03	08	08	12	17	17		
TAXIWAY				D			C2		
		TURN	TURN	TURN	TURN				
C	CLIMB LMT							EPR LMT	F
-10	238.5	257.4*	234.7	228.5	201.7	258.6*	245.4*	1.55	14
-5	238.6	255.4*	234.4	228.2	199.9	256.5*	243.5*	1.55	23
0	238.6	253.6*	234.2	228.0	198.4	254.7*	241.7*	1.55	32
5	238.6	251.8*	234.0	227.7	196.9	252.9*	240.0*	1.55	41
10	238.7	250.0*	233.9	227.5	195.5	251.1*	238.3	1.55	50
12	238.7	249.3*	233.8	227.4	194.9	250.4*	237.6	1.55	54
14	238.7	248.6*	233.7	227.3	194.3	249.7*	236.9	1.55	57
16	238.7	247.9*	233.6	227.2	193.8	249.0*	236.2	1.55	61
18	238.7	247.1*	233.6	227.1	193.2	248.3*	235.5	1.55	64
20	238.7	245.9*	233.4	226.8	192.2	247.0*	234.4	1.55	68
21	236.4	244.7*	231.4	224.9	191.2	245.8*	233.2	1.54	70
22	234.1	243.0*	229.2	222.8	189.9	244.1*	231.6	1.54	72
23	231.8	241.3*	227.1	220.7	188.5	242.4*	229.9	1.53	73
24	229.4	239.6*	225.0	218.6	187.2	240.7*	228.3	1.52	75
25	227.1	237.9*	222.8	216.6	185.8	239.0*	226.7	1.51	77
26	224.8	236.2*	220.6	214.5	184.5	237.3*	225.1*	1.51	79
27	222.5	234.5*	218.3	212.5	183.1	235.6*	223.4*	1.50	81
28	220.1	232.8*	216.2	210.3	181.7	233.9*	221.8*	1.49	82
29	217.8	231.1*	214.1	208.2	180.4	232.2*	220.2*	1.48	84
30	215.5	229.4*	211.9	206.2	179.0	230.5*	218.5*	1.48	86
31	213.2	227.7*	209.7	204.1	177.7	228.8*	216.9*	1.47	88
32	210.9	226.0*	207.5	202.1	176.3	227.1*	215.3*	1.46	90
33	208.5	224.3*	205.4	199.9	175.0	225.4*	213.6*	1.45	91
34	206.0	222.6*	203.2	197.8	173.6	223.6*	211.9*	1.44	93
35	203.5	220.8*	201.0	195.7	172.2	221.8*	210.2*	1.44	95
36	200.9	219.0*	198.8	193.6	170.7	220.0*	208.5*	1.43	97
37	198.3	217.2*	196.5	191.3	169.3	218.2*	206.8*	1.42	99
38	195.7	215.4*	194.1	188.9	167.9	216.4*	205.0*	1.41	100
39	193.1	213.4*	191.6	186.5	166.3	214.4*	203.1*	1.40	102
40	190.5	211.4*	189.0	184.1	164.7	212.4*	201.2*	1.40	104
41	187.9	209.4*	186.5	181.7	163.1	210.4*	199.3*	1.39	106
42	185.3	207.5*	184.0	179.2	161.6	208.4*	197.4*	1.38	108
43	182.7	205.5*	181.4	176.7	160.0	206.5*	195.5*	1.37	109

RUNWAY LENGTH	10000	13793	10325	6000	10000	8860
RUNWAY SLOPE	0.1	0.3	0.3	0.0	-0.1	-0.1
ADD LBS/KT HW	0	75	160	370	0	405
SUB LBS/KT TW	1800	795	865	1880	1805	1780
LEVEL OFF HT	900	990	1000	1000	900	900
LIMITED BY	RNWY	OBST	OBST	RNWY	RNWY	RNWY

APPLY PERFORMANCE CORRECTION AS REQUIRED
*** OBSERVE STRUCTURAL LIMITS ***

*** SEE SPECIAL PROCEDURE FOR THIS AIRPORT ***
ISSUED: 27 SEP '02

9.15.6. Vertically clear all obstacles along the planned departure path with one engine inoperative. If you are unable to comply with either alternative above, subtraction of 48 ft/nm (or 0.8%) from the published climb gradient is permissible for one-engine inoperative performance planning if your MAJCOM allows it. ***Aircrews will not subtract 24% from the published climb gradient under any circumstances.***

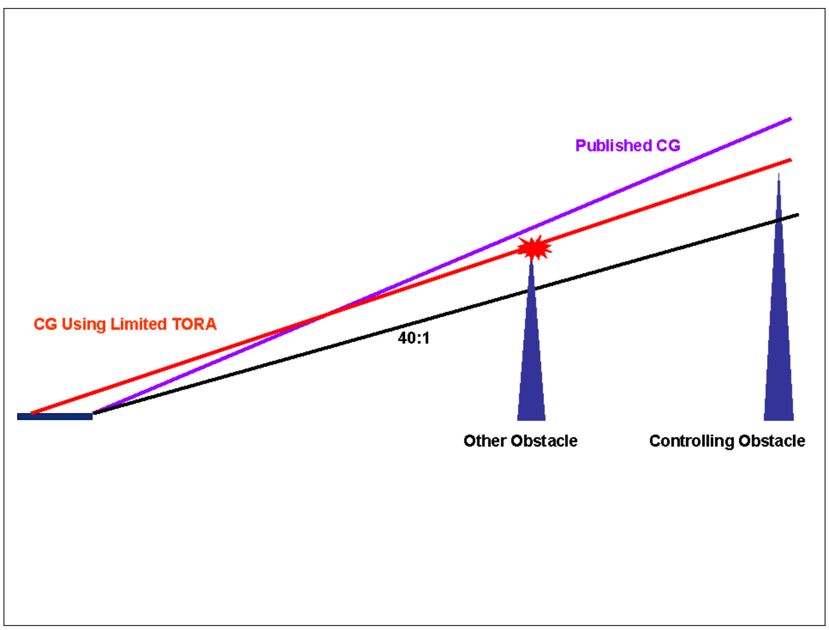
9.15.6.1. WARNING: When using this method, it is important to understand that you are removing all your safety margins that account for less than ideal conditions. ***Aircrews shall use the published climb gradient as the basis for all computations and will not use the prominent obstacles published on selected procedures to recompute their own climb gradient***.

9.15.7. "Limiting Takeoff Runway Available (TORA) to Reduce Climb Gradient" Procedure in TERPS (MAJCOM TERPS only). When computing required climb gradients, the TERPS specialist uses the end of the runway as a reference point. TERPS allows the use of a reduction in TORA to recompute required climb gradients. ***USAF crews are allowed to use procedures developed using a limiting TORA provided they were developed by their MAJCOM TERPS specialist(s) or are published in FLIP.***

9.15.7.1.1. WARNING: When using a reduced TORA to compute required climb gradient, the aircrew must realize the controlling obstacle may change. Since the use of a reduced TORA allows aircrews to use a lower climb gradient for departure, this may expose obstacles that were not a factor with the higher climb gradient. This is why crews may not construct this procedure on their own. ***USAF aircrews shall always use the DER as the reference point for obstacle clearance computations except when using a procedure specifically developed IAW 9.15.7.***

9.15.7.1.2. WARNING: When using procedures developed under 9.15.7, the runway available is effectively limited to the TORA used to construct the procedure. It is imperative the aircraft liftoff at or prior to the TORA used to develop the procedure or you will be below the OCS.

Figure 9.23. Limiting TORA and Obstacles.



9.15.8. VFR Departure or VFR Climb to IFR MEA.

9.15.8.1. When departing VFR, the aircrew is solely responsible for terrain, obstacle, traffic, and wake turbulence avoidance. Although a VFR departure relieves the aircrew of the responsibility to maintain IFR minimum climb gradients IAW AFI 11-202 Volume 3, *General Flight Rules*, crewmembers must still conduct a thorough study of terrain and obstacles. Do not discount the IFR climb gradients and obstacle information when departing VFR, as these are providing valuable information about obstacles that will affect the departure regardless of what type of flight plan is used for departure. When planning for engine-out requirements, close attention is required. For example, if the aircraft flight manual specifies limitations on bank angle following an engine loss or loss of thrust this could increase turn radius to the point that terrain clearance in a valley is no longer possible. In some cases planning a VFR departure or VFR climb to IFR MEA is a more complex endeavor than reducing the gross weight of the aircraft to ensure IFR climb gradient criteria can be met with one engine inoperative.

9.16. Examples. The following examples will illustrate various IFR departure scenarios. These examples apply when all engines are operating. For one-engine inoperative procedures, refer to One Engine Inoperative Decision Tree in this Chapter, AFI 11-202 Volume 3 *General Flight Rules*, flight manual and MAJCOM guidance. These examples are assessed assuming these airports are not SMC airports. For each airport, the following questions will be answered:

9.16.1. Is an IFR departure authorized for USAF aircrews?

9.16.2. What IFR departure procedures are authorized for USAF aircrews?

9.16.3. How should aircrews file the departure(s)?

9.16.4. What can the aircrew expect as an ATC clearance?

9.16.5. What is the required climb gradient with all engines operating?

9.16.6. How should the aircrew fly the departure procedure?

9.16.6.1. Example 1: Reno/Tahoe International (KRNO)

Figure 9.24. Departure Example #1: Reno/Tahoe International (KRNO).

RENO, NV

RENO/TAHOE INTL (KRNO) Amdt. 3 02360

Rwy 7: NA

Rwy 16R: CAT A/B: Standard with a minimum climb of 410/NM to 9200. CAT C/D: Standard with a minimum climb of 460/NM to 9200. Rwy 16L: Standard with a minimum climb of 740/NM to 8000.

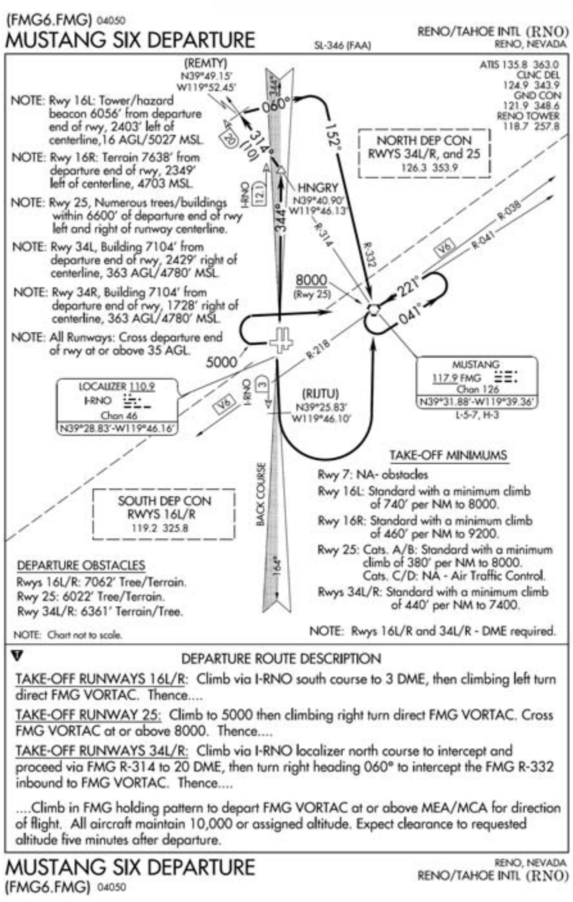
RWY 25: CAT A/B: Standard with a minimum climb of 380/NM to 8000. CAT C/D: Standard with minimum climb of 610/NM to 9800.

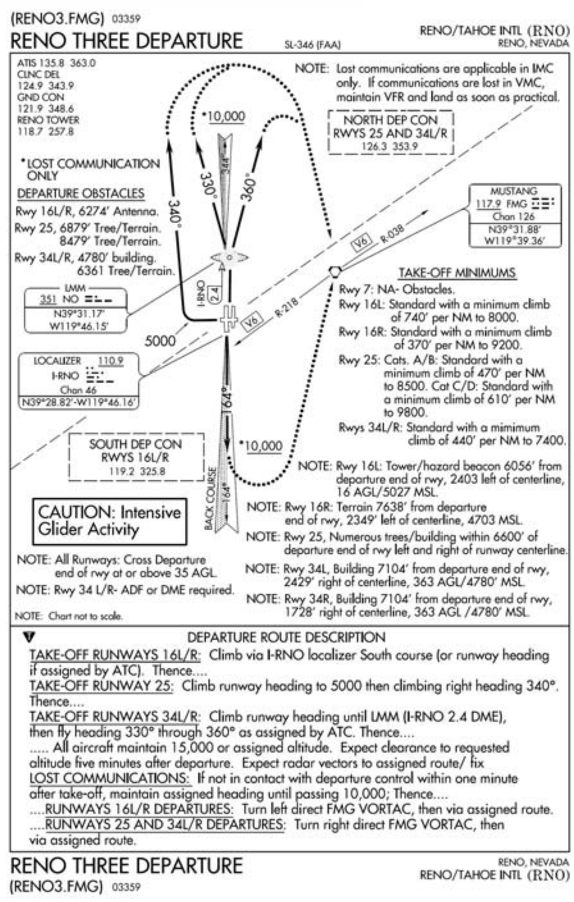
RWY 34L/R: Standard with a minimum climb of 440/NM to 7400.

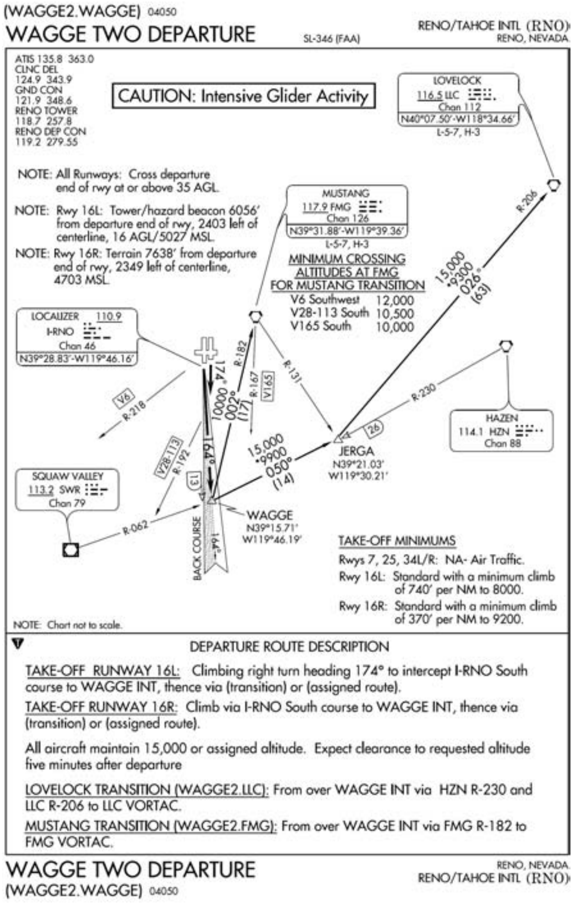
Rwy 16R: climb via I-RNO South course or runway heading to 6600 then climbing left turn direct FMG Vortac. Rwy 16L: climb runway heading to 6600 then climbing left turn direct FMG Vortac. Rwy 25: climb runway heading to 5000 then climbing right turn direct FMG Vortac. Rwy 34L/R: climb via I-RNO North course or Runway heading to 7500 then climbing right turn direct FMG VORTAC. All aircraft, climb in FMG Vortac holding pattern (hold NE, LT, 221 inbound) to depart FMG Vortac at or above MEA/MCA for direction of flight.

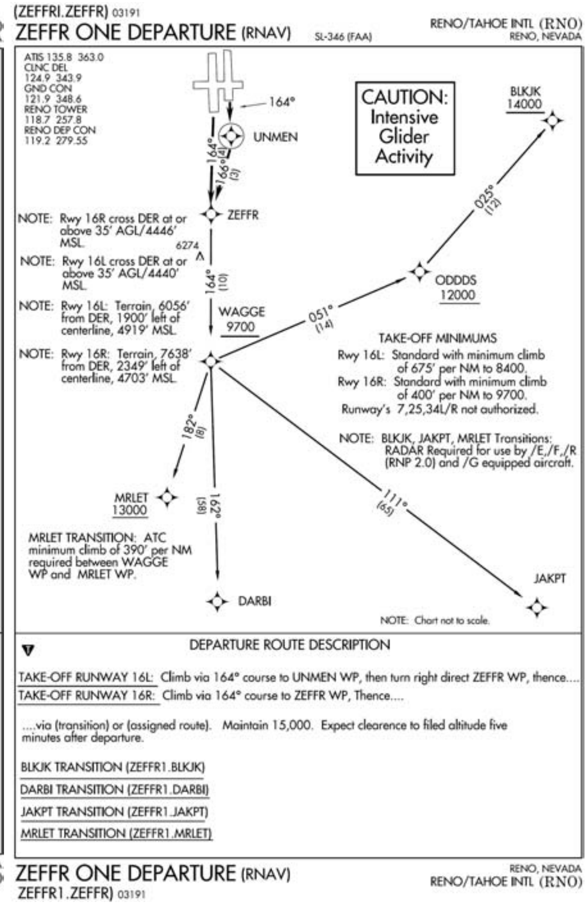
All runways: cross DER at or above 35 AGL.

TAKE-OFF OBSTACLES: Rwy 16R, terrain 7638 FT from DER 2348 FT left of centerline 4703 MSL. Rwy 16L, tower 6056 FT from DER 2403 FT left of centerline 16 AGL 5027 MSL. Rwy 25, numerous trees/buildings within 6600 FT of DER left and right of Rwy centerline. Rwy 34L, building 7104 FT from DER 2429 FT right of centerline 363 AGL/4780 MSL. Rwy 34R, building 7104 FT from DER 1728 FT right of centerline 363 AGL/4780 MSL.









9.16.6.1.1. Question: Is an IFR departure authorized for USAF aircrews?

9.16.6.1.2. Answer: Yes.

9.16.6.1.2.1.1. Reno/Tahoe is located in mountainous terrain and has the added hazard of high field elevation (4412) compounding the performance problem. However, an IFR departure is authorized for USAF aircrews, provided all climb gradients are complied with appropriate to aircraft approach category.

9.16.6.1.3. Question: What IFR departure procedures are authorized for USAF aircrews?

9.16.6.1.4. Answer: It depends on which runway and aircraft category.

9.16.6.1.4.1. Required climb gradients are published by aircraft category for runways 16R and 25 for categories A-D only. There is no published climb gradient for these runways for a category E aircraft or any other indication that these departures have been evaluated for category E aircraft. Therefore, a category E aircraft can depart using the Category D climb gradients provided airspeed does not exceed category D. If unable to remain below this airspeed, even though it is not published as "NA," an IFR departure is not authorized from these runways for a category E aircraft.

9.16.6.1.4.2. Since there is a "trouble T" for all runways at Reno, no diverse departures are authorized. Consequently, aircrews must use ODP ("trouble T"), SID, or specific ATC departure instructions.

9.16.6.1.4.3. For runway 7, there are no IFR departures authorized. The trouble "T" states "Rwy 7:NA". This is reiterated on all the SIDs as well. A quick look at the surrounding terrain explains why IFR departures are not allowed on this runway.

9.16.6.1.4.4. For runway 25, IFR departures are authorized provided you can meet the published climb gradients on certain procedures. However, if you are a category C or D aircraft, you cannot depart from runway 25 using the Mustang Six. Regardless of category you cannot depart on runway 25 using the Wagge Two due to air traffic control. You also cannot depart on the Zeffr One regardless of aircraft category; however, no reason for this restriction is given.

9.16.6.1.4.4.1. You can depart using radar vectors on runway 25, provided you can achieve the highest of the published climb gradients for runway 25. In this case, for category A or B, you must achieve a gradient of 470 ft/nm to 8500 feet (the highest published gradient shown on the Reno Three). For category C or D, you must achieve 610 ft/nm to 9800 feet.

9.16.6.1.4.4.2. You can also depart on runway 25 using the ODP ("trouble T") which states "Climb runway heading to 5000 then climbing right turn direct FMG VORTAC…All aircraft, climb in FMG VORTAC holding pattern (hold NE, LT, 221 inbound) to depart FMG VORTAC at or above MEA/MCA for direction of flight."

9.16.6.1.4.5. For runway 16L/R you can depart using any of the published SIDs provided you can make the climb gradients, which vary from 370 ft/nm to 9200 feet to 740 ft/nm to 8000.

9.16.6.1.4.5.1. There is also an ODP for runways 16L/R. When reading an ODP such as this one, you must be careful to capture the entire procedure, not just the initial instructions. For example, on runway 16R, the instructions read, "Climb via I-RNO South course or runway heading to 6600 then climbing left turn direct FMG VORTAC…All aircraft, climb in FMG VORTAC holding pattern (hold NE, LT, 221 inbound) to depart FMG VORTAC at or above MEA/MCA for direction of flight." Also note the climb gradients, which are again broken down by category.

9.16.6.1.4.6. For runways 34R/L, the Mustang Six and Reno Three are the only authorized SIDs. The Wagge Two is not authorized due to air traffic control and the Zeffr One is not authorized but no reason is given.

9.16.6.1.4.6.1. There is an ODP authorized for runways 34L/R, provided you can achieve 440 ft/nm to 7400 feet.

9.16.6.1.5. How should aircrews file the departure(s)?

9.16.6.1.6. Answer: It depends on your aircraft type and route of flight.

9.16.6.1.6.1. If your intention is to fly one of the ODPs, you should file FMG as your first point after departure since all the ODPs terminate in a holding pattern at the VORTAC. You can also annotate a remark that you intend to fly the ODP for Runway xx.

9.16.6.1.6.2. If your intention is to depart via specific ATC departure instructions, you can annotate the comment, "Request Radar Vector Departure" on your flight plan IAW FLIP GP.

9.16.6.1.6.3. If your intention is to fly one of the SIDs, then file the appropriate SID IAW FLIP GP. At an airport such as Reno, where both terrain and ATC are a factor, filing a SID will probably provide the most expeditious handling on departure. An important point to remember at an airport such as this is that SIDs are optimized for ATC and will accomplish the dual function of terrain avoidance and expeditious traffic flow.

9.16.6.1.7. What can the aircrew expect as an ATC clearance?

9.16.6.1.8. Answer: It depends on what you filed.

9.16.6.1.8.1. If you filed to FMG, you can expect to be issued a clearance that includes directions consistent with the ODP for that runway. If not, query the controller. You could also be "Cleared as Filed." This is a valid clearance and will be covered later in this example.

9.16.6.1.8.2. If your intention is to depart via specific ATC departure instructions, you can expect to receive those with your initial clearance or just prior to departure.

9.16.6.1.8.3. If you filed one of the SIDs, expect the SID to be included in your ATC clearance.

9.16.6.1.9. What is the required climb gradient with all engines operating?

9.16.6.1.10. Answer: It depends on specific runway, phase of departure and procedure.

9.16.6.1.10.1. NOTE: Required climb gradients listed in Table 9.3 do not apply to low close-in obstacles. These climb gradients apply from a height of 200 feet above DER. To determine the required climb gradient up to 200 feet above the DER, see low close-in obstacle discussion below. If you determine the low close-in obstacles are not a factor for your departure, maintain the climb gradients shown in Table 9.3 from 35 feet above DER.

Table 9.3. Summary of Climb Gradients for KRNO.

	Rwy 7	Rwy 25	Rwy 16L	Rwy 16R	Rwy 34L	Rwy 34R
ODP	Not Authorized	Cat A/B: 380 ft/nm to 8000 Cat C/D; 610 ft/nm to 9800 Cat E: Not Authorized	740 ft/nm to 8000	Cat A/B: 410 ft/nm to 9200 Cat C/D: 460 ft/nm to 9200 Cat E: Not Authorized	440 ft/nm to 7400	440 ft/nm to 7400
Specific ATC Dept Instructions	Not Authorized	Cat A/B: 470 ft/nm to 8500 Cat C/D: 610 ft/nm to 9800 Cat E: Not Authorized	740 ft/nm to 8000	460 ft/nm to 9200	440 ft/nm to 7400	440 ft/nm to 7400
Mustang 6	Not Authorized	Cat A/B: 380 ft/nm to 8000 Cat C/D: Not Authorized Cat E: Not Authorized	740 ft/nm to 8000	460 ft/nm to 9200	440 ft/nm to 7400	440 ft/nm to 7400
Reno 3	Not Authorized	Cat A/B: 470 ft/nm to 8500 Cat C/D: 610 ft/nm to 9800 Cat E: Not Authorized	740 ft/nm to 8000	370 ft/nm to 9200	440 ft/nm to 7400	440 ft/nm to 7400
Wagge 2	Not Authorized	Not Authorized	740 ft/nm to 8000	370 ft/nm to 9200	Not Authorized	Not Authorized
Zeffr 1	Not Authorized	Not Authorized	675 ft/nm to 8400	400 ft/nm to 9700	Not Authorized	Not Authorized

9.16.6.1.10.2. For all runways, for all departure procedures, you must cross the end of the runway at or above 35 feet per the notes on the ODP and all the SIDs.

9.16.6.1.10.3. All runways have low close-in obstacles annotated, both in the ODP and on the SID. The obstacles listed are not necessarily the same for all procedures. It depends on the initial routing. Note the location of each obstacle, and then determine which ones are in the planned departure path, IAW AFI 11-202 Volume 3 *General Flight Rules*. Determine the climb gradient required to clear the applicable obstacles. Plan to maintain this climb gradient to 200 feet above the DER. Then plan to maintain the appropriate climb gradient shown in Table 9.3.

9.16.6.1.11. Question: How should the aircrew fly the departure procedure?

9.16.6.1.12. Answer: It depends on the runway and clearance.

9.16.6.1.12.1. If you intend to fly the ODP, file FMG as your first point on departure, and are "Cleared as Filed," with no further instructions, comply with the following:

9.16.6.1.12.1.1. Cross the departure end of the runway at or above 35 feet.

9.16.6.1.12.1.2. Vertically clear the applicable obstacles annotated under low close-in obstacles for the runway from which you are departing. Maintain the required climb gradient to 200 feet above the DER.

9.16.6.1.12.1.3. After reaching 200 feet above the DER, maintain at or above the required climb gradient shown in the “trouble T” (ODP) applicable to the runway from which you departed.

9.16.6.1.12.1.4. Fly the “trouble T” (ODP) procedure applicable to the runway from which you departed.

9.16.6.1.12.1.5. Upon reaching FMG, enter holding as appropriate for your direction of flight.

9.16.6.1.12.1.6. Upon reaching the MEA/MCA for your route of flight, comply with your ATC clearance for departing FMG on course.

9.16.6.1.12.2. If you intend to depart via specific ATC departure instructions, use caution due to the mountainous terrain.

9.16.6.1.12.2.1. Cross the departure end of the runway at or above 35 feet.

9.16.6.1.12.2.2. Vertically clear the applicable obstacles annotated under low close-in obstacles for the runway from which you are departing. Maintain the required climb gradient to 200 feet above the DER.

9.16.6.1.12.2.3. After reaching 200 feet above the DER, maintain at or above the highest climb gradient required (via SID or ODP) for the runway from which you departed.

9.16.6.1.12.2.4. Comply with the ATC departure instructions issued to you. Use caution if they diverge significantly from the SID or ODP. The ODP has been optimized for obstacle clearance and the SID has been optimized for ATC and obstacles. In this type of environment, the SID or ODP are generally going to be the most expeditious and safest method of departure.

9.16.6.1.12.3. If you intend to depart via one of the SIDs, comply with the following:

9.16.6.1.12.3.1. Cross the departure end of the runway at or above 35 feet.

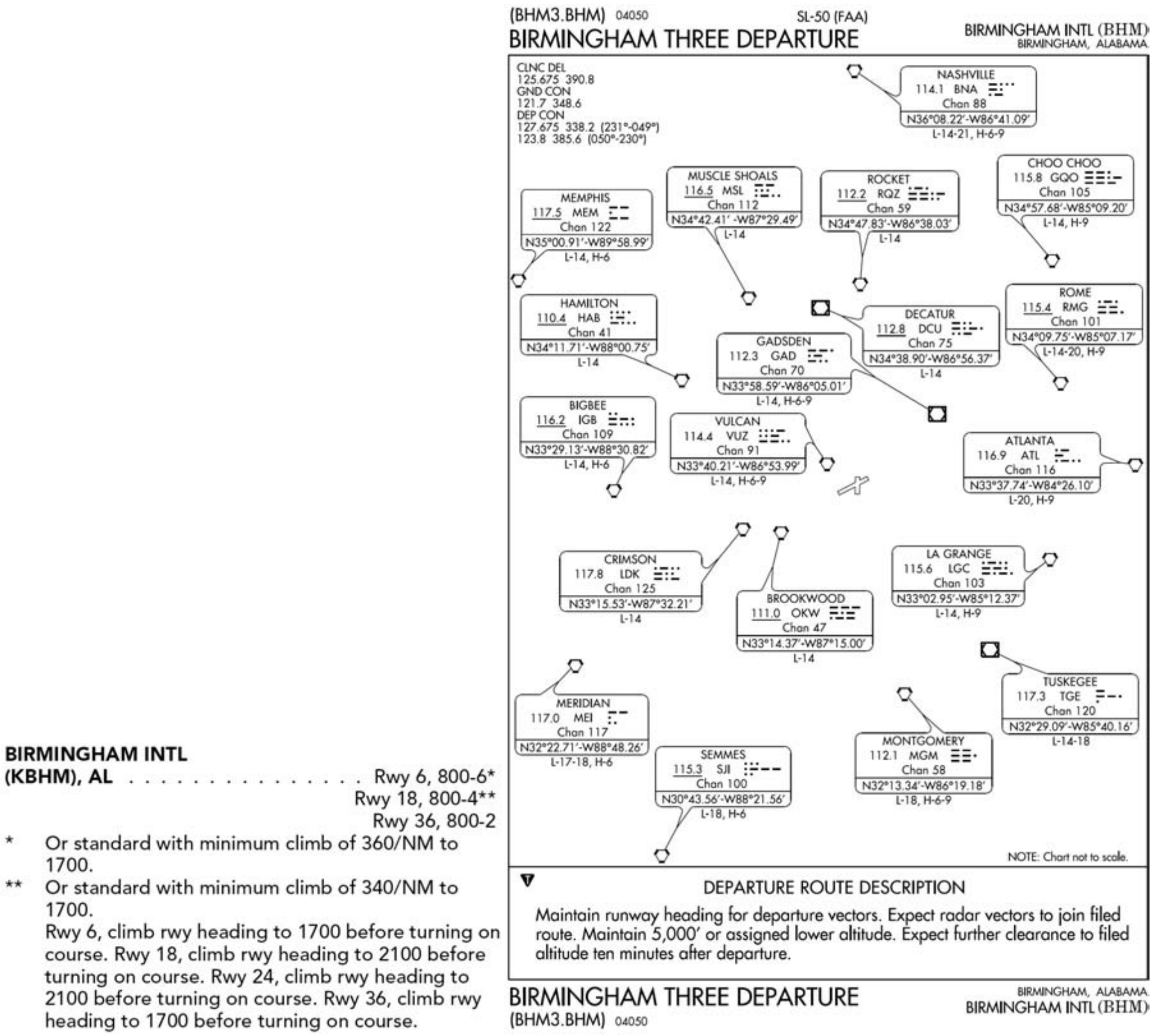
9.16.6.1.12.3.2. Vertically clear the applicable obstacles annotated under low close-in obstacles for the runway from which you are departing. Maintain the required climb gradient to 200 feet above the DER.

9.16.6.1.12.3.3. After reaching 200 feet above the DER, maintain at or above the required climb gradient shown on the applicable SID.

9.16.6.1.12.3.4. Fly the routing depicted on the applicable SID. If you compare the SID and ODP, you will see the initial portion of the routings are very similar and essentially follow the same ground track. This is not always the case and you must carefully compare the two to determine if all or portions of the ODP also apply to the SID.

9.16.6.2. Example 2: Birmingham AL (KBHM).

Figure 9.25. Departure Example #2: Birmingham AL (KBHM).



9.16.6.2.1. Question: Is an IFR departure authorized for USAF aircrews?

9.16.6.2.2. Answer: Yes.

9.16.6.2.2.1. Although Alabama is relatively flat, the Birmingham Airport is located in an area of relatively hilly terrain surrounding the airport. Although not excessively tall, these obstacles are located a short distance from the runways. However, an IFR departure is authorized for USAF aircrews, provided required climb gradients are achieved.

9.16.6.2.3. Question: What IFR departure procedures are authorized for USAF aircrews?

9.16.6.2.4. Answer: It depends upon which runway.

9.16.6.2.4.1. Birmingham has a “trouble T”; therefore, at least one runway is not suitable for diverse departure (i.e., one runway had penetrations of the 40:1 OCS). A further examination of Birmingham shows none of the runways are suitable for diverse departures. USAF aircrews can depart IFR from Birmingham using a SID, ODP, or specific ATC departure instructions.

9.16.6.2.4.1.1. The Birmingham Three is a vector SID. There is nothing that would obviously restrict a USAF crew from filing and flying this SID other than NAVAID compatibility issues, provided all required climb gradients can be achieved on the departure runway.

9.16.6.2.4.1.2. The ODPs for Birmingham are fairly straightforward. All require crews to climb on runway heading until reaching an altitude specified for that runway, then turn on course.

9.16.6.2.4.1.3. A radar vector departure is another option authorized in this case, provided you can achieve the published climb gradients for the departure runway. Don't forget to fly the ODP prior to the vector.

9.16.6.2.5. Question: How should aircrews file the departure(s)?

9.16.6.2.6. Answer: It depends on the intended departure procedure and route of flight.

9.16.6.2.6.1. If you intend to file to an initial NAVAID, the best way to file would be to use the Birmingham Three SID IAW FLIP GP.

9.16.6.2.6.2. If your intention is to depart via specific ATC departure instructions, you can annotate the comment, "Request Radar Vector Departure" on your flight plan IAW FLIP GP.

9.16.6.2.7. Question: What can the aircrew expect as an ATC clearance?

9.16.6.2.8. Answer: The clearance at Birmingham will probably be fairly straightforward. If you will be going to one of the fixes depicted on the SID, your clearance will be the SID and appropriate transition. If you will depart via the ODP or specific ATC departure instructions, you clearance will include specific headings, courses, altitudes, or fixes.

9.16.6.2.9. Question: What is the required climb gradient with all engines operating?

9.16.6.2.10. Answer: It depends on the runway.

9.16.6.2.10.1. Because there is no climb gradient published on the SID but the "trouble T" is depicted on the SID itself, use the climb gradients listed in the "trouble T."

9.16.6.2.10.2. There are no low close-in obstacles depicted so all climb gradients apply from 35 feet above DER.

9.16.6.2.10.2.1. For runway 6, you must achieve at least 360 ft/nm to 1700.

9.16.6.2.10.2.2. For runway 24, there is no climb gradient listed and also no prohibition on departing on this runway. However, there is an ODP for this runway, which indicates it was evaluated for departures. In this case, omission of a climb gradient indicates the requirement is 200 ft/nm.

9.16.6.2.10.2.3. For runway 18, you must achieve at least 340 ft/nm.

9.16.6.2.10.2.4. For runway 36, there are only non-standard weather minimums published (800-2). For USAF crews this means you must be at 800 feet by the departure end of the runway with one engine inoperative to depart IFR on runway 36, and then climb at 200 ft/nm thereafter.

9.16.6.2.11. Question: How should the aircrew fly the departure procedure?

9.16.6.2.12. Answer: Comply with the following:

9.16.6.2.12.1. Be at or above 35 feet by the DER unless you are departing runway 36. In that case you must be at or above 800 feet by DER.

9.16.6.2.12.2. After reaching the DER height (35 or 800 feet), climb at the climb gradient published for the runway of departure.

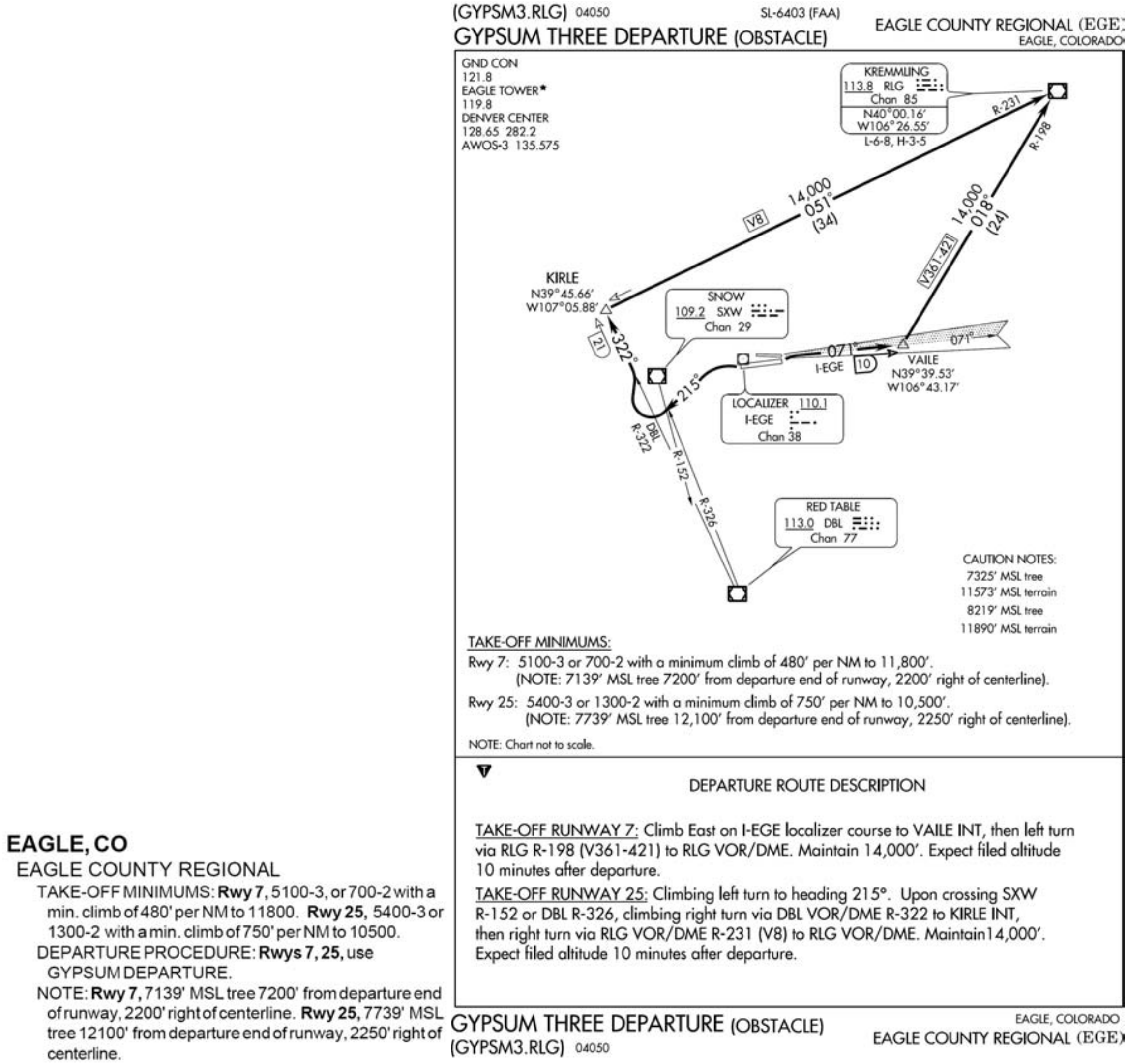
9.16.6.2.12.3. Climb on runway heading to the altitude specified in the ODP for the runway of departure prior to making any turns.

9.16.6.2.12.4. After reaching the ODP altitude, turn on course either via the SID or ATC departure instructions.

9.16.6.2.12.4.1. NOTE: This is a case where crews must comply with the ODP prior to complying with the SID or ATC departure instructions. Note, both the ODP and SID specify runway heading on departure. However, the SID does not include the altitude restrictions prior to turning on course. Because the ODP, by definition, is strictly for obstacle avoidance, then the minimum turning altitude is published due to obstacles or terrain and should be complied with prior to any turns on course.

9.16.6.3. Example 3: Eagle County CO (KEGE).

Figure 9.26. Departure Example #3: Eagle County (KEGE).



9.16.6.3.1. Question: Is an IFR departure authorized for USAF aircrews?

9.16.6.3.2. Answer: Technically, the answer is "yes," a USAF aircrew can depart IFR from Eagle County. However, most USAF aircraft are incapable of achieving the excessively high climb gradients required to comply with AFI 11-202 Volume 3 *General Flight Rules*. Consequently, from a practical viewpoint, IFR departures from Eagle County are not authorized for most USAF aircraft.

9.16.6.3.2.1. The "trouble T" states for runway 7, "5100-3, or 700-2 with a minimum climb of 480 ft/nm to 11,800." Runway 25 states, "5400-3, or 1300-2 with a minimum climb of 750 ft/nm to 10,500." These non-standard weather minimums and climb gradients have two ramifications for USAF aircrews. First, the climb gradient is still associated with a non-standard weather minimum. Second, IAW AFI 11-202 Volume 3 *General Flight*

Rules, USAF aircrews can use the non-standard weather minimum, provided they can be at the non-standard ceiling requirement by the end of the runway with one engine inoperative. This means for runway 7, a USAF aircraft would have to be at 700 feet by DER OEI and then climb at 480 ft/nm to 11,800. On runway 25, a USAF aircraft would have to be at 1300 feet by DER OEI and then climb at 750 ft/nm to 10,500. With an extremely high field elevation (6535) and only a moderate length runway (8000 feet) compounding the performance problem, it is doubtful most USAF aircraft could achieve these altitudes in the distances specified.

9.16.6.3.3. Question: What IFR departure procedures are authorized for USAF aircrews?

9.16.6.3.4. Answer: Because there is a "trouble T" for each runway at Eagle County, a diverse departure is not authorized. Provided the climb gradients can be achieved, the Gypsum Three Departure is the only safe and authorized method of departing Eagle County. An examination of the IFR Supplement reveals that Eagle County is non-radar; therefore, radar vectors are not available.

9.16.6.3.4.1. NOTE: The Gypsum Three Departure is an example of a graphical ODP. It is not a SID, as it is optimized for obstacle avoidance, not ATC. You can distinguish this by noting it is listed in the "trouble T" in lieu of textual instructions. Also, the word "obstacle" is annotated on the graphical depiction itself, although this is not always the case.

9.16.6.3.5. Question: How should aircrews file the departure(s)?

9.16.6.3.6. Answer: The Gypsum Three Departure, as a graphical ODP, has a coded identifier just like a SID. Follow instructions in FLIP GP for filing a SID and use the coded identifier listed at the bottom of the graphical depiction (GYPSM3.RLG).

9.16.6.3.7. Question: What can the aircrew expect as an ATC clearance?

9.16.6.3.8. Answer: Aircrews can expect to receive "Gypsum 3" as part of their normal ATC clearance. Due to the surrounding terrain, any other instructions should be queried.

9.16.6.3.9. Question: What is the required climb gradient with all engines operating?

9.16.6.3.10. Answer: It depends on which runway.

9.16.6.3.10.1. For runway 7, a climb gradient that will permit reaching the DER at or above 700 feet and then maintain at least 480 ft/nm to 11,800.

9.16.6.3.10.2. For runway 25, a climb gradient that will permit reaching the DER at or above 1300 feet and then maintain at least 750 ft/nm to 10,500.

9.16.6.3.10.3. There are also low close-in obstacles listed for each runway that must be accounted for in departure planning. A comparison of the low close-in obstacle data and the non-standard weather minimums shows that if you are at the non-standard ceiling by the DER (700 or 1300 feet), you will clear the published low close-in obstacles at Eagle County.

9.16.6.3.10.3.1. WARNING: This situation is not always the case at all airports, and crewmembers have no definitive method to determine that these are the particular obstacles that drove the non-standard weather minimums. The non-standard weather minimums do not specify the location of the obstacle. Therefore, do not disregard either the non-standard ceiling requirement or the published low close-in obstacles.

9.16.6.3.11. Question: How should the aircrew fly the departure procedure?

9.16.6.3.12. Answer: If your aircraft can achieve these excessive climb gradients, comply with the following.

9.16.6.3.12.1. Cross the departure end of the runway at or above 700 or 1300 feet as applicable.

9.16.6.3.12.1.1. NOTE: The normal FAA 35-foot restriction at the DER is obviously not applicable in this case, as USAF regulations require a higher altitude at the DER.

9.16.6.3.12.2. Maintain at or above the published climb gradient (480 ft/nm or 750 ft/nm) to the published altitude.

9.16.6.3.12.3. Fly the routing depicted in the Gypsum Three Departure.

9.17. Decision Trees For Departures.

9.17.1. IFR Departure Procedures is an extremely complex subject. The following decision trees are an aid for crewmembers to use to determine appropriate IFR departure procedures. These trees address only IFR departures. If no IFR departure is authorized, you may still be able to depart VFR or with a VFR climb to the IFR MEA IAW AFI 11-202 Volume 3, *General Flight Rules*.

Figure 9.27. Normal IFR Departure Options Decision Tree (Page 1).

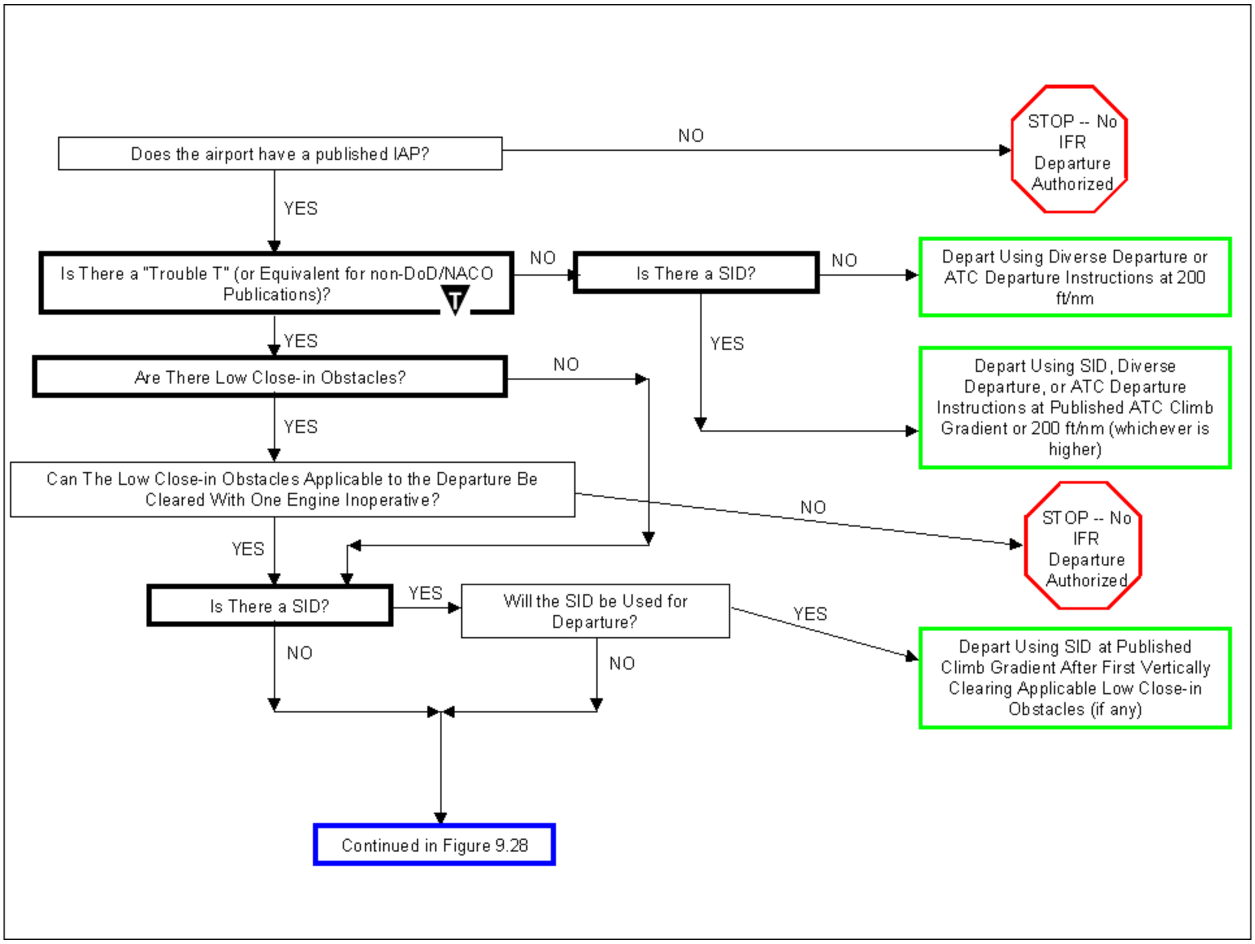


Figure 9.28. Normal IFR Departure Options Decision Tree (Page 2).

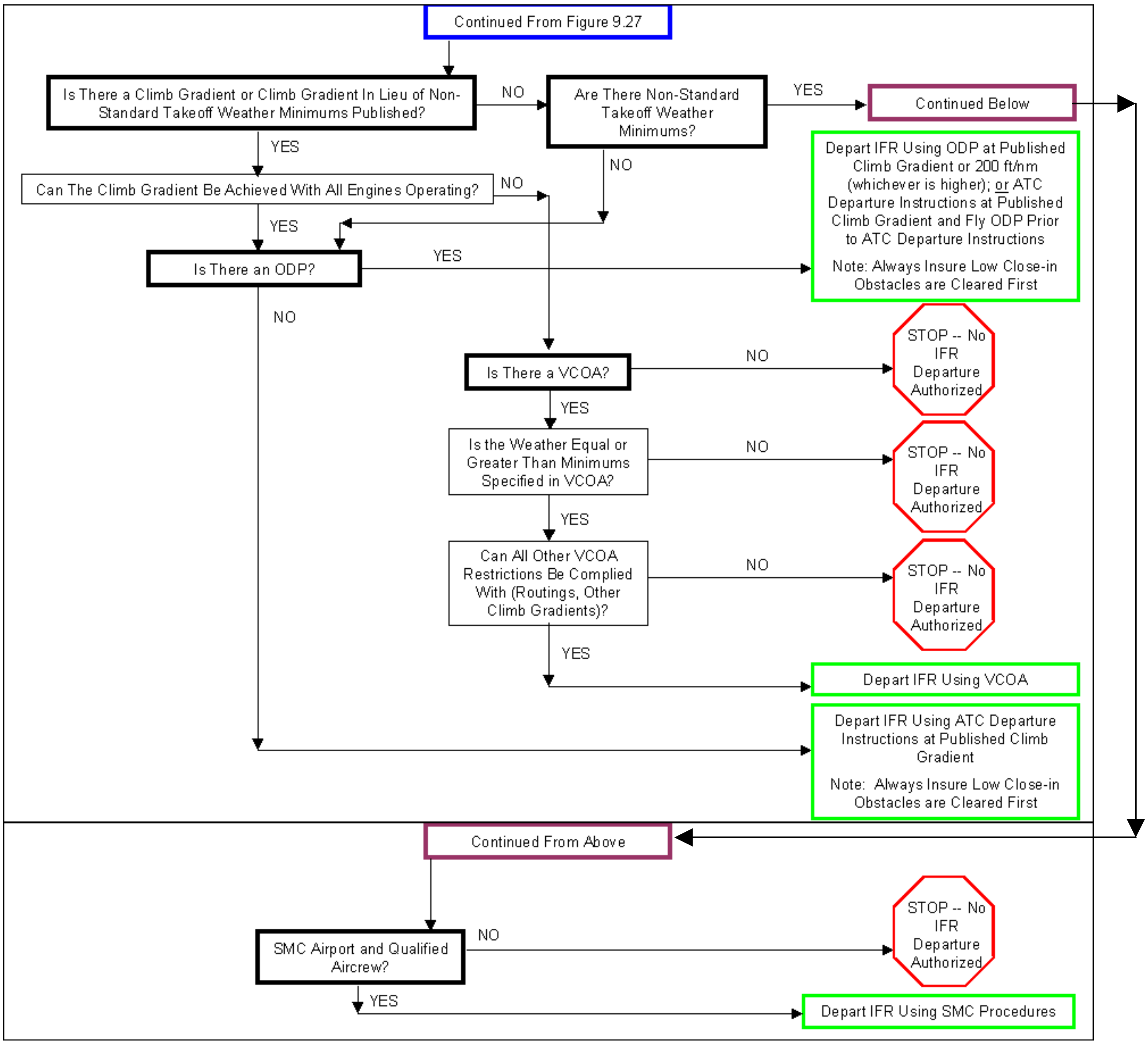
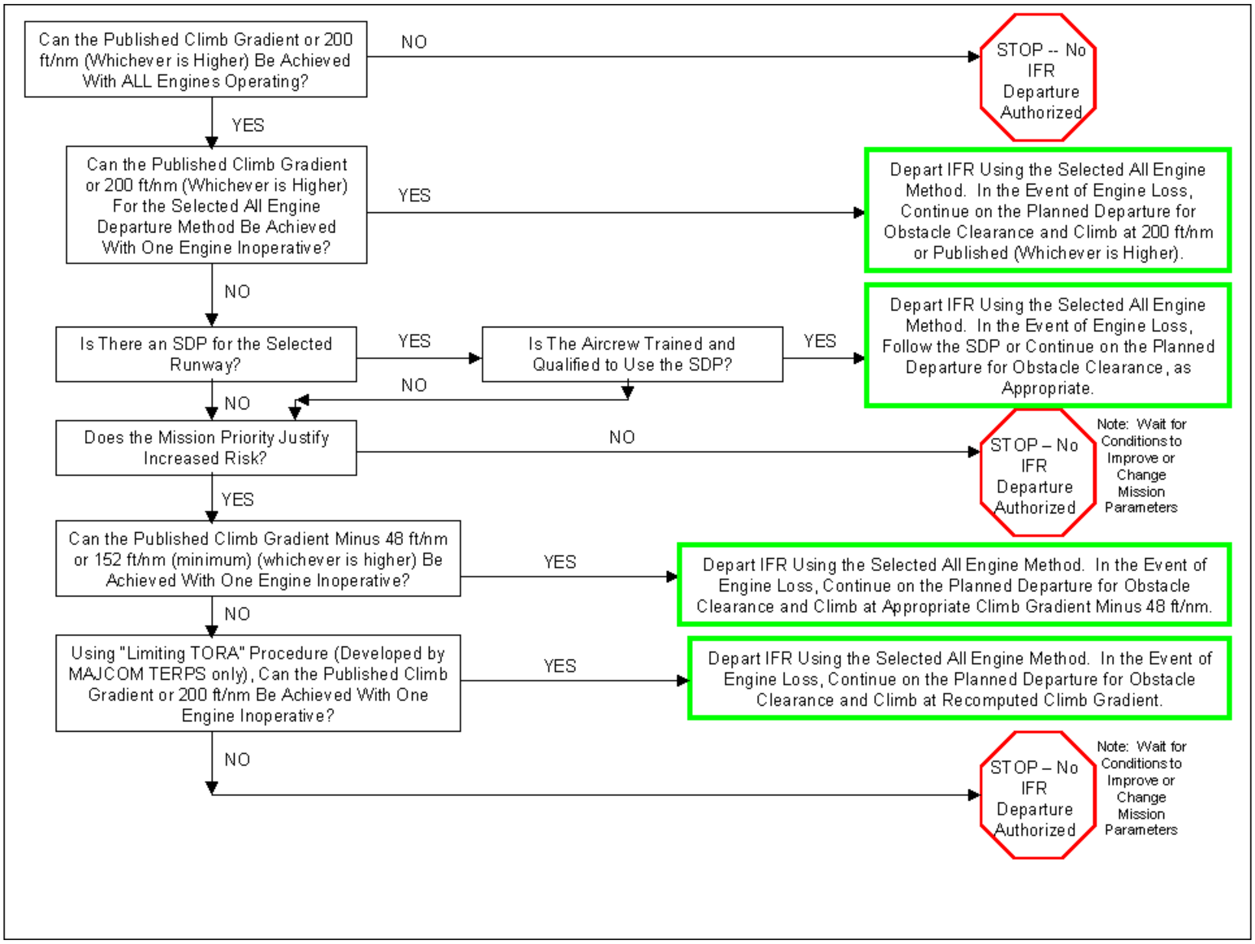
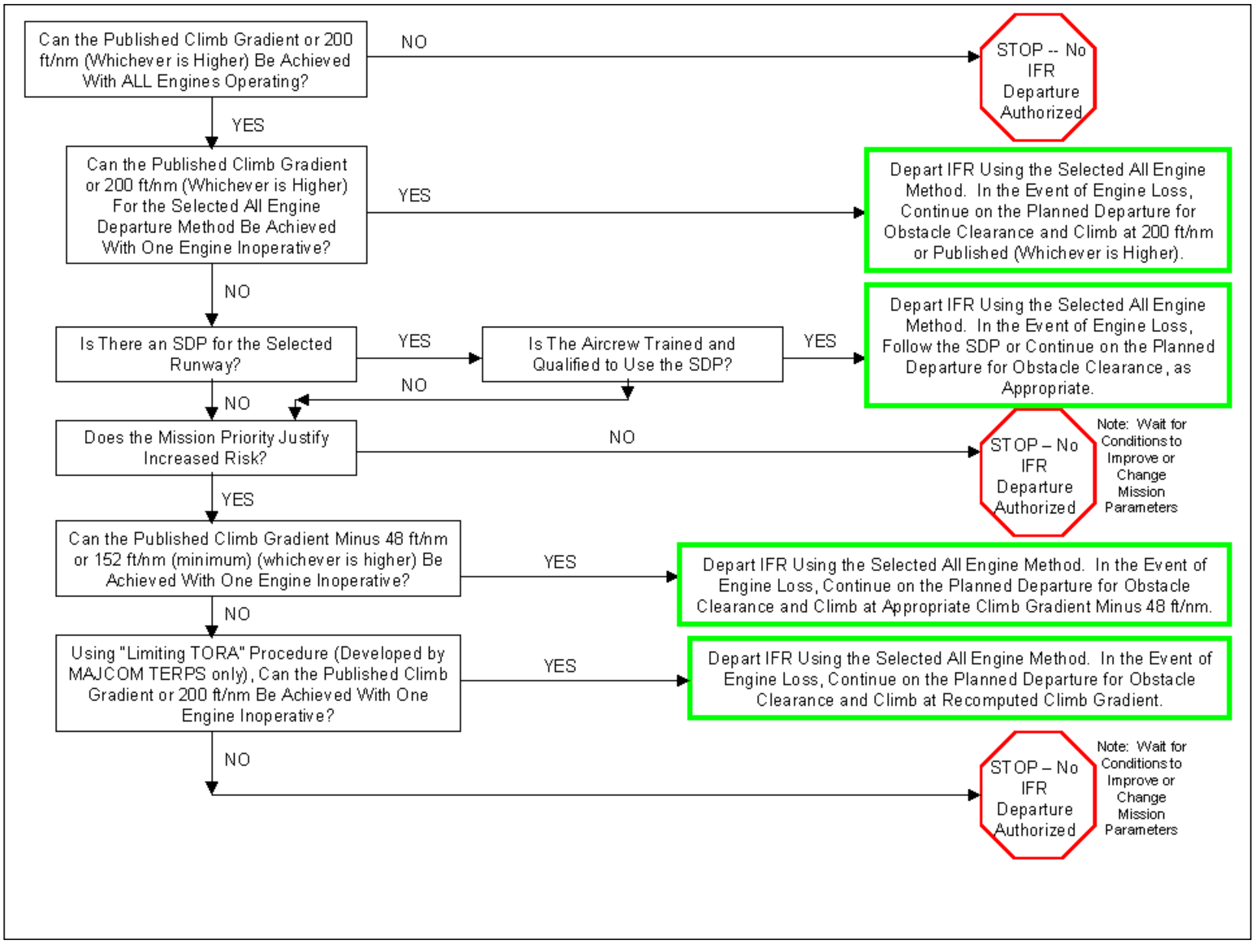


Figure 9.29. One Engine Inoperative Departure Decision Tree.




Can the Published Climb Gradient or 200 ft/nm (Whichever is Higher) Be Achieved With ALL Engines Operating?
NO
STOP -- No IFR Departure Authorized
YES
Can the Published Climb Gradient or 200 ft/nm (Whichever is Higher) For the Selected All Engine Departure Method Be Achieved With One Engine Inoperative?
YES
Depart IFR Using the Selected All Engine Method. In the Event of Engine Loss, Continue on the Planned Departure for Obstacle Clearance and Climb at 200 ft/nm or Published (Whichever is Higher).
NO
Is There an SDP for the Selected Runway?
YES
Is The Aircrew Trained and Qualified to Use the SDP?
YES
Depart IFR Using the Selected All Engine Method. In the Event of Engine Loss, Follow the SDP or Continue on the Planned Departure for Obstacle Clearance, as Appropriate.
NO
NO
Does the Mission Priority Justify Increased Risk?
NO
STOP – No IFR Departure Authorized
Note: Wait for Conditions to Improve or Change Mission Parameters
YES
Can the Published Climb Gradient Minus 48 ft/nm or 152 ft/nm (minimum) (whichever is higher) Be Achieved With One Engine Inoperative?
YES
Depart IFR Using the Selected All Engine Method. In the Event of Engine Loss, Continue on the Planned Departure for Obstacle Clearance and Climb at Appropriate Climb Gradient Minus 48 ft/nm.
NO
Using "Limiting TORA" Procedure (Developed by MAJCOM TERPS only), Can the Published Climb Gradient or 200 ft/nm Be Achieved With One Engine Inoperative?
YES
Depart IFR Using the Selected All Engine Method. In the Event of Engine Loss, Continue on the Planned Departure for Obstacle Clearance and Climb at Recomputed Climb Gradient.
NO
STOP – No IFR Departure Authorized
Note: Wait for Conditions to Improve or Change Mission Parameters

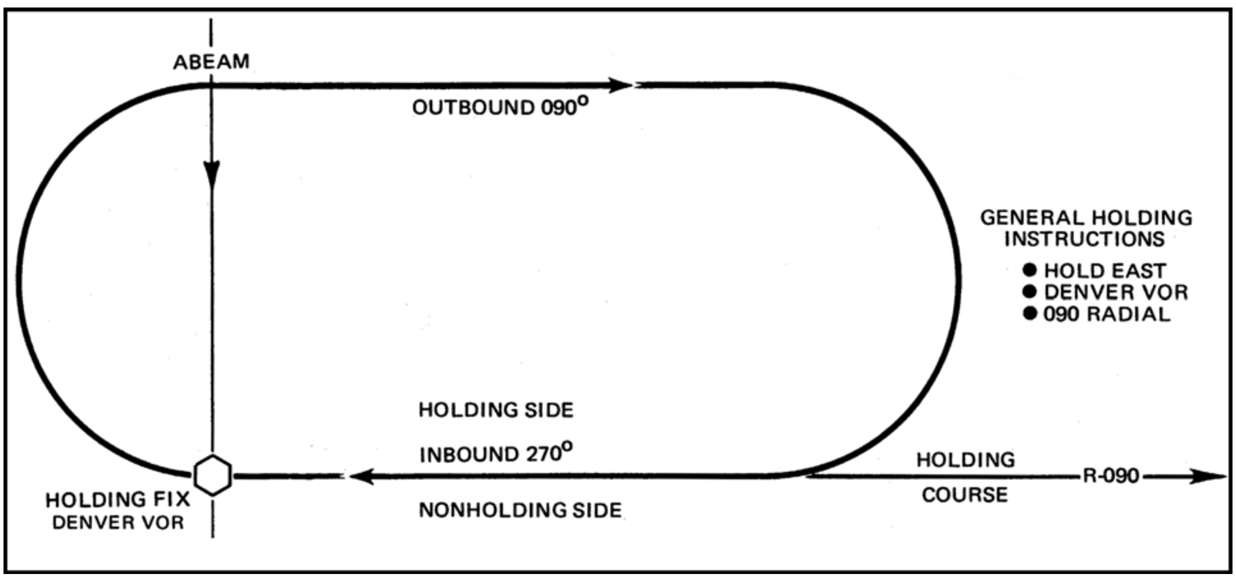
Chapter 10

HOLDING

10.1. Definition.

10.1.1. Basic. Holding is maneuvering an aircraft in relation to a navigation fix while awaiting further clearance. The standard no-wind holding pattern is flown by following a specified holding course inbound to the holding fix, making a 180° turn to the right, flying a heading outbound to parallel the holding course, and making another 180° turn to the right to intercept and follow the holding course to the fix (Figure 10.1). The holding pattern is nonstandard when the turns are made to the left. ***Unless otherwise instructed by ATC, pilots are expected to hold in a standard pattern***. The standard no-wind length of the inbound leg of the holding pattern is 1 minute when holding at or below 14,000 feet MSL and 1½ minutes when holding above 14,000 feet MSL. DME holding patterns specify the outbound leg length. If holding at a DME fix without specified outbound leg length, use timing procedures listed above.

Figure 10.1. Holding Pattern.



10.1.2. Course Guidance. Holding patterns have inbound course guidance provided by a VOR, TACAN, NDB, localizer, or RNAV/GPS. While in holding, the localizer signal is the most accurate method of determining aircraft position. However, if a VOR, TACAN or NDB also defines the holding pattern, it's the pilot's option as to which NAVAID to use.

10.1.2.1 NOTE: AFJMAN 11-226 *TERPS*, states that the use of TACAN station passage as a fix is not acceptable for holding fixes (regardless of altitude) or high altitude initial approach fixes (those IAFs which are at or above FL180). This restriction is driven by the TACAN fix error involved in station passage. ***Therefore,***

if the aircraft is TACAN-only equipped, do not hold directly over a TACAN or VORTAC facility or plan to use these facilities as high altitude IAFs. TACAN station passage can be used to identify an IAF below FL180 regardless of whether the approach is published as a Low or High altitude approach.

10.2. Holding Instruction.

10.2.1. Charted Holding Patterns. ATC clearances requiring holding where holding patterns are charted, include the following instructions:

10.2.1.1. Direction. Direction of holding from the fix.

10.2.1.2. Holding fix. The name of the holding fix.

10.2.1.2.1. Example*:* **"**Cleared to NIGEL, hold east as published."

10.2.1.2.1.1. NOTE**:** AIM describes "charted" holding patterns as "those holding patterns depicted on U.S. government or commercially produced (meeting FAA requirements) low/high altitude enroute, and area or STAR charts." Although the AIM and GP do not specifically mention the use of published holding patterns depicted on instrument approach procedures, in day-to-day operations they are used frequently. If the controller clears you to "hold as published" using a holding pattern published on an approach plate, make sure you are holding in the correct pattern. In some situations, there may be more than one published holding pattern at the same fix. (See Figure 10.2) If there is any doubt about your clearance, query the controller.

10.2.1.3. Expect Further Clearance. ATC is responsible to issue an Expect Further Clearance Time (EFC) based on the best estimate of any additional enroute/terminal delays. Pilots should request an EFC any time they are directed to hold without one.

10.2.1.3.1. Example: "Cleared to NIGEL, hold east as published, expect further clearance at 1645Z, time now 1635Z."

10.2.2. Non-charted Holding Patterns. If ATC clears you to hold in a non-charted holding pattern, they will provide you with the following information:

10.2.2.1. Direction. Direction of holding from the fix.

10.2.2.2. Holding fix. The holding fix.

10.2.2.3. Holding course. Radial, course, bearing, airway, or route on which the aircraft is to hold.

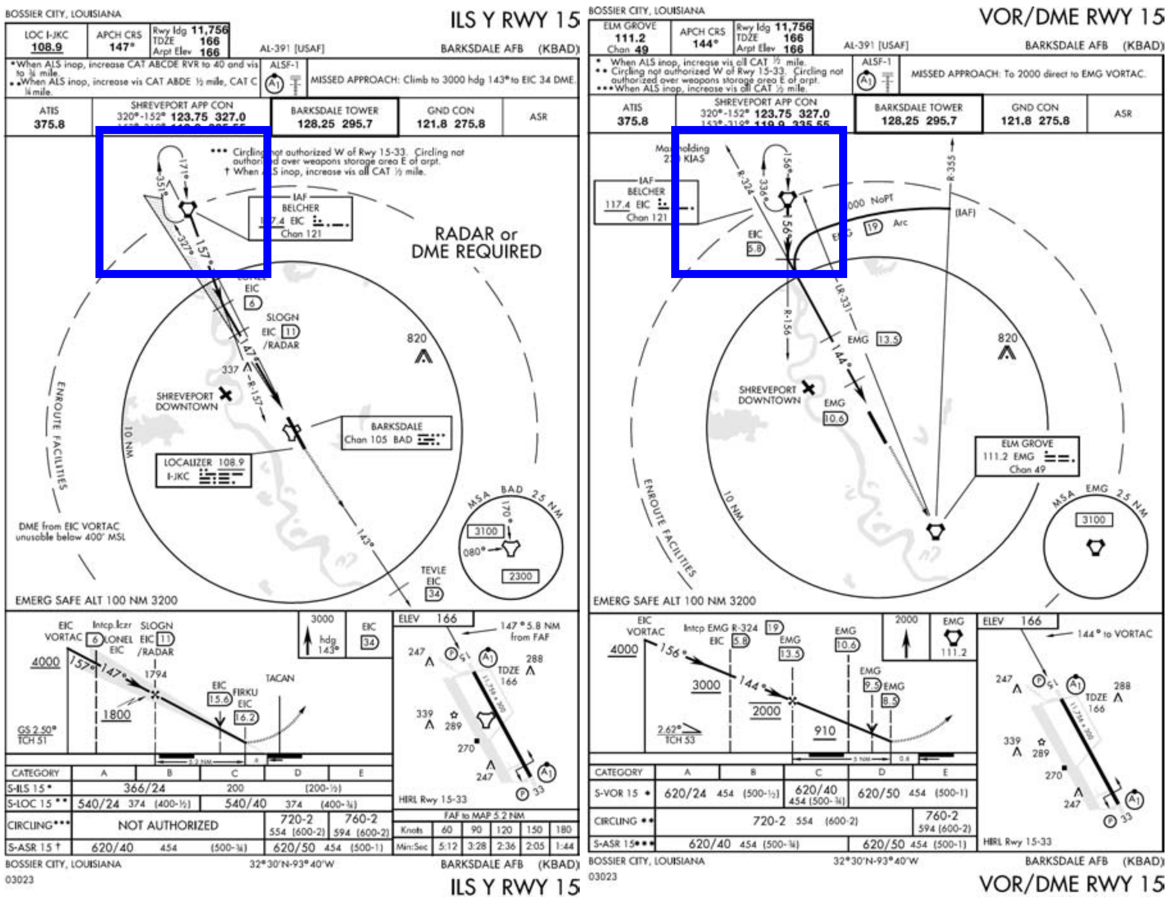
10.2.2.4. Leg length. Outbound leg length in miles, if DME or RNAV is to be used.

10.2.2.4.1. Direction of turn. Left turns, if nonstandard.

10.2.2.5. Expect Further Clearance. Time to expect further clearance and any pertinent additional delay information.

10.2.2.5.1. Example: Hold Northeast of the 106 radial, 40 DME fix, 10-mile legs, left turns. Expect further clearance at 1725Z, time now 1710Z.

Figure 10.2. Charted Holding Pattern.



10.2.3. Clearance Limit. ATC should issue holding instructions at least 5 minutes before reaching a clearance limit fix. When an aircraft is 3 minutes or less from a clearance limit and a clearance beyond the fix has not been received, the pilot is expected to start a speed reduction so that ***the aircraft will cross the fix at or below the maximum holding airspeed. If holding instructions have not been received upon arrival at the fix, hold in accordance with procedures in FLIP. For two-way radio failure holding procedures, refer to the FIH***.

10.2.4. Maximum Holding Speeds. Maximum holding airspeeds are defined by TERPS and have nothing to do with the holding speed specified in the aircraft flight manual. Holding speeds in the aircraft flight manual are typically minimum speeds that correspond to a maximum endurance speed. ***Do not exceed the maximum holding airspeeds listed below.*** ATC may be able to approve holding speeds in excess of these maximums, if aircraft performance considerations require. For ICAO holding airspeeds, refer to Chapter 18.

Table 10.1. Maximum Holding Airspeeds.

ALTITUDE	Maximum Speed
MHA through 6,000'	200 KIAS
Above 6,000' through 14,000'	230 KIAS
Above 14,000'	265 KIAS

10.2.4.1. NOTE: At USAF airfields, the maximum holding airspeed is 310 KIAS unless otherwise noted. At USN airfields, the maximum holding airspeed is 230 KIAS unless otherwise noted.

10.2.4.2. NOTE: Although FAAO 7130.3a *Holding Pattern Criteria*, details maximum holding airspeeds by aircraft type, these are not applied in the creation of holding patterns. Adherence to the maximum speeds shown above, or the published maximum holding speed, whichever is lower, will insure you remain within protected airspace.

10.3. Holding Pattern Procedures.

10.3.1. Holding Procedure. The angular difference between the inbound holding course and the heading at initial holding fix passage determines the direction of turn to enter the holding pattern. Holding pattern sizes can vary greatly depending on the altitude of the holding pattern, primary aircraft the procedure was designed for, and other factors. Pilots have no way of knowing the design limits of protected airspace for a particular holding pattern.

10.3.2. Established in Holding. You are considered established in the holding pattern upon initial passage of the holding fix.

10.3.3. Bank Angle. ***Unless correcting for known winds, make all turns during entry and while holding at: 3 degrees per second, or 30 degree bank angle, or bank angle commanded by the flight director system, whichever requires the least bank angle.***

10.3.4. Entry Turns. There are a number of techniques to enter holding which should keep you within holding airspace. Although any technique may be used to enter holding, using the commonly accepted ones described below will keep you within holding airspace and insure your actions are predictable to the air traffic controller. Therefore, it is recommended that you use one of the described techniques.

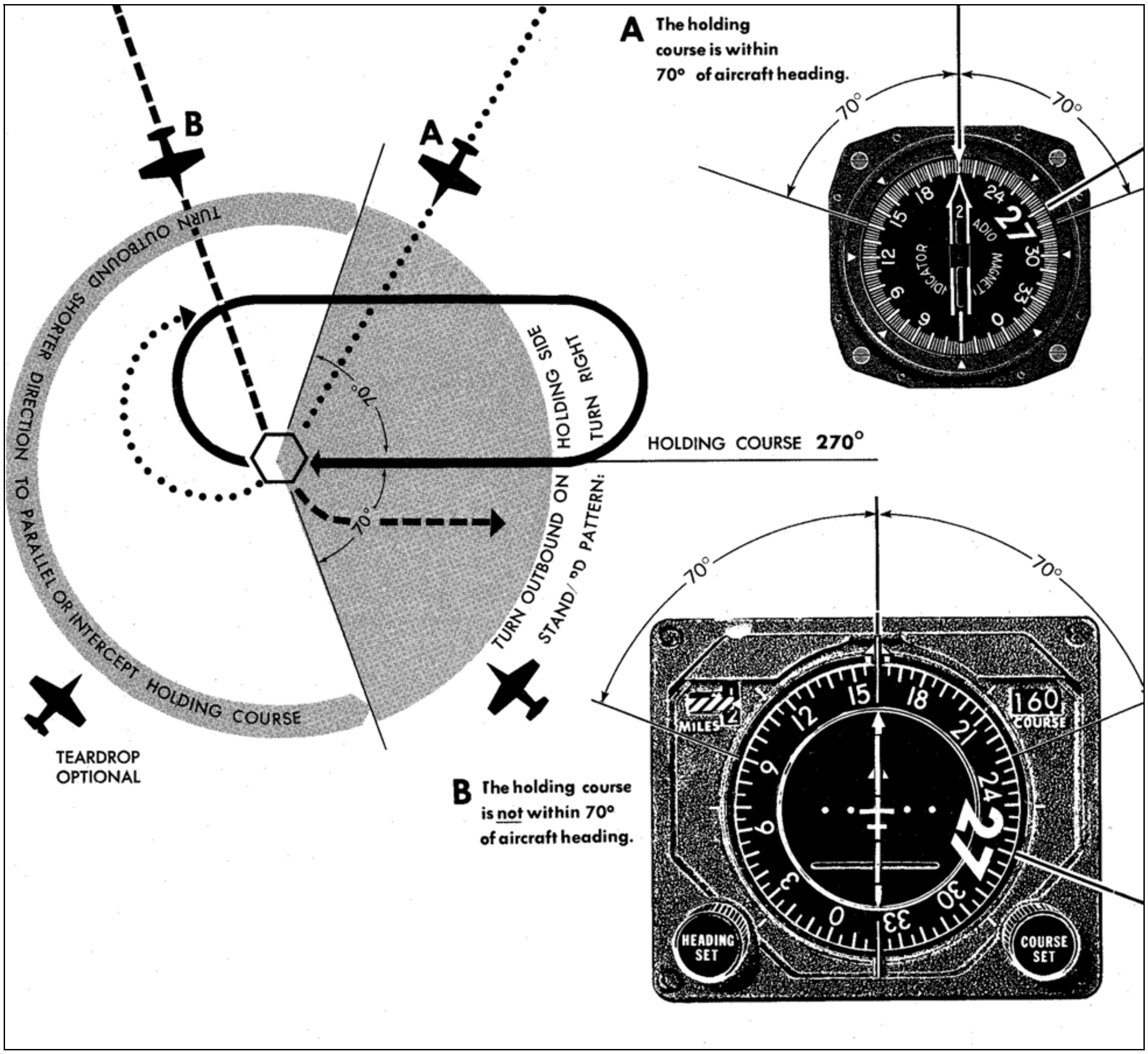
10.3.4.1. Technique A (“70 Degree Method”):

10.3.4.1.1. Within 70°. If the inbound holding course is within 70° of the aircraft heading, turn outbound on the holding side to parallel the holding course. (For a standard pattern, turn right to enter.) Upon completion of the outbound leg, proceed direct or intercept the holding course to the fix.

10.3.4.1.2. Not within 70°. If the inbound holding course is not within 70° of the aircraft heading, turn outbound in the shorter direction to parallel the holding course. If this turn places you on the non-holding side, either parallel (adjust for wind) or attempt to intercept the holding course outbound. If you are on the non-holding side or on the holding course at the completion of the outbound leg, turn toward the holding side, then proceed direct or intercept the holding course to the fix.

10.3.4.1.3. Teardrop. The teardrop entry may be used at pilot discretion when entering holding on a heading conveniently aligned with the selected teardrop course. As a guide, consider yourself conveniently aligned when your aircraft heading is within 45° of the selected teardrop course. Upon reaching the holding fix, turn on the holding side and proceed on an outbound track not to exceed 45° from the outbound course. (Depending on your offset requirements, a teardrop course of less than 45° may be desired.) If course guidance is available, attempt to intercept the selected teardrop course outbound.

Figure 10.3. 70 degree Method.



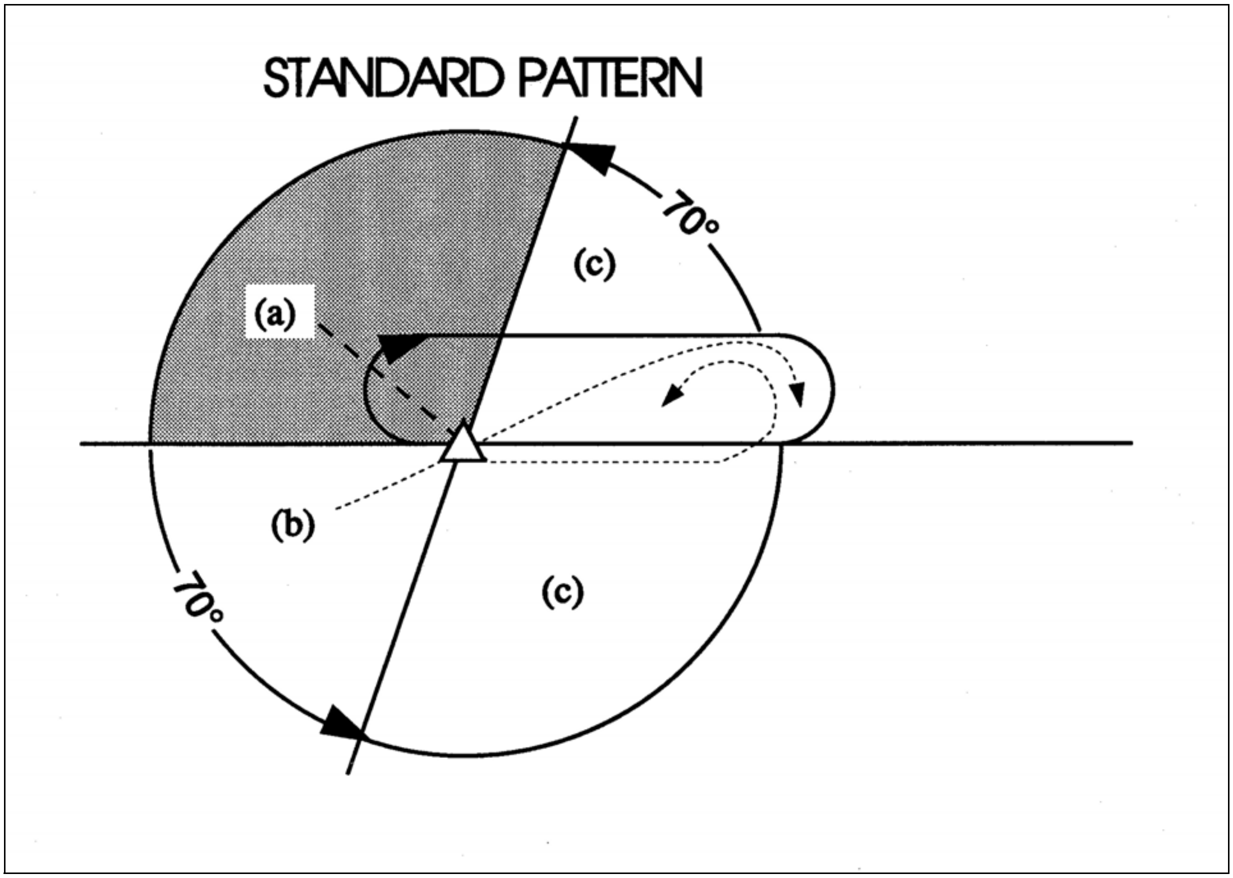
10.3.4.2. Technique B ("AIM Method"): Enter the holding pattern based on your heading (±5°) relative to the three entry sectors depicted in Figure 10.4. Upon reaching the holding fix, follow the appropriate procedure for your entry sector:

10.3.4.2.1. Sector A (Parallel). Turn to a heading to parallel the holding course outbound for the appropriate time or distance, then turn towards the holding side and return to the holding fix or intercept the holding course inbound.

10.3.4.2.2. Sector B (Teardrop). Turn outbound to a heading for a 30-degree teardrop entry (on the holding side) for the appropriate time or distance, and then turn towards the holding course to intercept the inbound holding course.

10.3.4.2.3. Sector C (Direct). Turn to follow the holding pattern.

Figure 10.4. AIM Method.



10.3.5. Timing. ***The maximum inbound leg time is 1 minute at or below 14,000 feet MSL and 1½ minutes above 14,000 feet MSL. On the initial outbound leg, do not exceed the appropriate time for the altitude unless compensating for a known wind. Adjust subsequent outbound legs as necessary to meet the required inbound time. When a specific DME or RNAV distance is specified, commence the inbound turn at that distance. ATC expects pilots to fly the complete holding pattern as published. Therefore, do not shorten the holding pattern without clearance from ATC.***

10.3.5.1. Outbound. ***Begin outbound timing when over or abeam the fix. If you cannot determine the abeam position, start timing when wings level outbound***.

10.3.5.2. Inbound. ***Begin inbound timing when wings level inbound***.

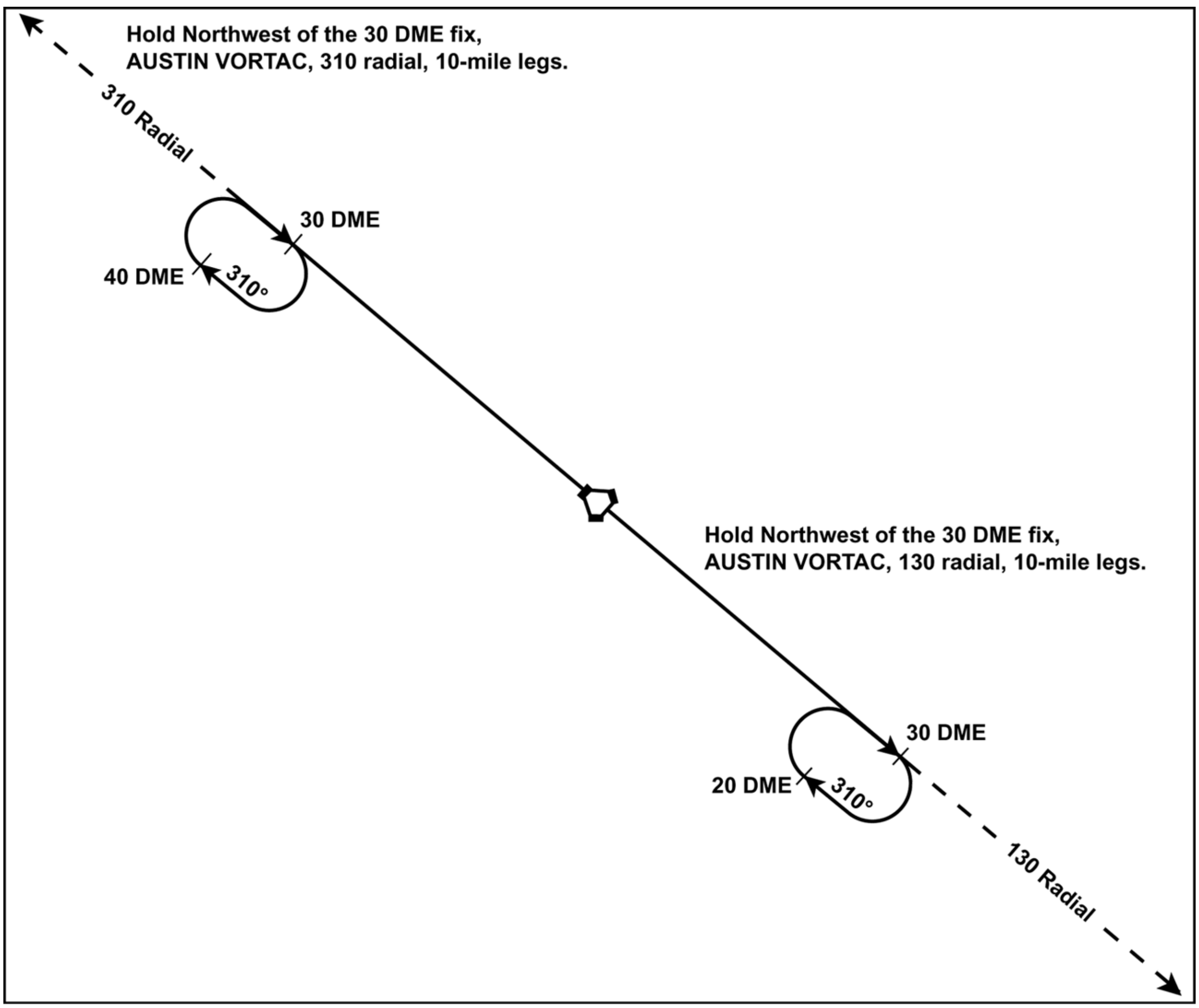
10.3.5.3. TACAN/DME/RNAV. ***For TACAN, charted DME holding, or RNAV holding; start turns at the specified DME limit or RNAV distance***.

10.3.5.4. Timed Approaches. ***When you receive a clearance specifying the time to depart a holding pattern, adjust the pattern within the limits of the established holding procedure so as to depart at the time specified***.

10.4. FMS Holding Procedures. FMSs may provide navigation guidance for holding pattern construction and entry. Depending on specific aircraft equipage, FMS holding pattern entry procedures may not match FAA or ICAO standards. Aircrews are responsible for understanding aircraft-specific FMS holding procedures and ensuring that holding entry procedures match the appropriate FAA/ICAO procedures. In some cases, pilot intervention may be required.

10.5. **Holding Pattern Suggestions**. Here are some suggestions and points to consider when flying holding patterns:

Figure 10.5. Copying Holding Instructions.



10.5.1. Copying Holding Instructions.

10.5.1.1. Direction. Compare the direction of holding to the wind arrow used in weather depictions. (The wind arrow shows the direction from which the wind comes.)

10.5.1.2. Fix. The head of the arrow is the fix; fly the inbound course to the head.

10.5.1.3. Draw. Draw or visualize the remainder of the pattern by the instructions given.

10.5.2. Timing.

10.5.2.1. Inbound Legs. After completing the first circuit of the holding pattern, adjust the time outbound as necessary to provide the desired inbound times. In extreme wind conditions, even though the turn inbound is initiated immediately after completing the outbound turn, the inbound leg may exceed the 1 or 1½ minute limit. In this case, you are authorized to exceed the time limit inbound.

10.5.2.2. Adjustments. Knowing the time it takes you to fly a holding pattern will allow you to meet an EFC. As an approximation, 1/100th of TAS will give the number of minutes to fly a 360° turn at 30° of bank. (For example, at 350 knots true airspeed (KTAS), a 360° turn takes about 3.5 minutes.) Aircraft flying standard rate turns cover 360° in 2 minutes. Add to the time for turning the number of minutes to fly the inbound and outbound legs.

10.6. Drift Corrections.

10.6.1. Calculating drift corrections. Knowledge of drift correction and TAS relationship can be very useful, especially in those instances where course guidance is not available; for example, the outbound leg of a holding pattern or a procedure turn. The following techniques may be used to determine approximate drift correction when the crosswind component is known:

10.6.1.1. Mach. Divide the crosswind component by the mach times 10. Example: 50 knots crosswind and 300 KTAS (.5M) = 10° drift correction, or

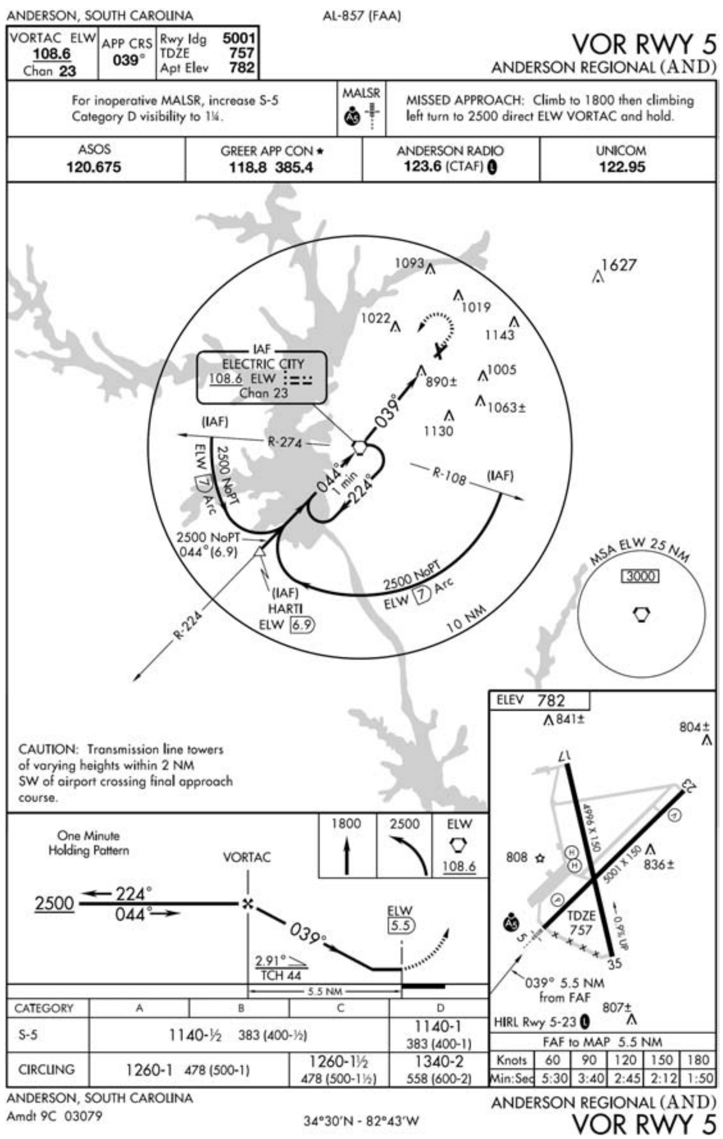
10.6.1.2. TAS. Divide the crosswind component by the aircraft speed in nautical miles per minute. Example: 30 knots crosswind and 180 KTAS (3NM per minute) 30÷3 = 10° drift correction.

10.6.2. Applying drift corrections. Compensate for wind effect primarily by drift correction on the inbound and outbound legs. When outbound, triple the inbound drift correction; e.g., if correcting left by 8 degrees when inbound, correct right by 24 degrees when outbound.

10.7. High Altitude Approach Plate Depiction (postage stamp). Holding pattern entry turns depicted on high altitude approach charts are provided for pilot convenience and are consistent with the intent of the AIM entry procedures. The teardrop depiction shows a teardrop entry if the aircraft heading is within 35° of a 30° teardrop course at the holding fix passage.

10.8. Descent. If you are established in a holding pattern that has a published minimum holding altitude, and are assigned an altitude above that published altitude, you may descend to the published minimum holding altitude when you have been cleared for the approach (unless specifically restricted by ATC). Minimum holding altitude is the same as the IAF altitude for holding patterns where the IAF is located in the holding pattern unless otherwise noted or depicted. For those holding patterns where there is no published minimum altitude at the IAF and no depicted holding altitude, the minimum holding altitude is the same as the minimum altitude at the FAF (or next segment). In this case, upon receiving an approach clearance, maintain the last assigned altitude until established on a segment of the instrument approach procedure being flown. (If a lower altitude is desired, request clearance from the controlling agency.)

Figure 10.6. Minimum Holding Altitude.



Chapter 11

ARRIVAL

11.1. En Route Descent Procedure/Technique.

11.1.1. En route. The en route descent frequently allows a pilot to transition from an en route altitude to the final approach instead of flying an entire FLIP IAP. It may be flown either via radar vectors or nonradar routings, using approved navigation aids. ATC will not insist on an en route descent. ATC will not authorize an en route descent if abnormal delays are anticipated, nor will they terminate the service without the pilot's consent except in an emergency.

11.1.2. Final Approach. The type of final approach to be flown must be understood by you and the controller (ILS, PAR, visual pattern, etc.). Except for radar finals, request an en route descent to a specific final approach. If the requested en route descent is to a radar final, select a backup approach that is compatible with existing weather and aircraft equipment. If you experience lost communications, you are automatically cleared to fly any published approach. For further guidance on lost communications, see the FIH.

11.2. Descent. ATC requirements probably have more influence over when to begin the descent than any other single factor. Other items to consider before starting an en route descent are range, desired descent rate, weather, terrain, and low altitude fuel consumption. If ATC issues a radar vector and/or an altitude to maintain, all applicable altitude restrictions must be restated if the vector takes the aircraft off an assigned procedure that contains altitude restrictions or previously issued clearance included crossing restrictions.

11.2.1. Descend at an optimum rate (consistent with the operating characteristics of the aircraft) to 1,000 feet above the assigned altitude. Then attempt to descend at a rate of between 500 and 1,500 fpm until the assigned altitude is reached. ***If at anytime you are unable to descend at a rate of at least 500 fpm, advise ATC.*** Advise ATC if it is necessary to level off at an intermediate altitude during descent. An exception to this is when leveling off at 10,000 feet MSL on descent, or 2,500 feet above airport elevation (prior to entering a Class B, Class C, or Class D surface area) when required for speed reduction.

11.2.1.1. NOTE: FAA controllers are not required to respond to clearance readbacks. However, if the readback is incorrect or incomplete, the controller should make corrections. Absence of a correction does not imply your readback was correct. The controller may not hear the mistaken readback.. If you are unsure of the clearance and/or instructions, query the controller.

11.2.1.2. CAUTION: Descent gradients in excess of 10° (1,000 ft/nm) in IMC may induce spatial disorientation. In addition, exceeding a 10° descent gradient below 15,000 feet AGL substantially decreases margin for error in avoiding obstacles and terrain, and may not provide effective radar monitoring.

11.2.2. Starting Descent. ***Before starting descent, review the IAP for the type of final planned, recheck the weather (if appropriate), check the heading and attitude systems,***

and coordinate lost communication procedures (if required). Review of the IAP for any approach (non-precision and precision) should include, but is not limited to, the following: minimum and/or emergency safe altitudes, navigation frequencies, descent rates, approach minimums, missed approach departure instructions, and aerodrome sketch.

11.2.3. During Descent.

11.2.3.1. Descent Rate. During the descent, control descent rate and airspeed to comply with any altitude or range restrictions imposed by ATC.

11.2.3.2. Reduce Airspeed. Reduce airspeed to 250 KIAS or less when below 10,000 feet MSL as required by AFI 11-202 Volume 3 *General Flight Rules*.

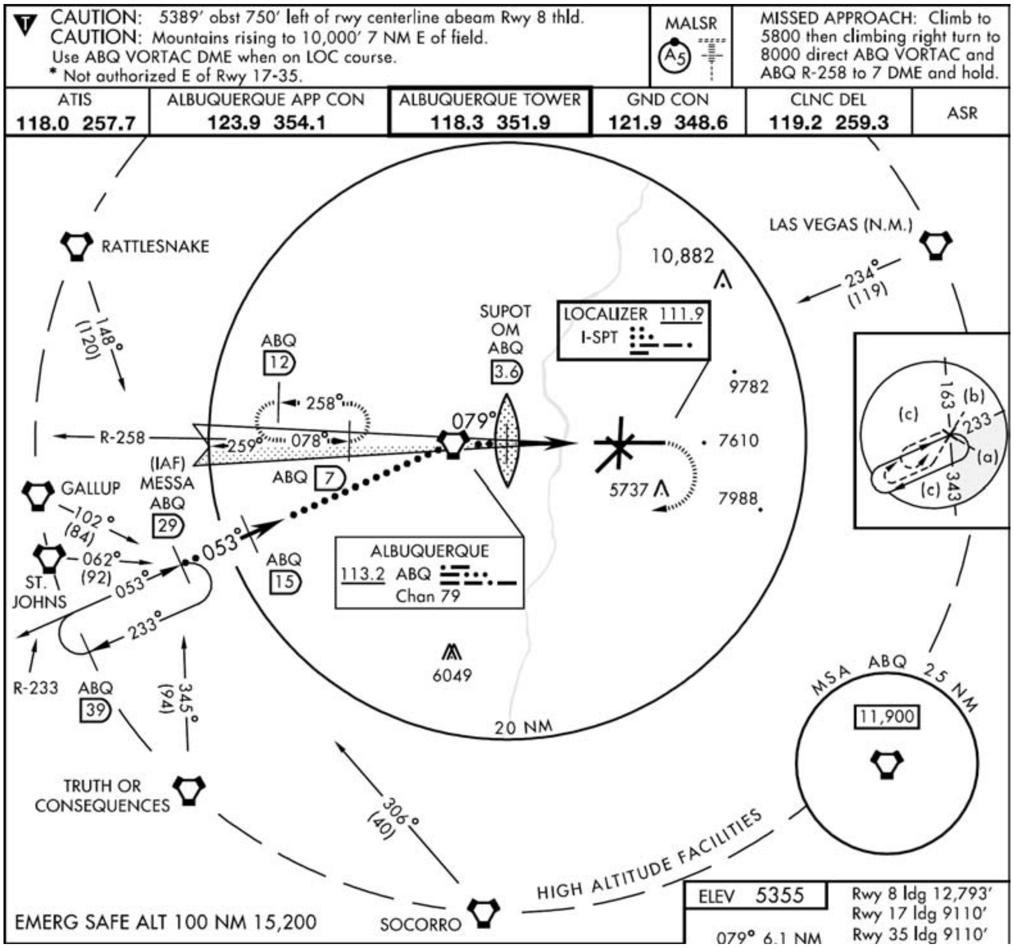
11.2.3.3. Radar Vectors. When descending via radar vectors, remain oriented in relation to the final approach fix by using all available navigation aids. Have the IAP available for the approach to be flown along with an alternate or backup procedure to be used if available. Note the minimum safe, sector, or emergency safe altitudes. Be prepared to fly the approach when cleared by the controller. ***Once cleared for the approach, maintain the last assigned altitude and heading until established on a segment of a published route or IAP.*** Use normal lead points to roll out on course. Do not climb above last assigned altitude to comply with published altitude restrictions unless instructed to do so. If at any time there is doubt as to whether adequate obstacle clearance is provided or controller instructions are unclear, query the controller. The controller should inform you if radar contact is lost and provide you with a new clearance or additional instructions. If advised that radar contact is lost while in IFR conditions and there is a delay in receiving new instructions, ask the controller for a new clearance or advise the controller of your intentions. (This is particularly important if below minimum safe, sector, or emergency safe altitude.)

11.3. Established on Course. The ICAO defines "established on course" as being within half full-scale deflection for an ILS or VOR/TACAN/RNAV/GPS procedure and within ± 5° of the required bearing for the NDB. The FAA does not define "established on course," however in the interest of consistency, the USAF has adopted the ICAO standard as a procedure. Adherence to the ICAO standard will insure you are within protected airspace when conducting an approach. Therefore, ***do not consider yourself "established on course" until you are within these limits***.

11.4. High Altitude Procedures.

11.4.1. Terminal Routings. Terminal routings from en route or feeder facilities normally provide a course and range in nautical miles (not DME) to the IAF but in some circumstances may take you to a point other than the IAF. If you use other than a published routing, do not exceed the operational limitations of the selected NAVAIDs.

Figure 11.1. Feeder Routes (High Altitude).



11.4.2. Before the IAF. ***Before reaching the IAF, review the IAP, recheck the weather (if appropriate), check the heading and attitude systems, and obtain clearance for the approach***. If holding is not required, reduce to penetration airspeed or below before reaching the IAF. Accomplish the descent check in accordance with the aircraft flight manual. Set the altimeter in accordance with FLIP instructions.

11.4.3. En route Approach Clearance. ***If cleared for an approach while en route to holding fix that is not collocated with the IAF, proceed to the IAF via the holding fix, unless specifically cleared to proceed direct to the IAF. However, if the IAF is located along the route of flight to the holding fix, begin the approach at the IAF.*** If in doubt as to the clearance, query the controller.

11.4.4. Approach Clearance. ***When ATC issues an approach clearance, proceed to the IAF then turn immediately in the shortest direction to intercept the approach course.*** Clearance for the approach does not include clearance to use holding airspace. ***However, if you are established in holding and cleared for the approach, complete the holding pattern to the IAF unless an early turn is approved by ATC.*** If your heading to the IAF is within 90° of the approach course, you may use normal lead points to intercept the course. If your heading is not within 90° of the approach course and you desire to maneuver the aircraft into a more favorable alignment prior to starting the approach, obtain clearance from ATC.

Figure 11.2. Cleared for the Approach While En Route to the Holding Fix.

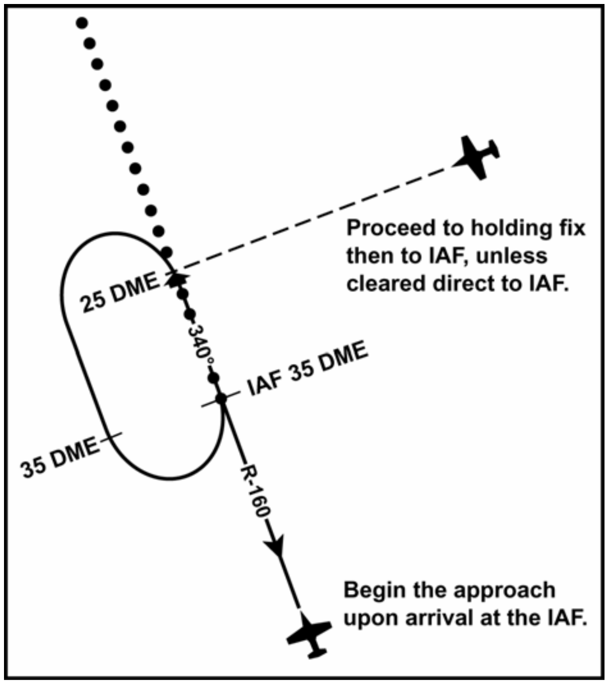
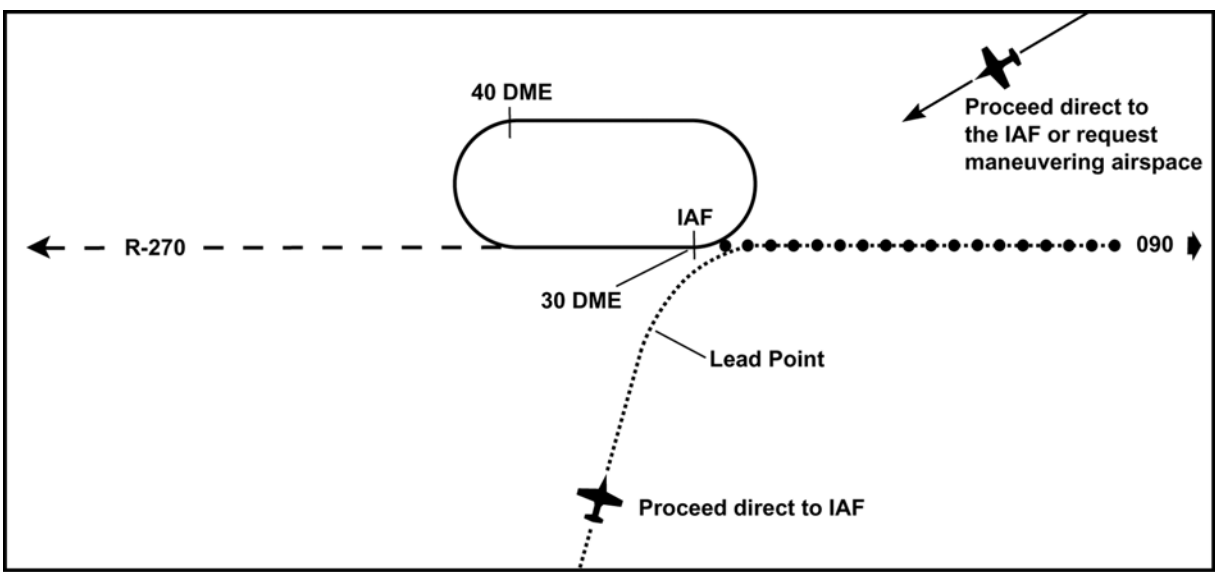


Figure 11.3. Leading the Turn at the IAF.



11.4.5. Altitude. ***When cleared for the approach, maintain the last assigned altitude until established on a segment of the published routing or IAP. Once on the published routing or a segment on the IAP, do not descend below the minimum safe altitude for that segment. High altitude penetration descent may be initiated when abeam or past the IAF with a parallel or intercept heading to the course***. The controller should assign you the depicted IAF altitude. If you are not assigned the IAF altitude and cannot make the descent gradient by starting the penetration from your last assigned altitude, request a lower altitude.

11.4.5.1. NOTE: For non-DME teardrop approaches, you should not penetrate from an altitude above the depicted IAF altitude. If maneuvering, such as a holding pattern, is necessary to lose excess altitude, obtain clearance to do so. Remember that you must be able to comply with subsequent mandatory and maximum altitudes.

11.5. Low Altitude Procedures.

11.5.1. Terminal routings. Terminal routings from en route or feeder facilities are considered segments of the IAP and normally provide a course, range, and minimum altitude to the IAF. They may take the aircraft to a point other than the IAF if it is operationally advantageous to do so. If you use other than a published routing, do not exceed the operational limitations of the selected NAVAIDs. A low altitude IAF is any fix labeled as an IAF or any procedure turn/holding-in-lieu-of a procedure turn fix.

11.5.2. Ranges and Altitudes. Ranges published along the terminal routing are expressed in nautical miles (not DME). The altitudes published on terminal routing are minimum altitudes and provide the same protection as an airway MEA.

11.5.3. Before the IAF. ***Before reaching the IAF, review the IAP chart, recheck the weather (if appropriate), check the heading and attitude systems, and obtain clearance for the approach***. If holding is not required, reduce to maneuvering airspeed before reaching the IAF. Accomplish the descent check in accordance with the aircraft flight manual.

11.5.4. Enroute Approach Clearance. ***If cleared for an approach while en route to a holding fix that is not collocated with the IAF, either proceed via the holding fix or request clearance direct to the IAF*** **(Figure 11.2).** ***If the IAF is located along the route of flight to the holding fix, begin the approach at the IAF. If you overfly a transition fix, fly the approach via the terminal routing.*** If in doubt as to the clearance, query the controller.

11.5.5. Altitude. ***When cleared for the approach, maintain the last assigned altitude until established on a segment of a published route or IAP.*** At that time, the pilot may descend to the minimum altitude associated with that segment of the published routing or instrument approach procedure.

11.5.6. Approach Clearance. When clearance for the approach is issued, ATC expects an immediate turn in the shortest direction to intercept the procedural course upon reaching the IAF. Clearance for the approach does not include clearance for the holding airspace. ***However, if established in holding and cleared for the approach, complete the holding pattern to the IAF unless an early turn is approved by ATC.*** If your heading is within 90° of the procedural course, you may use normal lead points to intercept the course. If your heading is not within 90° of the procedural course, you may need to maneuver the aircraft for a more favorable alignment prior to starting the approach. If maneuvering (other than an immediate turn at the IAF to intercept the procedural course) is desired, obtain clearance from ATC since clearance for the approach does not include clearance for use of holding or maneuvering airspace.

11.5.6.1. NOTE: ATC will not assign an altitude that does not provide obstacle clearance; however, pilots are ultimately responsible for terrain clearance. The following information will aid you in monitoring assigned altitudes:

11.5.6.2. Low altitude charts may provide several different altitudes that will ensure obstacle clearance, depending upon aircraft position.

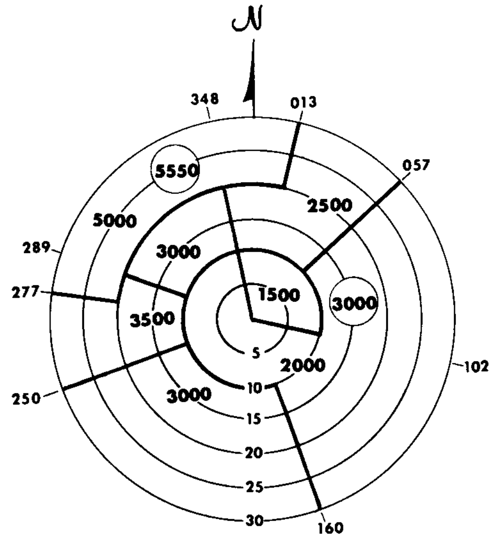
11.5.6.3. If proceeding to an IAF via an airway, the MEA/MOCA will provide obstacle clearance. If using a published terminal route, the published minimum altitude along that route ensures obstacle clearance.

11.5.6.4. If not proceeding via a published route, obstacle clearance can be guaranteed by maintaining the OROCA, ORTCA, minimum sector altitude, or emergency safe altitude (depending upon aircraft position and altitudes printed on the approach chart).

11.5.6.5. If you require a lower altitude to start the approach, request it from ATC. Remember that you may start an approach at a higher than published IAF altitude provided it is not a mandatory or maximum altitude. If you do this, you must comply with the remaining altitude restrictions on the approach. If maneuvering is required to lose excess altitude prior to starting the approach, a clearance from ATC is also required.

11.6. Radar Vectors. The use of radar vectors is the simplest and most convenient way to position an aircraft for an approach. Using radar, air traffic controllers can position an aircraft at almost any desired point, provide obstacle clearance by the use of minimum vectoring altitudes, and ensure traffic separation. This flexibility allows an aircraft to be vectored to any segment of a published routing shown on the IAP or to a radar final. Radar controllers use MVA charts that are prepared by the air traffic facilities at locations where there are numerous different minimum IFR altitudes. The MVA chart is divided into sectors that are large enough to accommodate vectoring of aircraft within the sector at the MVA. Minimum altitudes are established at 1,000 feet or 2,000 feet in designated mountainous areas (in mountainous areas, MVAs may be authorized at 1,000 feet in order to achieve compatibility with terminal routes or IAPs). Obstructions may be enclosed in a 3 NM buffer area (5 NM if the obstruction is beyond 40 NM from the radar antenna); MVAs may be lower than nonradar MEAs/MOCAs. They may also be below emergency safe, or minimum sector altitudes. When being radar vectored, IFR altitude assignments will be at or above MVA.

Figure 11.4. Minimum Vector Altitude (MVA) Chart.



11.6.1. WARNING: "Traffic Advisories" is an additional service that the controller will provide to you if the workload permits. Be aware that traffic information while on a PAR final is almost nil due to narrow azimuth scan of the PAR equipment. "Radar monitoring" during a nonprecision instrument approach will not provide altitude warning information if the aircraft descends below a safe altitude. The controller may vector the aircraft to any segment of an IAP prior to the FAF and clear an aircraft for an approach from that point. The controller will issue an approach clearance only after you are established on a segment of the IAP; or you will be assigned an altitude to maintain until you are established on a segment of the IAP. The following general guidance applies to the radar controller when positioning an aircraft for a final approach:

11.6.2. Radar Vector Weather Requirements. When the reported ceiling is at least 500 feet above the minimum vectoring altitude and the visibility is at least 3 miles, aircraft will be vectored to intercept the final approach course as follows:

11.6.2.1. At least 1 mile from the FAF at a maximum intercept angle of 20°.

11.6.2.2. At least 3 miles from the FAF at a maximum intercept angle of 30°.

11.6.3. Final Approach Intercept Requirements. At all other times, unless specifically requested by the pilot, aircraft will be vectored to intercept the final approach course at least 3 miles from the FAF at a maximum intercept angle of 30°.

11.6.4. Vectoring Requirements. In either case, aircraft will be vectored:

11.6.4.1. At an altitude not above the glide slope for a precision approach.

11.6.4.2. At an altitude that will allow descent in accordance with the published procedure for a nonprecision approach.

11.6.4.3. NOTE: These procedures do not apply to vectors to a visual approach.

11.7. Pilot Responsibilities.

11.7.1. During Vectors. ***While being radar vectored, repeat all headings, altitudes***

(departing and assigned), and altimeter settings; and comply with controller instructions.

11.7.2. Orientation. Remain oriented in relation to the final approach fix by using available navigation aids. ***Have the printed IAP available for the approach to be flown***. Note the minimum sector, or emergency safe altitudes. Start the before-landing checklist (landing check), review approach minimums, and determine the approximate initial rate of descent required on final approach. Be prepared to fly the approach when cleared by the controller. ***Once you receive approach clearance, maintain the last assigned altitude and heading until established on a segment of a published routing or IAP***. Use normal lead points to roll out on course. Then use any available means (such as DME, crossing radials, or radar) to accurately determine your position. From that point, comply with all course and altitude restrictions as depicted on the approach procedure except that you must not climb above the last assigned altitude to comply with published altitude restrictions unless so instructed by the controlling agency. Establish final approach configuration and airspeed prior to the FAF (unless flight manual procedures require otherwise).

11.7.3. Maneuvering. If maneuvering is required to lose excess altitude prior to the FAF, obtain a clearance from the controlling agency. Descent maneuvering may include execution of a procedure turn, descent in a published holding pattern, additional radar vectors, or other such maneuver.

11.7.3.1. CAUTION: If at any time there is doubt as to whether adequate obstacle clearance is provided, or controller instructions are unclear, query the controller. The controller should inform you if radar contact is lost and give a new clearance or instructions. If you are advised that radar contact is lost and there is a delay in receiving new instructions, ask the controller for a new clearance or advise the controller of your intentions. (This is particularly important if below minimum sector, or emergency safe altitude.)

11.8. Standard Terminal Arrivals (STARs).

11.8.1. Definition. A STAR is an ATC coded IFR arrival route established for assignment to arriving IFR aircraft for certain airports. The purpose of a STAR is to simplify clearance delivery procedures and facilitate transition between enroute and instrument approach procedures.

11.8.1.1. STARs can be based on conventional NAVAIDS or RNAV. For all STARs, follow the guidance in the following paragraphs. For RNAV-specific procedures, see paragraphs 11.8.1.2.

11.8.1.1.1. Mandatory Speeds and/or Altitudes. Some STARs may have mandatory speeds and/or crossing altitudes published. Some STARs have planning information depicted to inform pilots what clearances or restrictions to "expect." "Expect" altitudes/speeds are not considered STAR restrictions until verbally issued by ATC. They are published for planning purposes and should not be used in the event of lost communications unless ATC has specifically advised the pilot to expect these altitudes/speeds as part of a further clearance. Additionally, STARs will normally depict MEAs. MEAs are not considered restrictions. However, pilots are expected to remain above MEAs.

11.8.1.1.2. Altitude Clearance. ***Pilots shall maintain last assigned altitude until receiving authorizations/clearance to change altitude.*** At that time, ***pilots are expected to comply with all published/issued restrictions***. The authorization may be via a normal descent clearance or the phraseology "DESCEND VIA."

11.8.1.1.2.1. Example of Lateral Routing Clearance Only. "Track 32, cleared the EAU CLAIRE SIX ARRIVAL." In this case, you are cleared the EAU CLAIRE SIX routing but are expected to maintain your present altitude awaiting further clearance.

11.8.1.1.2.2. Example of Routing with Assigned Altitude. "Fame 22, cleared EAU CLAIRE SIX arrival; descend and maintain flight level two four zero." In this situation, you are cleared via the EAU CLAIRE SIX routing and cleared to descend to FL240.

11.8.1.1.2.3. "DESCEND VIA" Clearances. A "DESCEND VIA" clearance authorizes pilots to vertically and laterally navigate, in accordance with the depicted procedure, to meet published restrictions. Vertical navigation is at pilot's discretion; however, ***adherence to published altitude crossing restrictions and speeds is mandatory unless otherwise cleared.*** MEAs are not considered restrictions; however, pilots are expected to remain above MEAs.

11.8.1.1.2.4. Example of "DESCEND VIA" Clearance. "Track 66, Descend Via the EAU CLAIRE SIX arrival." If you receive this "DESCEND VIA" clearance, you are expected to vertically and laterally navigate in accordance with the EAU CLAIRE SIX arrival.

11.8.1.1.2.4.1. Notify ATC. Pilots cleared for vertical navigation using the phraseology "Descend Via" shall inform ATC upon initial contact with a new frequency. For example, "Track 32, descending via the EAU CLAIRE SIX ARRIVAL."

11.8.1.1.3. Anticipate Use of STARs. Normally, pilots of IFR aircraft destined to locations where STARs have been published should expect to be issued a clearance containing the appropriate STAR for the destination airport.

11.8.1.1.4. Must Have Chart. Use of STARs requires pilot possession of at least the approved chart. As with any ATC clearance or portion thereof, it is the responsibility of each pilot to accept or refuse an issued STAR. Pilots should notify ATC if they do not wish to use a STAR by placing "NO STAR" in the remarks section of the flight plan or by verbally stating the same to ATC (this is the less desirable method).

11.8.1.1.5. Pilot Responsibilities. Before filing or accepting a clearance for a STAR, make sure you can comply with any altitude and/or airspeed restrictions associated with the procedure. If you filed a STAR in your flight plan, then an initial ATC clearance of "Cleared as filed" clears you for the STAR routing (not altitudes) as well. Clearance for the STAR is not clearance for the approach the procedure may bring you to.

11.8.1.1.6. Where STARs Are Published. The DoD FLIP STAR book contains many, but not all of the CONUS STARs. Its contents are determined by military requirements. The NACO IAP books contain all STARs, both DoD and civil. They are located in the front of the appropriate IAP book for the airport of arrival. In areas outside CONUS, STARs are generally included in the appropriate FLIP terminal book along with the airport's IAPs.

11.8.1.2. RNAV STARs. RNAV STARs can be stand-alone or "overlay". In order to fly a STAR using RNAV (either stand-alone or "overlay"), comply with the following:

11.8.1.2.1. ***Aircraft equipment must meet requirements specified on the STAR.***

11.8.1.2.2. ***Aircraft RNAV system must meet appropriate certification standards as addressed in AFI 11-202 Volume 3 General Flight Rules.***

11.8.1.2.3. ***Procedure must be retrieved in its entirety from a current, approved navigation database***. Waypoint and waypoint type (e.g., flyby, flyover) may not be modified.

11.8.1.2.4. ***Pilots must verify all waypoint names, waypoint type (flyby vs. flyover), altitude, and airspeed information from the database against information listed on the paper copy of the terminal procedure. Should differences between the approach chart and database arise, the published approach chart, supplemented by NOTAMs, holds precedence. Users may not alter terminal procedures retrieved from the equipment database.***

11.8.1.2.4.1. Aircrews must verify the information in the database with the published STAR. ***The maximum allowable difference between the database course(s) and published course(s) is ±5°.***

11.8.1.2.4.2. Certain segments of a STAR may require some manual intervention by the pilot, especially when radar vectored to a course or required to intercept a specific course to a waypoint. This is permissible, as this is not altering the waypoints retrieved from the database; it is insuring the navigation system properly executes the procedure.

11.8.1.2.5. ***If GPS is used, RAIM must be available to execute the procedure. Terminal (or better) RAIM must be available.***

11.8.1.2.5.1. System must either provide RAIM alerts based on terminal criteria, or pilot must be able to monitor navigation performance (Actual Navigation Performance).

11.8.1.2.5.1.1. NOTE: Terminal RAIM for a STAR may not be available unless the waypoints are part of the active flight plan.

11.8.1.2.5.1.2. NOTE: Actual Navigation Performance (ANP) is a technical term that describes the navigation accuracy of the system. Other terms synonymous with ANP are Figure of Merit, Estimation of Position Uncertainty, or Quality Factor.

11.8.1.2.6. ***Comply with any navigation system requirements if published on the***

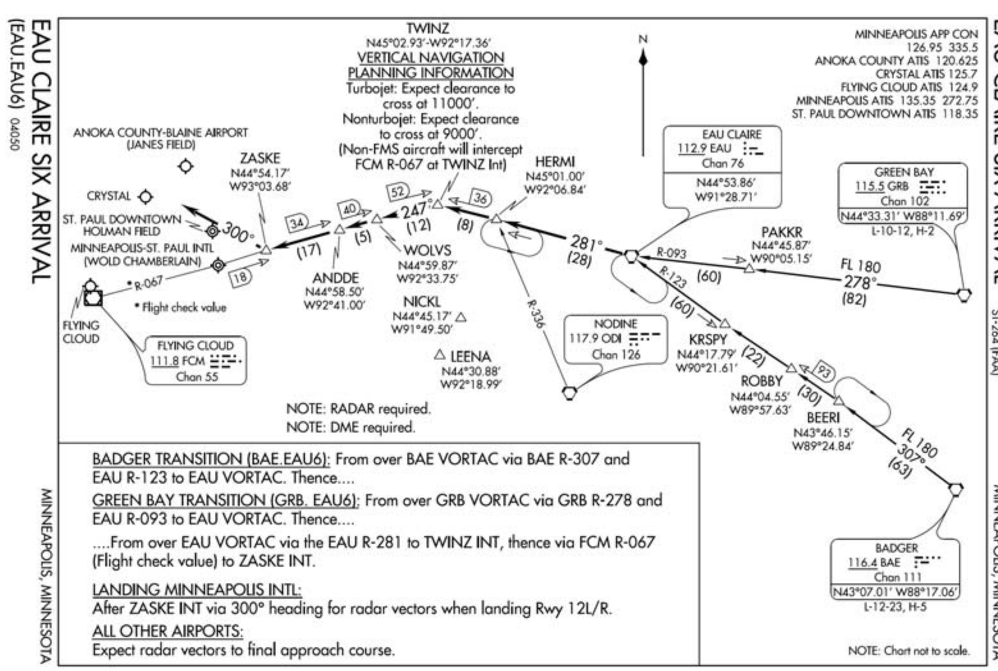
STAR (ex. /E, /G, etc.).

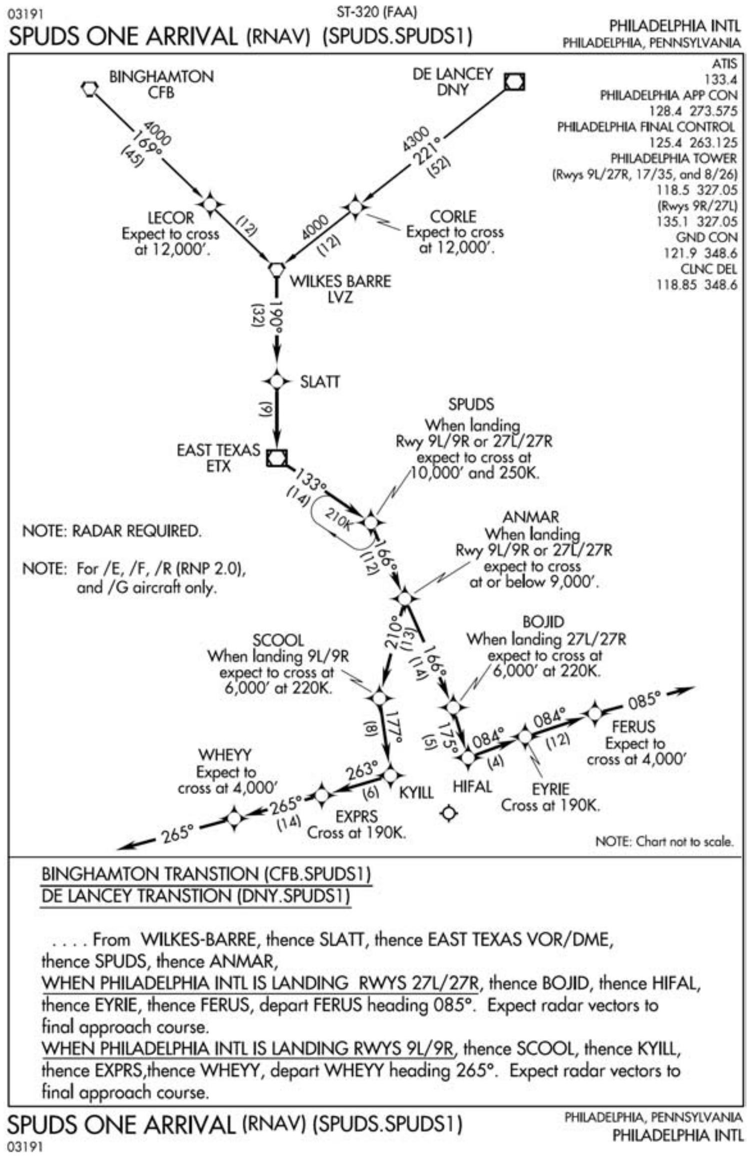
11.8.1.2.7. ***Underlying NAVAIDS must be monitored if available for stand-alone RNAV STARs.***

11.8.1.2.8. STARs based on conventional NAVAIDS in some cases are retrievable from an RNAV database. ***USAF aircrews are authorized to fly these procedures as an "overlay" in IMC provided it is retrieved from the database and underlying NAVAIDS are installed, operational, tuned, and monitored.***

11.8.1.2.8.1. In some cases, because of the software programming, there can be tracking inaccuracies when flying non-RNAV/FMS STARs using an FMS. These tracking inaccuracies have resulted in less-than-required air traffic control separation and air traffic control intervention to prevent a possible Controlled Flight Into Terrain (CFIT) accident. Non-RNAV/FMS procedures often require navigational tracking over all the specified fixes. Many FMS databases code the points in these procedures as Fly-by waypoints, instead of Fly-over waypoints. Unlike a stand-alone RNAV STAR, which will specify on the printed FLIP which waypoints are Fly-by and which are Fly-over, a conventional STAR will not make this distinction. Consequently, the FMS will lead the turn on these points. This turn anticipation could result in a turn being started miles prior to the expected turn point depending on the amount of required track change, wind, and true airspeed. When verifying waypoints prior to flying a non-RNAV/FMS STAR using an FMS, aircrews must determine how the points are coded (Fly-by vs. Fly-over) in their database. If there are large course changes coded as Fly-by waypoints, the aircrew must be prepared to manually intervene to insure the aircraft tracks the procedure as published to remain within protected airspace.

Figure 11.5. Standard Terminal Arrival (STAR).





11.9. Flight Management System Procedures (FMSP) for Arrivals.

11.9.1. FMSPs for arrivals serve the same purpose as STARs but are only used by aircraft equipped with Flight Management Systems (FMS). Procedures for flying FMSPs are identical to any other STAR. FMSPs will list the equipment requirements for flying the procedure (/E, /G, etc.).

Chapter 12

HIGH ALTITUDE APPROACHES

12.1. Application. An en route descent or a high altitude instrument approach enables an aircraft to transition from the high altitude structure to a position on and aligned with an inbound course to the FAF, at FAF altitude in the final approach configuration. ATC will usually issue a clearance for a specific type of approach. The omission of a specific type in the approach clearance indicates that any published instrument approach to the aerodrome may be used. ***Unless you receive an appropriate ATC clearance to deviate, fly the entire instrument approach procedure starting at the IAF.***

12.2. **Non-DME Teardrop Approaches**. Teardrop approaches are usually associated with VOR or NDB facilities (Figure 12.1).

12.2.1. Station Passage. ***When station passage occurs at the IAF, turn immediately in the shorter direction toward the outbound course and attempt to intercept it. Begin descent when you are established on a parallel or intercept heading to the approach course and outbound from the IAF. If you arrive at the IAF at an altitude below that published, maintain altitude and proceed outbound 15 seconds for each 1,000 foot the aircraft is below the published altitude before starting descent. If you arrive at the IAF at an altitude above that published, a descent to the published IAF altitude should be accomplished prior to starting the approach. If descent is required at the IAF, obtain clearance to descend in a holding pattern. Set the altimeter in accordance with FLIP.***

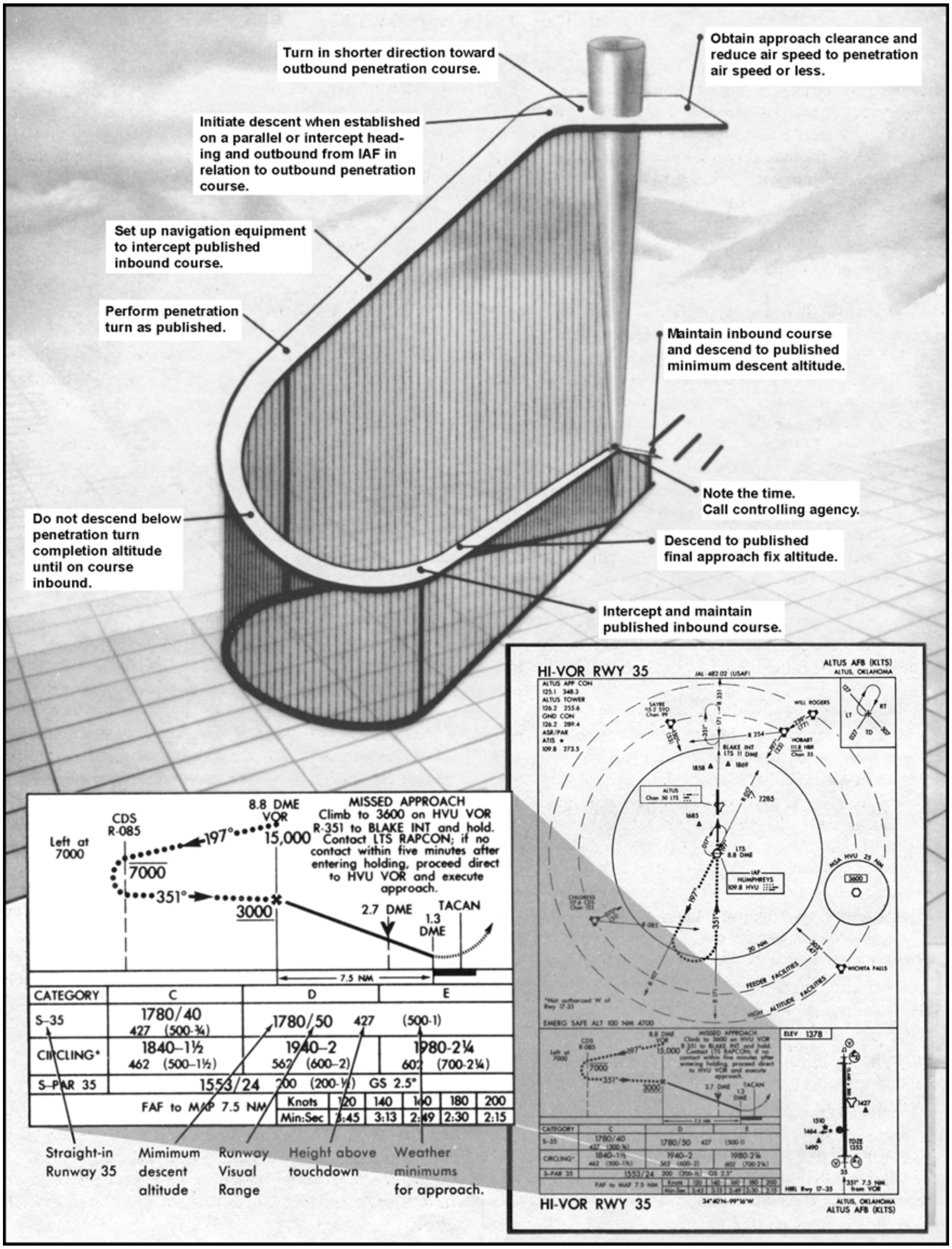
12.2.1.1 NOTE: Use a descent gradient of 800-1,000 ft/NM (8-10°) to ensure you remain within protected airspace.

12.2.2. Fly-off. Some approaches use a fly-off (altitude or range) restriction before starting descent. In these cases, ***attempt to intercept the outbound course and comply with the altitudes depicted on the approach chart unless otherwise instructed by ATC***. Since the pilot cannot be expected to determine accurate groundspeed during a constantly changing true airspeed descent, depicted range restrictions should not be shown on non-DME teardrop high altitude approaches. Penetration turns should be annotated "left or right turn at (altitude)." ***When a penetration turn altitude is not published, start the turn after descending one-half the total altitude between the IAF and FAF altitudes***. One technique to determine the start turn altitude is to add the IAF and FAF altitudes and divide by two. ***Before reaching the penetration turn altitude, set up the navigation equipment to intercept the published inbound approach course. Recheck the altimeter and the direction of penetration turn***.

12.2.3. Penetration Turn. ***Fly the penetration turn in the direction published***. A 30° angle of bank is normally used during the penetration turn; however, bank may be shallowed if undershooting course. If it is apparent that you will undershoot the inbound penetration course, roll out on an intercept heading. Use normal inbound course interception procedures to intercept the course.

12.2.3.1. NOTE: If a penetration turn completion altitude is depicted, do not descend below this altitude until you are established on the inbound segment of the published approach procedure. Remember, obstacle clearance is based on the pilot attempting to maintain the course centerline; a pilot must use position orientation and pilot judgment to determine when to descend while attempting to intercept the course.

Figure 12.1. Non-DME Teardrop-High Altitude Approach.



12.2.4. Descent. Continue descent to FAF altitude. Establish approach configuration and airspeed prior to the final approach fix unless the aircraft flight manual procedures require otherwise.

12.3. Radial Approaches. These approaches are associated with TACAN or VORTAC facilities (Figure 12.2). One or more radials form the entire approach track.

12.3.1. Crossing the IAF**.** ***When over the IAF, turn immediately in the shorter direction toward the approach course***. Intercept the published approach course using appropriate course intercept procedures. If your heading is within 90° of the approach course, you are not required to overfly the IAF; you may use normal lead points to intercept the course.

12.3.2. Descent. ***Start the descent when the aircraft is abeam or past the IAF on a parallel or intercept heading to the approach course***. (For DME approaches, crossing the arc is considered abeam the IAF.) ***Intercept the course and comply with the altitudes depicted on the approach chart***. (Aircraft configuration and airspeed requirements prior to the FAF are the same as for non-DME teardrop.)

Figure 12.2. Radial - High Altitude Approach.

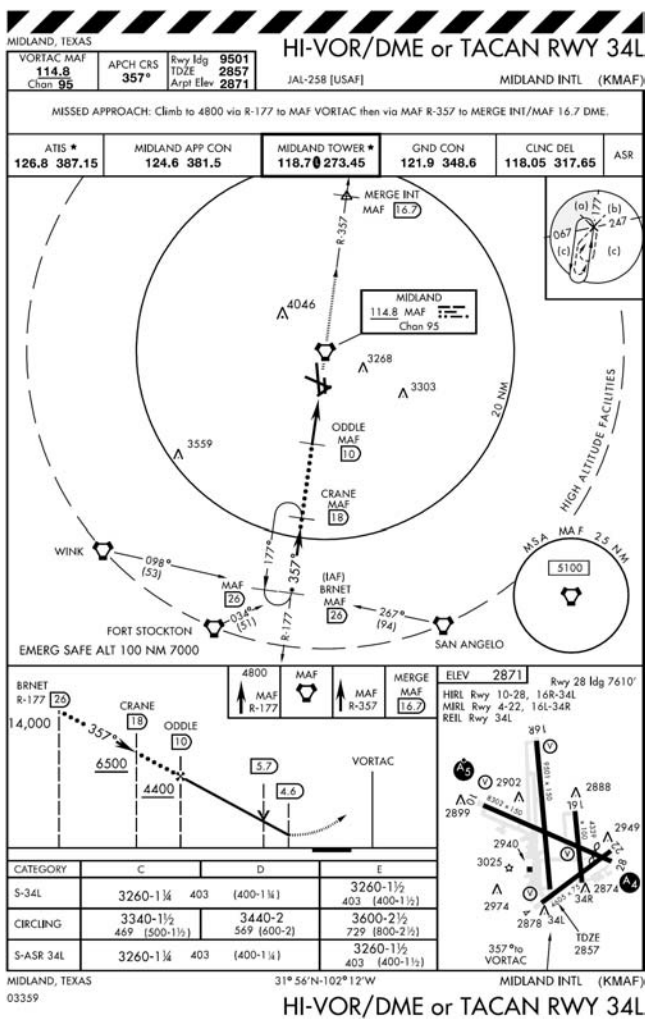
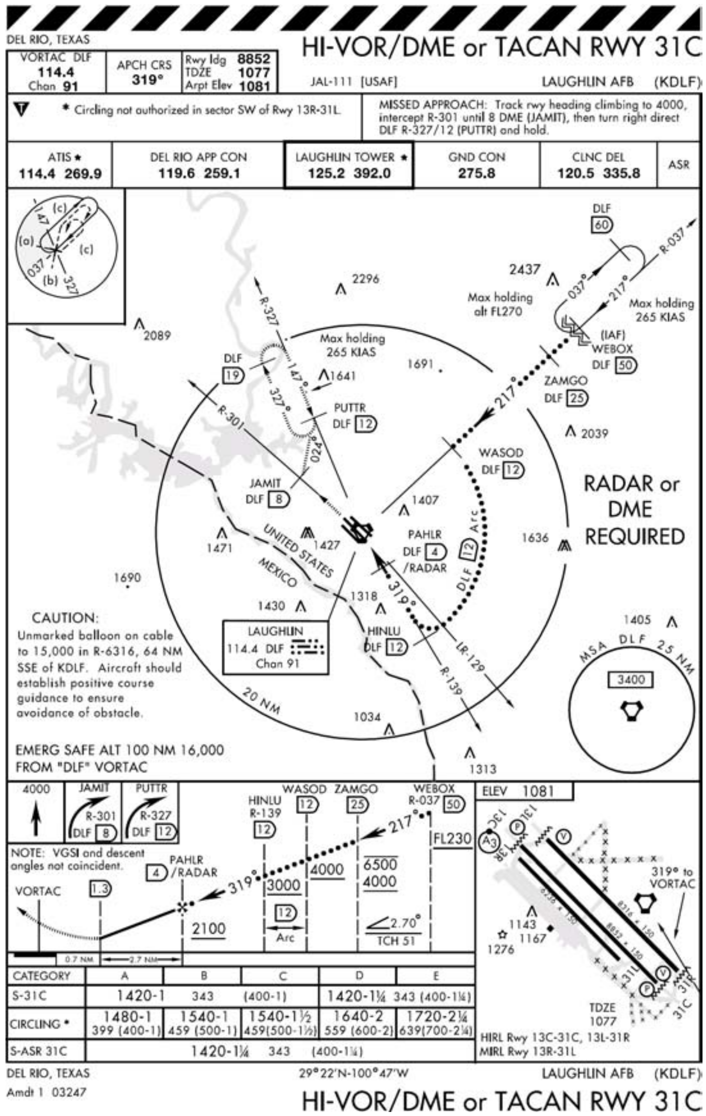
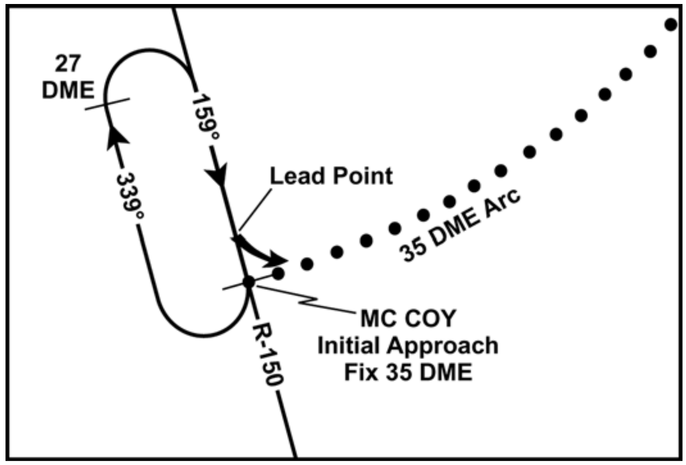


Figure 12.3. Radial and Arc Combination Approach.



12.4. **Radial and Arc Combination Approaches** (Figure 12.3). These require the use of arc intercept procedures. Flight procedures are the same as for a radial approach. However, if established in a holding pattern and the IAF is located on an arc or on a radial at a distance less than that required for a normal lead point, you may turn early to intercept the arc. ***Start the descent when you are established on an intercept to the arc and abeam or past the IAF in relation to the initial approach track***. (Aircraft configuration and airspeed requirements prior to the FAF are the same as for non-DME teardrop.) An arc or radial altitude restriction only applies while established on that segment of the approach to which the altitude restriction applies. Once a lead point is reached, and a turn to the next segment is initiated, the pilot may descend to the next applicable altitude restriction. This may be especially important to facilitate a reasonable rate of descent to final approach fix altitude.

Figure 12.4. Determining Lead Point.



12.4.1. NOTE: When an altitude restriction is depicted at a fix defined as an intersection of a radial and an ARC the restriction must be complied with no later than the completion of the lead turn associated with that fix. If the restriction is met during the lead turn, consider yourself established on the next segment and continue to descend to the next applicable altitude restriction.

12.5. **Multiple Facility Approaches** (Figure 12.5). The multiple facility type approach normally uses a combination of two or more VORs, NDB, TACANs, etc., to provide the track.

12.5.1. Entry Procedures. The approach entry procedures are the same as prescribed for non-DME teardrop approaches.

12.5.2. Restriction. ***The entire approach must be flown as depicted to comply with all course and altitude restrictions***. (Aircraft configuration and airspeed requirements prior to the FAF are the same as for non-DME teardrop approaches.)

12.6. Approach With Dead Reckoning (DR) Courses. Many IAPs utilize DR courses (Figure 12.6). Course guidance is not available; however, ***the DR course should be flown as closely as possible to the depicted ground track.***

12.6.1. Lead points. ***Use lead points for turns to and from the DR legs so as to roll out on the depicted ground track.***

12.6.2. Ground track. Attempt to fly the depicted ground track by correcting for wind.

Figure 12.5. Multiple Facility Approach

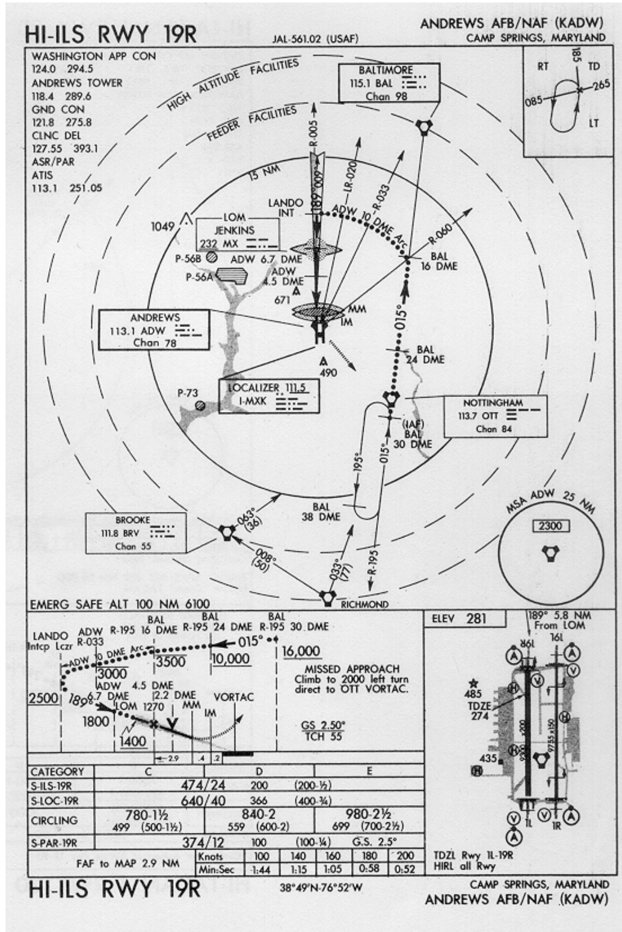
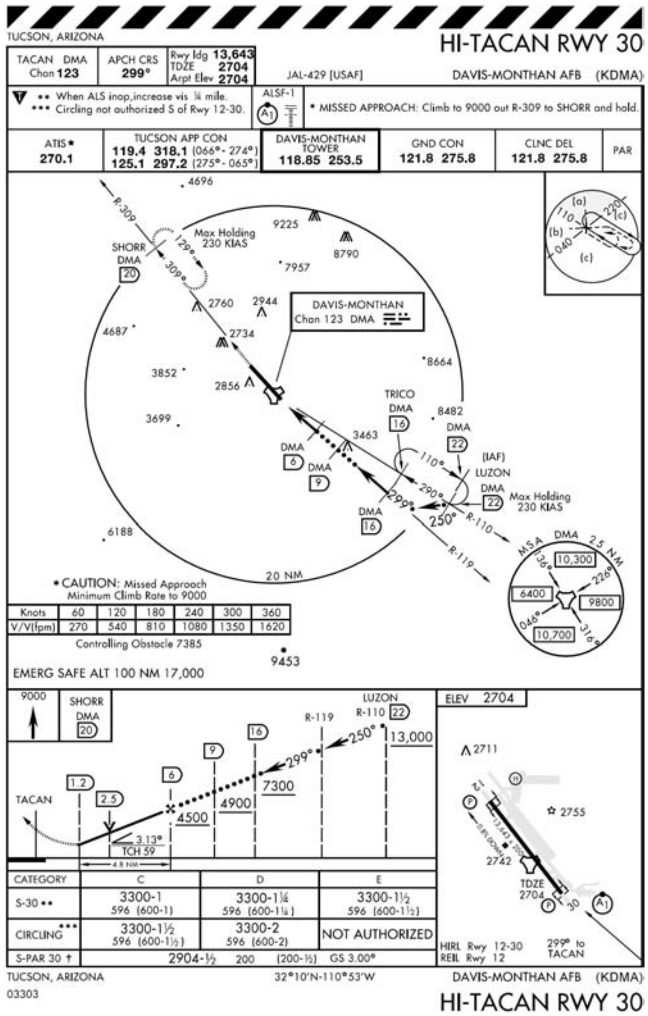


Figure 12.6. Dead Reckoning Courses.



Chapter 13

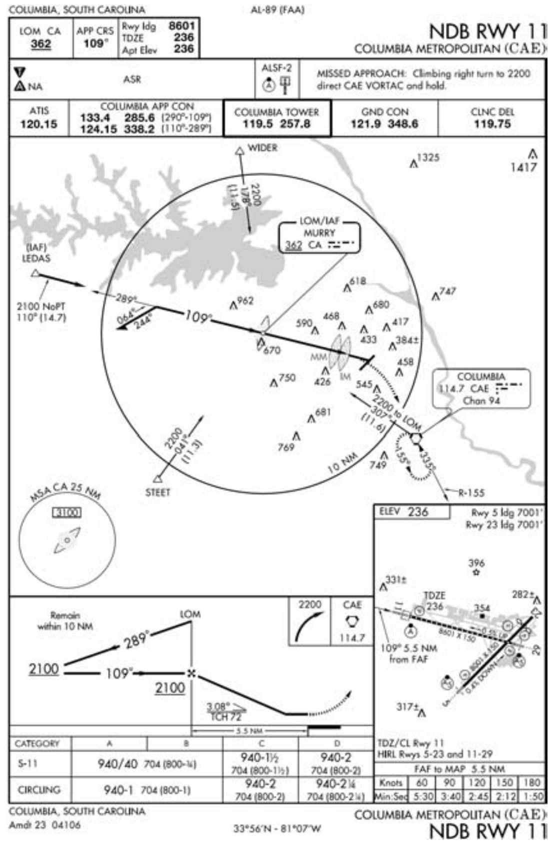
LOW ALTITUDE APPROACHES

13.1. Introduction. Low altitude approaches are used to transition aircraft from the low altitude environment to final approach for landing. Low altitude instrument approach procedures exist for one purpose -- to assist you in guiding your aircraft to the final approach fix, on course, on altitude, and in the final approach configuration. It has become normal to expect ATC to provide radar vectors to final; however, you must always be prepared to execute the "full procedure" when appropriate.

13.1.1. NOTE: This chapter deals primarily with low altitude approaches flown in FAA airspace. All procedures detailed in this chapter apply to FAA and ICAO airspace unless annotated otherwise in Chapter 18, ICAO Procedures.

13.1.2. CAUTION: Aircrews should use caution when flying a "high altitude" IAP in the low altitude environment, especially if there are multiple approaches based on the same NAVAID at the airport. If you are receiving radar vectors in the low altitude structure, ATC expects you to fly the low altitude version of the approach. Often the high and low altitude approaches are the same, but sometimes they are not. Ask for and receive a clearance for the exact approach you intend to fly. Query the controller if you receive an unclear or incomplete approach clearance.

Figure 13.1. Low Altitude Approach.

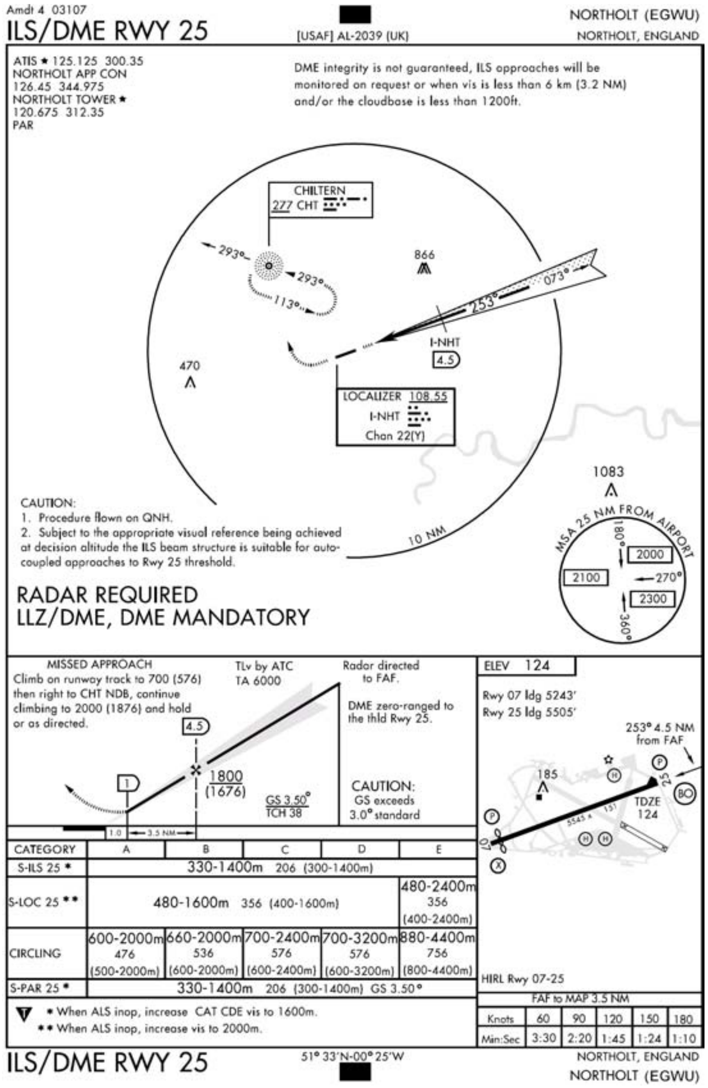


13.2. **Overview.** There are two broad categories of low altitude approaches: course reversals and procedure tracks. Before we look at each type in detail, here are some guidelines that apply to all low altitude approaches:

13.2.1. Initial Approach Fix (IAF). Most approaches begin at an IAF. ATC will normally clear you to the appropriate IAF and then clear you for the approach. ***Unless ATC specifically clears you otherwise, you are expected to fly to the IAF and execute the full instrument approach procedure as published.***

13.2.2. Final Approach Segment. Some approaches depict only a final approach segment, starting at the FAF. In these cases, radar is required to ensure you are properly aligned with the final approach course at the appropriate altitude. ***When ATC clears you for the approach, maintain the last assigned altitude until established on a segment of the published IAP.***

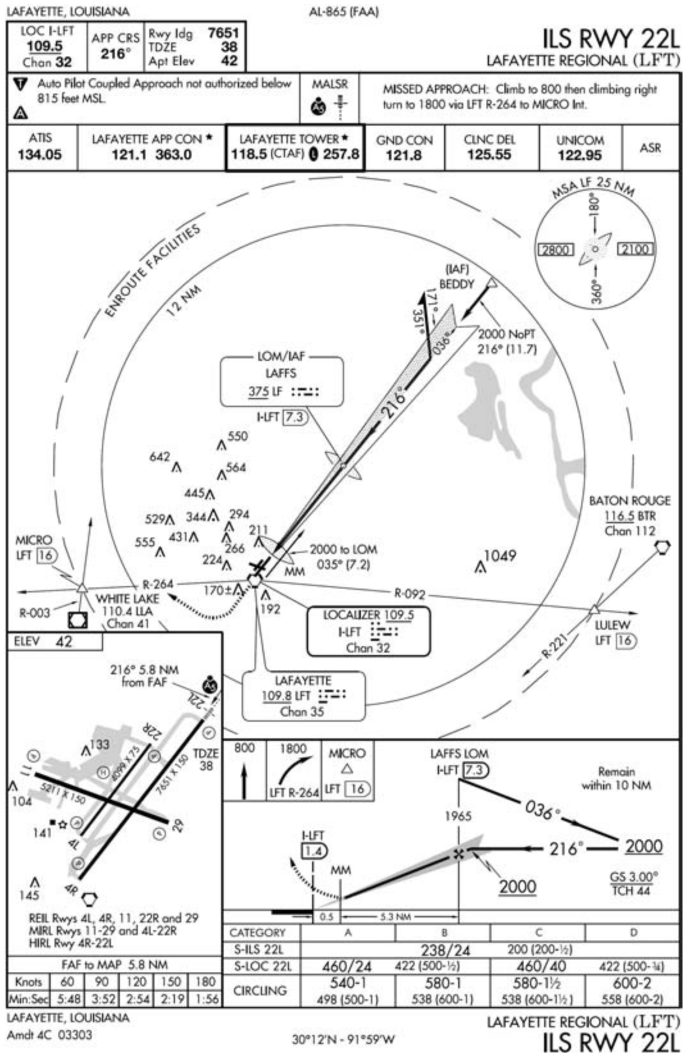
Figure 13.2. Approach Depicting Only the Final Approach Segment.



13.2.3. Aircraft Speed***. Prior to reaching the initial approach fix, slow to maneuvering speed for your aircraft.*** Use holding airspeed if maneuvering airspeed is not specified for your aircraft. Establish approach configuration and airspeed before the final approach fix unless your aircraft flight manual procedures require otherwise.

13.2.4. DR Courses. Many IAPs utilize DR courses (Figure 13.3). Although course guidance is not available, the DR course should be flown as closely as possible to the depicted ground track. ***Use lead points for turns to and from the DR legs to roll out on the depicted ground track. Fly the depicted ground track by correcting for wind.***

Figure 13.3. Approach Using a DR Course.



13.3. **Types of Course Reversals.** There are two common types of course reversals: the procedure turn (PT) and the holding pattern in lieu of procedure turn (HILO PT). Before discussing each type of course reversal in detail, here are some guidelines that apply to all course reversals:

13.3.1. Restrictions. ***Do not execute a procedure turn or HILO PT in the following situations.*** (Many people use the memory aid – SNERT).

13.3.1.1. When ATC gives you clearance for a "**S**traight-in" approach.

13.3.1.2. If you are flying the approach via **N**o PT routing (Figure 13.5).

13.3.1.3. When you are **E**stablished in holding, subsequently cleared the approach, and the holding course and procedure turn course are the same.

13.3.1.3.1. NOTE: This generally applies if you are already established at the minimum holding altitude. If you are in doubt as to what action the controller expects, query the controller.

13.3.1.4**.** When ATC provides **R**adar vectors to the final approach course.

13.3.1.5**.** When ATC clears you for a **T**imed approach. Timed approaches are in progress when you are established in a holding pattern and given a time to depart the FAF inbound.

Figure 13.4. HILO Approach.

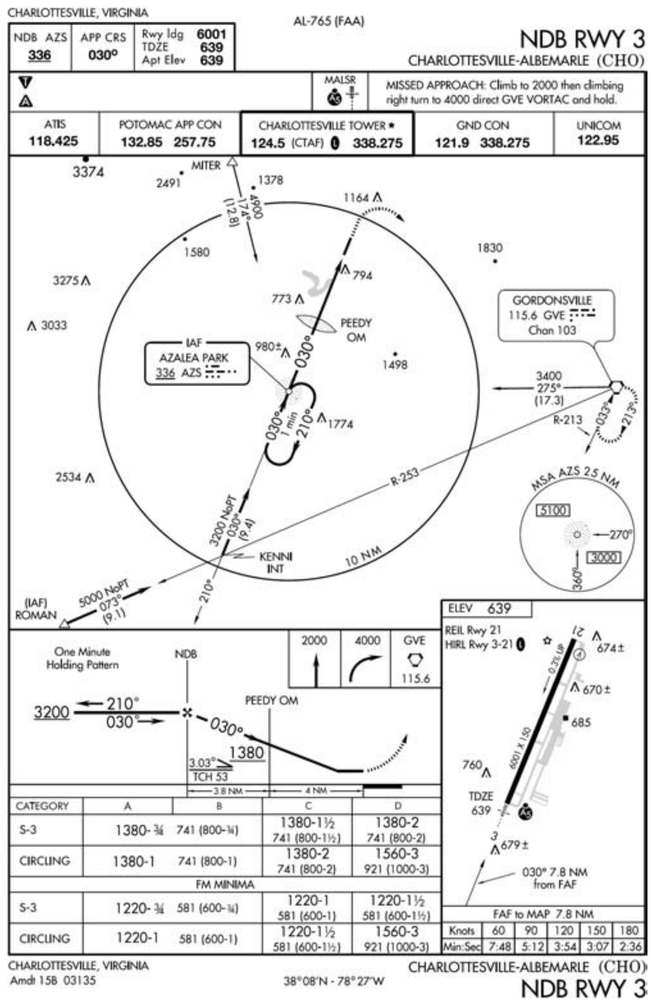
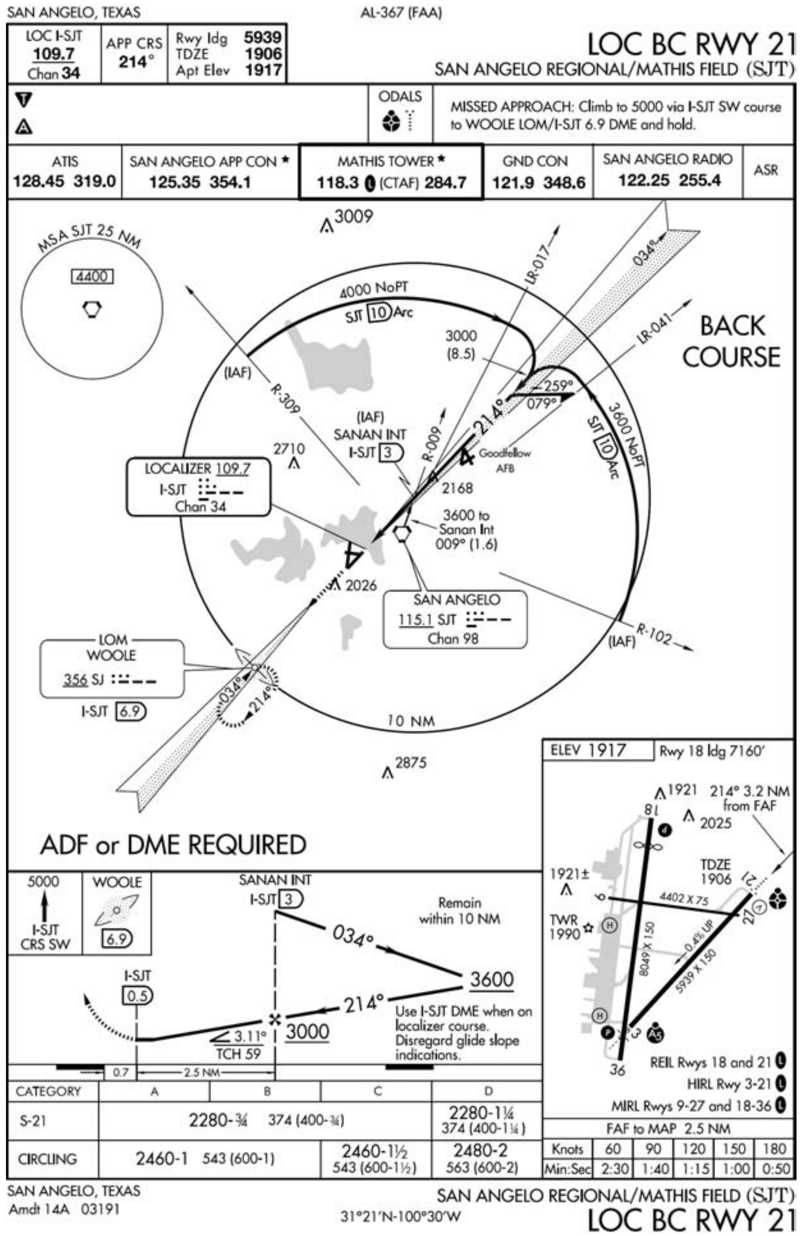


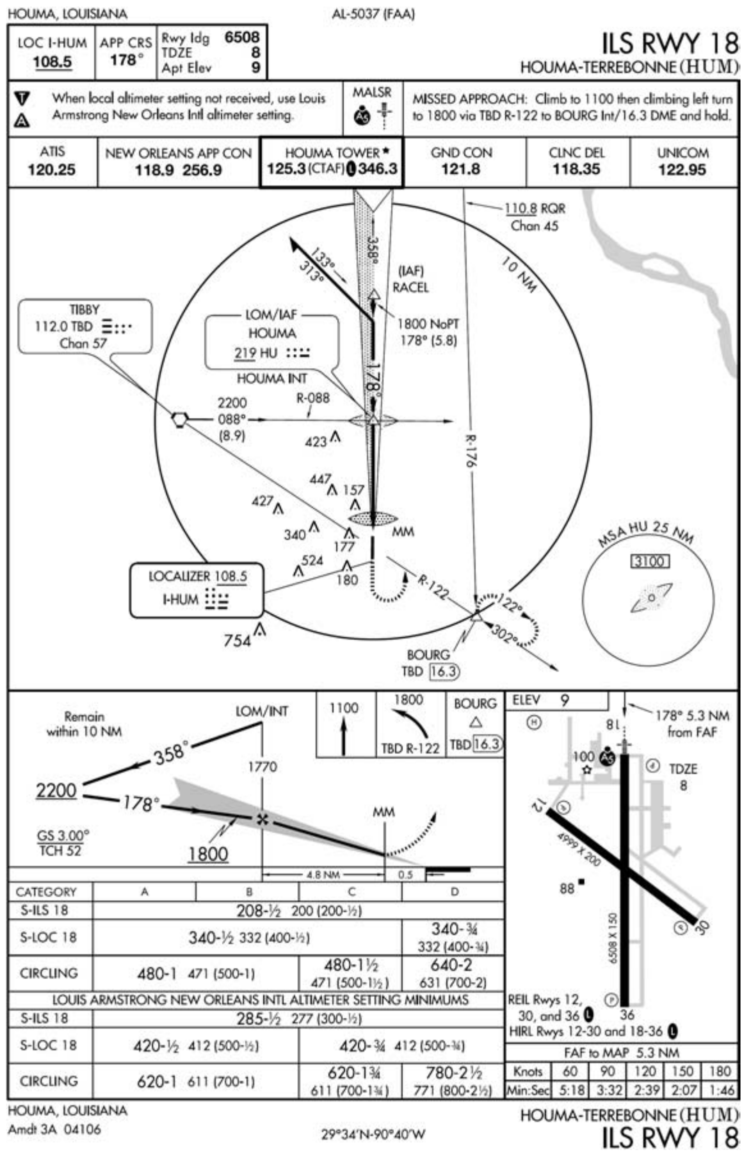
Figure 13.5. NoPT Routing.



13.3.1.6. ***In any of the situations described above, proceed over the FAF at the published FAF altitude and continue inbound on the final approach course without making a procedure turn, holding pattern, or any other aligning maneuver before the FAF unless otherwise cleared by ATC***. If you need to make additional circuits in a published holding pattern or to become better established on course before departing the FAF, it is your responsibility to request such maneuvering from ATC.

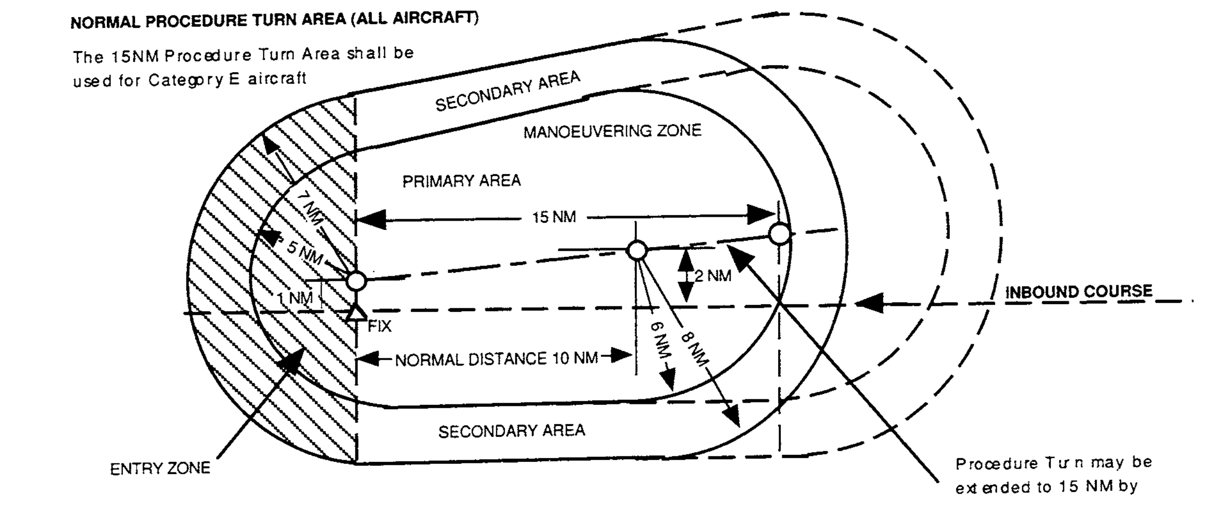
13.3.1.6.1. NOTE: Historically, these restrictions have created a lot of confusion between pilots and controllers. If you are ever in doubt about what ATC expects you to do, query the controller.

Figure 13.6. Procedure Turn Course Reversal.



13.4. Procedure Turns. One of the most common types of low altitude course reversals is the procedure turn. Procedure turns are depicted in the plan view of U.S. government charts with a barb symbol (—) indicating the direction or side of the outbound course on which the procedure turn or maneuvering is to be accomplished (Figure 13.6). The procedure turn fix is identified on the profile view of the approach at the point where the IAP begins. To give you an idea of what the procedure turn airspace looks like, refer to Figure 13.7.

Figure 13.7. Procedure Turn Area.



In the diagram above, note the maneuvering side is the side above the inbound course line – the airspace is much larger. The dashed lines to the right depict the procedure turn area for Category E aircraft; it is typically 15 miles versus 10 miles for the normal area.

13.4.1. Aircraft Speed. Procedure turns may be safely flown at speeds up to 250 KIAS provided the pilot takes into consideration all factors which may affect the aircraft's turn performance (e.g., winds, TAS at altitude, bank angle, etc.).

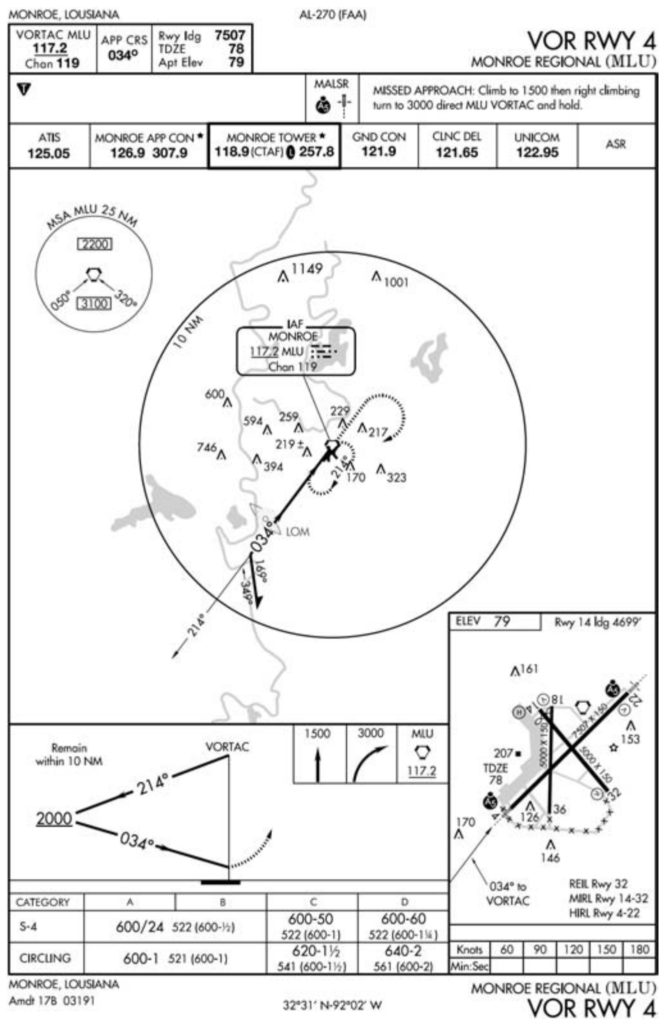
13.4.1.1. NOTE: The FAA recommends a maximum airspeed of 200 KIAS while performing procedure turn course reversals, and when possible, USAF aircraft should also observe this speed restriction. If a speed of 200 KIAS is not practical, you must exercise caution to ensure your aircraft remains in the protected airspace provided by TERPS.

13.5. Techniques for Flying Procedure Turns. There are three common techniques for executing a procedure turn course reversal: the holding technique, the 45/180, and the 80/260. Regardless of the method you choose to fly the procedure turn, take the following two notes into consideration when planning your approach:

13.5.1. Plan the outbound leg to allow enough time for configuration and any descent required prior to the FAF. ***Ensure you adjust the outbound leg length so you will stay inside the "remain within distance" noted on the profile view of the approach plate***. The remain within distance is measured from the procedure turn fix unless the IAP specifies otherwise. At the completion of the outbound leg, turn to intercept the procedure turn course inbound.

13.5.2. When the NAVAID is on the field and no FAF is depicted (Figure 13.8), plan the outbound leg so the descent to MDA can be completed with sufficient time to acquire the runway and position the aircraft for a normal landing. Consideration should be given to configuring on the outbound leg to minimize pilot tasking on final. When flying this type of approach, the FAF is considered to be the point when you begin your descent from the procedure turn completion altitude. Since this point is considered the FAF, you should establish approach configuration and airspeed prior to departing procedure turn completion altitude unless your aircraft flight manual procedures require otherwise.

Figure 13.8. Procedure Turn Approach with No FAF Depicted.



13.6. Holding Technique. ***Enter the procedure turn according to the holding procedures described in Chapter 10 with the following exceptions*****:**

13.6.1. If your heading is within 90° of the outbound procedure turn course, you may use normal lead points to intercept the procedure turn course outbound.

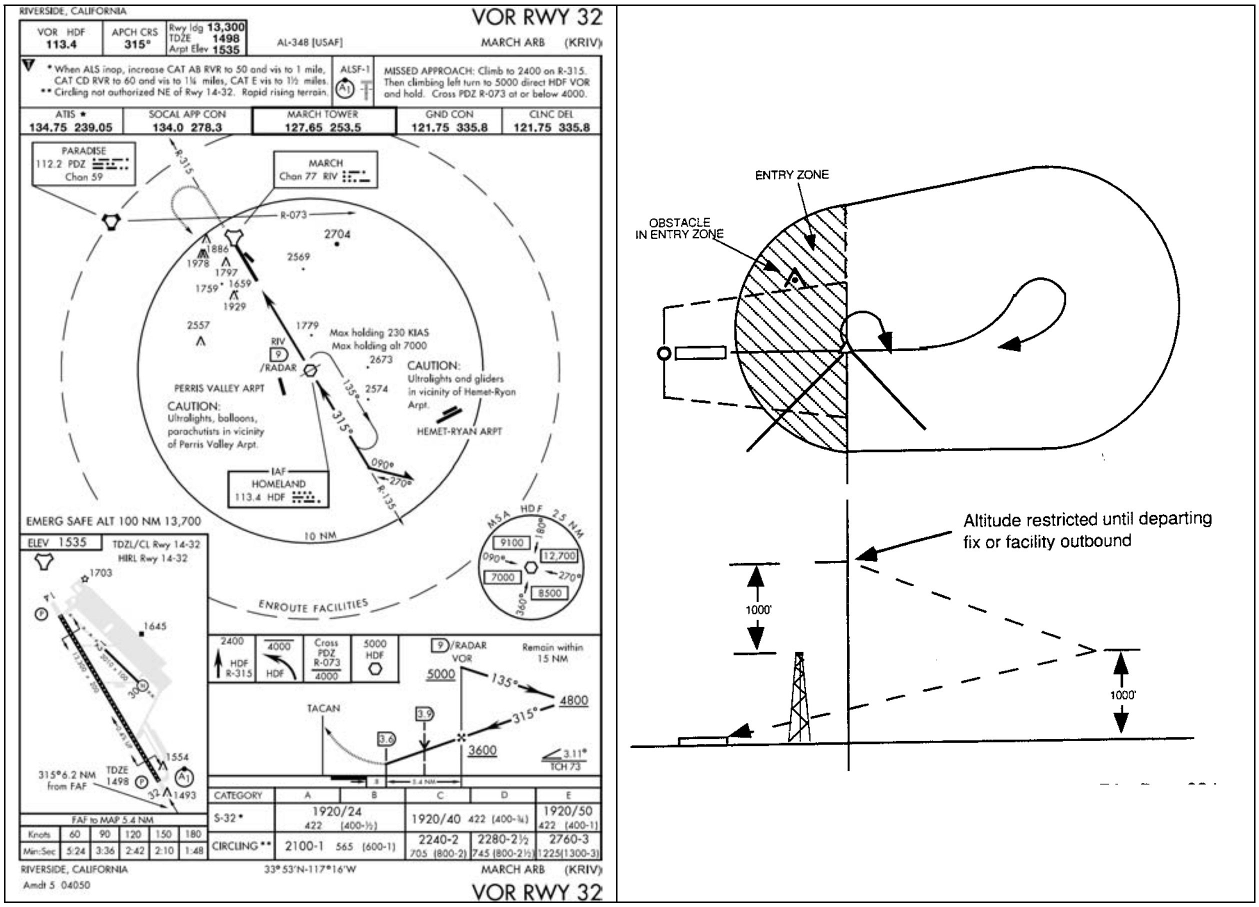
13.6.2**.** ***If you elect a teardrop entry, your teardrop course must be within 30 degrees of the procedure turn course.*** Use course guidance if it is available.

13.6.3. If the entry turn places the aircraft on the non-maneuvering side of the procedure turn course and you are flying in excess of 180 KTAS, you must correct toward the procedure turn course using an intercept angle of at least 20°.

13.6.4. If you intercept the procedure turn course outbound, maintain the course for

the remainder of the outbound leg, then turn toward the maneuvering side to reverse course.

Figure 13.9. PT Fix Altitude.



13.6.5. Timing. ***Begin timing once you are outbound abeam the procedure turn fix. If you cannot determine the abeam position while in the turn, start timing after completing the outbound turn***.

13.6.6. Descent. ***Do not descend from the procedure turn fix altitude (published or assigned) until you are abeam the procedure turn fix heading outbound. If you cannot determine when you are abeam, start your descent after completing the outbound turn. Do not descend from the procedure turn completion altitude until you are established on the inbound segment of the approach.***

13.7. The 45°/180° and the 80°/260° Course Reversals. Two other methods you may use to accomplish a procedure turn approach are the 45°/180° and the 80°/260° course reversal maneuvers. The procedures for flying each maneuver are identical with the exception of the actual course reversal.

13.7.1**. Entry.** Upon reaching the procedure turn fix, turn in the shortest direction to intercept the procedure turn course outbound. You may use normal lead points if practical.

13.7.2**. Proceeding Outbound.** ***Intercept and maintain the procedure turn course outbound as soon as possible after passing the procedure turn fix.***

13.7.3**. Descent.** ***Do not descend from the procedure turn fix altitude (published or assigned) until you are abeam the procedure turn fix and on a parallel or intercept heading to the outbound track. Do not descend from the procedure turn completion altitude until you are established on the inbound segment of the approach.***

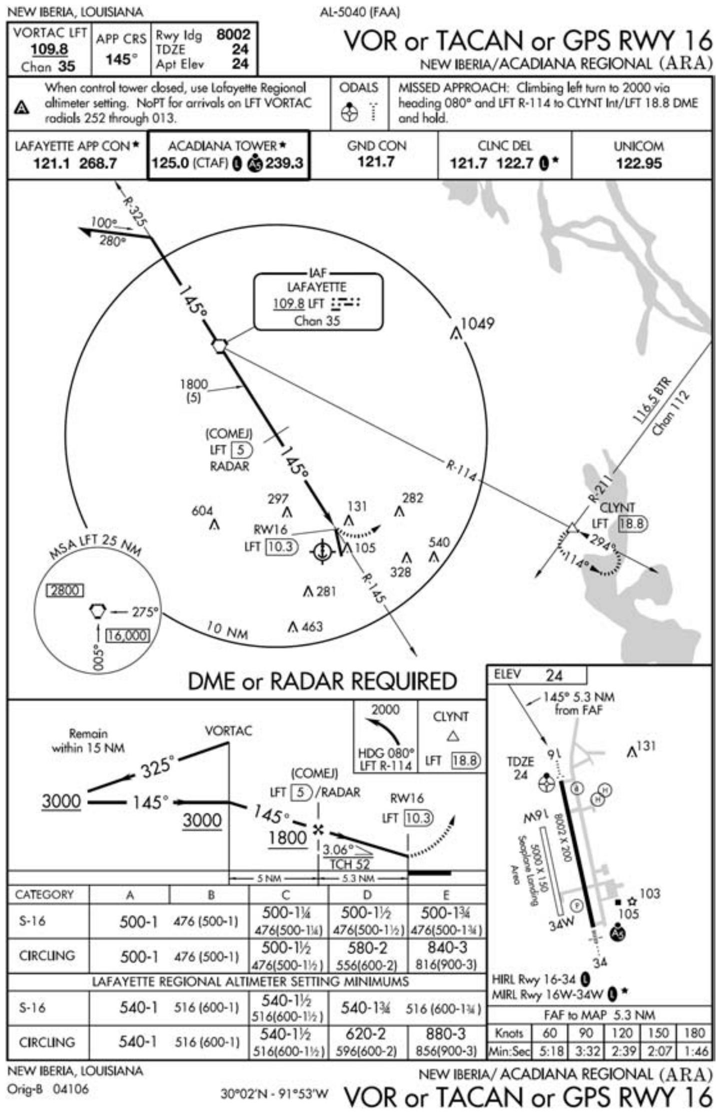
13.7.3.1. NOTE: When flying procedure turns designed in FAA airspace, there is no requirement to wait until you are on a parallel or intercept heading to begin descent from the procedure turn fix altitude; however, when flying these types of course reversals in ICAO airspace, this procedure is MANDATORY due to different TERPS criteria. In the interest of forming good habit patterns, the ICAO method has been adopted by the USAF as procedural.

13.7.4. Executing the Course Reversal Maneuver. ***At the appropriate time on the outbound leg, begin the course reversal maneuver. In both cases, comply with the published remain within distance***.

13.7.4.1. The 45°/180°. ***To begin the reversal maneuver, turn 45° away from the outbound track toward the maneuvering side.*** Begin timing upon initiating the 45° turn; time for 1 minute (Categories A and B) or 1 minute and 15 seconds (Categories C, D, and E); then begin a 180° turn in the opposite direction from the initial turn to intercept the procedure turn course inbound.

13.7.4.2. The 80°/260°. ***To begin the reversal maneuver, make an 80° turn away from the outbound track toward the maneuvering side followed by an immediate 260° turn in the opposite direction to intercept the inbound course.***

Figure 13.10. The 45°/180° Course Reversal.



13.8. Holding Pattern in Lieu of Procedure Turn (HILO PT). The HILO PT is another common way to execute a low altitude course reversal. The HILO PT is depicted like any other holding pattern except the holding pattern track is printed with a heavy black line (⬭) in the plan view. The depiction of the approach in the profile view varies depending on where the descent should begin.

13.8.1. Flying the Holding Pattern. ***Enter and fly the HILO PT holding pattern according to the holding procedures described in Chapter 10***.

13.8.2. Descent. Descent from the minimum holding altitude may be depicted in two ways: descent at the holding fix or descent on the inbound leg. ***When a descent is depicted on the inbound leg, you must be established on the inbound segment of the approach before beginning the descent***.

Figure 13.11. HILO PT With Descent at Holding Fix/FAF.

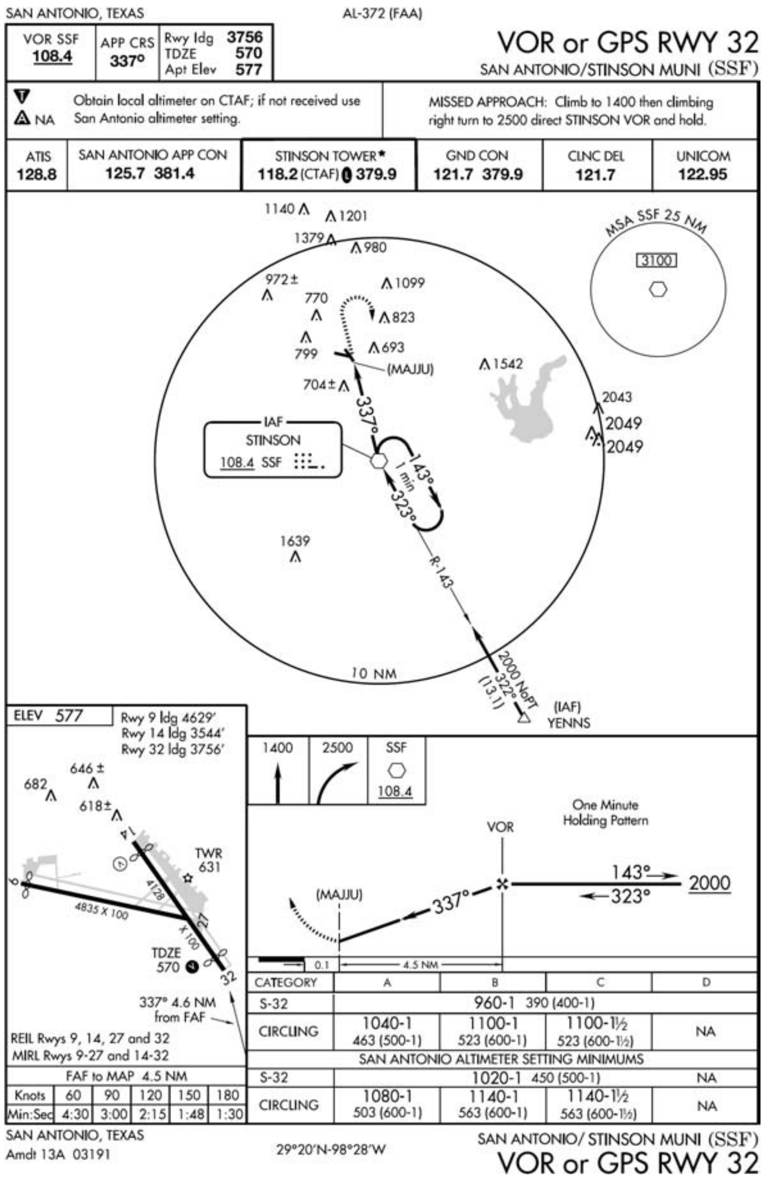
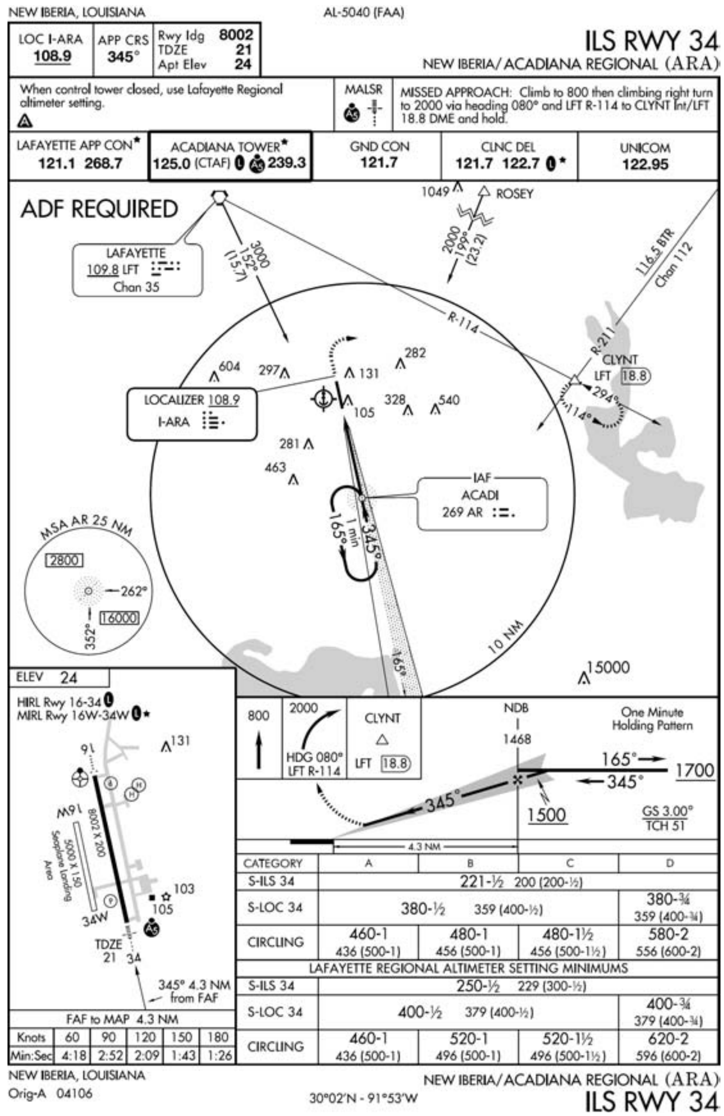


Figure 13.12. HILO PT With Descent on Inbound Leg.



13.8.3. Additional Guidance for HILO PTs. ***If cleared for the approach while holding in a published HILO PT, complete the holding pattern and commence the approach without making additional turns in the holding pattern (altitude permitting).*** If an additional turn is needed to lose excessive altitude, request clearance from ATC since additional circuits of the holding pattern are not expected by ATC. If the aircraft is at an altitude from which the approach can be safely executed and you are ready to turn inbound immediately, you may request approval for an early turn from ATC.

13.9. Procedural Tracks.

13.9.1. Depiction. There is no specific depiction for a procedural track. It may employ arcs, radials, courses, turns, etc. When a specific flight path is required, procedural track symbology is used to depict the flight path between the IAF and FAF. The depiction used is a heavy black line showing intended aircraft ground track.

Figure 13.13. Procedure Track Approach (Straight-in).

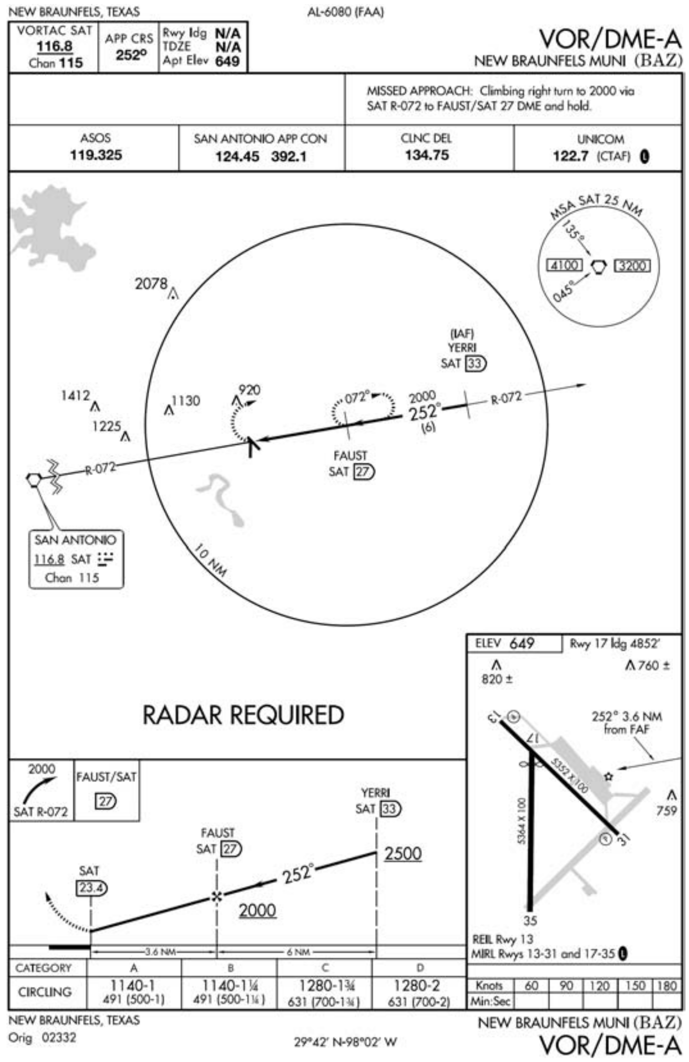
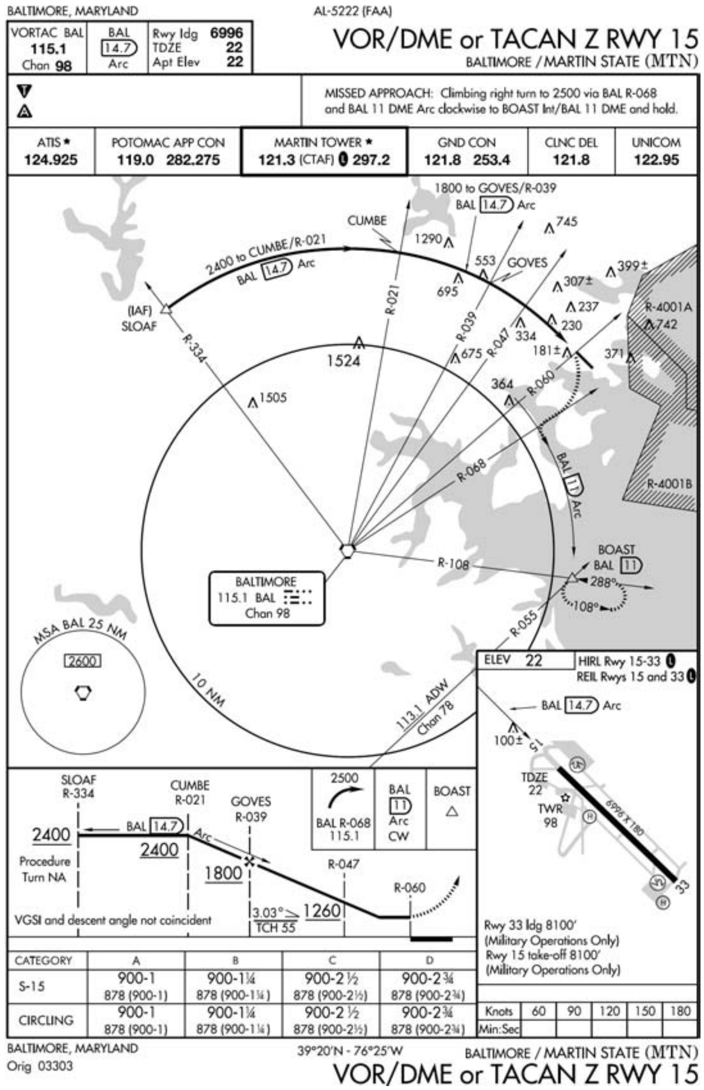


Figure 13.14. Procedure Track Approach (Arcing Final).



13.9.2. Entry. ***When over the IAF, turn immediately in the shorter direction to intercept the published track. If your heading is within 90° of the procedure track course, you may use normal lead points to intercept the course. If your heading is not within 90° of the course, overfly the fix and turn in the shorter direction to intercept the procedure track course.***

13.9.3. Maneuvering. ***Conform to the specific ground track shown on the IAP***. Where a teardrop turn is depicted, you may turn to the inbound course at any time unless otherwise restricted by the approach plate. Determine when to turn by using the aircraft turn performance, winds, and the amount of descent required on the inbound course; however, ***do not exceed the published remain within distance.***

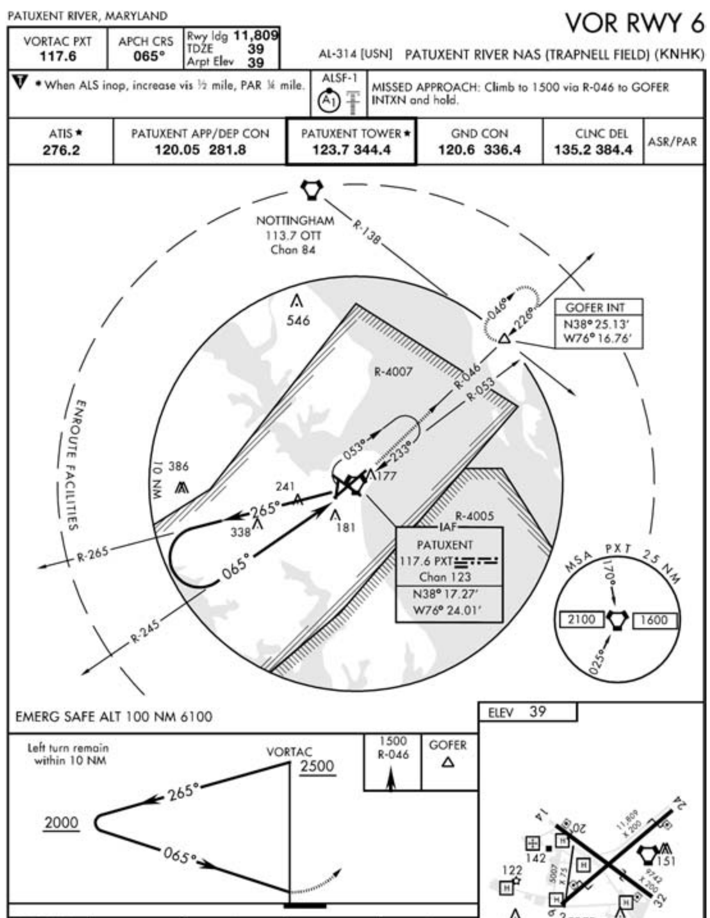
13.9.4 Descent. A descent can be depicted at any point along the procedural track.

13.9.4.1. IAF. ***When a descent is depicted at the IAF, start descent when abeam or past the IAF and on a parallel or intercept heading to the procedural track course.***

Except for initial descents at an IAF, be established on the appropriate segment of the procedural track before descending to the next altitude shown on the IAP.

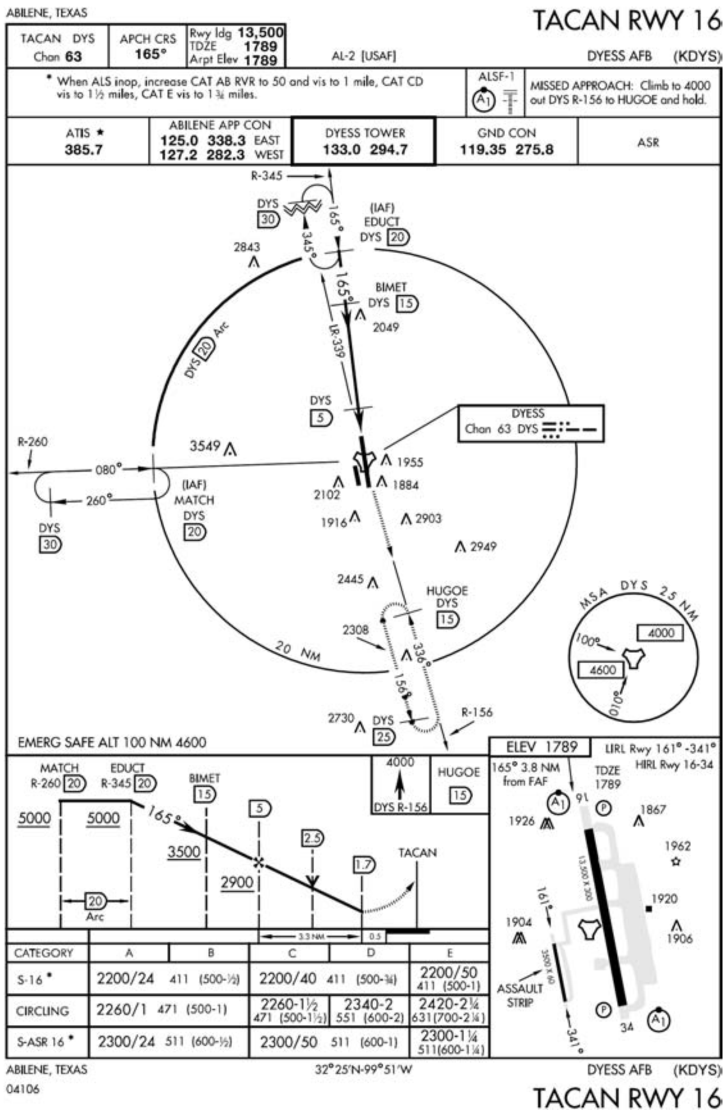
13.9.4.1.1. NOTE: Low altitude approaches may include arc-to-radial and radial-to-arc combinations. An arc-to-radial altitude restriction applies only while established on that segment of the IAP. Once a lead point is reached and a turn to the next segment is begun, you may consider yourself established on the next segment and descend to the next applicable altitude. ***When an altitude restriction is depicted at a fix defined as an intersection of a radial and an arc, the restriction must be complied with no later than the completion of the lead turn associated with that fix***. If the restriction is met during the lead turn, consider yourself established on the next segment, and you may continue to descend to the next applicable altitude restriction.

Figure 13.15. Procedure Track Approach (Teardrop).



CATEGORY	A	B	C	D
S-6*	640-½	601 (700-½)	640-1¼ 601 (700-1¼)	640-1½ 601 (700-1½)
CIRCLING	640-1	601 (700-1)	640-1¾ 601 (700-1¾)	640-2 601 (700-2)
S-PAR 6*	139-¼	100	(100-¼) GS 3.0°	

Figure 13.16. Procedure Track Approach (Arc to Radial).



13.9.4.1.2. CAUTION: Maximum designed obstacle clearance is based on your ability to maintain the course centerline; you must use your position orientation and your judgment to determine when to descend while attempting to intercept the procedural track.

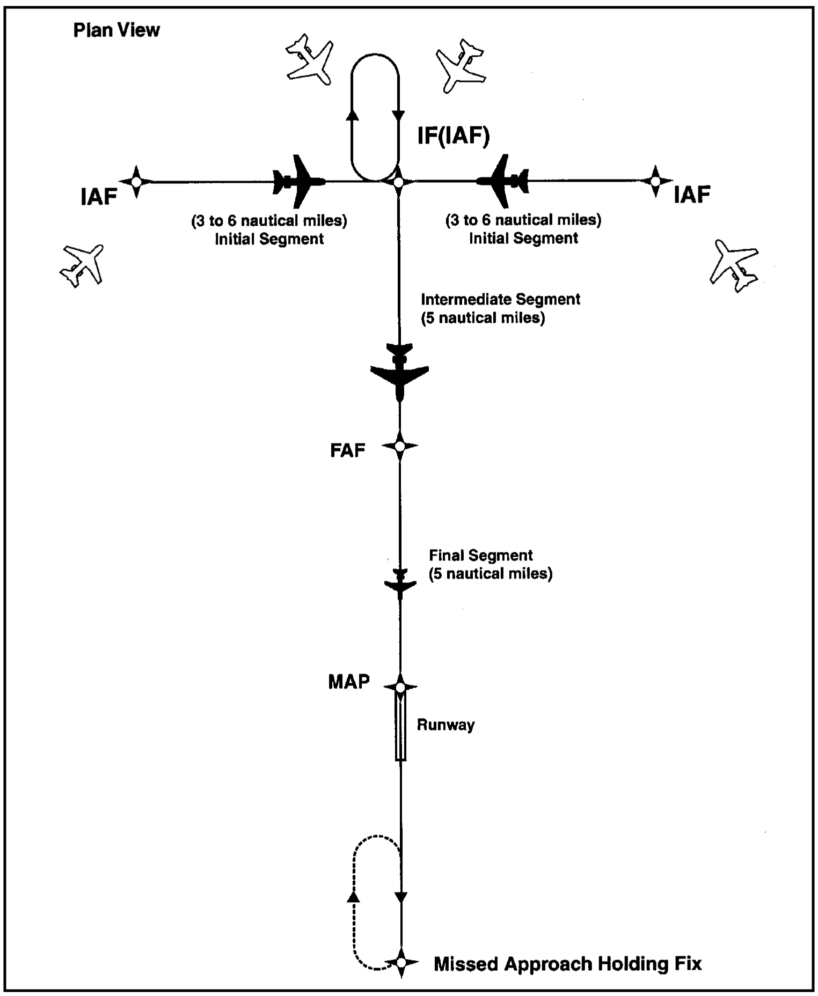
13.9.4.2. Teardrop. ***Where a teardrop is depicted, do not descend from the turn altitude until you are established on the inbound segment of the procedural track.***

13.10. RNAV (GPS) Entry Procedures Via the Terminal Arrival Area (TAA). Entry for RNAV (GPS) approaches is normally accomplished via the TAA. Entry may be accomplished either via a NoPT routing, or via a course reversal maneuver if depicted.

13.10.1. Objective. The objective of the TAA is to provide a seamless transition from the en route structure to the terminal environment for arriving aircraft equipped with Flight Management System (FMS) and/or Global Positioning System (GPS) navigational equipment. The TAA will not be found on all RNAV procedures, particularly in areas of heavy concentration of air traffic. When the TAA is published, it replaces the MSA for that approach procedure.

13.10.2. The TAA structure. The RNAV procedure underlying the TAA will be the "T" design (also called the "Basic T"), or a modification of the "T." The "T" design incorporates from one to three IAFs; an intermediate fix (IF) that serves as a dual purpose IF (IAF); a final approach fix (FAF), and a missed approach point (MAP) usually located at the runway threshold (see Figure 13.17). The three IAFs are normally aligned in a straight line perpendicular to the intermediate course, which is an extension of the final course leading to the runway, forming a "T." The initial segment is normally from 3-6 NM in length; the intermediate 5-7 NM, and the final segment 5 NM. Specific segment length may be varied to accommodate specific aircraft categories for which the procedure is designed. However, the published segment lengths will reflect the highest category of aircraft normally expected to use the procedure.

Figure 13.17. Terminal Arrival Area (TAA).

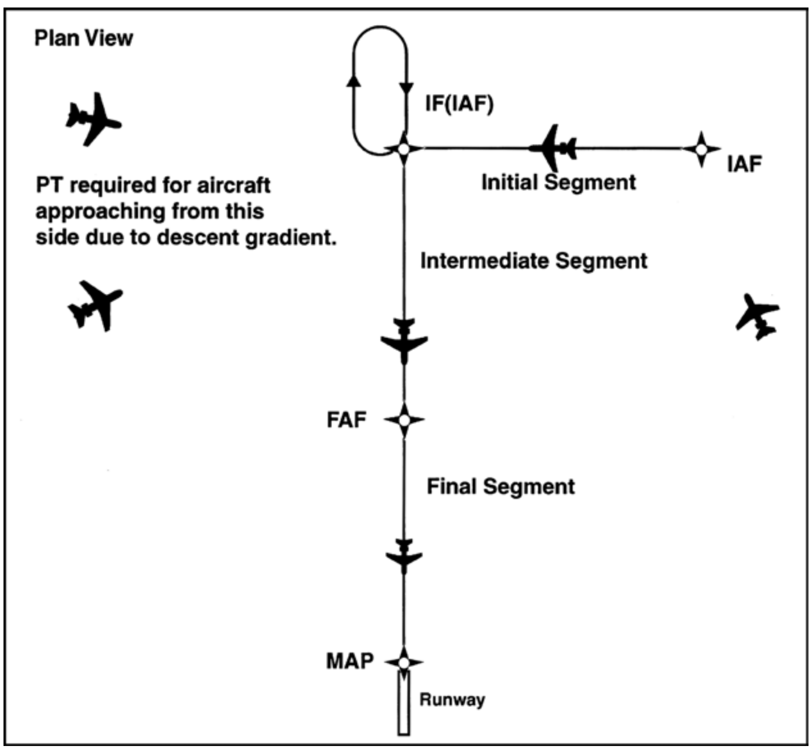


13.10.3. **Holding-in-Lieu Entry**. A standard racetrack holding pattern may be provided at the center IAF, and if present may be necessary for course reversal and for altitude adjustment for entry into the procedure. In the latter case, the pattern provides an extended distance for the descent required by the procedure. Depiction of this pattern in U.S. Government publications will utilize the "hold-in-lieu-of-PT" holding pattern symbol.

13.10.4. **Entry via NoPT routing**. The published procedure will be annotated to indicate when the course reversal is not necessary when flying within a particular TAA area; e.g., "NoPT." Otherwise, the pilot is expected to execute the course reversal. ***The pilot may elect to use the course reversal pattern when it is not required by the procedure, but must inform air traffic control and receive clearance to do so.***

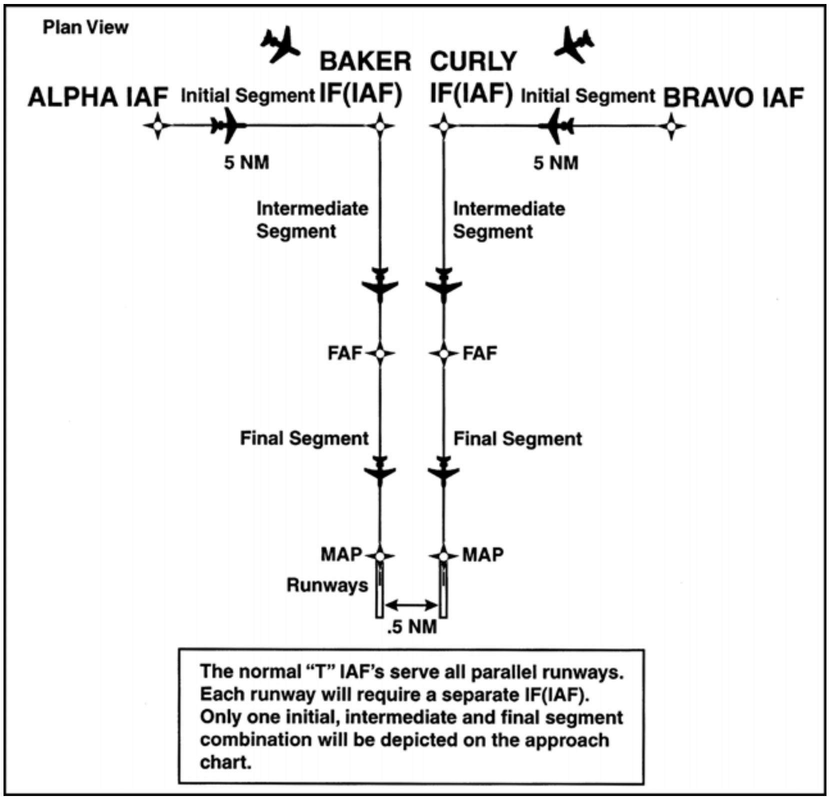
13.10.4.1. Modified “T” designs. The "T" design may be modified by the procedure designers where required by terrain or air traffic control considerations. For instance, the "T" design may appear more like a regularly or irregularly shaped "Y", or may even have one or both outboard IAFs eliminated resulting in an upside down "L" or an "I" configuration. Further, the leg lengths associated with the outboard IAFs may differ.

Figure 13.18. Modified T Design.



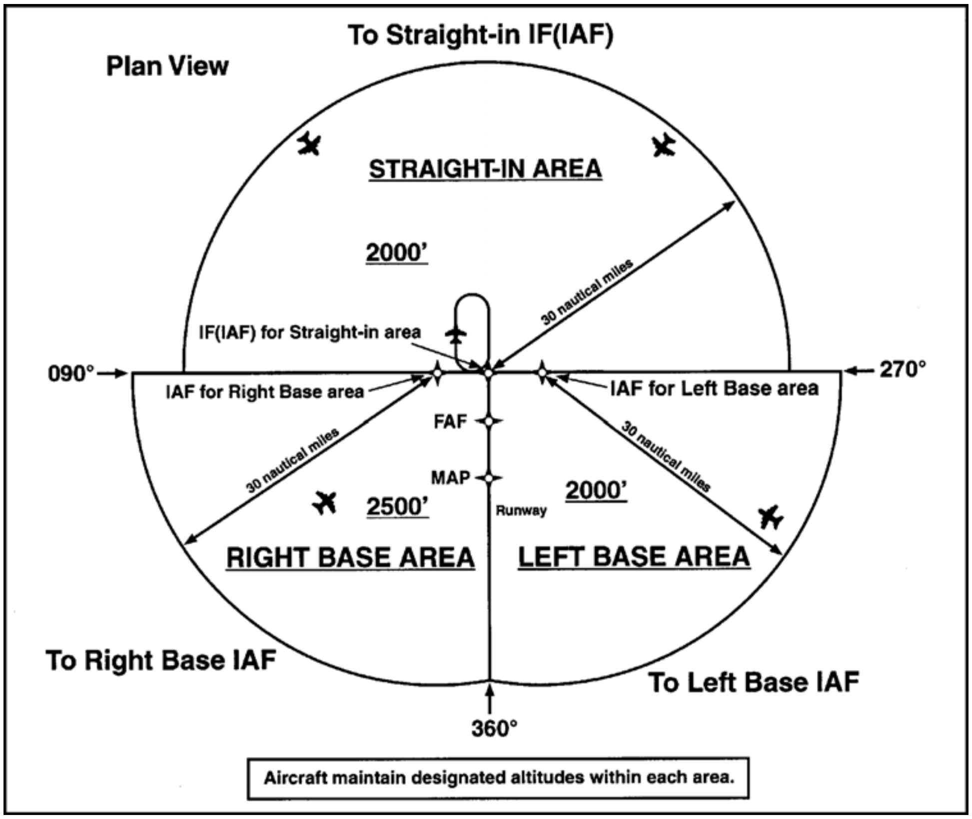
13.10.4.1.1. Parallel Runway “T”. Another modification of the "T" design may be found at airports with parallel runway configurations. Each parallel runway may be served by its own "T" IAF, IF (IAF), and FAF combination, resulting in parallel final approach courses. Common IAFs may serve both runways; however, only the intermediate and final approach segments for the landing runway will be shown on the approach chart.

Figure 13.19. Parallel T Design.



13.10.5. TAA areas. The standard TAA consists of three areas defined by the extension of the IAF legs and the intermediate segment course. These areas are called the straight-in, left-base, and right-base areas. TAA area lateral boundaries are identified by magnetic courses TO the IF (IAF). The straight-in area can be further divided into pie-shaped sectors with the boundaries identified by magnetic courses TO the IF (IAF), and may contain stepdown sections defined by arcs based on RNAV distances (DME or ATD) from the IF (IAF). The right/left-base areas can only be subdivided using arcs based on RNAV distances from the IAFs for those areas. Minimum MSL altitudes are charted within each of these defined areas/subdivisions that provide at least 1,000 feet of obstacle clearance, or more as necessary in mountainous areas.

Figure 13.20. Standard TAA Area.

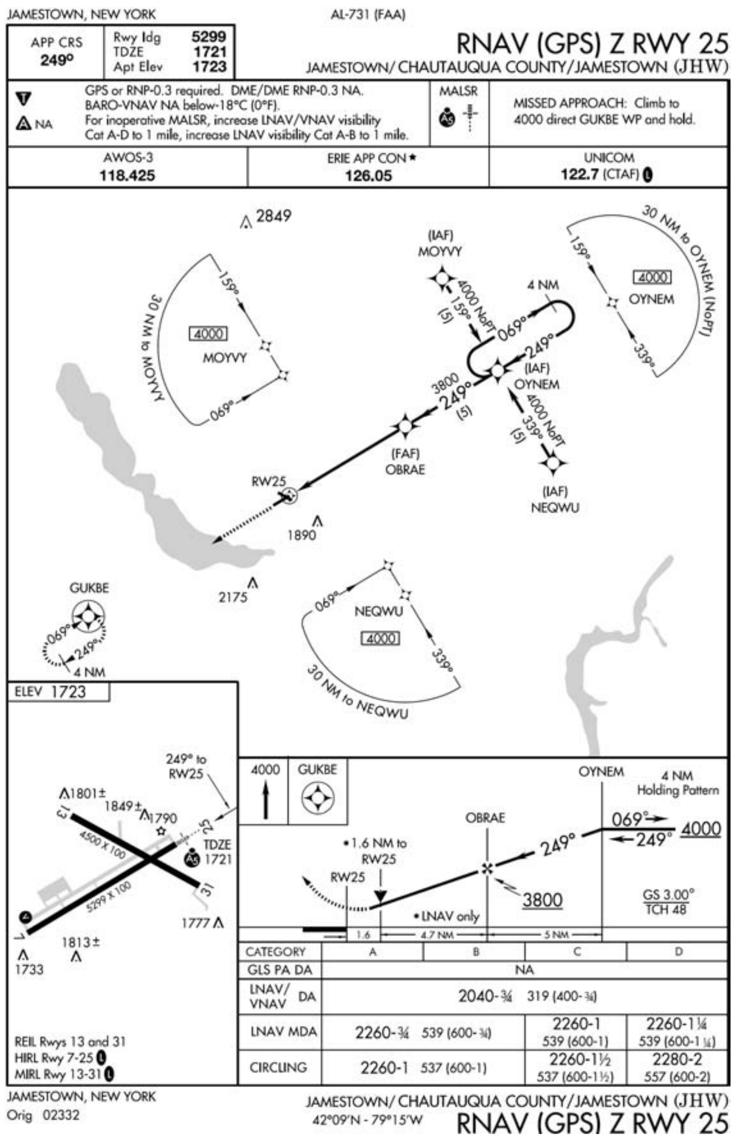


13.10.6. **Selecting the Entry IF**. ***Prior to arriving at the TAA boundary, the pilot should determine which area of the TAA the aircraft will enter by selecting the IF (IAF) and determine the magnetic bearing TO the IF (IAF). That bearing should then be compared with the published bearings that define the lateral boundaries of the TAA areas***. This is critical when approaching the TAA near the extended boundary between the left and right-base areas, especially where these areas contain different minimum altitude requirements.

13.10.7. Proceeding Direct to IAF. ***Pilots entering the TAA and cleared by air traffic control are expected to proceed directly to the IAF associated with that area of the TAA at the altitude depicted, unless otherwise cleared by air traffic control. If in doubt, query ATC. Pilots entering the TAA with two-way radio communications failure must maintain the highest altitude assigned, expected, or filed until arriving at the appropriate IAF.***

13.10.8. Depiction of TAA Icons. Depiction of the TAA on U.S. Government charts will be through the use of icons located in the plan view outside the depiction of the actual approach procedure. Use of icons is necessary to avoid obscuring any portion of the "T" procedure (altitudes, courses, minimum altitudes, etc.). The icon for each TAA area will be located and oriented on the plan view with respect to the direction of arrival to the approach procedure, and will show all TAA minimum altitudes and sector/radius subdivisions for that area. The IAF for each area of the TAA is included on the icon where it appears on the approach, to help the pilot orient the icon to the approach procedure. The IAF name and the distance of the TAA area boundary from the IAF are included on the outside arc of the TAA area icon. Examples here are shown with the TAA around the approach to aid pilots in visualizing how the TAA corresponds to the approach and should not be confused with the actual approach chart depiction.

Figure 13.21. RNAV GPS Approach With TAA.

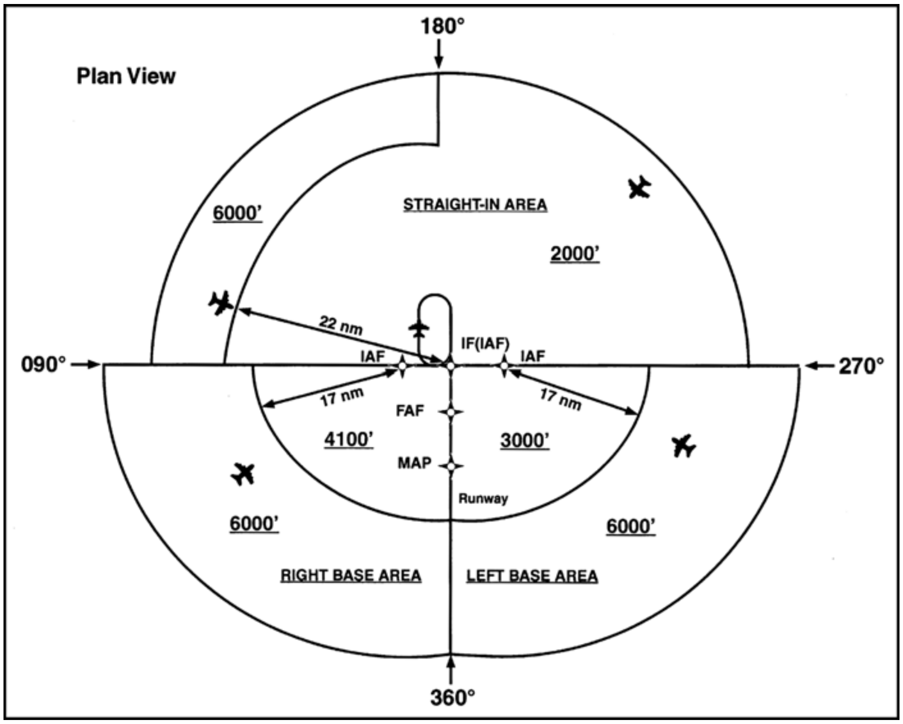


13.10.9. Waypoint names. Each waypoint on the "T", except the missed approach waypoint, is assigned a pronounceable 5-character name used in air traffic control communications, and which is found in the RNAV databases for the procedure. The missed approach waypoint is assigned a pronounceable name when it is not located at the runway threshold.

13.10.10. Descents. ***Once cleared to fly the TAA, pilots are expected to obey minimum altitudes depicted within the TAA icons, unless instructed otherwise by air traffic***

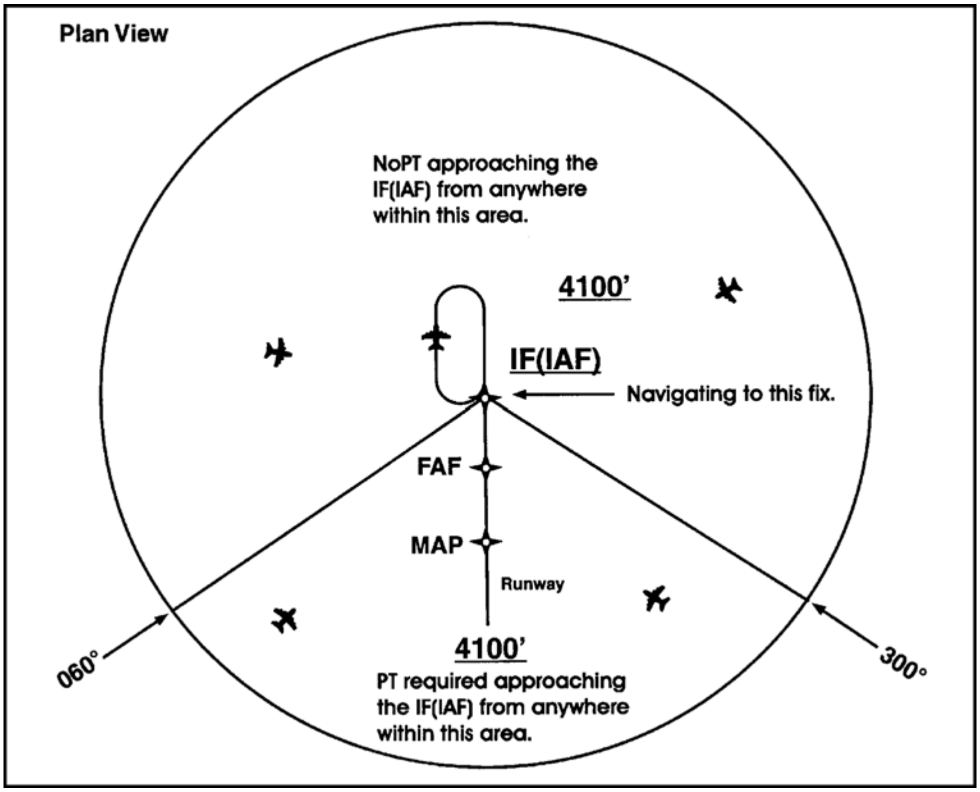
control. In Figure 13.22, pilots within the left or right-base areas are expected to maintain a minimum altitude of 6,000 feet until within 17 NM of the associated IAF. After crossing the 17 NM arc, descent is authorized to the lower charted altitudes. Pilots approaching from the northwest are expected to maintain a minimum altitude of 6,000 feet, and when within 22 NM of the IF (IAF), descend to a minimum altitude of 2,000 feet MSL until reaching the IF (IAF).

Figure 13.22. Descents in TAA.



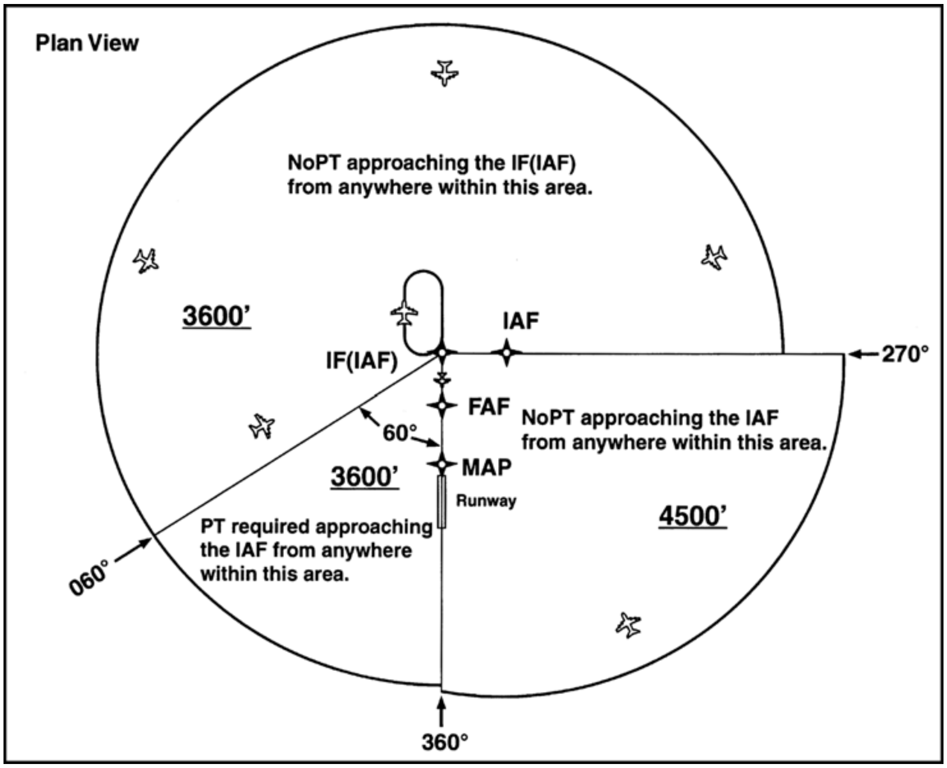
13.10.11. Entry procedures for Modified TAAs. Just as the underlying "T" approach procedure may be modified in shape, the TAA may contain modifications to the defined area shapes and sizes. Some areas may even be eliminated, with other areas expanded as needed. Figure 13.23 is an example of a design limitation where a course reversal is necessary when approaching the IF (IAF) from certain directions due to the amount of turn required at the IF (IAF). Design criteria require a course reversal whenever this turn exceeds 120 degrees. In this generalized example, pilots approaching on a bearing TO the IF (IAF) from 300° clockwise through 060° are expected to execute a course reversal. The term "NoPT" will be annotated on the boundary of the TAA icon for the other portion of the TAA.

Figure 13.23. Entry Procedures for Modified TAAs.



13.10.12. Entry Procedures for one-base TAAs. Figure 13.24 depicts another TAA modification that pilots may encounter. In this generalized example, the right-base area has been eliminated. Pilots operating within the TAA between 360° clockwise to 060° bearing TO the IF (IAF) are expected to execute the course reversal in order to properly align the aircraft for entry onto the intermediate segment. Aircraft operating in all other areas from 060° clockwise to 360° degrees bearing TO the IF (IAF) need not perform the course reversal, and the term "NoPT" will be annotated on the TAA boundary of the icon in these areas.

Figure 13.24. Entry Procedures for One-Base TAAs.



13.10.13. Feeder Routes. When an airway does not cross the lateral TAA boundaries, a feeder route will be established to provide a transition from the en route structure to the appropriate IAF. Each feeder route will terminate at the TAA boundary, and will be aligned along a path pointing to the associated IAF. ***Pilots should descend to the TAA altitude after crossing the TAA boundary and cleared by air traffic control***.

13.10.14. Backup Approach. AFI 11-202 Volume 3, *General Flight Rules*, details procedures for flying GPS stand-alone and "overlay" approaches, including requirements for monitoring of underlying conventional navaids.

13.10.14.1. When flying a stand-alone GPS procedure, it is prudent to monitor a backup approach when available. If the GPS approach becomes unreliable, comply with procedures outlined in AFI 11-202 Volume 3 *General Flight Rules*, for missed approach. If you are in a safe position to do so and are outside the FAF, request a clearance to fly your backup approach. ***Do not transition to your backup approach without a clearance***.

Chapter 14

FINAL APPROACH

14.1. Types of Final Approach Guidance. There are numerous different types of final approach guidance that can be categorized in a number of different ways. For the purposes of this chapter, final approach guidance will be categorized as follows:

14.1.1. Non-radar Approaches. These are approaches that do not require radar vectoring or radar services on final approach. Non-radar approaches can be further subdivided among those that provide electronic glide path guidance and those that do not provide electronic glide path guidance.

14.1.2. Radar Approaches. These are approaches that require radar vectoring on final approach. There are two types PAR and ASR.

14.1.3. Procedures with a Visual Component. Sometimes it is not possible to construct an instrument procedure that meets all requirements. Incorporating a visual component into an instrument procedure is an acceptable alternative. There are four types of approaches that fall into this category: visual approach, contact approach, IAP with a visual segment, and a charted visual flight procedure.

14.1.4. Other Specialized Procedures. These are specialized subsets of particular approach types listed above. There are four approaches that fall into this category: converging approaches, ILS/PRM, SOIA, and TLS. All require specialized training and crew qualifications except converging approaches.

14.2. Non-radar Approaches.

14.2.1. General Procedures.

14.2.1.1. Final Approach.

14.2.1.1.1. Starts. The final approach starts at the FAF and ends at the MAP. The optimum length of the final approach is 5 miles; the maximum length is 10 miles.

14.2.1.1.2. Navigation receiver. ***Once the aircraft is inside the final approach fix, one navigation receiver must remain tuned to and display the facility that provides final approach course guidance***. For example, if an aircraft is equipped with only one VOR receiver, that receiver cannot be retuned inside the final approach fix to another VOR station that identifies subsequent stepdown fixes and/or the missed approach point.

14.2.1.2. Flying the Approach.

14.2.1.2.1. Descent. Avoid rapid descent requirements on final by crossing the FAF at the published altitude.

14.2.1.2.2. Timing. Timing is required when the final approach does not terminate at a published fix, as is usually the case with VOR, NDB, and localizer. ***If timing is required to identify the missed approach point, begin timing when***

passing the FAF or the starting point designated in the timing block of the approach plate. This point is usually the FAF, but it may be a fix not co-located with the FAF such as a LOM, NDB, crossing radial, DME fix or outer marker. Time and distance tables on the approach chart are based on groundspeed; therefore, the existing wind and TAS must be considered to accurately time the final approach. If timing is published on the approach plate, then timing can also be valuable as a backup in the event of DME loss or other problems that might preclude determination of the MAP. ***If timing is not published, do not use timing to identify the missed approach point***.

14.2.1.2.2.1. If timing is not specifically depicted on the instrument approach procedure, timing is not authorized as a means of identifying the MAP.

14.2.1.2.2.2. Timing is the least precise method of identifying the missed approach point; therefore, when the use of timing is not authorized for a particular approach because of TERPS considerations, timing information will not be published.

14.2.1.2.2.3. If other means of identifying the MAP are published (e.g. DME), they should be used as the primary means to determine the MAP. In these situations, timing is a good backup, but it is not the primary means of identifying the MAP. For example, if you reach the published DME depicting the MAP, do not delay executing the missed approach just because you have not reached your timing.

14.2.1.2.3. ***Turns. When a turn is required over the FAF, turn immediately and intercept the final approach course to ensure that obstruction clearance airspace is not exceeded***.

14.2.1.2.4. ***Minimum Descent Altitude. Do not descend to the minimum descent altitude (MDA) or step down fix altitude until passing the FAF (if published).***

14.2.1.2.5. Visual Descent Point. Arrive at MDA (MDA is determined by the barometric altimeter) with enough time and distance remaining to identify the runway environment and depart MDA from a normal visual descent point to touchdown at a rate normally used for a visual approach in your aircraft.

14.2.1.2.6. ***Runway Environment. Descent below MDA is not authorized until sufficient visual reference with the runway environment has been established and the aircraft is in a position to execute a safe landing***. Thorough preflight planning will aid you in locating the runway environment (lighting, final approach displacement from runway, etc.). The definition of runway environment for non-precision and precision approaches is the same. ***The runway environment consists of one or more of the following elements***:

14.2.1.2.6.1. The ***approach light system*** (except that the pilot may not descend below 100 feet above the TDZE using the approach lights as a reference unless the red termination bars or the red side row bars are also visible and identifiable).

14.2.1.2.6.2. The ***threshold, threshold markings or threshold lights***.

14.2.1.2.6.3. The ***runway end identifier lights***.

14.2.1.2.6.4. The ***touchdown zone, touchdown zone markings, or touchdown zone lights***.

14.2.1.2.6.5. The ***runway or runway markings***.

14.2.1.2.6.6. The ***runway lights***.

14.2.1.2.6.7. The ***visual approach slope indicator***.

14.2.1.2.6.7.1. CAUTION: Most approach lighting systems serving runways where no electronic glide path guidance is available do not have red termination bars or red side row bars; therefore you must have at least one of the other elements of the runway environment in sight in order to descend below 100 feet above the TDZE.

14.2.1.2.6.7.2. CAUTION: Depending on the location of the MAP, the descent from the MDA (once the runway environment is in sight) often will have to be initiated prior to reaching the MAP in order to execute a normal (approximately 3°) descent to landing.

14.2.1.2.6.8. In many cases, the minimum visibility required for the approach will not allow you to see the runway environment until you are beyond the VDP. This accentuates the need to compute a VDP and determine a point along the approach when you will no longer attempt to continue for a landing. A common error is to establish a high descent rate once the runway environment is in sight. This can go unnoticed during an approach without visual glide path guidance and may lead to a short and/or hard landing. Caution should also be used to avoid accepting a long touchdown and landing roll.

14.2.1.2.7. Alignment. Be aware that the final approach course on a non-radar final may vary from the runway heading as much as 30° (except localizer) and still be published as a straight-in approach.

14.2.1.2.8. Stepdown Fix. A stepdown fix between the FAF and the missed approach point is sometimes used. ***Descent below stepdown fix altitude is limited to aircraft capable of simultaneous reception of final approach course guidance and the stepdown fix.*** Regardless of the type or number of navigation facilities used to define the stepdown fix, one navigation receiver must remain tuned to and display the navigation facility that provides final approach course guidance. For example, aircraft equipped with a single VOR receiver will not descend below a stepdown fix altitude when two VOR radials define that fix. The VOR receiver must remain tuned to and must display the facility that provides the final approach course.

14.2.1.2.8.1. NOTE: Fixes that require RADAR for identification are depicted with the word "RADAR" appearing next to the fix. Only ground-based radar, such as airport surveillance, precision, or air route surveillance radar, may be used to position the aircraft.

14.2.2. Procedures that can be flown with or without glide path guidance using the same final approach course guidance include ILS, MLS, and RNAV/GPS.

14.2.2.1. ILS (Includes LOC, LLZ, BC, LDA, and SDF).

14.2.2.1.1. Required Components. In the United States, the glide slope, the localizer, and the outer marker are required components for an ILS. If the outer marker is inoperative or not installed, it may be replaced by DME, another NAVAID, a crossing radial, or radar provided these substitutes are depicted on the approach plate or identified by NOTAM. If the glide slope fails or is unavailable, the approach reverts to an approach without glide path guidance. If the localizer fails, the procedure is not authorized. ***If the OM (or at least one of its substitutes) is not available, then the procedure is not authorized.***

14.2.2.1.2. Transition to the ILS Localizer Course. This is performed by using either radar vectors or a published approach procedure.

14.2.2.1.2.1. Tune. Tune the ILS as soon as practicable during the transition and monitor the identifier during the entire approach. Refer to Chapter 7, paragraph 7.1.4, for discussion of procedures.

14.2.2.1.2.2. Front Course. ***Set the published localizer front course in the course selector window prior to attempting localizer interception***.

14.2.2.1.2.2.1. NOTE: If using a flight director system or flight management system, the switches should be positioned in accordance with instructions in the aircraft flight manual for intercept and final approach modes of operation. Normally, manual selection of the final approach mode would be delayed until the aircraft heading is within 15 ° of the localizer course and the CDI is within one dot of center.

14.2.2.1.2.3. Orientation. Use any available navigation facility (for example, TACAN) to aid in remaining position oriented in relation to the localizer course and glide slope intercept point. (The glide slope has a usable range of 10 miles.)

14.2.2.1.2.3.1. WARNING: It is possible to receive a false or erroneous glide slope signal with both the ground and air components of the glide slope system operating normally, with normal ident, no off flags or warnings, and established on the localizer course. ***Use any available means to confirm your position and expected altitude when flying an ILS approach.***

14.2.2.1.3. Accomplish the Approach.

14.2.2.1.3.1. Intercepting the Localizer. Once the localizer course is intercepted, reduce heading corrections as the aircraft continues inbound. Heading changes made in increments of 5° or less will usually result in more precise course control.

14.2.2.1.3.1.1. Localizer signal. The localizer signal typically has a usable range of at least 18 miles within 10° of the course centerline unless otherwise stated on the IAP. ATC may clear you to intercept the localizer course beyond 18 miles or the published limit, however, this practice is only acceptable when your aircraft is in radar contact and ATC is sharing responsibility for course guidance.

14.2.2.1.3.2. Descent. When on the localizer course, maintain glide slope intercept altitude (published or assigned) until intercepting the glide slope. Published glide slope intercept altitudes may be minimum, maximum, mandatory, or recommended altitudes and are identified by a lightning bolt (⇝). When the glide slope intercept altitude is a recommended altitude, you must only comply with other IAP altitudes (FAF altitude for example) until established on the glide slope. When on glide slope, crosscheck the aircraft altitude with the published "Glide slope Altitude at Outer Marker/FAF" to ensure you are established on the correct glide slope. ***Do not descend below a descent restrictive altitude (minimum or mandatory) if the CDI indicates full-scale deflection***. On approaches where the "Glide slope Altitude at outer Marker/FAF" is not published, you should use all means available to ensure you are on the proper glide slope and a normal descent rate is established (ref. Paragraph 14.2.1.2.6.).

14.2.2.1.3.2.1. NOTE: Airborne marker beacon receivers that have a selective sensitivity feature should always be operated in the "Low" sensitivity position to ensure proper reception of the ILS marker beacons.

14.2.2.1.3.3. Glide slope Indicator. Prepare to intercept the glide slope as the glide slope indicator (GSI) moves downward from its upper limits. Determine the approximate rate of descent to maintain the glide slope. The vertical velocity required to maintain this angle of descent will be dependent upon the aircraft groundspeed and the ILS glide slope angle. Slightly before the GSI reaches the center position, coordinate pitch and power control adjustments to establish the desired rate of descent.

14.2.2.1.3.3.1. Pitch Adjustments. Pitch adjustments made in increments of 2° or less will usually result in more precise glide path control. As the approach progresses, smaller pitch and bank corrections are required for a given CDI/GSI deviation.

14.2.2.1.3.3.2. Over Controlling. During the latter part of the approach, pitch changes of 1° and heading corrections of 5° or less will prevent over controlling.

14.2.2.1.3.4. Steering Commands. If using pitch and bank steering commands supplied by a flight director system or FMS, monitor flight path and aircraft performance instruments to ensure the desired flight path is being flown and aircraft performance is within acceptable limits. A common and dangerous error when flying an ILS on the flight director is to concentrate on the steering bars and ignore flight path and aircraft performance instruments. Failure of the flight director computer (steering bars) may NOT always be accompanied by the appearance of warning flags. Steering commands must be correlated with flight path (CDI and Glide Slope Indicator (GSI)) and aircraft performance instruments.

14.2.2.1.3.5. Crosscheck. Maintain a complete instrument crosscheck throughout the approach, with increased emphasis on the altimeter during the latter part (DH is determined by the barometric altimeter). Establish a systematic scan for the runway environment prior to reaching DH

14.2.2.1.3.6. Decision Height. DH is the height at which a decision must be made during a precision approach to either continue the approach or to execute a missed approach. ***Continued descent below DH is not authorized until sufficient visual reference with the runway environment has been established. A momentary deviation below DH without the runway environment in sight is only authorized in conjunction with a proper missed approach initiated at DH.*** Definition of runway environment is found in paragraph 14.2.1.2.6.

14.2.2.1.3.6.1. CAUTION: The ILS/LOC approach must be discontinued if the localizer course becomes unreliable, or any time full-scale deflection of the CDI occurs on final approach. ***Do not descend below localizer minimums if the aircraft is more than one dot (half scale) below or two dots (full scale) above the glide slope. If the glide slope is recaptured to within the above tolerance, descent may be continued to DH.***

14.2.2.1.3.6.2. NOTE: If making an autopilot coupled approach or landing, use the aircraft flight manual procedures for the category of ILS approach being conducted. When the weather is below 800 foot ceiling and/or 2 miles visibility, vehicles and aircraft are not authorized in or over the ILS critical area when an arriving aircraft is between the ILS final approach fix and the airport (except for aircraft that land, exit a runway, depart or miss approach). However, ***when autopilot coupled or auto land operations are to be conducted, and the weather is above ceiling 800 feet and/or visibility 2 miles, advise the ATC approach or tower controller as soon as practical but not later than the FAF***. This will allow time for the appropriate ILS critical area to be cleared or an advisory issued. The advisory used by controllers will be: "Localizer/glide slope signal not protected." In this case be alert for unstable or fluctuating ILS indications that may prevent an autopilot-coupled approach. When aircraft equipment and crew qualification permit, the localizer and glide slope may be used for autopilot operations to the points specified in FLIP for each category of ILS approach, unless a restriction is published on the approach procedure.

14.2.2.1.3.6.3. NOTE: Erroneous Glide slopes. Some types of tests performed by ground technicians may produce “erroneous” glide slopes. It is possible to have an “on glide slope” indication in the cockpit whenever and wherever the signal is received (i.e. well above or below the actual glide slope) without an off flag. Usually technicians carry out these tests in good weather with the effected runway not in use, however this is not always possible. It is extremely important to monitor for a proper identifier and have current NOTAM information for the ILS being flown. You must also listen for your specific approach clearance (i.e. glide slope out of service) in addition to doing a proper altitude check at the glide slope intercept point. Several near Controlled Flight Into Terrain (CFIT) incidents involving commercial airliners have occurred in recent years highlighting the seriousness of this problem. A similar phenomenon may occur with the localizer portion of the signal during certain ground test conditions.

14.2.2.1.4. LOC Procedures Without Glide Path Guidance.

14.2.2.1.4.1. ***The middle marker may never be used as the sole means of identifying the MAP.*** The middle marker may assist you in identifying the MAP on certain localizer approaches provided it is coincident with the published localizer MAP. To determine the location of the MAP, compare the distance from the FAF to MAP adjacent to the timing block. It may not be the same point as depicted in the profile view. If the MM is received while executing such an approach, and your primary indications (DME and/or timing) agree, you may consider yourself at the MAP and take appropriate action. ***If the middle marker is the only way to identify the MAP (i.e., timing is not published), then the approach is not authorized***.

14.2.2.1.4.2. CAUTION: Approach procedures without glide path guidance (i.e. LOC) published in conjunction with an ILS cannot always clearly depict the FAF crossing altitude. Careful review of the IAP using the following guidance is required. ***The minimum altitude to be maintained until crossing the fix following the glide slope intercept point (normally the FAF will be the next fix) is the published glide slope intercept altitude, altitude published at that fix, or ATC assigned altitude.*** For most approaches without glide path guidance the glide slope intercept altitude will be the minimum FAF crossing altitude.

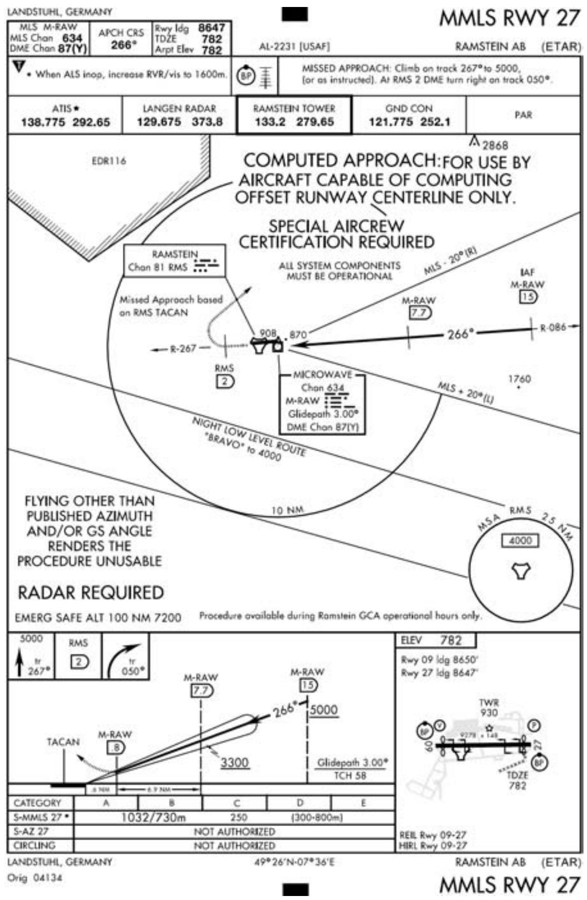
14.2.2.1.4.3 . "Back Course" Localizer. In order to fly a back course localizer approach, ***set the published front course in the course selector window.*** The term "front course" refers to the inbound course depicted on the ILS/localizer approach for the opposite runway. On the back course approach plate, the published front course is depicted in the feather as an outbound localizer course.

14.2.2.2. MLS.

14.2.2.2.1. Final Approach With Glide Path Guidance.

14.2.2.2.1.1. There are two types of MLS approaches: non-computed and computed. These approaches may be flown in the automatic mode (preferred) or the manual mode. MLS approaches are assumed to be non-computed unless noted on the approach procedure. Computed MLS approaches will have the following note in the plan view of the approach plate: "COMPUTED APPROACH: FOR USE BY AIRCRAFT CAPABLE OF COMPUTING OFFSET RUNWAY CENTERLINE ONLY." An example of a computed approach is provided in Figure 14.1.

Figure 14.1. Computed MLS Approach.



14.2.2.2.2. Non-Computed. When flying a non-computed MLS approach, the azimuth signal steers your aircraft to the azimuth antenna just as approaches to traditional NAVAIDs such as VOR or TACAN do. Consequently, it is important for you to know where the azimuth antenna is located on the airfield. Non-computed approaches should be flown using the default settings (AUTO and NON-COMP) of your MLS equipment.

14.2.2.2.2.1. Standard Installation. In the most common MLS installation, the antenna is located along the runway centerline between 1,000 and 1,500 feet from the departure end of the runway. When flying a non-computed approach to this type of installation, your final approach will normally be lined up along the extended runway centerline.

14.2.2.2.2.2. Offset Installation. In some installations, the azimuth antenna may be installed alongside the runway (offset). In this case, when flying a non-computed approach, the azimuth guidance will not steer your aircraft to the runway along the extended runway centerline. In this particular configuration, the azimuth is rotated so that the azimuth signal guides your aircraft to the azimuth antenna along a course that is not parallel to the runway centerline. It is important to realize that MLS approaches can have final approach courses that are not parallel to the runway centerline. Review the approach plate carefully for notes to that effect and for the arrow leading up to the aerodrome sketch to determine where to look for the runway at the missed approach point.

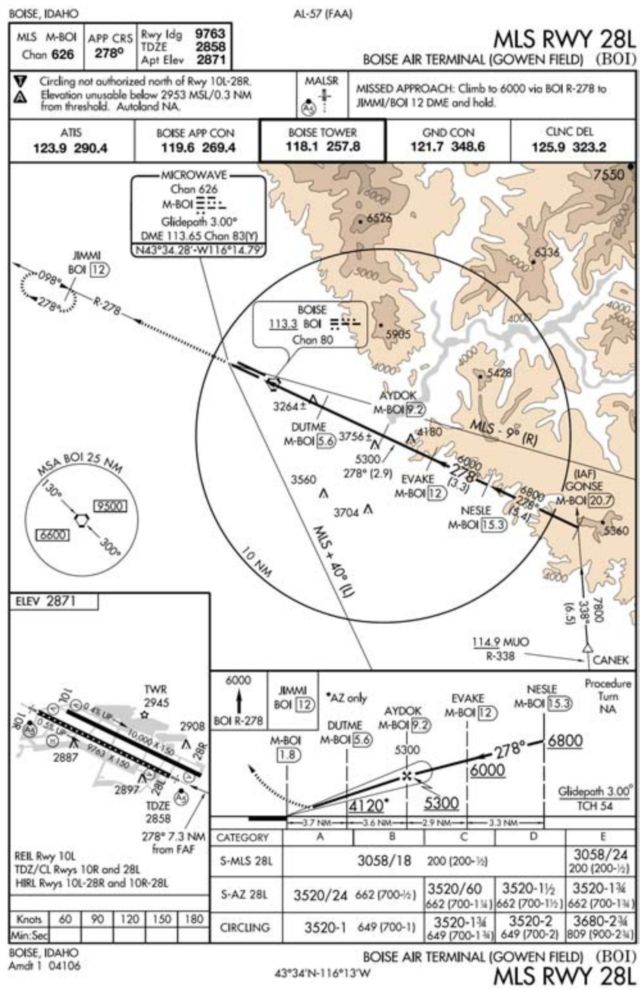
14.2.2.2.2.2.1. WARNING: If you are flying a non-computed MLS approach, and you select the "COMPUTED" approach mode on your MLS equipment, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance. The only time the "COMPUTED" mode should be selected is when the approach to be flown is a computed approach as indicated on the approach plate.

14.2.2.2.2.3. Computed (COMP). A computed MLS approach steers your aircraft to the runway along a course aligned with the extended runway centerline regardless of the location of the ground transmitters. Aircraft having MLS receivers capable of using computed approach guidance can only fly computed approaches. Using slant-range DME and elevation, the MLS receiver computes the along-track-distance which is used with the azimuth transmitter's known location and offset distance from the runway centerline to compute an offset approach path which will steer the aircraft to the runway along the extended runway centerline. Computed approaches should be flown using the AUTO and COMP settings of your MLS equipment.

14.2.2.2.2.3.1. WARNING: In order to fly a computed MLS approach, all system components (AZ, EL, and DME) must be operational. Failure of any component will result in aircraft receiver course and glide slope off/warning flags and loss of course information.

14.2.2.2.2.3.2. WARNING: If you are flying a computed MLS approach, and you select the "NON-COMPUTED" approach mode on your MLS equipment, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance. "COMPUTED" mode should be selected when the approach to be flown is a computed approach as indicated in the plan view on the approach plate.

Figure 14.2. MLS Approach at Boise, ID.



14.2.2.2.2.4. Manual vs. Automatic Mode. Likewise, if you switch to manual mode and change either the approach azimuth or glide slope, the IAP you are using is no longer valid.

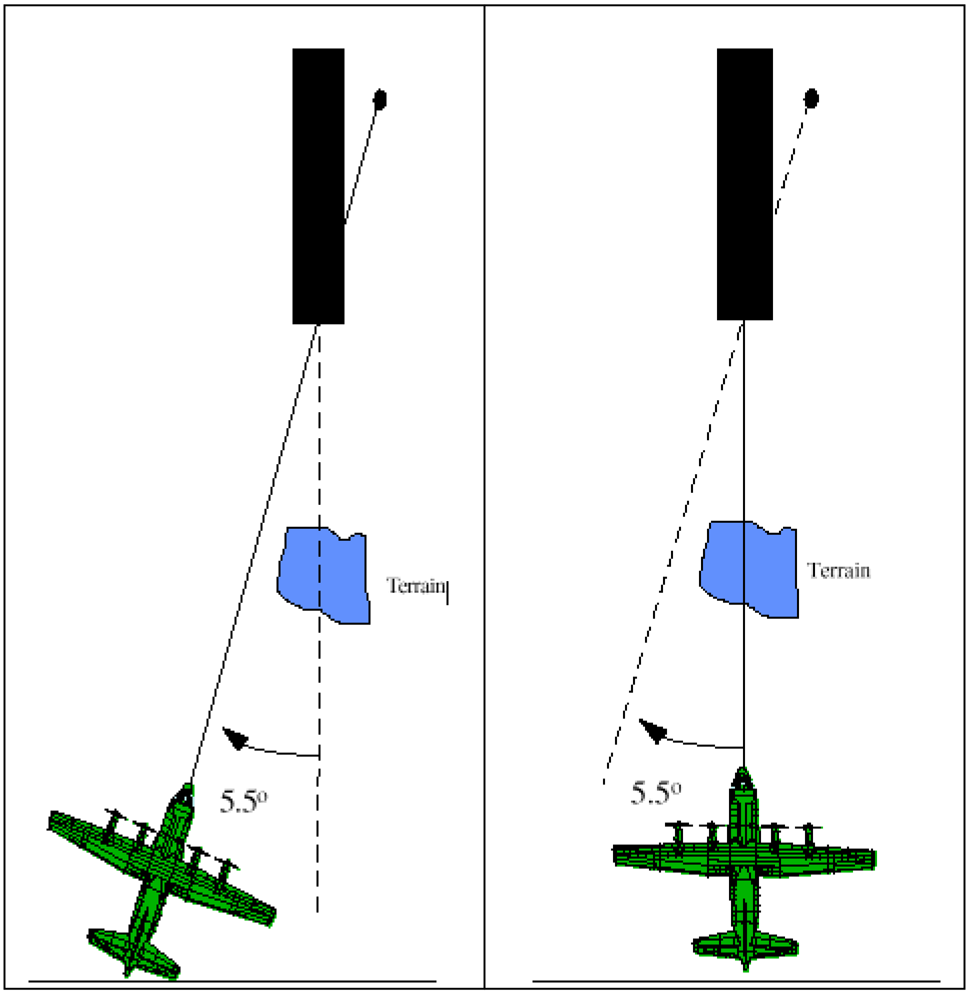
14.2.2.2.2.5. Elevation Angle. An elevation angle less than what the approach was designed for may not give you obstacle clearance, and an elevation higher than the published angle mandates higher approach minima.

14.2.2.2.2.6. Approach Azimuth. If you change the published approach azimuth in manual mode, your aircraft will be steered to the runway along a different course than published which may take you outside of the airspace the TERPS specialist has protected for you.

14.2.2.2.2.6.1. WARNING: When flying an MLS approach, if operating in manual mode and the pilot selects an azimuth and/or elevation angle different from the published procedure, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance. Follow MAJCOM directives regarding flying MLS approaches in the manual mode.

Figure 14.3. Non-Computed Mode.

Figure 14.4. Computed Mode.



14.2.2.2.2.7. Transition to the MLS Course. Transition to the MLS final approach course by using either radar vectors or a published instrument approach procedure.

14.2.2.2.2.7.1. Tune. Tune the MLS as soon as practicable during the transition to final and monitor the MLS identifier during the entire approach. The MLS is identified by a four-letter identifier always beginning with the letter "M." The four-letter ident is transmitted at least six times per minute by the approach azimuth (or back azimuth) ground equipment. Some aircraft installations do not include the audible identification feature; in this case, observing the correct 4-letter identifier on the aircraft's avionics display can identify the MLS.

14.2.2.2.2.8. Azimuth and Glide Slope Selection. The MLS receiver will automatically select the appropriate azimuth and glide slope as well as tune the TACAN for distance information. When operating in the manual mode, you may change the published azimuth and glide slope angle.

14.2.2.2.2.8.1. WARNING: If operating in manual mode and the pilot selects a course and/or glide slope different from the published procedure, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance.

14.2.2.2.2.9. Orientation. Use appropriate navigation facilities (for example: VOR, TACAN, GPS, or NDB) to remain position-oriented during the approach.

14.2.2.2.2.10. Using a Flight Director. When using a flight director system, the flight director should be configured in accordance with instructions in the aircraft flight manual for the intercept and final approach modes of operation.

14.2.2.2.2.10.1. NOTE: aircraft may only fly MMLS approaches with the proper equipment as determined by aircraft flight manual and/or MAJCOM. All other procedures to fly the approach will be the same as for conventional MLS.

14.2.2.2.2.10.2. WARNING: If you are flying a non-computed approach and you select the "COMPUTED" approach mode on your MLS equipment, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance. The only time the "COMPUTED" mode should be selected is when the approach to be flown is a computed approach.

14.2.2.2.2.10.3. WARNING: If you are flying a computed MLS approach, and you select the "NON-COMPUTED" approach mode on your MLS equipment, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance. "COMPUTED" mode should be selected when the approach to be flown is a computed approach as indicated in the plan view on the approach plate.

14.2.2.2.2.11. Accomplish the Approach.

14.2.2.2.2.11.1. Interception. Once the MLS course is intercepted, reduce heading corrections as the aircraft continues inbound. Heading changes made in increments of 5° or less will usually result in more precise course control.

14.2.2.2.2.11.2. Descent. When on the MLS course, maintain glide slope intercept altitude (published or assigned) until intercepting the glide slope. Published glide slope intercept altitudes may be minimum, maximum, mandatory, or recommended altitudes and are identified by a lightning bolt. When the glide slope intercept altitude is a recommended altitude, you must only comply with other IAP altitudes (FAF altitude for example) until established on the glide slope. Do not descend below a descent restrictive altitude (minimum or mandatory, not recommended) if the CDI indicates full-scale deflection.

14.2.2.2.2.11.3. Glide Slope Indicator. Prepare to intercept the glide slope as the GSI moves downward from its upper limits. Determine the approximate rate of descent to maintain the glide slope. The vertical velocity required to maintain this angle of descent will be dependent upon the aircraft groundspeed and the glide slope angle. Slightly before the GSI reaches the center position, coordinate pitch and power control adjustments to establish the desired rate of descent.

14.2.2.2.2.12. Pitch Adjustments. Pitch adjustments made in increments of 2° or less will usually result in more precise glide slope control. As the approach progresses, smaller pitch and bank corrections are required for a given CDI/GSI deviation.

14.2.2.2.2.12.1. Over-Controlling. During the latter part of the approach, pitch changes of 1° and heading corrections of 5° or less will prevent over-controlling.

14.2.2.2.2.12.2. Steering Commands. If using pitch and bank steering commands supplied by a flight director system, monitor basic flight data (raw data) and aircraft performance instruments to ensure the desired flight path is being flown and aircraft performance is within acceptable limits. A common and dangerous error when flying an MLS approach using a flight director is to concentrate only on the steering bars and ignore other flight path and aircraft performance instruments. Failure of the flight director computer (steering bars) may NOT always be accompanied by the appearance of warning flags. Steering commands must be correlated with flight path (CDI and GSI) and aircraft performance instruments.

14.2.2.2.2.12.3. Crosscheck. Maintain a complete instrument crosscheck throughout the approach, with increased emphasis on the altimeter during the latter part (DH is determined by the barometric altimeter). Establish a systematic scan for the runway environment prior to reaching DH. At DH, if visual reference with the runway environment is established, continue the approach to landing using flight instruments to complement the visual reference.

14.2.2.2.2.12.4. WARNING: The MLS approach must be discontinued if the course becomes unreliable, or any time full-scale deflection of the CDI occurs on final approach. Do not descend below azimuth-only minimums if the aircraft is more than one dot (half scale) below or two dots (full scale) above the glide slope. If the glide slope is recaptured to within the above tolerances, descent may be continued to DH.

14.2.2.2.2.12.5. NOTE: If making an autopilot-coupled approach or landing, follow the aircraft flight manual procedures. When autopilot coupled operations are to be conducted, advise the ATC approach controller as soon as practical, but not later than the FAF. This will allow time for the appropriate critical area to be cleared or an advisory issued.

14.2.2.2.2.13. Final Approach Without Glide Path Guidance.

14.2.2.2.2.13.1. Final Approach Segment. The final approach segment starts at the FAF and ends at the MAP. The optimum length of the final approach is 5 miles; the maximum length is 10 miles.

14.2.2.2.2.13.2. Azimuth-Only MLS signal. The azimuth signal has a usable range of at least 20 miles (at least 15 NM for MMLS) within ± 40° of the course centerline unless otherwise stated on the IAP. If operating in the automatic mode (the preferred mode), the receiver will automatically select the appropriate azimuth as well as tune the TACAN or DME for distance information. If operating in manual mode, you must manually set the desired azimuth.

14.2.2.2.2.13.3. NOTE: Computed MLS azimuth-only approaches may only be flown by aircraft with the proper equipment, and all system components (azimuth, elevation, and DME) must be operational.

14.2.2.2.2.13.4. WARNING: When flying an MLS azimuth-only approach, if operating in manual mode and the pilot selects an azimuth different from the published procedure, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance.

14.2.2.2.2.13.5. WARNING: If you are flying a non-computed approach and you select the "COMPUTED" approach mode on your MLS equipment, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance. The only time the "COMPUTED" mode should be selected is when the approach to be flown is a computed approach.

14.2.2.2.2.13.6. WARNING: If you are flying a computed MLS approach, and you select the "NON-COMPUTED" approach mode on your MLS equipment, the published approach is no longer valid and the actual approach flown will no longer guarantee obstacle clearance. "COMPUTED" mode should be selected when the approach to be flown is a computed approach as indicated on the approach plate.

14.2.2.2.2.14. Flying the Approach.

14.2.2.2.2.14.1. Descent. Avoid rapid descent requirements on final by crossing the FAF at the published altitude.

14.2.2.2.2.14.2. CAUTION: Non-precision approach procedures published in conjunction with an MLS do not always clearly depict the FAF crossing altitude. Careful review of the IAP using the following guidance is required. The minimum altitude to be maintained until crossing the fix following the glide slope intercept point (normally the FAF will be the next fix) is the published glide slope intercept altitude, altitude published at that fix, or ATC assigned altitude. For most non-precision approaches, the glide slope intercept altitude will be the minimum FAF crossing altitude.

14.2.2.2.2.15. Timing. Timing is required when the final approach does not terminate at a published fix, as is usually the case with VOR, NDB, and localizer. Begin timing when passing the FAF or the starting point designated in the timing block of the approach plate. This point is usually the FAF, but it may be a fix not collocated with the FAF such as a LOM, NDB, crossing radial, DME fix or outer marker. Time and distance tables on the approach chart are based on groundspeed; therefore, the existing wind and TAS must be considered to accurately time the final approach. If timing is published on the approach plate, then timing can also be valuable as a backup in the event of DME loss or other problems that might preclude determination of the MAP. If timing is not published, timing is not authorized as a means of identifying the missed approach point. Time/distance tables will not be published on computed MLS approaches.

14.2.2.2.2.15.1. NOTE: If timing is not specifically depicted on the instrument approach procedure, timing is not authorized as a means of identifying the MAP.

14.2.2.2.2.15.2. NOTE: Timing is the least precise method of identifying the missed approach point; therefore, when the use of timing is not authorized for a particular approach because of TERPS considerations, timing information will not be published.

14.2.2.2.2.15.3. NOTE: The middle marker may be an accurate means of identifying the MAP on certain azimuth only approaches provided it is coincident with the published localizer MAP. To determine the location of the MAP, compare the distance from the FAF to MAP adjacent to the timing block. It may not be the same point as depicted in the profile view. However, if the MM is received while executing such an approach, and other indications (DME and/or timing) agree, you may consider yourself at the MAP and take appropriate action.

14.2.2.2.2.16. Turns. If a turn is required over the FAF, turn immediately and intercept the final approach course to ensure that obstruction clearance airspace is not exceeded.

14.2.2.2.2.17. MDA. Do not descend to the minimum descent altitude (MDA) or step down fix altitude until passing the FAF (if published).

14.2.2.2.2.18. VDP. Arrive at MDA (MDA is determined by the barometric altimeter) with enough time and distance remaining to identify runway environment and depart MDA from a normal visual descent point to touchdown at a rate normally used for a visual approach in your aircraft.

14.2.2.2.2.19. Runway environment. Descent below MDA is not authorized until sufficient visual reference with the runway environment has been established and the aircraft is in a position to execute a safe landing. Thorough preflight planning will aid you in locating the runway environment.

14.2.2.2.2.19.1. CAUTION: Depending on the location of the MAP, the descent from the MDA (once the runway environment is in sight) often will have to be initiated prior to reaching the MAP in order to execute a normal (approximately 3°) descent to landing.

14.2.2.2.2.20. Alignment. Be aware that the final approach course on a non-radar final may vary from the runway heading as much as 30° and still be published as a straight-in approach.

14.2.2.2.2.20.1. NOTE: When fixes on the IAP are depicted as defined by radar, only ground-based radar, such as airport surveillance, precision, or air route surveillance radar may be used to position the aircraft.

14.2.2.2.3. Inoperative System Components.

14.2.2.2.3.1. Non-Computed Approaches.

14.2.2.2.3.1.1. Azimuth Failure. If the azimuth transmitter is inoperative, no approach is authorized.

14.2.2.2.3.1.2. Elevation Failure. If the elevation transmitter is inoperative, only the non-precision (azimuth-only) approach is authorized.

14.2.2.2.3.1.3. DME Failure. Ensure you can identify all required fixes with the MLS DME inoperative.

14.2.2.2.3.2. Computed Approaches. All components must be fully operational; if any component is not available, then the approach is not authorized.

14.2.2.2.3.2.1. WARNING: In order to fly a computed MLS approach, all system components (AZ, EL, and DME) must be operational. Failure of any component will result in aircraft receiver course and glide slope off/warning flags and loss of course information.

14.2.3. RNAV (GPS) and GPS Approach Procedures.

14.2.3.1. RAIM Procedures

14.2.3.1.1. Predictive RAIM not Available. If predictive RAIM is not available, another type of navigation and approach system must be used, another destination selected, or the trip delayed until RAIM is predicted to be available on arrival. A predictive RAIM check must be accomplished prior to arrival in order to allow for crews to plan for an alternate means of navigation.

14.2.3.1.2. RAIM Failure Prior to the Final Approach Waypoint (FAWP). If a RAIM failure/status annunciation occurs prior to the final approach waypoint, do not commence the approach. Coordinate for an alternate clearance.

14.2.3.1.3. Approach does not activate prior to the FAWP. If the receiver does not transition from "armed" to the approach mode prior to the FAWP (usually transition occurs 2NM prior), do not commence the approach. If a RAIM failure/status annunciation occurs prior to the FAWP, do not descend to MDA, instead proceed to the Missed Approach Waypoint (MAWP) via the FAWP and perform a missed approach. Contact ATC as soon as practical to coordinate for an alternate clearance.

14.2.3.1.4. RAIM Failures after the FAWP. If a RAIM failure occurs after the FAWP, the receiver, based on equipage, is allowed to continue operating without an annunciation for up to 5 minutes to allow completion of the approach. You must check the receiver operator manual to ensure you have this capability. If you do not have this capability and a RAIM flag/status annunciation appears after the FAWP, climb to the missed approach altitude, proceed to the MAWP and execute a missed approach.

14.2.3.2. Flying the Approach Procedure

14.2.3.2.1. Retrieving the procedure from the Data Base. Do not fly the approach unless it can be retrieved in its entirety from a current approved database. Cross check data base waypoints against those contained on the published approach plate. If discrepancies exist, do not fly the approach. Exception: The FAWP altitude may be raised above that shown on the published chart in order to ensure adequate clearance at a step down fix.

14.2.3.2.2. Prior to commencing the approach. Determine which area of the TAA the aircraft will enter using bearing and distance to the IF (IAF). ***Fly the full approach from an Initial Approach Waypoint (IAWP) or feeder fix unless specifically cleared otherwise.*** Entry from other than an IAWP does not assure terrain clearance.

14.2.3.2.3. Approach Arming. Some receivers automatically arm the approach mode, while others require manual arming. Arming the approach mode switches the aircraft to terminal CDI scaling (± 1 NM). If the IAWP is beyond 30NM from the airfield, CDI sensitivity will not change until the aircraft is within 30NM of the airport reference point. Feeder route obstacle clearance is predicated on terminal sensitivity and RAIM at the IAWP. ***For manual systems, aircrews must ensure the approach is loaded prior to being established on any portion of the approach.***

14.2.3.2.4. Activating the approach. When within 2NM of the FAWP with the approach mode armed, the receiver will automatically initiate a RAIM check, and switch to approach sensitivity and RAIM (0.3NM***).*** Distance is provided based on the active WP. Pilots must cross check the active WP identifier to ensure situational awareness. Some operations (e.g., holding, course reversal maneuvers) may require manual intervention to either stop or resume automatic waypoint sequencing. ***Pilots must ensure the receiver is sequenced to the appropriate waypoint, especially if not flying the full procedure***. ***If on vectors to final, ensure that receiver is set IAW flight manual procedures***. Being established on the final approach course prior to the initiation of the sensitivity change at 2 NM from the FAWP will aid in CDI interpretation prior to descent to MDA/DA. Also, requesting or accepting vectors that will cause the aircraft to intercept the final approach course within 2 NM of the FAWP is not recommended. When receiving vectors to final, most receiver operating manuals suggest placing the receiver in the non-sequencing mode prior to the FAWP and manually setting the course. This provides an extended final approach course in cases when vectors will place the aircraft outside any existing segment that is aligned with the runway. ***Assigned altitudes must be maintained until established on a published segment of the approach***. Required altitudes at waypoints outside the FAWP or stepdown fixes must also be considered.

14.2.3.2.5 Flying point to point on the approach does not assure compliance with the published procedure. The proper RAIM sensitivity will not be available and the CDI sensitivity will not automatically change to ±0.3 NM. Manually setting CDI sensitivity does not automatically change the RAIM sensitivity on some receivers.

14.2.3.2.6. Loss of final approach guidance on an RNAV or GPS approach procedure is annunciated in a variety of ways depending on your particular avionics installation. In some aircraft the CDI will center when the "GPS Integrity" light illuminates and can give the illusion that you are on course. Insure you are thoroughly familiar with failure annunciations for your aircraft and discontinue the approach immediately if course guidance is suspect.

14.2.3.3. Final Approach

14.2.3.3.1. Descent to MDA or DA. Do not descend to MDA, DA, or step down fix altitude until passing the FAF.

14.2.3.3.2. Vertical Navigation. ***Unless circling from the approach, VNAV guidance should be followed if provided by aircraft avionics and certified for use IAW AFI 11-202 Volume 3, General Flight Rules.*** VNAV guidance may be used to LNAV minimums; however, the aircraft must level off prior to MDA if the runway environment is not in sight. Due to the temperature and pressure altitude effects, USAF crews shall not use VNAV guidance below published MDA or DA.

14.2.3.3.3. Step Down Fixes. ***USAF pilots must comply with all stepdown fixes depicted on the IAP.*** VNAV guidance should provide clearance from all step down fix altitudes, however, crews must monitor altitude at all step down fixes to ensure compliance.

14.2.3.3.4. Runway Environment. Do not descend below MDA/DA unless sufficient visual reference with the runway environment has been established and the aircraft is in position to execute a safe landing.

14.2.3.3.4.1. Missed Approach. ***To execute a missed approach, activate the missed approach after crossing the MAWP***. GPS missed approach procedures require pilot action to sequence from the MAWP to the missed approach procedure. If the missed approach is not activated, the GPS receiver will display an extension of the inbound final approach course, and displayed distance will increase from the MAWP. ***Do not activate the missed approach prior to the MAWP***. Once the missed approach is activated, CDI sensitivity is set to 1NM. Missed approach routings in which the first track is via a course rather than direct to the next waypoint require additional action from the pilot to set the course (consult your flight manual). ***Do not turn off of the final approach course prior to the MAWP***.

14.3. Radar.

14.3.1. Precision and Surveillance Approaches. There are two basic types of approaches: the precision approach and the surveillance approach. The precision approach provides the pilot with precise course, glideslope, and range information; the surveillance approach provides course and range information and is classified as a nonprecision approach. Upon request, the controller will provide recommended altitudes on final to the last whole mile that is at or above the published MDA. Recommended altitudes are computed from the start descent point to the runway threshold. (At the MAP, the straight-in surveillance system approach error may be as much as 500 feet from the runway edges.)

14.3.2. Lost Communications.

14.3.2.1. Backup. ***In preparation for the radar approach, select a backup approach that is compatible with the existing weather and your aircraft where available.*** Be prepared to fly this approach in the event of radar failure or lost communications. If you experience lost communications, you are automatically cleared to fly any published approach unless the controller previously issued a specific lost communications approach.

14.3.2.2. Contact. Attempt contact with the controlling agency if no transmissions are received for approximately:

14.3.2.2.1**.** One minute while being vectored to final,

14.3.2.2.2**.** Fifteen seconds while on final for an ASR approach, or

14.3.2.2.3. Five seconds while on final for a PAR approach.

14.3.2.3. Backup Approach. If unable to reestablish communications and unable to maintain VFR, transition to your backup approach. Intercept the approach at the nearest point that will allow a normal rate of descent and not compromise safety. ***Maintain the last assigned altitude or the minimum safe/sector altitude (emergency safe altitude if more than 25 NM from the facility); whichever is higher, until established on a segment of the published approach***.

14.3.2.4. No Backup Approach. If there are no backup approaches compatible with the weather or with your aircraft, advise the controller upon initial contact of your intentions in the event of lost communications. If local conditions dictate, the controller may specify the approach to fly if you experience lost communications. It is the pilot's responsibility to determine the adequacy of any issued lost communications instructions.

14.3.3. Voice Procedures. The radar approach is predicated entirely upon voice instructions from the approach control or radar controller. ***Repeat all headings, altitudes (departing and assigned), and altimeter settings until the final controller advises "do not acknowledge further transmissions."*** During high-density radar operations, a limiting factor is the communication time available. Keep transmissions brief and specific, commensurate with safety of flight. Never sacrifice aircraft control to acknowledge receipt of instructions.

14.3.4. Transitioning to Final.

14.3.4.1. Dogleg. The transition to final segment of the approach includes all maneuvering up to a point where the aircraft is inbound and approximately 8 nautical miles from touchdown. A dogleg to final is considered to be part of the "transition to final" segment.

14.3.4.2. Complying with ATC. During the transition to final, the radar controller directs heading and altitude changes as required to position the aircraft on final approach. Turns and descents should be initiated immediately after instructed. Perform turns by establishing an angle of bank, on the attitude indicator, which will approximate a standard rate turn for the TAS flown but not to exceed 30° of bank. When the aircraft or mission characteristics dictate very low turn rates, it is advisable to inform the controller. The controller uses this information to assist in determining lead points for turns or corrections.

14.3.4.3. Weather. Weather information issued by the radar controller will include altimeter setting, ceiling, and visibility. The controller is required to issue ceiling and visibility only when the ceiling is below 1,500 feet (1,000 feet at civil airports) or below the highest circling minimum, whichever is greater, or if the visibility is less than 3 miles.

14.3.4.4. Field Conditions. The controller will furnish pertinent information on known field conditions that the controller considers necessary to the safe operation of the aircraft concerned. You should request additional information, as necessary, to make a safe approach.

14.3.4.5. Orientation. Use available navigation aids to remain position-oriented in relation to the landing runway and the glideslope intercept point. The controller will advise you of the aircraft position at least once before starting final approach.

14.3.4.6. Planning. Start the before landing checklist (landing check), review approach minimums, and tune navigation equipment to comply with lost communication instructions when practical. Determine the approximate initial descent rate required on final approach by referring to the VVI chart in the IAP books or by using one of the formulas for two of the most common glideslopes:

$$3° \text{ glideslope VVI} = \frac{\text{Groundspeed x 10}}{2}$$

$$2½° \text{ glideslope VVI} = \frac{\text{Groundspeed x 10 - 100}}{2}$$

Example: For a final approach groundspeed of 180 knots and a 3° glideslope:

$$\text{VVI} = \frac{180 \text{ x } 10}{2} = 900 \text{ fpm}$$

14.3.4.7. Establish Configuration. Establish the aircraft configuration and airspeed in accordance with the aircraft flight manual. If final approach configuration is established prior to turning onto final, avoid using excessive bank angles that could make precise aircraft control difficult.

14.3.5. Accomplishing the Approach.

14.3.5.1. Nonprecision -- Airport Surveillance Radar (ASR).

14.3.5.1.1. Controller. The controller will inform the pilot of the runway to which the approach will be made, the straight-in MDA (if a straight-in approach is being made), and the MAP location, and will issue advance notice of where the descent to MDA will begin. When the approach will terminate in a circling approach, furnish the controller with your aircraft category. The controller will then issue the circling MDA. Circling MDA for ASR approaches are found in the FLIP Terminal Book (the circling MDA found on the individual IAP refers only to non-radar approaches).

14.3.5.1.2. Descent. When the aircraft reaches the descent point, the controller will advise you to descend to MDA. If a descent restriction exists, the controller will specify the prescribed restriction altitude. When the aircraft is past the altitude limiting point, the controller will advise you to continue descent to MDA. The descent rate should be sufficient to allow the aircraft to arrive at the MDA in time to see the runway environment and make a normal descent to landing.

14.3.5.1.3. Runway Environment. Arrive at the MDA with enough time and distance remaining to identify the runway environment and descend from MDA to touchdown at a rate normally used for a visual approach in your aircraft.

14.3.5.1.3.1. NOTE: Upon request, the controller will provide recommended altitudes on final to the last whole mile that is at or above the published MDA. Due to the possible different locations of the MAP, recommended altitudes may position you at MDA at or slightly prior to the MAP. Consider this in relation to the normal VDP required for your aircraft.

14.3.5.1.4. Course Guidance. The controller will issue course guidance when required and will give range information each mile while on final approach. You may be instructed to report the runway in sight. Approach guidance will be provided until the aircraft is over the MAP unless you request discontinuation of guidance. The controller will inform you when you are at the MAP.

14.3.5.1.5. ***MDA. Fly the aircraft at or above MDA until arrival at the MAP or until establishing visual contact with the runway environment. If you do not report the runway environment in sight, missed approach instructions will be given.***

14.3.5.1.5.1. CAUTION: Depending upon the location of the MAP, the descent from the MDA (once the runway environment is in sight) often will have to be initiated prior to reaching the MAP to execute a normal (approximately 3°) descent to landing.

14.3.5.2. Precision Approach Radar (PAR).

14.3.5.2.1. Starts. The precision final approach starts when the aircraft is within range of the precision radar and contact is established with the final controller. Normally this occurs at approximately 8 miles from touchdown.

14.3.5.2.2. Final Descent. Approximately 10 to 30 seconds before final descent, the controller will advise that the aircraft is approaching the glide path. When the aircraft reaches the point where final descent is to start, the controller will state "begin descent." At that point, establish the predetermined rate of descent. Adjust power or use drag devices as required to maintain desired airspeed or angle of attack. When the airspeed or angle of attack and glide path are stabilized note the power, attitude, and vertical velocity. Use these values as guides during the remainder of the approach.

14.3.5.2.3. Controller Guidance. The controller issues course and glide path guidance, and frequently informs you of any deviation from course or glide path. The controller's terminology will be: on course; on glide path; slightly/well above/below glide path; or slightly/well left/right of course. Controllers may also issue trend information to assist you in conducting a PAR approach. Examples of trend information phraseologies that may be used are: going above/below glide path, holding above/below glide path, holding left/right or course, etc. Trend information may be modified by the use of the terms rapidly or slowly as appropriate. The terms "slightly" or "well" are used in conjunction with the trend information.

14.3.5.2.4. Corrections. Corrections should be made immediately after instructions are given or when deviation from established attitude or desired performance is noted. Avoid excessive throttle, pitch, or bank changes. Normally pitch changes of one degree will be sufficient to correct back to glide path.

14.3.5.2.5. Heading Control. Accurate heading control is important for runway alignment during the final approach phase. When instructed to make heading changes, make them immediately. Heading instructions are preceded by the phrase "turn right" or "turn left." To prevent overshooting, the angle of bank should approximate the number of degrees to be turned, not to exceed a one-half standard rate turn. At high final approach speeds, a large angle of bank may be required to prevent a prolonged correction. In any case, do not exceed the one-half standard rate turn. After a new heading is directed, the controller assumes it is being maintained. Additional heading corrections will be based on the last assigned heading.

14.3.5.2.6. Decision Height (DH). DH is the height at which a decision must be made during a precision approach to either continue the approach or to execute a missed approach. ***Continued descent below DH is not authorized until sufficient visual reference with the runway environment has been established***. ***A momentary deviation below DH without the runway environment in sight is only authorized in conjunction with a proper missed approach initiated at DH***. Definition of runway environment is found in paragraph 14.2.1.2.6. The controller will advise the pilot when the aircraft reaches the published DH. DH is determined in the cockpit either as read on the altimeter or when advised by the controller, whichever occurs first. The controller will continue to provide advisory course and glide path information until the aircraft passes over the landing threshold at which time the controller will advise "over landing threshold." To provide a smooth transition from instrument to visual conditions, a systematic scan for runway environment should be integrated into the crosscheck prior to reaching DH.

14.3.5.2.7. Approach Guidance Termination. The controller will cease providing course and glide path guidance when:

14.3.5.2.7.1. The pilot reports the runway/approach lights in sight, and

14.3.5.2.7.2. The pilot requests to or advises that he/she will proceed visually (E.g. "TRACK 32, runway in sight, taking over visual.").

14.3.5.2.7.2.1. NOTE: A pilot's report of "runway in sight" OR "visual" alone does not constitute a request/advisement to proceed visually and the controller will continue to provide course and glide path guidance.

14.3.5.2.7.3. If the decision is made to discontinue the approach, based on pilot judgment or radar controller guidance, advise the controller as soon as practical during execution of the missed approach.

14.3.5.3. No-Gyro Approach (Heading Indicator Inoperative).

14.3.5.3.1. Advise controller. If the heading indicator should fail during flight, advise the radar controller and request a no-gyro approach. The final approach may be either precision or surveillance.

14.3.5.3.2. Turns. Perform turns during the transition to final by establishing an angle of bank on the attitude indicator that will approximate a standard rate turn, not to exceed 30° of bank. Perform turns on final by establishing an angle of bank on the attitude indicator that will approximate a half-standard rate turn. If unable to comply with these turn rates, advise the controller so that the controller may determine lead points for turn and heading corrections. Initiate turns immediately upon hearing the words "turn right" or "turn left." Stop the turn on receipt of the words "stop turn." ***Acknowledge the controller's commands to start and stop turns until advised not to acknowledge further transmissions.***

14.3.5.3.2.1. NOTE: Do not begin using half-standard rate turns on final until the controller tells you. The controller may want standard rate turns even on final if abnormal conditions exist (i.e., strong crosswinds, turbulence, etc.).

14.4. Visual Approach. Visual approaches reduce pilot/controller workload and expedite traffic by shortening flight paths to the airport. A visual approach is conducted on an IFR flight plan and authorizes the pilot to proceed visually and clear of clouds to the airport. ***The pilot must have either the airport or the preceding identified aircraft in sight, and the approach must be authorized and controlled by the appropriate ATC facility.***

14.4.1. Conditions Required to Conduct Visual Approaches. Before a visual approach can be authorized, several conditions must be met:

14.4.1.1. 1,000 and 3 at the Airport. The reported weather at the airport must have a ceiling at or above 1,000 feet and visibility 3 miles or greater.

14.4.1.2. Operational Benefit. ATC will authorize visual approaches when it will be operationally beneficial.

14.4.1.3. Cloud Clearance Requirements. Visual approaches are IFR procedures conducted under IFR in VMC with one exception -- cloud clearance requirements described in AFI 11-202, Volume 3 *General Flight Rules* are not applicable. Pilots must be able to proceed visually while remaining clear of clouds.

14.4.1.4. Airport or Preceding Aircraft in Sight. ATC will not issue clearance for a visual approach until the pilot has the airport or the preceding aircraft in sight. If the pilot has the airport in sight but cannot see the preceding aircraft, ATC may still clear the aircraft for a visual approach; however, ATC retains both aircraft separation and wake separation responsibility. When visually following a preceding aircraft, acceptance of the visual approach clearance constitutes acceptance of pilot responsibility for maintaining a safe approach interval and adequate wake turbulence separation.

14.4.2. A Visual Approach is an IFR Approach. Although you are cleared for a "visual" approach, you are still operating under IFR. ***Do not cancel your IFR clearance when cleared for a visual approach.*** Be aware that radar service is automatically terminated (without advising the pilot) when the pilot is instructed to change to advisory frequency.

14.4.3. What ATC Expects You to Do When Cleared for a Visual Approach. After being cleared for a visual approach, ATC expects you to proceed visually and clear of clouds to the airport in the most direct and safe manner to establish the aircraft on a normal straight-in final approach. Clearance for a visual approach does not authorize you to do an overhead/VFR traffic pattern.

14.4.4. Visual Approaches Have No Missed Approach Segment. A visual approach is not an instrument approach procedure and therefore does not have a missed approach segment. If a go-around is necessary for any reason, aircraft operating at controlled airports will be issued an appropriate advisory, clearance, or instruction by the tower. At uncontrolled airports, aircraft are expected to remain clear of clouds and complete a landing as soon as possible. If a landing cannot be accomplished, the aircraft is expected to remain clear of clouds and contact ATC as soon as possible for further clearance (separation from other IFR aircraft will be maintained under these circumstances).

14.4.5. Pilot Responsibilities During Visual Approaches. When cleared for a visual approach, the pilot has the following responsibilities:

14.4.5.1. ***Advise ATC as soon as possible if a visual approach is not desired***.

14.4.5.2. ***Comply with controller's instructions for vectors toward the airport of intended landing or to a visual position behind a preceding aircraft***.

14.4.5.3. ***After being cleared for a visual approach, proceed visually and clear of clouds to the airport in the most direct and safe manner to establish the aircraft on a normal final approach. You must have the airport or the preceding aircraft in sight.***

14.4.5.4. ***If instructed by ATC to follow another aircraft, notify the controller if you do not see it, are unable to maintain visual contact with it, or for any other reason you cannot accept the responsibility for visual separation under these conditions.***

14.5. Contact Approach. Pilots operating on an IFR flight plan, when clear of clouds with at least 1-mile flight visibility and can reasonably expect to continue to the destination airport in those conditions, may request ATC authorization for a contact approach.

14.5.1. ATC may only issue clearance for a contact approach under the following conditions:

14.5.1.1. The pilot specifically requests the approach. ATC cannot initiate this approach.

14.5.1.2. The reported ground visibility at the destination airport is at least 1 SM.

14.5.1.3. The contact approach is made to an airport having a standard or special instrument approach procedure.

14.5.1.3.1. NOTE: A contact approach is a procedure that may be used by a pilot in lieu of conducting a standard or special approach IAP to an airport. It is not intended for use by a pilot to operate into an airport without a published and functioning IAP. Nor is it intended for an aircraft to conduct an approach to one airport, and then in the clear, proceed to another airport.

14.5.2. When executing a contact approach, the pilot assumes responsibility for obstruction clearance. If radar service is being received, it will automatically terminate when the pilot is instructed to change to advisory frequency.

14.5.3. Being cleared for a visual or contact approach does not authorize the pilot to fly a 360° overhead traffic pattern. An aircraft conducting an overhead maneuver is VFR and the instrument flight rules (IFR) flight plan is canceled when the aircraft reaches the “initial point.” ***Aircraft operating at an airport without a functioning control tower must initiate cancellation of the IFR flight plan prior to executing the overhead maneuver or after landing***.

14.6. IAP with Visual Segment.

14.6.1. Published Visual Segment. In isolated cases, due to procedure design peculiarities, an IAP procedure may contain a published visual segment. In general, when the distance from the MAP to the end of the runway exceeds 3SM, the words "fly visual " will appear in the profile view of the IAP. A long dashed line in the profile view with an approximate heading and distance to the end of the runway will be depicted. The depicted ground track associated with the visual segment should be flown as "DR" course. ***When executing the visual segment, remain clear of clouds and proceed to the airport maintaining visual contact with the ground.***

14.6.2. MAP. Since missed approach obstacle clearance is assured only if the missed approach is commenced at the published MAP or above the MDA, the pilot should have preplanned climbout options based on aircraft performance and terrain features.

14.6.2.1. CAUTION: Be aware that obstacle clearance becomes the sole responsibility of the aircrew when the approach is continued beyond the MAP.

14.7. Charted Visual Flight Procedures (CVFPs). A published visual approach where an aircraft on an IFR flight plan, operating in VMC when authorized by air traffic control, may proceed to the destination airport under VFR via the route depicted on the CVFP**.** ***When informed CVFPs are in use, the pilot must advise the arrival controller on initial contact if unable to accept the CVFP***.

14.7.1. Characteristics. CVFPs are established for noise abatement purposes to a specific runway equipped with a visual or electronic vertical guidance system. These procedures are used only in a radar environment at airports with an operating control tower. The CVFPs depict prominent landmarks, courses, and altitudes and most depict some NAVAID information for supplemental navigational guidance only.

14.7.2. Altitudes. Unless indicating a Class B airspace floor, all depicted altitudes are for noise abatement purposes and are recommended only. Pilots are not prohibited from flying other than recommended altitudes if operational requirements dictate. Weather minimums for CVFPs provide VFR cloud clearance at minimum vectoring altitudes. Therefore, clearance for a CVFP is possible at MVA, which may be below the depicted altitudes.

14.7.3. Clearance. CVFPs usually begin within 20 miles from the airport. When landmarks used for navigation are not visible at night, the approach will be annotated "PROCEDURE NOT AUTHORIZED AT NIGHT." ATC will clear aircraft for a CVFP after the pilot reports sighting a charted landmark or a preceding aircraft. If instructed to follow a preceding aircraft, pilots are responsible for maintaining a safe approach interval and wake turbulence separation. ***Pilots should advise ATC if at any point they are unable to continue an approach or lose sight of a preceding aircraft.***

14.7.4. Climb-outs. CVFPs are not instrument approaches and do not have missed approach segments. Missed approaches are handled as a go-around (IAW FLIP, GP). The pilot should have preplanned climb-out options based on aircraft performance and terrain features.

Figure 14.5. IAP with Visual Segment.

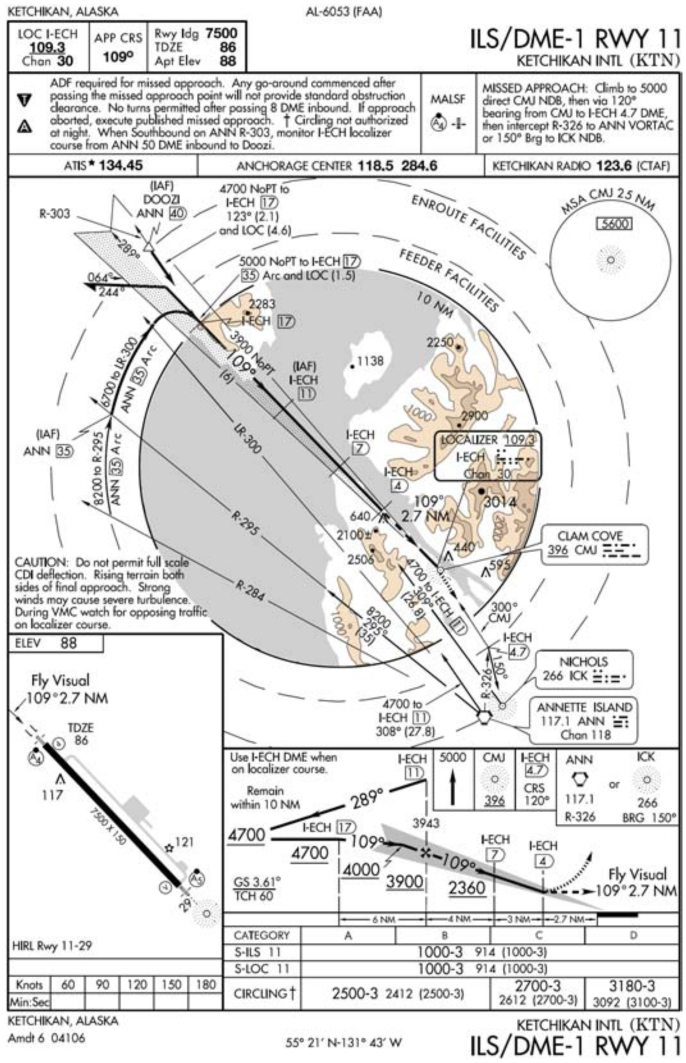
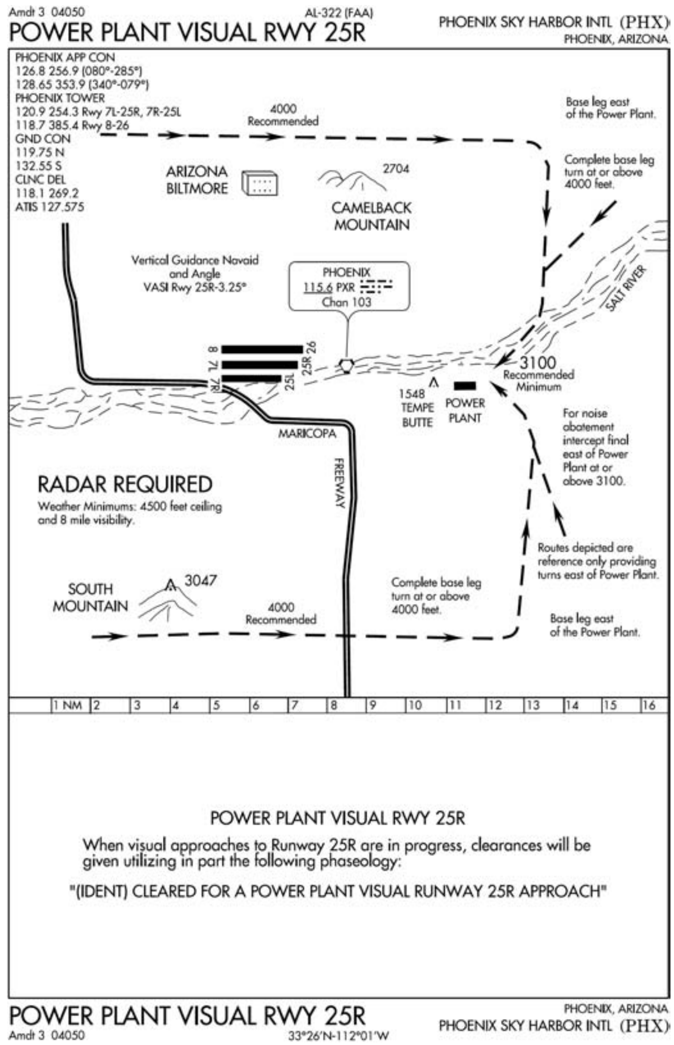


Figure 14.6. Charted Visual Flight Procedure.



14.8. Converging Approaches (Figure 14.7). Converging approaches provide procedures for conducting simultaneous precision instrument approaches (normally ILS) to converging runways. Converging runways are defined as runways having a 15° to 100° angle between them. In simpler terms, if the runways are pointed at each other (extended centerlines intersect) they are converging runways and procedures must be established to de-conflict possible simultaneous missed approaches.

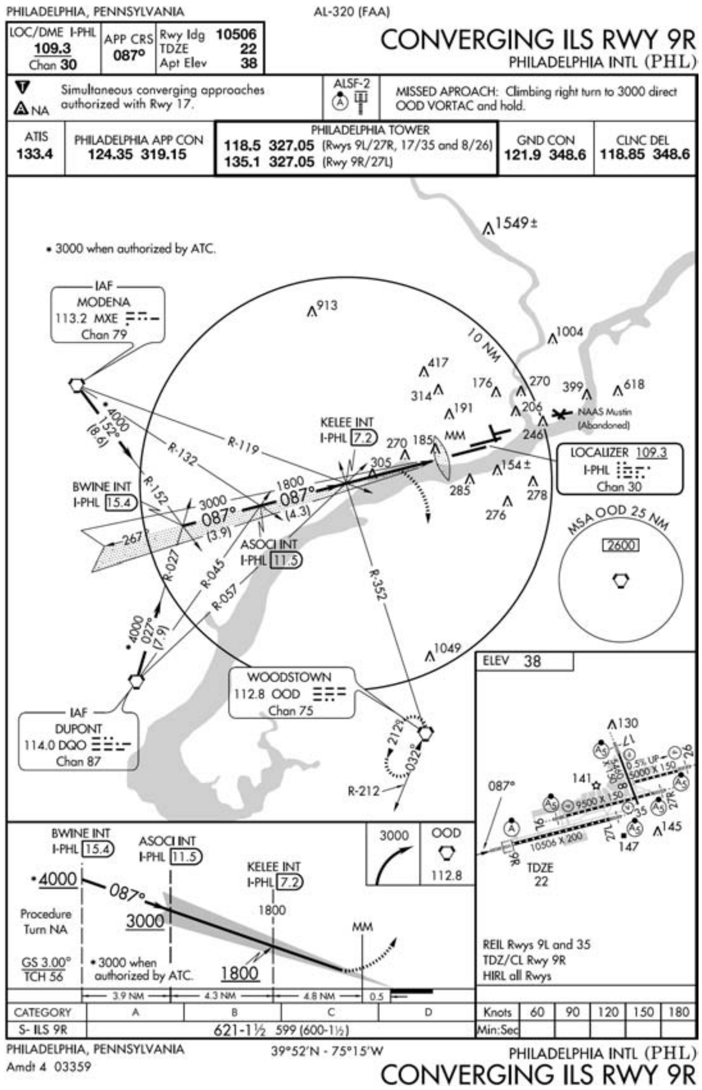
14.8.1. Procedures. Converging approaches are implemented when the volume and complexity of aircraft operations require the use of simultaneous converging instrument approaches. These approaches are specifically designed to ensure traffic deconfliction during all phases of the arrival procedure. Converging approaches are labeled as "converging" and ATC clearance must specify this type of approach. Theoretically no operational hardships on users and control facilities will result from these operations.

14.8.2. Differences. There are two subtle differences found in converging approaches that a pilot must be aware of. The missed approach departure instruction printed on the approach is the procedure the controller expects to be flown during a missed approach and it will not normally be modified. Although missed approach departure instructions for regular approaches are based primarily on obstacle clearance, converging approaches also include the deconfliction of aircraft on the other converging approach's missed approach. This is often done by moving the MAPs of each converging approach further out from the runway and turning the aircraft away from each other.

14.8.3. Missed Approach**.** ***Beginning the missed approach departure instruction no later than the published missed approach point is mandatory.*** If a pilot delays beginning the missed approach, clearance from an aircraft on the other converging approach may decrease such as to cause a traffic conflict. For this reason, anytime a pilot continues flight beyond the MAP the pilot must be highly confident of completing the landing since traffic deconfliction cannot be assured for missed approaches initiated beyond the MAP.

14.8.4. Decision Height. Since converging approaches must provide precision approach guidance (normally ILS) the only way to adjust the missed approach point is to increase the decision height. Therefore, normally the primary difference between the converging approach and the regular approach to the same runway will be the approach minimums and the missed approach departure instruction. This increase in approach minimums will also result in an increase in the weather minimums required for the approach.

Figure 14.7. Converging ILS Approach.



14.9. ILS Precision Runway Monitor (ILS/PRM) Approaches.

14.9.1. ILS/PRM approaches are authorized at selected airports where parallel runways are separated by less than 4300 feet. Specialized equipment, procedures and training for both air traffic controllers and pilots are required prior to conducting an ILS/PRM approach at these airports. All USAF aircrews must be cognizant of the requirements for operations at these airports when ILS/PRM approaches are in use. ILS/PRM approaches allow for increased arrival operations at airports with closely spaced parallel runways. All pilots flying into these airports must be able to accept a clearance for the ILS/PRM approach when the services are offered or risk extensive delays.

14.9.2. Simultaneous close parallel ILS/PRM approaches are published on a separate Approach Procedure Chart named ILS/PRM (Simultaneous Close Parallel).

14.9.3. For an airport to qualify for reduced lateral separation between runways there must be “high update radar” and associated high resolutions radar displays (Final Monitor

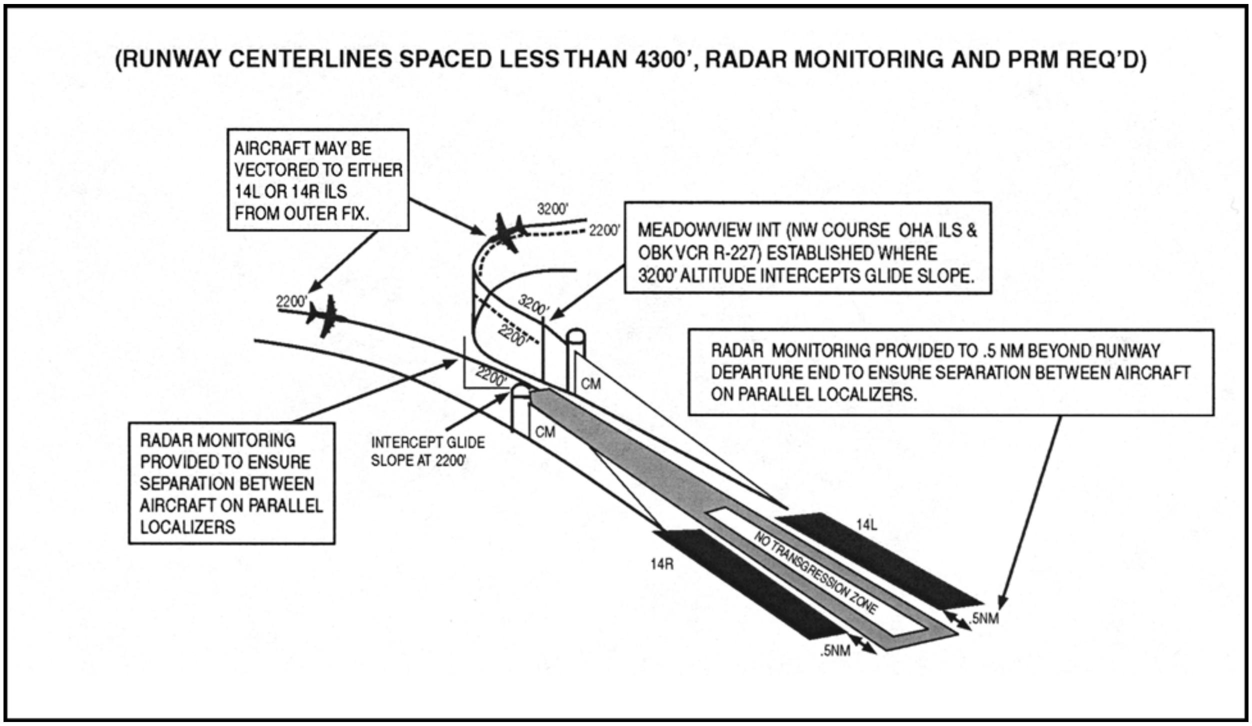
Aids - FMAs) installed. The high update radar provides near instantaneous position and altitude information to the FMAs. Automated tracking software provides "monitor controllers" with aircraft identification, position, altitude, and the predicted position ten seconds ahead, as well as visual and aural alerts to the controller. This equipment, trained controllers, an enhanced communications capability that includes a secondary monitor frequency with tower override, and the ILS equipment collectively make up the ILS/PRM system.

14.9.3.1. ***When flying appropriately equipped aircraft and trained as outlined in AFI 11-202 Volume 3, General Flight Rules and MAJCOM directives, USAF aircrews are authorized to fly ILS/PRM approaches***.

14.9.3.1.1. NOTE: These procedures are also applicable to Simultaneous Offset Instrument Approaches (SOIA).

14.9.4. Simultaneous close parallel ILS/PRM approaches require a "monitor controller" using the PRM system be assigned to each runway and to ensure prescribed separation standards are met. Standard radar and/or vertical separation is used during turn-ons to final approaches. Vertical separation will continue until reaching an intermediate fix between ten and fifteen miles from the runway. From this point to the airport, aircraft may be at the same altitudes, be side by side, or pass traffic on the parallel final approach. Also from this point, or just outside, a block of airspace has been established as a buffer between the final approach courses. This airspace is 2,000-foot wide, equal distance from the finals, and is called the No Transgression Zone (NTZ). The NTZ is shown on the "monitor controller's" display and as the name implies, if planes enter or approach the NTZ, the "monitor controllers" issue instructions to correct the transgression.

Figure 14.8. ILS/PRM Approach.



14.9.5. When conducting an ILS/PRM approach, the following procedures shall be used:

14.9.5.1. ***ILS/PRM approach charts have an "Attention All Users Page" that must be referred to in preparation for flying this approach***. The Attention All Users Page covers the following:

14.9.5.1.1. ***Two operational VHF radios are required***.

14.9.5.1.1.1. Each runway will have two frequencies, the primary tower frequency for that runway and a monitor frequency discreet to that runway. To avoid blocked transmissions during a breakout, ATC transmissions will be transmitted on both frequencies simultaneously. Transmissions from the "monitor controller" will over-ride the "tower controller" on both frequencies. Pilots will ONLY transmit on the primary tower frequency. It is important that pilots do not select the monitor frequency audio until instructed to contact the tower. The volume levels should be set about the same on both radios so the pilots will be able to hear transmissions on at least one frequency if the other is blocked.

14.9.5.1.2. ***The approach must be briefed as an ILS/PRM approach IAW AIM***.

14.9.5.1.2.1. When the ATIS broadcast advises ILS/PRM approaches in progress, pilots should brief to fly the ILS/PRM approach. If later advised to expect the ILS approach, the ILS/PRM chart may be used after completing the following briefing items:

14.9.5.1.2.1.1. Minimums and missed approach procedures are unchanged.

14.9.5.1.2.1.2. Monitor frequency no longer required.

14.9.5.1.3. ***If unable to accept an ILS/PRM approach, notify ATC prior to departure IAW FLIP AP to coordinate alternative arrival procedures.***

14.9.5.1.3.1. NOTE: Failure to pre-coordinate a non-ILS/PRM arrival during a period when ILS/PRM procedures are in use will result in denial of approach clearance. ATC will direct diversion to an alternate airport.

14.9.5.1.4. ***All breakouts from the approach shall be hand flown. Autopilots shall be disengaged when a breakout is directed.***

14.9.5.1.4.1. A "blunder" is an unexpected turn by an aircraft already established on the localizer toward another aircraft on an adjacent approach course. A "breakout" is a technique used to direct aircraft out of the approach stream. For close parallel operations, a breakout is used to direct an aircraft away from a blundering aircraft while simultaneous operations are being conducted.

14.9.5.1.4.2. Breakouts differ from other types of abandoned approaches in that they can happen anywhere and unexpectedly. Pilots directed by ATC to break off an approach must assume that an aircraft is blundering toward them and a breakout must be initiated immediately.

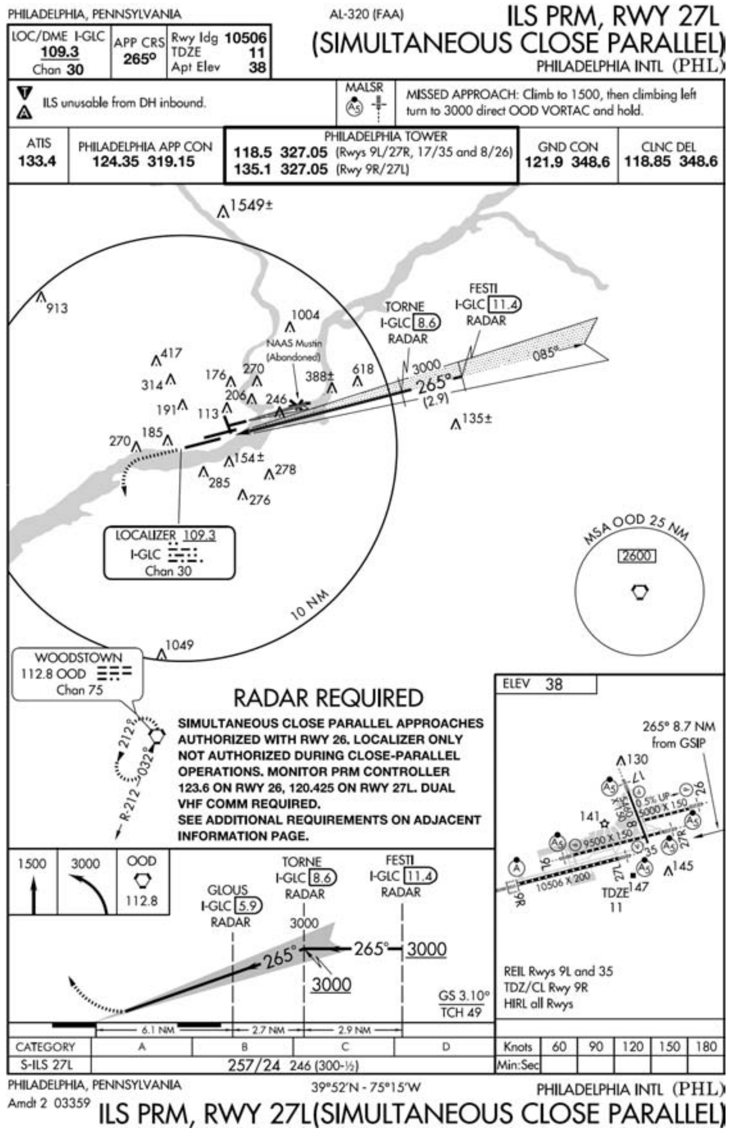
14.9.5.1.4.2.1. ATC Directed "Breakouts". ATC directed breakouts will be an air traffic controller instruction to turn and climb or descend. Pilots must always initiate the breakout in response to an air traffic controller instruction. Controllers will give a descending breakout only when there is no other reasonable option available, but in no case will the descent be below MVA which provides at least 1,000 feet required obstruction clearance.

14.9.5.1.4.2.2. If an aircraft enters the "NO TRANSGRESSION ZONE" (NTZ), the controller will breakout the threatened aircraft on the adjacent approach. The phraseology for the breakout will be: "TRAFFIC ALERT", (aircraft call sign) Turn (left/right) IMMEDIATELY, HEADING (degrees), CLIMB/DESCEND AND MAINTAIN (altitude)."

14.9.5.1.5. ***Should a TCAS resolution advisory (RA) be received, the pilot shall immediately respond to the RA. If following an RA requires deviating from an ATC clearance, the pilot shall advise ATC as soon as practical. While following an RA, comply with the turn portion of the ATC breakout instruction unless the pilot determines safety to be factor.***

14.9.5.1.5.1. The TCAS provides only vertical resolution of aircraft conflicts, while the ATC breakout instruction provides both vertical and horizontal guidance for conflict resolutions. Should a TCAS RA be received, the pilot should immediately respond to the RA. Adhering to these procedures assures the pilot that acceptable "breakout" separation margins will always be provided, even in the face of a normal procedural or system failure.

Figure 14.9. ILS/PRM Approach.



ILS PRM, RWY 27L Amdt 2 03303
(SIMULTANEOUS CLOSE PARALLEL) AL-320 (FAA)
PHILADELPHIA INTL (PHL)
PHILADELPHIA, PENNSYLVANIA

ATTENTION ALL USERS OF ILS PRECISION RUNWAY MONITOR (PRM)

Special pilot training required before accepting a clearance for a simultaneous close parallel ILS/PRM approach (See Note: Special Pilot Training required**). Pilots shall notify ATC no less than 100 nautical miles from Philadelphia International Airport if they cannot meet the requirements on this information page.

1. **ATIS**: When the ATIS broadcast advises ILS/PRM approaches are in progress, pilots should brief to fly the ILS/PRM approach. If later advised to expect the ILS approach, the ILS/PRM chart may be used after completing the following briefing items:

(a) Minimums and missed approach procedures are unchanged.
(b) Monitor frequency no longer required.

2. **Dual VHF Communication required**: To avoid blocked transmissions, each runway will have two frequencies, a primary and a monitor frequency. The tower controller and monitor controller will transmit on both frequencies. Pilots will ONLY transmit on the primary frequency, but will listen to both frequencies. It is important that pilots do not select the monitor frequency audio until instructed by approach to contact the tower. The volume levels should be set about the same on both radios so that the pilots will be able to hear transmissions on at least one frequency if the other is blocked.

3. **ALL "Breakouts"** are to be hand flown to assure that the maneuver is accomplished in the shortest amount of time. Pilots, when directed by ATC to break off an approach, must assume that an aircraft is blundering toward their course and a breakout must be initiated immediately.

(a) ATC Directed "Breakouts" : ATC directed breakouts will consist of a turn and a climb or descent. Pilots must always initiate the breakout in response to an air traffic controller instruction. Controllers will give a descending breakout only when there is no ofther reasonable option available, but in no case will the descent be below minimum vectoring altitude (MVA) which provides at least 1000 feet required obstuction clearance. The MVA is 1800 feet at Philadelphia International Airport.

(b) Phraseology - "TRAFFIC ALERT" : If an aircraft enters the "NO TRANSGRESSION ZONE" (NTZ), the controller will breakout the threatened aircraft on the adjacent approach. The phraseology for the breakout will be:

"TRAFFIC ALERT, (aircraft call sign) TURN (left/right) IMMEDIATELY, HEADING (degrees), CLIMB/DESCEND AND MAINTAIN (altitude)".

**NOTE SPECIAL PILOT TRAINING REQUIRED. All pilots must complete ILS/PRM Approach Training before accepting a clearance for a simultanous close parallel ILS/PRM approach. For operations under Part 121, 129, and 135 pilots must comply with FAA approved company training. For operations under Part 91, pilots must be familiar and comply with the information as provided in the Aeronautical Informattion Manual or as provided at http://www.faa.gov/AVR/AFS/PRMtraining/.

(SIMULTANEOUS CLOSE PARALLEL) 39°52'N-75°15'W
ILS PRM, RWY 27L Amdt 2 03303
PHILADELPHIA, PENNSYLVANIA
PHILADELPHIA INTL (PHL)

14.10. Simultaneous Offset Instrument Approaches (SOIA).

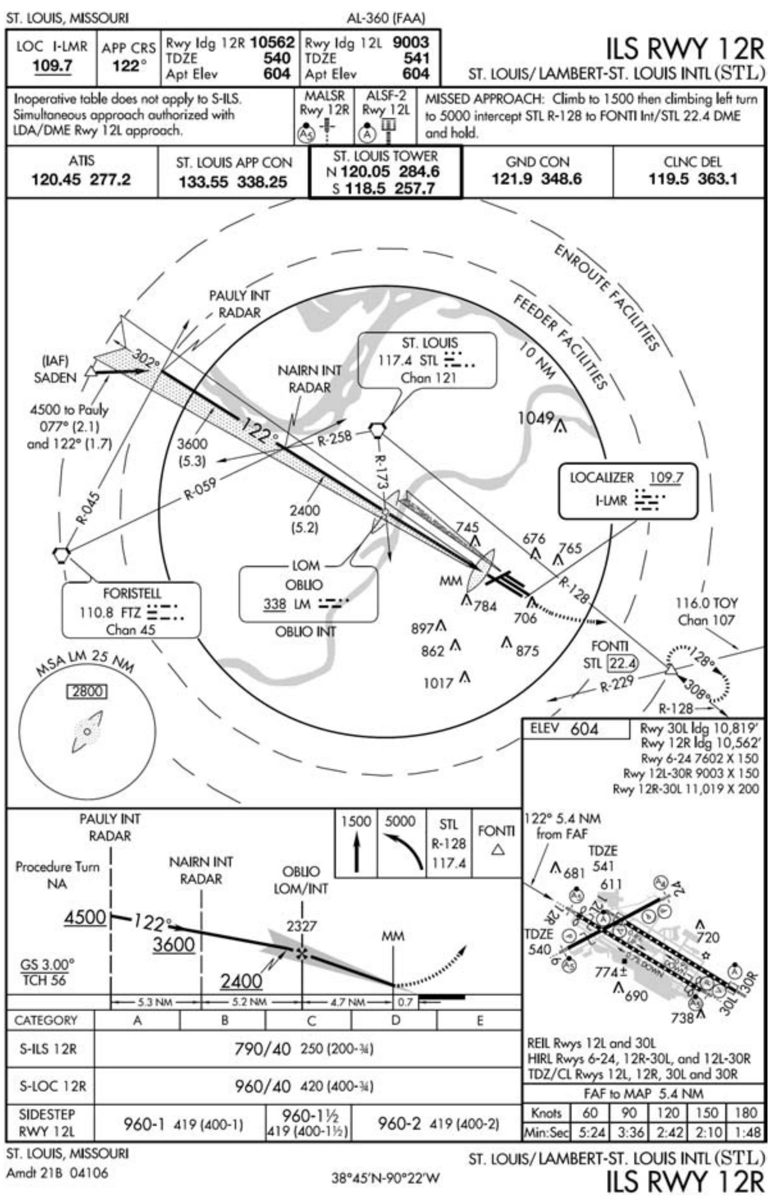
14.10.1. A simultaneous approach to a set of parallel runways using a straight-in ILS approach to one runway and an offset LDA with glide slope instrument approach to the other runway is called SOIA. The parallel runway centerlines are separated by **less** than 3,000 feet. Controllers monitor the approaches with a PRM system using high update radar and high-resolution ATC radar displays. ***The procedures and system requirements for SOIA are identical with those used for simultaneous close parallel ILS/PRM approaches until the MAP--at which time visual separation between aircraft on the adjacent approach courses must be applied. An understanding of the previous section, paragraph 14.9 is essential to conduct SOIA operations***.

14.10.1.1. ***When flying appropriately equipped aircraft and trained as outlined in AFI 11-202 Volume 3, General Flight Rules and MAJCOM directives, USAF aircrews are authorized to fly SOIA approaches.***

14.10.2. In SOIA, the approach course separation (instead of the runway separation) meets established approach criteria. A visual segment of the LDA approach is established between the LDA MAP and the runway threshold. Aircraft transition in visual conditions from the LDA course to align with the runway and be stabilized by 500 feet above ground level. ***The pilot of the trailing aircraft must accept responsibility for visual separation prior to the LDA aircraft reaching the LDA MAP, or a missed approach must be executed.***

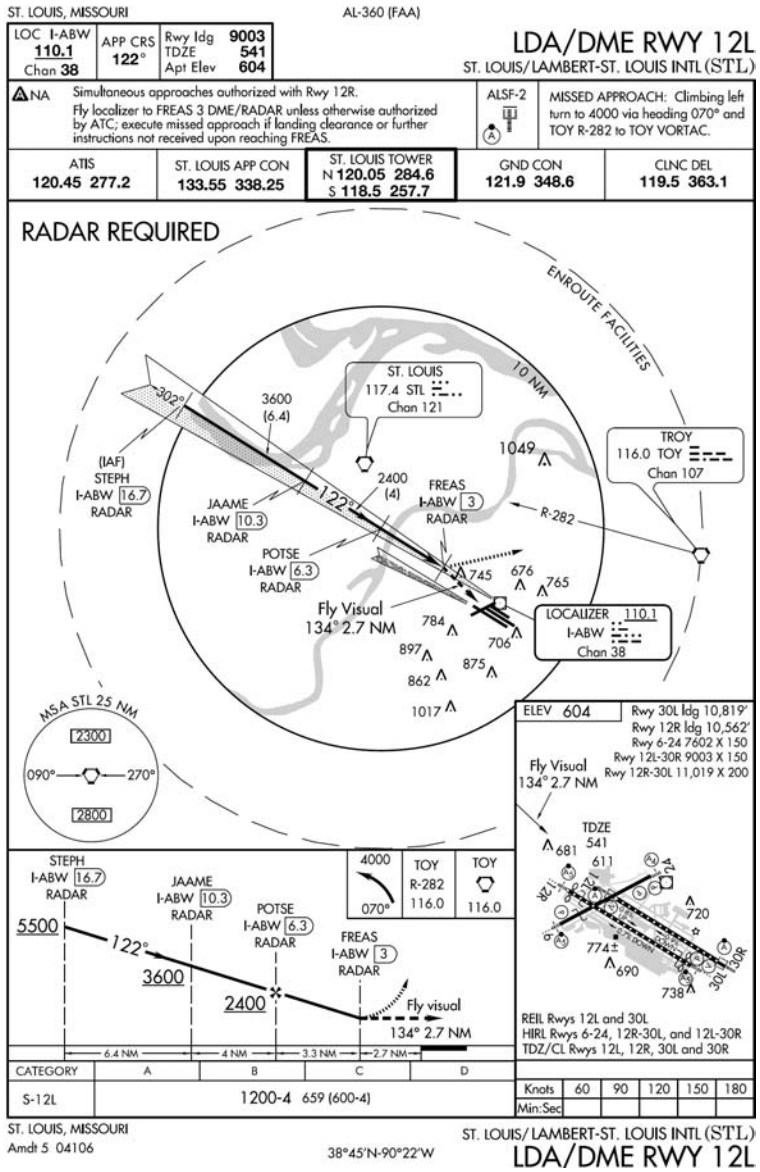
14.10.3. Final monitor controllers use the Precision Runway Monitor system to ensure prescribed separation standards are met. ***Procedures and communications phraseology are described in paragraph 14.9 ILS/PRM Approaches***. PRM monitoring is provided to the LDA MAP or when the pilot has accepted visual separation responsibility. Final monitor controllers will **not** notify pilots when radar monitoring is terminated.

Figure 14.10. SOIA Approaches.



CATEGORY	A	B	C	D	E
S-ILS 12R	790/40 250 (200-¾)				
S-LOC 12R	960/40 420 (400-¾)				
SIDESTEP RWY 12L	960-1 419 (400-1)		960-1½ 419 (400-1½)	960-2 419 (400-2)	

FAF to MAP 5.4 NM					
Knots	60	90	120	150	180
Min:Sec	5:24	3:36	2:42	2:10	1:48



14.11. Transponder Landing System (TLS).

14.11.1. The TLS is designed to provide approach guidance utilizing existing airborne ILS, localizer, glide slope, and transponder equipment.

14.11.2. Ground equipment consists of a transponder interrogator, sensor arrays to detect lateral and vertical position, and ILS frequency transmitters. The TLS detects the aircraft's position by interrogating its transponder. It then broadcasts ILS frequency signals to guide the aircraft along the desired approach path. The TLS ground equipment tracks one aircraft, based on its transponder code, and provides correction signals to course and glidepath based on the position of the tracked aircraft. Even though the TLS signal is received using the ILS receiver, no fixed course or glidepath is generated. The concept of operation is very similar to an air traffic controller providing radar vectors. As with radar vectors, the guidance is only valid for the intended aircraft.

14.11.2.1. TLS ground equipment provides approach guidance for only one aircraft at a time.

14.11.2.1.1. WARNING: If more than one aircraft is on final when another is conducting a TLS approach, the non-cleared aircraft will receive course and glide path information based on the position of the cleared aircraft.

14.11.3. ***When properly trained IAW MAJCOM directives, USAF aircrews are authorized to fly TLS approaches***.

14.11.3.1. TLS signals are displayed on the ILS receiver in the aircraft the same as a conventional ILS. Cockpit set-up and course intercept procedures for a TLS approach are the same as a conventional ILS (i.e. set correct frequency, dial the published front course into the course select window, etc).

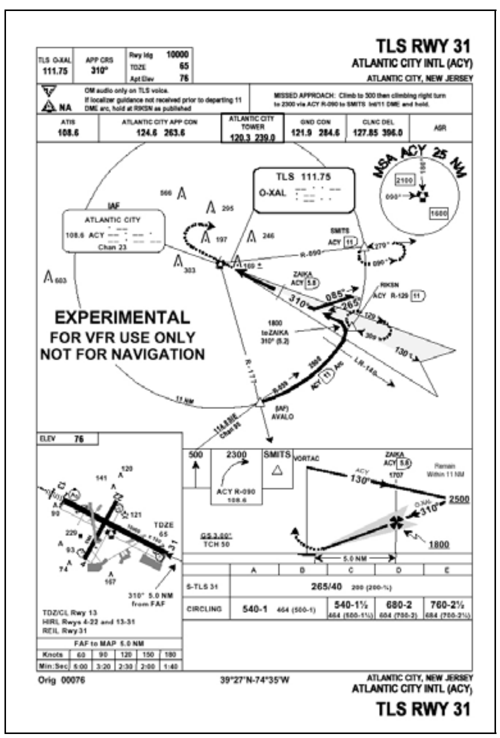
14.11.3.2. ***Aircrews must receive a clearance for the TLS approach***.

14.11.3.2.1. WARNING: If more than one aircraft is on final when another is conducting a TLS approach, the non-cleared aircraft will receive course and glide path information based on the position of the cleared aircraft.

14.11.3.3. ***Aircrews must complete required coordination with TLS ground equipment operator prior to commencing the approach***.

14.11.3.4. Navigation fixes based on conventional ground-based radio NAVAIDS or GPS are provided in the approach procedure to allow aircrews to verify TLS guidance. ***Navigation equipment must be set-up to reference these fixes during the approach***.

Figure 14.11. TLS Approach.



Chapter 15

LANDING FROM INSTRUMENT APPROACHES

15.1. Planning the Approach and Landing.

15.1.1. Begin Before Flight. A successful approach and landing in marginal weather conditions requires considerable planning, which should begin before the flight. Checking the forecast weather, winds, NOTAMs, and runway conditions at your destination and alternate will normally help you determine the runway and type of approach that is likely to be used. A study of the instrument approach procedure for the destination airport will show the approach as well as the runway layout, obstructions, type of lighting installed, and minimum data.

15.1.2. Mental Picture. When planning, try to form a mental picture of the airfield layout as well as the location of prominent landmarks. Be familiar with the types of lighting installed on the landing runway. This means knowing more than just the type of lighting system installed. A picture of what the lighting system looks like should be firmly implanted in your mind. When viewing only a part of the lighting system, you should be able to determine aircraft position relative to the runway. Note the distance to the airfield from available NAVAIDs in the immediate area. There is no substitute for proper and thorough planning as this will help prepare you for the transition from instrument to visual conditions.

15.2. Transitioning From Instrument to Visual Flight Conditions. The transition from instrument to visual flight conditions varies with each approach. Pilots seldom experience a distinct transition from instrument to visual conditions during an approach in obscured weather. Obscured conditions present you with a number of problems not encountered during an approach that is either hooded or has a cloud base ceiling. At the point where the hood is pulled or the aircraft breaks out below the ceiling, the visual cues used to control the aircraft are usually clear and distinct, and there is instantaneous recognition of the position of the aircraft in relation to the runway. With obscured ceilings or partially obscured conditions, the reverse is usually true; visual cues are indistinct and easily lost, and it is difficult to discern aircraft position laterally and vertically in relation to the runway. Consider every factor that might have a bearing on the final stages of an approach and landing. The visibility, type of weather, expected visual cues, and even crew procedures and coordination are some of the tangibles requiring careful consideration. Preparation and understanding are the keys that will make the transition smooth and precise. Only through a thorough understanding of the weather environment and how it affects the availability and use of visual cues will you be prepared to transition safely and routinely. The following information deals with some of the conditions you may encounter during this phase of flight.

15.2.1. Straight-In. When flying a straight-in approach in VMC, the pilot has almost unlimited peripheral visual cues available for depth perception, vertical positioning, and motion sensing. Even so, varying length and width of unfamiliar runways can lead to erroneous perception of aircraft height above the runway surface. A relatively wide runway may give the illusion that the aircraft is below a normal glide path; conversely, a relatively narrow runway may give the illusion of being high. With an awareness of these illusions under unlimited visibility conditions, it becomes easy to appreciate a pilot's problems in a landing situation in which the approach lights and runway lights are the only visual cues available.

15.2.2. No Vertical Guidance. Instrument approach lights do not provide adequate vertical guidance to the pilot during low visibility instrument approaches. In poor visibility, especially when the runway surface is not visible, or in good visibility at night, there simply are not enough visual cues available to adequately determine vertical position or vertical motion. Studies have shown that the sudden appearance of runway lights when the aircraft is at or near minimums in conditions of limited visibility often gives the pilot the illusion of being high. They have also shown that when the approach lights become visible, pilots tend to abandon the established glide path, ignore their flight instruments and instead rely on the poor visual cues. Another similar situation occurs when a pilot flies into ground fog from above. If the pilot initially sees the runway or approach lights, these cues will tend to disappear as the pilot enters the fog bank. The loss of these visual cues will often induce the illusion or sensation of climbing. These situations of erroneous visual cues convincing the pilot that the aircraft is above normal glide path generally result in a pushover reaction, an increase in the rate of descent, and a short or hard landing.

15.2.3. Descent Rate. Since approach lights are usually sighted close to the ground in limited visibility, an increase in the rate of descent during the final approach when the aircraft is very close to the ground may create a situation in which sufficient lift cannot be generated to break the rate of descent when the pilot realizes he or she will land short.

15.2.4. Crosscheck. A recommended method to ensure against a dangerously high rate of descent and a short or hard landing is to maintain continuous crosscheck of the GSI or flight director and pay continuous attention to PAR controller instructions as well as VVI and ADI indications. The pilot should establish predetermined limitations on maximum rates of descent for the aircraft that he or she will accept when landing out of a low visibility approach. Exceeding these limits during the transition to landing should result in a go-around and missed approach in the interest of aircraft and aircrew safety. Knowing that visual cues can be extremely erroneous, the pilot must continue to crosscheck instruments and listen to the PAR controller's advisories even after runway and/or approach lights have come into view. Most pilots find it extremely difficult to continue to crosscheck their flight instruments once the transition to the visual segment has been made, as their natural tendency is to believe the accuracy of what they are seeing, or they continue to look outside in an effort to gain more visual cues. To successfully continue reference to VVI and/or GSI when approach lights come into view, a scan for outside references should be incorporated into the crosscheck at an early stage of the approach, even though restrictions to visibility may preclude the pilot from seeing any visual cues. If such a scan is developed into the crosscheck, it will facilitate the recheck of flight instruments for reassurances of glide path orientation once visual cues come into view and the visual transition is begun. See Chapter 20 for crosscheck and landing considerations for those aircraft equipped with a Head-Up Display (HUD). The following information deals with some of the conditions you may encounter during this phase of flight.

15.2.4.1. Restrictions to Visibility. There are many phenomena, such as rain, smoke, snow, and haze, which may restrict visibility. When surface visibility restrictions do exist and the sky or clouds are totally hidden from the observer, the sky is considered totally obscured and the ceiling is the vertical visibility from the ground. If you are executing an approach in an obscured condition, you will not normally see the approach lights or runway condition as you pass the level of the obscured ceiling. You should be able to see the ground directly below; however, the transition from instrument to visual flight will occur at an altitude considerably lower than the reported vertical visibility. In partially obscured conditions, vertical visibility is not reported since the ground observer can see the sky through the obscuration. When clouds are visible with a partial obscuration, their heights and amounts are reported. The amounts (in 8ths) of the sky or clouds obscured by a partial obscuration are included in the remarks section of weather reports. Although this may help clarify the reported conditions in many cases, it still does not provide an idea of the height at which visual cues will be sighted or the slant range visibility. In some cases the partial obscuration can be associated with shallow patchy fog so you can expect to lose visual references once the fog condition is entered. Also of concern is the visual range at which you will be able to discern visual cues for runway alignment and flare. Be aware that the runway visibility or runway visual range (RVR) may not be representative of the range at which you will sight the runway. In fact, slant range visibility may be considerably less than the reported RVR. Knowledge of these various factors will aid you in making a safe, smooth transition from instrument to visual flight.

15.2.4.1.1. Shallow Fog. Fog that extends no more than 200 feet in height is considered shallow fog and is normally reported as a partial obscuration. Since the fog may be patchy, it is possible that the visual segment may vary considerably during the approach and rollout. RVR may not be representative of actual conditions in this situation if measured by transmissometer located in an area of good visibility. One of the most serious problems with this type of fog stems from the abundance of cues available at the start of the approach. You may see the approach lighting system and possibly even some of the runway during the early stages of the approach. However, as the fog level is entered, most or all the cues become confused and disoriented. In these conditions, you should not rely entirely on visual cues for guidance. They can be brought into the crosscheck to confirm position, but instrument flight must be maintained until visual cues can be kept in view and the runway environment can provide sufficient references for alignment and flare.

15.2.4.1.2. Deep Fog. Fog that extends to a height of several hundred feet usually forms a total obscuration. You will not normally see cues during the early portion of an approach. Most likely, you will pick up cues from only the last 1,000 feet of the approach lighting system. From a US standard approach lighting system, in rapid succession you will probably see cues from the 1,000-foot roll bar, the last 1,000 feet of the centerline approach lights, red terminating bar, red wing lights, green threshold lights, and the high intensity runway edge lights. If operating at night and the strobe lights are on, these may produce a blinding effect. Care should be taken with the use of landing lights as they also may cause a blinding effect at night. The transition from an approach in a total obscuration involves the integration of visual cues within the crosscheck during the latter portion of the approach. Again, be thoroughly familiar with the approach lighting system to develop the proper perspective between these cues and the runway environment.

15.2.4.1.3. Fog Below Clouds. This fog is usually reported as a partial obscuration below a cloud ceiling. After penetrating through a ceiling, visibility usually increases when you descend below the cloud ceiling. Therefore, the transition from instrument to visual flight is sharper, with more pronounced use of visual cues after passing the ceiling. However, with fog below clouds all of the problems mentioned above with shallow fog and deep fog may be found. Night approaches may produce the sensation that the aircraft is high once the cloud base is passed. You should continue on instruments, cross-checking visual cues to confirm runway alignment. During the flare you may experience a sensation of descending below the surface of the runway. This will be especially pronounced at facilities with 300-foot wide runways. In either case, avoid abrupt or large attitude changes.

15.2.4.1.4. Advection Fog. Advection fog can present wind and turbulence problems not normally associated with other types of fog. Advection fog may possess characteristics similar to shallow, deep, or cloud base fog. It may be more difficult to maintain precise instrument flight because of turbulence. The characteristics of advection fog will be related to the wind speed increases. Wind greater than 15 knots usually lifts the fog and it forms a cloud base. The best procedure is to be aware of the conditions that might be encountered and to integrate visual cues within the crosscheck during the later portion of the approach. Also closely monitor airspeed because of the effects of turbulence and crosswinds.

15.2.4.1.5. Ice Fog. This type of fog is most common to the Arctic region; however, it can occur in other areas if the air temperature is below approximately 0° C (32° F). It consists of a suspension of ice crystals in the air and is more common around airports and cities. Condensation nuclei caused by human activity often cause the fog to form. When there is little or no wind, it is possible for an aircraft to generate enough fog during landing or takeoff to cover the runway and a portion of the field. Depending on the atmospheric conditions, ice fogs may last for several minutes or days. The piloting hazards and procedures are basically the same as with other fogs.

15.2.4.1.6. Rain. Approaches and the ensuing transition to visual flight can be very hazardous since moderate to heavy rain conditions can seriously affect the use of visual cues. Night approaches in these conditions can be even more critical as flashing strobes or runway end identifier lights may distract you. Transition to visual flight can be severely hampered by the inability to adequately maintain aircraft control and interpret the instruments as a result of gusty or turbulent conditions. The moderate or heavy rain conditions can also render the rain removal equipment ineffective, causing obscuration of visual cues at a critical time during the transition. In these conditions, be prepared for an alternate course of action and act without hesitation to prevent the development of an unsafe situation.

15.2.4.1.7. Snow. Blowing snow is accompanied by many of the same hazards as rain, such as turbulence, difficulties in reading the flight instruments, obscured visual cues, and aircraft control problems. Of special interest will be a lack of visual cues for runway identification for the visual portion of the approach. The approach and runway lights will provide some identification; however, runway markings and the contrast with relation to its surroundings may be lost in the whiteness. Therefore, depth perception may be difficult, requiring more emphasis on instruments for attitude control. It is extremely important to avoid large attitude changes during approaches in snow.

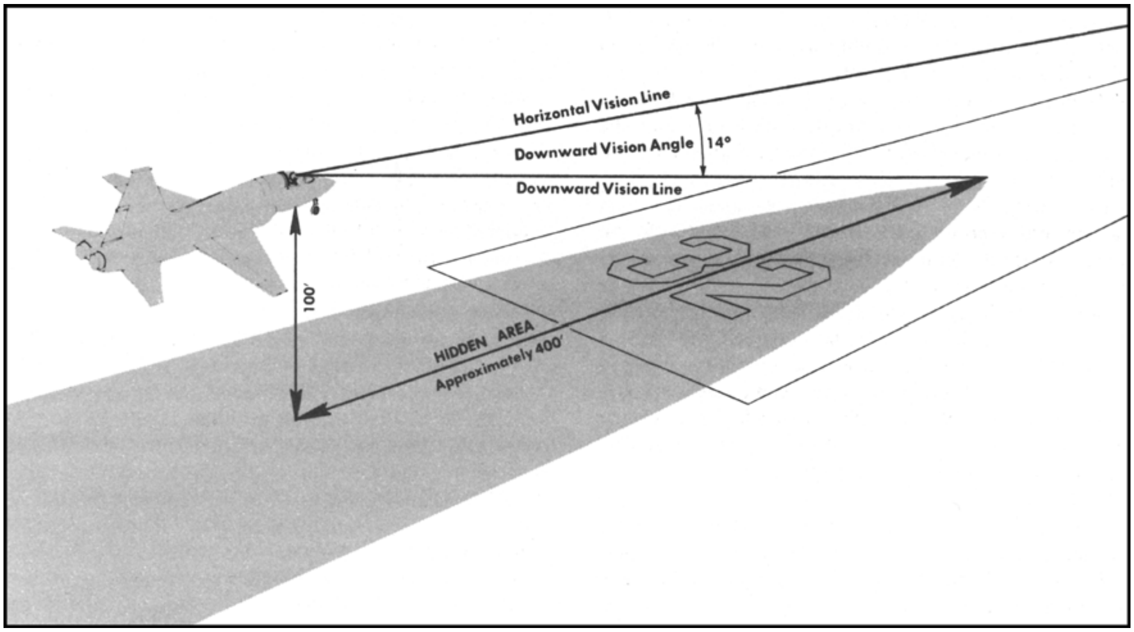
15.2.4.2. Visual Cues.

15.2.4.2.1. Runway Contact Point. Approach lights, runway markings, lights, and contrasts are the primary sources of visual cues. At some facilities, touchdown zone and centerline lights may also be available. Become familiar with the lighting and marking patterns at your destination and correlate them with the weather so you will be prepared to transition to visual flight. In minimum visibility conditions, the visual cues and references for flare and runway alignment are extremely limited compared to the normal references used during a visual approach. Therefore, the aircraft's projected runway contact point may not be within your visual segment until considerably below published minimums.

15.2.4.2.1.1. WARNING: Any abrupt attitude changes to attempt to bring the projected touchdown point into your visual segment may produce high sink rates and thrust or lift problems at a critical time. Those so-called duck-under maneuvers must be avoided during the low visibility approach.

15.2.4.2.2. Duck-under. Another potential duck-under situation occurs when you attempt to land within the first 500 to 1,000 feet of the runway after breaking out of an overcast condition. In this case, you may attempt to establish a visual profile similar to the one you use most often. Establishing the visual profile usually involves reducing power and changing attitude to aim the aircraft at some spot short of the end of the runway. In this maneuver you may attempt to use as much of the available runway as possible because of a short runway or due to poor braking conditions. The duck-under is not recommended since high sink rates and poor thrust/lift relationships can develop which may cause undershoots or hard landings. Base your landing decision upon the normal touchdown point from the instrument approach, and if stopping distances are insufficient, proceed to an alternate.

Figure 15.1. Downward Vision Angle.



15.2.4.3. Downward Vision Angle (Figure 15.1). There is an area hidden by the nose of an aircraft that cannot be seen from the cockpit. The downward vision line from the pilot's eye projected over the nose of the aircraft forms an angle with the horizontal vision line. This angle is called the "downward vision angle." The area hidden from the pilot's view can then be determined from a trigonometric relationship based on aircraft elevation and downward vision angle. An aircraft with a 14° downward vision angle 100 feet above the surface will conceal about 400 feet beneath its nose. Consider an approach in 1,600-foot visibility. This means your visual segment at 100-foot elevation with a 14° downward vision will be reduced to about 1,200 feet. Other factors, such as a nose-high pitch attitude and a slant range visibility less than the RVR, can further reduce your visual segment.

15.2.4.4. Pilot Reaction Time. At 100-foot elevation and a 3° glide slope, an aircraft is approximately 1,900 feet from the runway point of intercept (RPI). If your aircraft's final approach speed is 130 knots (215 feet per second), you have about 9 seconds to bring visual cues into the crosscheck, ascertain lateral and vertical position, determine a visual flight path, and establish appropriate corrections. More than likely, 3 to 4 seconds will be spent integrating visual cues before making a necessary control input. By this time, the aircraft will be 600 to 800 feet closer to the RPI, 40 to 60 feet lower, and possibly well into the flare. Therefore, it is absolutely essential to be prepared to use visual cues properly and with discretion during the final stages of a low visibility approach. Prior to total reliance on visual information, confirm that the instrument indications support the visual perspective.

15.2.4.5. Crew Procedures**.**

15.2.4.5.1. Copilot. A copilot can assist the pilot in a number of ways. The copilot can fly the approach, control airspeed, be responsible for communications, direct the checklist, perform the missed approach, establish aircraft configurations, or perform any other duties assigned by the pilot. However, the copilot must understand exactly what those duties and responsibilities are before the approach.

15.2.4.5.2. Technique One. One technique that has proven quite successful has been to allow highly qualified copilots to fly the approach, while the pilot makes the decision to continue or go-around at DH. The pilot assumes control if a landing is to be made; if not, the copilot executes the go-around. This procedure puts fewer burdens on the pilot, allowing more time to obtain information from the visual cues for landing. If the approach is unsatisfactory or insufficient visual references are available to continue the approach at DH, the copilot, since the aircraft is on instruments, is prepared to execute a missed approach on command. If the pilot executes the approach, the copilot may be allowed to control power or airspeed until DH where the pilot assumes control for the landing or missed approach.

15.2.4.5.3. Technique Two. Another technique is to have the pilot not flying the approach continue to monitor flight instruments from DH or minimum descent altitude to touchdown and notify the pilot flying the approach of excessive deviations in rates of descent, glide slope, course, or airspeed. This technique will help detect duck-under maneuvers and will prevent both pilots from being deceived by a visual illusion that may be present.

15.2.4.5.4. Technique Three. A final technique is to have the autopilot fly the approach to the DH or MDA and then have the pilot assume control to either land or execute the go-around as required. This technique can be quite helpful especially after a long duty day and/or with instrument conditions.

15.3. Approach Lighting Systems.

15.3.1. Types of Approach Lighting Systems.

15.3.1.1. Visual Aids. Approach lighting systems are visual aids used during instrument conditions to supplement the guidance information of electronic aids such as VOR, TACAN, PAR, and ILS. The approach lights are designated high intensity (the basic type of installation) and medium intensity, according to candlepower output.

15.3.1.2. Adjustment. Most runway and approach light systems allow the tower controller to adjust the lamp brightness for different visibility conditions, or at a pilot's request. The extreme brilliance of high intensity lights penetrates fog, smoke, precipitation, etc., but may cause excessive glare under some conditions.

15.3.1.3. Depiction. The approach lighting systems now in use, along with their standard lengths, appear in the FIH. Each IAP chart indicates the type of approach lighting system by a circled letter on the airport sketch. Actual length is shown on the airport diagram for any system, or portion thereof, which is not of standard length. The IFR Supplement indicates availability of airfield, runway, approach, sequenced flashing, runway end identification lights, runway centerline lights, and VGSI.

15.3.1.4. Pilot Activation. Some airports have installed airport lighting systems that can be activated by the pilot "keying the microphone" on selected frequencies.

Information concerning these systems can be found in the Flight Information Handbook and Terminal FLIP.

15.3.2. Runway End Identifier Lights (REIL). Runway end identifier lights are installed at many airfields to help identify the approach end of the runway. The system consists of two synchronized flashing lights, one of which is located laterally on each side of the runway threshold facing the approach area. They are effective for identifying a runway that lacks contrast with the surrounding terrain or which is surrounded by other lighting, and for approaches during reduced visibility.

15.3.3. Visual Glide Slope Indicators (VGSI).

15.3.3.1. There are many different types of visual glide slope indicators in use, many in conjunction with instrument approach procedures. They provide visual glide path guidance from the instrument approach minimums to a point on the runway and can provide assistance in the transition from instrument to visual flight. Configurations are depicted in the Flight Information Handbook.

15.3.3.1.1. It is important to heed information supplied by visual glide path indicators, as they do provide obstacle clearance in the final approach segment.

15.3.3.1.1.1. The TERPS specialist will evaluate a visual assessment area for penetrations of a 20:1 surface. If there is a penetration of the 20:1 surface, the obstacle must be removed. If the obstacle cannot be removed, there will be no VDP published for the approach, visibility minimums will be at least 1 mile, and the obstacle must be lighted. If the obstacle cannot be lighted (or the lights are out of service), the approach (both straight-in and circling) will not be available at night. Absence of a VDP does not always indicate presence of an obstacle. It could also indicate lighting issues.

15.3.3.1.1.1.1. At some airports, a VGSI is being used to mitigate the risk of obstacles that penetrate the 20:1 surface and provide relief from the requirement for obstacle lighting at night. If any one of the following notes are on the approach plate, there is an obstacle that penetrates the 20:1 surface and is not lighted at night: "When VGSI inop, procedure NA at night"; "When VGSI inop, straight-in/circling Rwy XX procedure NA at night"; or "When VGSI inop, circling Rwy XX NA at night". Strict adherence to VGSI indications is imperative to insure obstacle clearance at these airports, especially at night.

15.3.3.1.2. Depending upon which approach is flown, the visual glide path indicator may not guide the aircraft to the same point on the runway as the instrument approach being flown. This is depicted on many approach procedures with a note such as, "PAPI and ILS RPI not coincident."

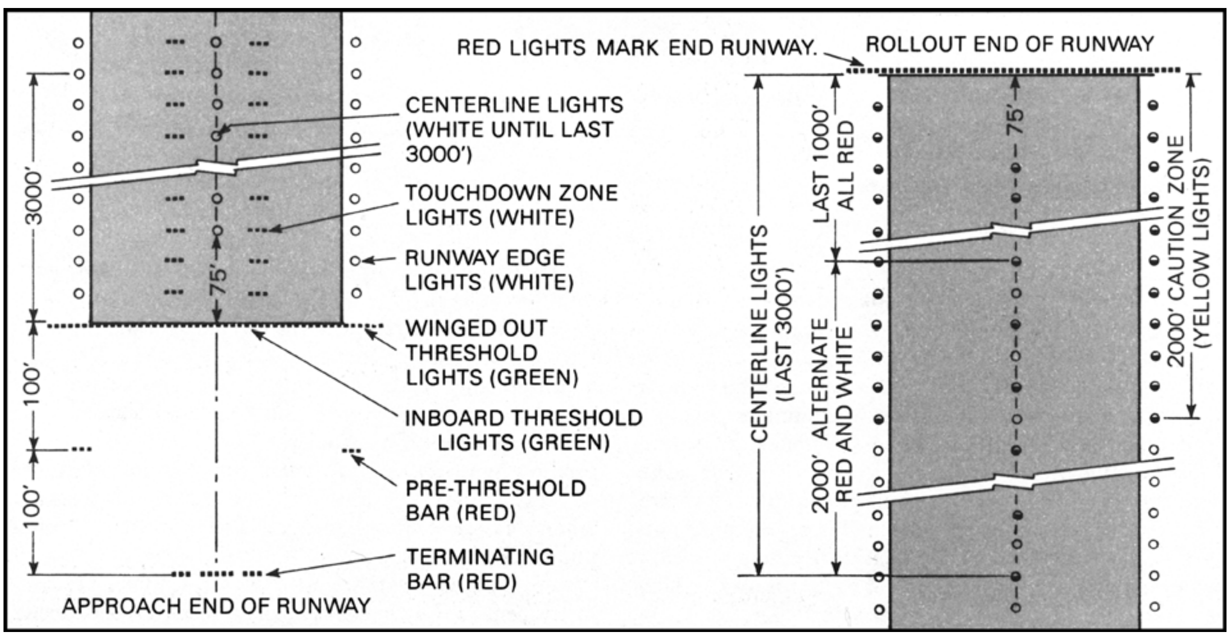
15.3.3.1.2.1. This is especially common at airports with frequent jumbo-jet operations (C-5, 747, 777, etc). The VGSI at these airports is frequently adjusted to compensate for the greater vertical distance between the ground and the cockpit in these large aircraft. A smaller aircraft (KC-135, C-130, fighter, etc) that follows these VGSI indications to touchdown will touchdown beyond their normal touchdown point.

15.4. Runway Lighting Systems. Two basic runway lighting systems are used to aid the pilot in defining the usable landing area of the runway. These systems are Runway Edge Lights and Runway Centerline and Touchdown Zone Lights**.** For discussion of airport markings and signs used during ground operations, see AFI 11-218, *Aircraft Operations and Movement on the Ground*.

15.4.1. Runway Edge Lighting. The runway edge lighting system is a configuration of lights that defines the limits of the usable landing area. The lateral limits are defined by a row of white lights on either side of the runway. The longitudinal limits are defined at each end by the threshold lighting configuration. This configuration includes threshold lights, a pre-threshold light bar, and a terminating bar. The threshold lights emit green light toward the approach end of the runway and red light toward the rollout end of the runway.

15.4.1.1. NOTE: The distance from the threshold lights to the landing surface of the runway can be up to 10 feet without a waiver. The pre-threshold wing light bars and the terminating light bar emit red light toward the approach area.

Figure 15.2. Runway Lighting Systems.



15.4.1.2. HIRL. The High Intensity Runway Lighting (HIRL) system is the basic type of installation used by the Air Force. These elevated bi-directional lights, which extend the length of the runway, emit a white light the entire length of the runway at some military fields. Most military and all civil field HIRLs also emit a white light except in the caution zone, which is the last 2,000 feet (610m) of an instrument runway or one-half the runway length, whichever is less. The lights in the caution zone emit a yellow light in the direction of the approach end and white light in the opposite direction. The yellow lights are intended for rollout information after landing and are sometimes used in place of runway remaining markers.

15.4.1.3. MIRL. The Medium Intensity Runway Lighting (MIRL) system, which consists of elevated, omni-directional lights, may be installed on runways that are not to be used under IMC due to impaired clearance, short length, or other factors.

15.4.2. Runway Centerline and Touchdown Zone Lighting. The runway centerline and touchdown zone lighting systems are designed to facilitate landings, rollouts, and takeoffs under adverse day and night low visibility conditions. The touchdown zone lights, which define the touchdown area, are primarily a landing aid while the centerline lights are most effective for rollout and takeoff.

15.4.2.1. Touchdown Zone Lighting. The touchdown zone lighting system consists of two rows of high intensity light bars arranged on either side of the runway centerline. Each bar consists of three unidirectional white lights toward the approach area. The two rows of light bars are 3,000 feet long and extend from the threshold of the runway toward the rollout end of the runway.

15.4.2.2. Runway Centerline Lighting. The runway centerline lighting system is a straight line of lights located along the runway centerline. The system starts 75 feet (23m) from the threshold and extends down the runway to within 75 feet of the rollout end of the runway. The last 3,000 feet are color coded for landing rollout information. The last 3,000-foot to 1,000-foot section displays alternate red and white lights, while the last 1,000-foot section displays all red lights.

15.5. Runway Markings. Runway markings are designed to make the landing area more conspicuous and to add a third dimension for night and low visibility operations. For discussion of airport markings and signs used during ground operations, see AFI 11-218, *Aircraft Operations and Movement on the Ground*. When visual contact has been established, runway markings aid the pilot in aligning the aircraft with the runway and determining if a safe landing is possible. Serviceable runways are marked and classified according to the instrument approach facilities serving them. The classifications are precision instrument runways that are served by precision approach facilities, non-precision instrument runways to which a straight-in non-precision approach has been approved, and basic runways that are used for visual flight operations and circling non-precision approaches. Standard runway markings in most cases are in reflective white, while markings of non-traffic areas, such as blast pads and overruns, are in reflective yellow.

15.5.1. Basic Runways. Basic runway markings consist of a runway direction number and centerline marking. In addition, any of the elements of the nonprecision and precision instrument runway markings may be used.

15.5.2. Nonprecision Instrument Runways. The markings used on nonprecision instrument runways are the runway direction number, centerline, and threshold markings. Additional elements of the precision instrument runway markings may be added.

15.5.3. Precision Instrument Runways. The precision instrument runway markings consist of a runway direction number, centerline, threshold, touchdown zone, and side stripe markings.

15.5.4. Runway Touchdown Zone Marking. The runway touchdown zone marking pattern consists of groups of rectangular markings to outline the touchdown zone and to provide distance coded information by means of the "3-3-2-2-1-1" marking pattern. Groups of rectangular markings begin 500 feet from the threshold and are spaced at 500-

foot intervals up to 3,000 feet from the threshold. Fixed distance markings begin 1,000 feet from the threshold and provide an aiming point for touchdown.

15.5.5. Runway Direction Numbers. All runways are marked with a runway direction number. This number is the number nearest the 10° increment of the magnetic azimuth of the centerline of the runway. A zero does not precede single numbers. To differentiate between two parallel runways, the runway direction number has a letter "L" or "R" following it. With three parallel runways, the center runway has the letter "C" added to the runway direction number.

15.5.5.1. On four or more parallel runways, one set of adjacent runways is numbered to the nearest tenth of the magnetic azimuth and the other set of adjacent runways is numbered to the next nearest tenth of the magnetic azimuth.

15.5.6. Associated Runway Area Markings.

15.5.6.1. Overruns. Overruns (called stopways at civil airfields) are areas beyond the takeoff runway designated by the airport authorities for use in decelerating an airplane during an aborted takeoff. Air Force overruns are marked by a series of equally spaced yellow chevrons. The apex of the chevrons is on the centerline extension of the runway and points to and terminates at the threshold of the usable runway. A pilot should not taxi on an overrun or stopway except in an emergency or an aborted takeoff, unless it is designated for taxiing and takeoff.

15.5.6.2. Displaced Threshold. Where it has been necessary to position the landing threshold up the runway from the end of the paving, it is known as a displaced threshold. Two methods of marking this area are used. When the paved area on the approach side of the displaced threshold can be used for taxiing and takeoff, it will be marked with a series of large white arrows. The arrows are placed along the centerline on the approach side of the displaced threshold and point to the landing area. Where the paved area on the approach side of the displaced threshold is not to be used for taxiing or takeoff, the area is marked in the same manner as the overrun or blast pad areas previously discussed. In all cases, a white stripe across the width of the full strength runway precedes the threshold markings.

Figure 15.3. Runway Markings.

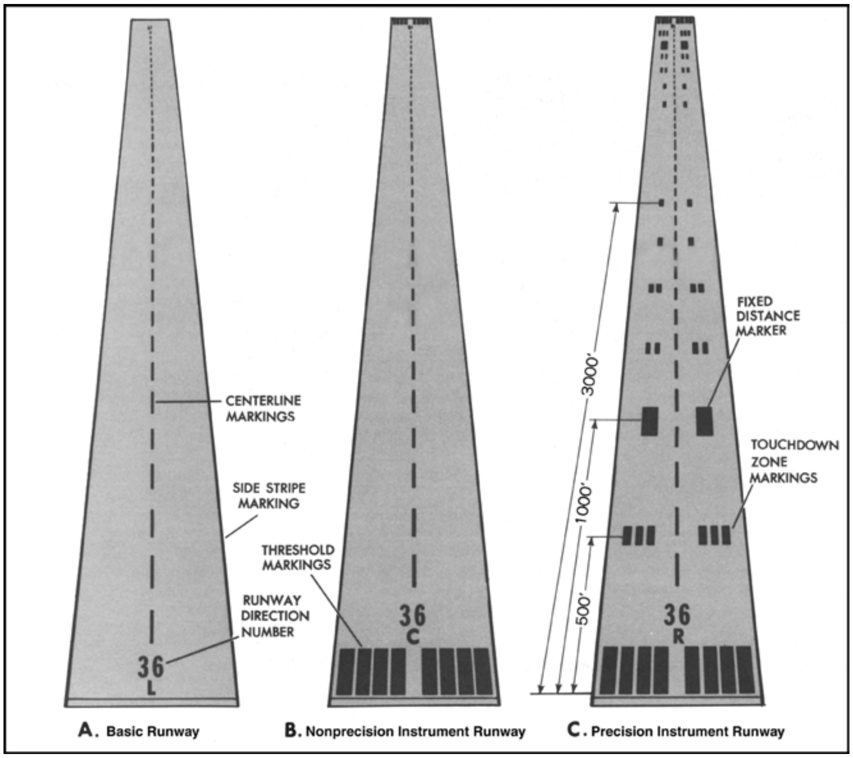


Figure 15.4. Displaced Threshold Markings (USAF).

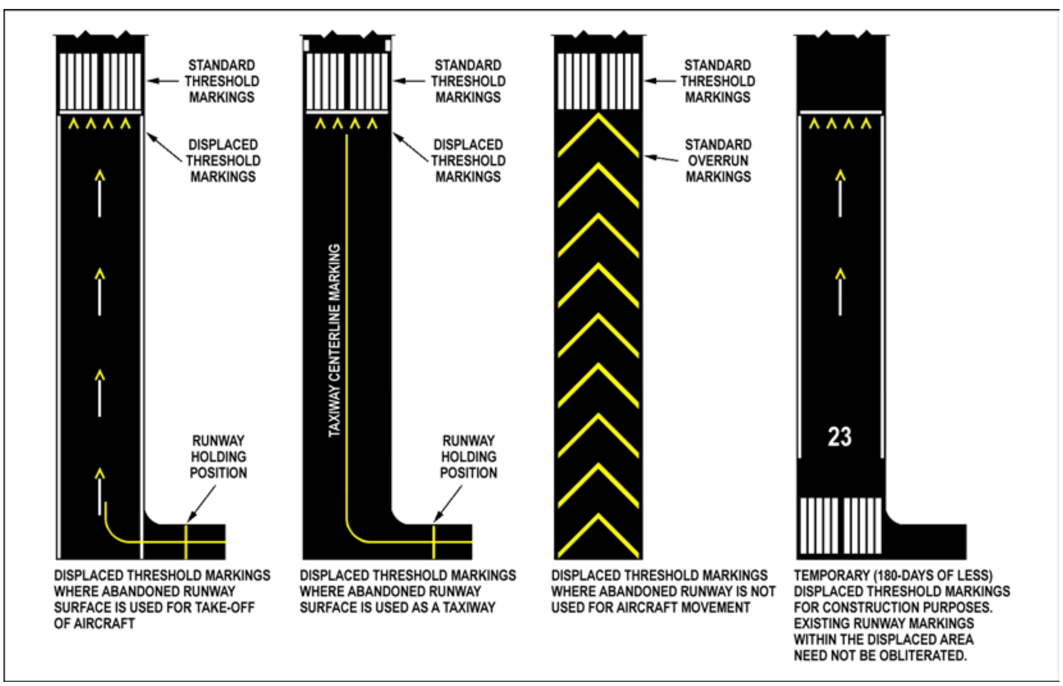
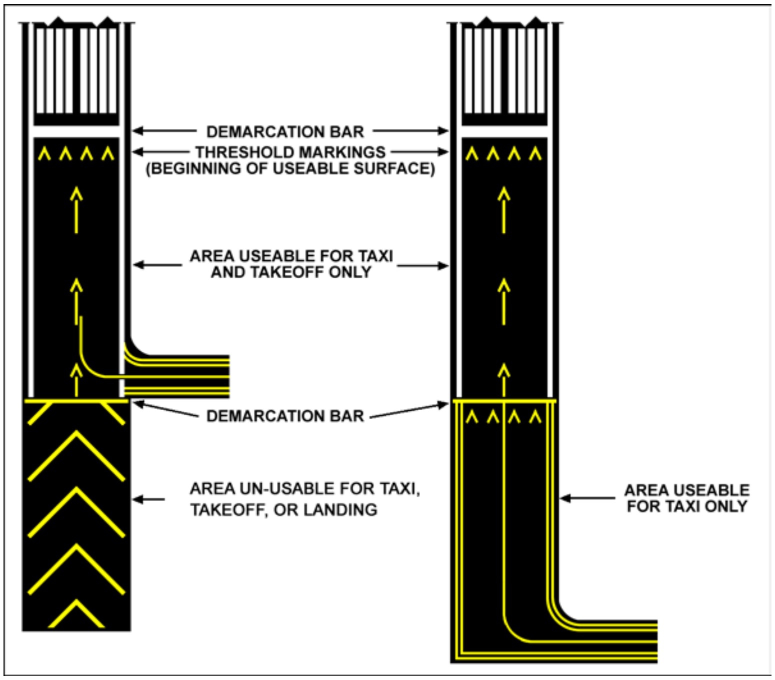


Figure 15.5. Displaced Threshold Markings (FAA).



15.5.6.3. Side Stripe Markings. Side stripe markings are required on precision approach runways that are 150 feet or wider and on all runways where there is a lack of contrast between runway edges and shoulders or surrounding terrain. The distance between the inner edges of the stripes is 140 feet for runways 150 feet or wider. This distance will be less for runways less than 150 feet wide. Runway shoulders that have been stabilized with materials that give the appearance of paving but are not intended for use by aircraft are marked with a series of partial yellow chevrons. When a center section of a runway has been strengthened, the unstrengthened sections on either side are marked in the same manner as stabilized runway shoulders.

15.5.6.4. Runway Hold Lines. Runway hold lines (holding position markers) indicate where the taxiway and runway intersect. Do not cross without clearance from the tower to proceed onto the runway. Airfields with ILS facilities will have instrument hold lines (Air Force) or CAT II ILS hold lines. These markings ensure proper ILS operation during weather conditions less than 800 feet ceiling and/or 2 miles visibility. The airport control tower will issue instructions for aircraft to hold short of these markings.

15.6. Circling Approaches.

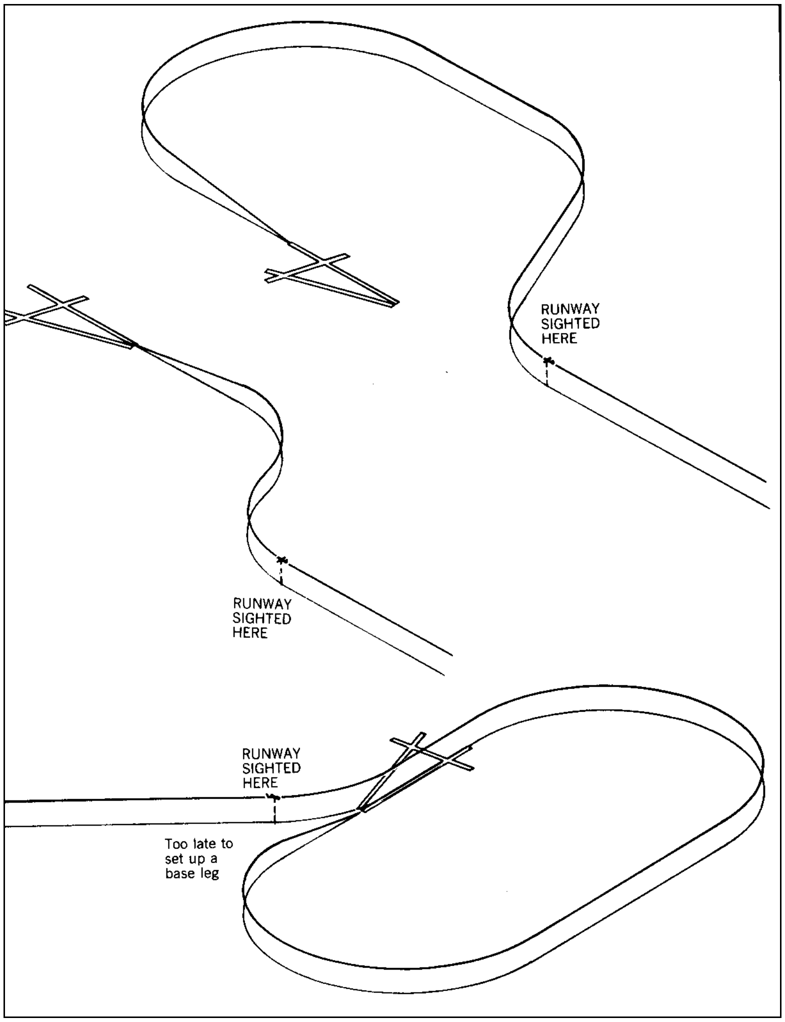
15.6.1. General Procedures. Circling to land is a visual flight maneuver. When the instrument approach is completed, it is used to align the aircraft with the landing runway. Each landing situation is different because of the variables of ceiling visibility, wind direction and velocity, obstructions, final approach course alignment, aircraft performance, cockpit visibility, and controller instructions. The circling MDA and weather minima to be used are those for the runway to which the instrument approach is flown (this is not always the landing runway). The circling minima listed on IAPs apply to nonradar nonprecision approaches (LOC, VOR, TACAN, etc.). Circling procedures and techniques are not compatible with precision approach criteria, and under normal circumstances, should not be attempted. Since the MAP associated with the precision approach is determined by the pilot in terms of a DH and not a specific point along the final approach course, it becomes difficult to ascertain when to discontinue the approach if visual conditions are not encountered. Therefore, pilots should not plan to circle from a precision approach.

15.6.1.1. Circling from RNAV/GPS Approaches. Circling may be accomplished from an RNAV (GPS) approach if circling minimums are published. However, depending on the type of circling maneuver required, following RNAV (GPS) vertical guidance to the circling MDA may result in visually acquiring the airport environment too late to accomplish a safe circling maneuver. Pilots must ensure they remain within the required obstacle clearance radius and maintain situational awareness, especially in reduced visibility. In reduced visibility, pilots must maintain situational awareness and insure they remain within the required obstacle clearance radius. ***If there is any doubt as to maintaining required distance, or a loss of situational awareness, accomplish the missed approach and request an alternate approach.***

15.6.2. Instructions. If the controller has a requirement to specify the direction of the circling maneuver in relation to the airport or runway, the controller will issue instructions in the following manner: “Circle (direction given as one of eight cardinal compass points) of the airport/runway for a right/left base/downwind to runway (number).” For example, “Circle west of the airport for a right base to runway one eight.”

15.6.2.1. NOTE: Obstruction clearance areas are determined by aircraft category. Maneuver the aircraft to remain within the circling area for your aircraft category (see AFMAN 11-217 Volume 3, *Supplemental Information* for radii of circling approaches). If it is necessary to maneuver at speeds in excess of the upper limit of the speed range authorized for your aircraft’s category, use the landing minima for the category appropriate to the maneuvering speed. When you request circling MDA from the controller for a circling ASR approach, state your aircraft category.

Figure 15.6. The Circling Approach.



15.6.3. Accomplishing the Approach (Figure 15.6).

15.6.3.1. Descent. After descending to circling minimum descent altitude and when the airport environment is in sight, determine if the ceiling and visibility are sufficient for performing the circling maneuver. The airport environment is considered the runways, its lights and markings, taxiways, hangars, and other buildings associated with the airport. (Since the MDA is a minimum altitude, a higher altitude may be maintained throughout the maneuver.)

15.6.3.2. Pattern. Choose a pattern that best suits the situation. Maneuver the aircraft to a position that allows you to keep as much of the airport environment in sight as possible. Consider making your turn to final into the wind if this maneuvering allows you to also keep the airport environment in sight. You may make either left or right turns to final unless you are:

15.6.3.2.1. Directed. Directed by the controlling agency to do otherwise.

15.6.3.2.2. Required. Required to do otherwise by restrictions on the approach chart or IFR Supplement.

15.6.3.3. Weather -- High Ceiling/Good Visibility. If weather permits, fly the circling approach at an altitude higher than the circling MDA, up to your normal VFR traffic pattern altitude. This allows the maneuver to be flown with a more familiar perspective and better visual cues. Do not descend below circling MDA until in a position to place the aircraft on a normal glide path to the landing runway. (In order to prepare pilots for the worst situation fly practice circling approaches at the circling MDA if feasible and conditions permit.)

15.6.3.4. ***Weather -- Low Ceiling/Restricted visibility. If weather does not permit circling above the MDA, do not descend below circling MDA until the aircraft is in a position to execute a normal landing. Descend from the MDA as necessary to place the aircraft on a normal glide path to the landing runway***.

15.6.3.5. ***Missed Approach. If there is any doubt whether the aircraft can be safely maneuvered to touchdown, execute the missed approach***.

15.6.3.5.1. WARNING: Be aware of the common tendency to maneuver too close to the runway at altitudes lower than your normal VFR pattern altitude. Using the same visual cues that you use from normal VFR pattern altitudes causes this. Select a pattern that displaces you far enough from the runway that will allow you to turn to final without overbanking or overshooting final.

15.7. Side-Step Maneuver Procedures. Where a side-step procedure is published, aircraft may make an instrument approach to a runway or airport and then visually maneuver to land on an alternate runway specified in the procedure. Landing minimums to the adjacent runway will be higher than the minimums to the primary runway, but will normally be lower than the published circling minimums.

15.7.1. Phraseology. Examples of ATC phraseology used to clear aircraft for these procedures are: "Cleared for ILS runway seven left approach. Side-step to runway seven right."

15.7.2. Begin Side-step. Pilots are normally expected to commence the side-step maneuver as soon as possible after the runway or runway environment is in sight. Typically this occurs inside the FAF. Beginning the side-step maneuver prior to the FAF could cause a conflict with other traffic, especially when using parallel runways. ***The side-step MDA will be maintained until reaching the point at which a normal descent to land on the side-step runway can be started***.

15.7.3. Lose Visual. As in a circling approach, if you lose visual reference during the maneuver, follow the missed approach specified for the approach procedure just flown, unless otherwise directed. An initial climbing turn toward the landing runway will ensure that the aircraft remains within the obstruction clearance area.

Chapter 16

MISSED APPROACH

16.1. Planning. Performing a missed approach successfully is the result of thorough planning. You should familiarize yourself with the missed approach departure instructions during preflight planning. The missed approach departure instruction is designed to return the aircraft to an altitude providing en route obstruction clearance. In some cases the aircraft may be returned to the initial segment of the approach.

16.2. Missed Approach Point (MAP). The missed approach point for a nonprecision straight-in approach is located along the final approach course and no farther from the FAF than the runway threshold (or over an on-airport navigation facility for a no-FAF procedure and some selected FAF procedures). To determine the location of the MAP, compare the distance from the FAF to the MAP adjacent to the timing block. It may not be the same point as depicted in the profile view. If there is not a timing block, the MAP should be clearly portrayed on the IAP.

16.2.1. NOTE: The MAP depicted on the IAP is for the non-radar approach with the lowest HAT. For example, on an ILS approach designed by the FAA, the MAP printed will be for the ILS DH. The MAP for the localizer will probably be at the approach end of the runway and the only way to determine this is by the distance listed on the timing block.

16.2.2. Circling. The MAP for a circling approach is also located along the final approach course. It will be no farther from the FAF than the first portion of the usable landing surface (or over an on-airport navigation facility for a no-FAF procedure).

16.2.3. Precision. The missed approach point for any precision approach is the point at which the decision height is reached. This is normally the point depicted on the IAP as the start of a climbing dashed line.

16.2.4. Obstacle Clearance. The obstacle clearance area provided for the missed approach is predicated upon the missed approach being started at the MAP.

16.2.5. Initiation. ***When the missed approach is initiated prior to the MAP, proceed to the MAP along the final approach course and then via the route and altitudes specified in the published missed approach departure instruction***.

16.2.6. Delayed Decision. ***Initiate the missed approach no later than the missed approach point (MAP).*** If the decision to execute the missed approach is delayed beyond the MAP, you may be below the missed approach obstacle clearance surface or outside the missed approach obstacle clearance area.

16.2.7. Radar Approach. When flying a radar approach, missed approach departure instructions will be given if weather reports indicate that any portion of the final approach will be conducted in IFR conditions. At USAF bases where missed approach instructions are published in base flying regulations, controllers may not issue missed approach instructions to locally assigned aircraft.

16.3. **Missed Approach/Departure Instructions.** A clearance for an approach includes clearance for the missed approach published on the IAP, unless ATC issues alternate missed approach instructions.

16.3.1. Multiple Approaches. Prior to the FAF, the controller is required to issue appropriate departure instructions to be followed upon completion of approaches that are not to full stop landings. The pilot should tell the controller how the approach will terminate prior to beginning the approach. The controller will state, "After completion of your low approach/touch-and-go/stop-and-go/option, climb and maintain (altitude), turn right/left heading (degrees)." These instructions are often referred to as "climbout instructions" and are designed to return you to the traffic pattern. ***At locations where ATC radar service is provided, the pilot should conform to radar vectors when provided by ATC in lieu of the published missed approach procedure. Unless otherwise instructed, initiate an immediate climb to the assigned altitude. Delay any turns until past the departure end of the runway, if visible, and 400 feet AGL). If the departure end is not visible, climb on runway heading until 400 feet AGL before beginning your turn. If you are unable to comply with previously issued climbout instructions, comply with the published missed approach procedure and inform ATC immediately.*** This will ensure ATC is aware of your intentions and can issue alternative instructions if necessary.

16.3.1.1. When practicing instrument approaches under VFR IAW AFI 11-202 Volume 3, *General Flight Rules*, you are expected to comply with climbout instructions and are NOT automatically cleared for the published missed approach procedure if you cannot comply with the climbout instructions. ***When practicing instrument approaches under VFR, you must request and receive a specific clearance to execute the published missed approach procedure***.

16.3.2. Circling Approaches. Executing climbout instructions in conjunction with a circling approach is more complicated. ***If upon reaching the missed approach point the airport environment is not in sight, execute the climbout instructions from the missed approach point. If the circling maneuver has begun and the airport environment is visually lost, begin an initial climbing turn toward the landing runway to ensure the aircraft remains within the obstruction clearance area. Continue this turn until established on the climbout instructions***.

16.4. Actual Missed Approach. If you have been cleared to land (full stop), ATC expects you to land; therefore, ***if you have been cleared to land and must subsequently execute a missed approach, notify ATC as soon as possible and execute the published missed approach unless you have been issued climbout instructions.***

16.4.1. Various Terms. There are various terms in the missed approach departure instruction written on the IAP that have specific meanings with respect to climbing to an altitude, executing a turn for obstruction avoidance and other reasons. Here are some examples:

16.4.1.1. "Climb and maintain" means a normal climb along the prescribed course.

16.4.1.2. "Climb and maintain (altitude), turn right (heading)" means climbing right turn as soon as safety permits, normally to clear obstructions. This instruction may be given with the turn direction stated first.

16.4.1.3. "Climb and maintain 2,400" means climb to 2,400 feet before ATC will issue a turn instruction, normally to clear obstructions. ATC may state: "Climb and maintain 2,400, then turn right (heading)," to accomplish the same.

16.4.2. Accomplishing the Missed Approach.

16.4.2.1. When to do the Missed Approach. ***Perform the missed approach when the missed approach point, decision height (DH), or decision altitude (DA) is reached and any of the 3 following conditions exists***:

16.4.2.1.1. ***The runway environment is not in sight.***

16.4.2.1.2. ***You are unable to make a safe landing.***

16.4.2.1.3. ***You are directed by the controlling agency.***

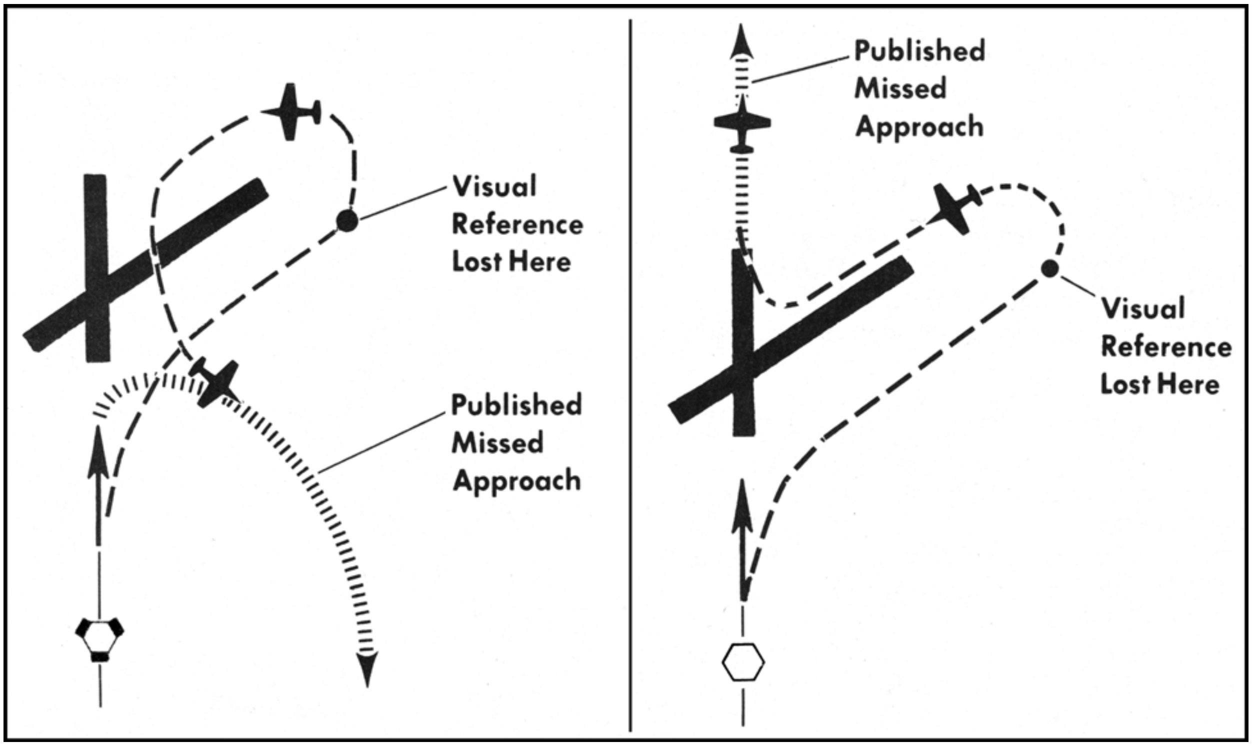
16.4.2.2. Fly the Aircraft. When you decide to execute the missed approach, fly the aircraft in accordance with the flight manual missed approach procedures. They are normally similar to those used for the instrument takeoff.

16.4.2.3. Transition. Transition from the approach to the missed approach in a positive manner using precise attitude and power control changes. Establish the missed approach attitude, power setting, and configuration prescribed in the flight manual. Crosscheck the vertical velocity indicator and altimeter for positive climb indications before retracting the gear and wing flaps. Since aircraft control will require almost total attention, you should have the first heading, course, and altitude in mind before reaching the missed approach point.

16.4.2.3.1. If you decide to execute a missed approach prior to reaching the missed approach point, ***continue along the IAP routing at or above the MDA/DH until reaching the missed approach point***. You may climb to the missed approach altitude while following the IAP routing. ***Do not initiate any turns on the missed approach until reaching the missed approach point.*** If ATC issues you a vector on the missed approach, consider this your new clearance.

16.4.2.4. Lose Visual Reference. ***If you lose visual reference while circling to land, follow the missed approach specified for the approach procedure just flown, unless otherwise directed. An initial climbing turn toward the landing runway will ensure that the aircraft remains within the circling obstruction clearance area. Continue to turn until established on the missed approach course (Figure 16.1). An immediate climb must be initiated to ensure climb gradient requirements are met***.

Figure 16.1. Missed Approach from the Circling Approach.



16.4.3. Climb Gradient. ***Ensure your aircraft can achieve the published climb gradient. When the gradient is not published, climb at least 200 feet per nautical mile in order to clear obstructions. See AFI 11-202 Volume 3 General Flight Rules, for engine out performance requirements.***

16.4.4. Request clearance. As soon as practical after initiating the missed approach, advise ATC and request clearance for specific action; that is, to an alternate airport, another approach, or holding. Do not sacrifice aircraft control for the sake of a voice transmission.

16.4.5. Obstacle Clearance. Terrain clearance is provided within established boundaries of the approach course and the missed approach path. It is essential that you follow the procedure depicted on the IAP chart or the instructions issued by the controller. Be aware of the minimum safe altitudes found on the IAP charts. Remember that the missed approach climb gradient begins at the published MAP.

Chapter 17

SPATIAL DISORIENTATION

17.1. General Information.

17.1.1. Occurrence. The USAF Safety Center, during the period of 1990 to 1997, reported that spatial disorientation (SD) has been a significant factor in at least 20 percent of all major aircraft accidents and 19 percent of all associated fatalities. These losses amounted to about $140 million per year and a significant personnel toll as well. Although the potential for spatial disorientation increased dramatically with the introduction of high performance, single-seat fighters into the Air Force inventory, pilots of multi-place aircraft are not exempt from spatial disorientation.

17.1.1.1. The Spatial Disorientation Countermeasures web site is at http://www.spatiald.wpafb.af.mil. The intent of this site is to disseminate SD related information that can help reduce the loss of personnel and aircraft caused by spatial disorientation. The Human Effectiveness Directorate of the Air Force Research Laboratory (AFRL) sponsors this site and the Human Systems Information Analysis Center (HSIAC) located at Wright-Patterson Air Force Base, Ohio. Aircrews should reference this site often to review the latest developments in the field of spatial disorientation research.

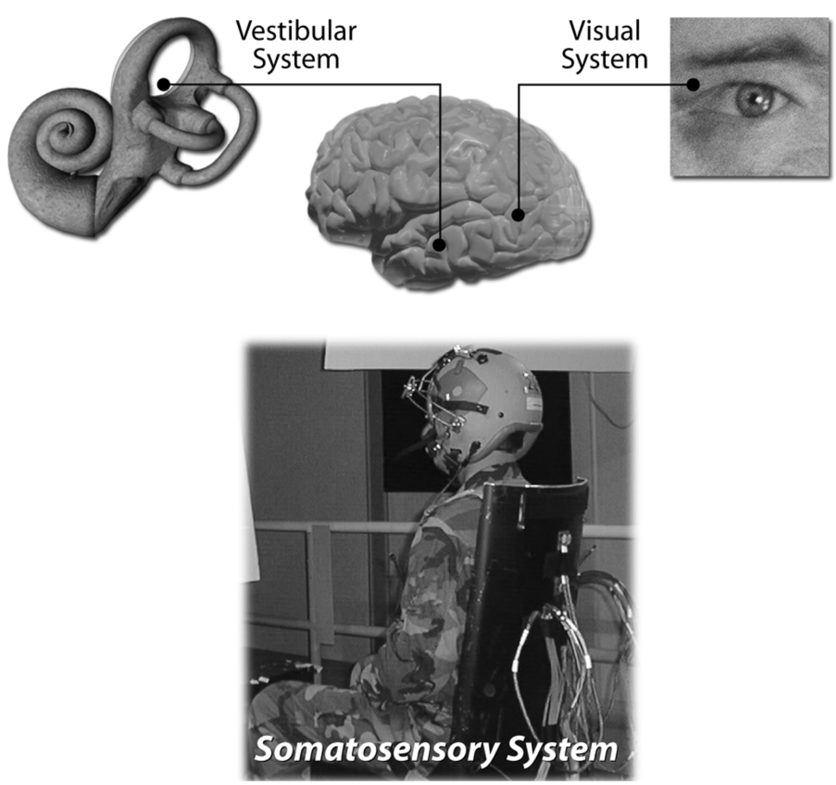
17.1.2. Definition. SD is an incorrect perception of one's linear and angular position and motion relative to the plane of the earth's surface. Specifically in the flight environment, SD is an erroneous percept of any of the parameters displayed by aircraft control and performance flight instruments. Regardless of a pilot's experience or proficiency, sensory illusions can lead to differences between instrument indications and what the pilot "feels" the aircraft is doing. It should be stressed that disoriented pilots frequently are not aware of their orientation error and upon recognizing a conflict exists, often believe an instrument to be in error. Many crashes occur when pilots fail to recognize that SD is happening or when there is not enough time to recover once a conflict has been properly diagnosed. In general, unrecognized spatial disorientation tends to occur during task intensive portions of the mission, while recognized spatial disorientation occurs during attitude changing maneuvers.

17.1.3. Susceptibility. It is important to remember that sensory illusions occur regardless of pilot experience or proficiency. All pilots are susceptible to illusions while flying at night, flying in various weather conditions, flying demanding maneuvers with extreme linear or angular accelerations, or even in VMC. In other words, just about any time. A basic understanding of the sensory systems, physiological mechanisms of various illusions, and conditions of flight where these illusions may be expected can help the pilot successfully cope with spatial disorientation.

17.2. Orientation and Equilibrium. A person's perception of spatial orientation develops from the interpretation of sensory input by the conscious and subconscious aspects of the brain. The subconscious mind uses sensory information from the ambient (or peripheral) visual system, the vestibular system and the somatosensory system to maintain orientation and equilibrium. This information is processed automatically at very high rates and without conscious effort. The conscious mind employs central (focal) vision to determine spatial orientation by comparing sensory inputs to known experiences. In contrast to the speedy processes of the subconscious, information processed in the conscious mind is relatively slow, requiring active thought, and is normally very accurate. For earthbound activities, our subconscious orientation system receives adequate information from the sensory systems. However, when a person is subjected to the flight environment, these sensory systems are no longer adapted to the environment and may provide the subconscious mind with false information about its orientation in space. For example, when flying in IMC or without reliable external attitude or motion cues, only the conscious mind, through the use of focal vision and attention to flight instruments, can correctly determine true orientation.

17.2.1. Vestibular System (Figure 17.2). The vestibular system contains the primary organs of equilibrium and thus plays a major role in the sensation of motion and spatial orientation. It aids vision by providing angular and linear acceleration information to stabilize the eyes when motion of the head and body would otherwise result in blurred vision. On the ground, the vestibular system provides reasonably accurate perception of position and motion. In flight, however, the ability to sustain motion in the aircraft results in a mismatch between the vestibular input of the inner ear and the actual aircraft motion. To understand how this vestibular information can be erroneous, one must look at its two sensors: the semicircular canals and the otolith organs of the inner ear.

Figure 17.1. Organs of Equilibrium.



17.2.1.1. Semicircular Canals. The three semicircular canals on each side of the head are positioned at approximate right angles to each other so that angular accelerations in any spatial plane (pitch, roll, or yaw) can be detected. The fluid within the semicircular canals moves relative to the canal walls when angular accelerations are applied to the head. This fluid movement bends sensory hair filaments in specialized portions of the canals, which sends nerve impulses to the brain resulting in the perception of rotary motion in the plane of the canal stimulated. Again, since the response characteristics of the semicircular canal system evolved for our ground-based environment of sudden stop-and-go movements, peculiar errors may be induced during sustained motion in flight. For example, a very small or short-lived angular acceleration may not be perceived accurately, and the resulting sustained angular velocity may not be perceived at all, either one resulting in a large change in actual attitude awareness over a short period of time. Additionally, angular accelerations experienced in flight can be quite different from those experienced on the ground. Hence, we often erroneously interpret the sensations produced by the fluid movement in the semicircular canal.

17.2.1.2. Otolith Organs. In the presence of linear acceleration or gravity, the relative movements of the otolithic membranes bend the sensory hairs that penetrate the otolithic membranes over the underlying structures (the result of a shearing force). Without any linear acceleration, shearing force due to gravity is transformed into nerve impulses to the brain, which convey information about head position relative to true vertical. With linear acceleration, a resultant shearing force is generated and the signals to the brain are the same as those produced by a shift in the direction of gravity. During flight, inertial forces are combined with the force of gravity and act upon the otolithic membranes to produce a net combined force. The direction of this combined or resultant force is almost never in the direction of the true vertical. Hence, it is almost impossible to correctly determine the true direction of “down” from the otolith organs.

17.2.2. Visual System. Vision is by far the most important sensory system for providing true spatial orientation during flight. In the absence of vision, orientation would be derived solely from the less accurate vestibular or somatosensory systems, and these systems do not provide reliable motion and position cues in the flight environment.

17.2.2.1. Visual Dominance. Of great importance in minimizing the effects of spatial disorientation is understanding and experiencing the concepts of visual dominance and vestibular suppression. Visual dominance is a result of evolution. We rely heavily on the visual system to successfully function within our normal everyday environment. This visual system must dominate the other sensory inputs. Particularly in the flight environment, we must learn to suppress the vestibular input. Vestibular suppression is the ability to suppress unwanted vestibular sensations and reflexes. A pilot’s ability to accomplish vestibular suppression comes from practice or exposure to the motion of the flight environment. An experienced pilot is more likely to suppress vestibular signals than an inexperienced pilot.

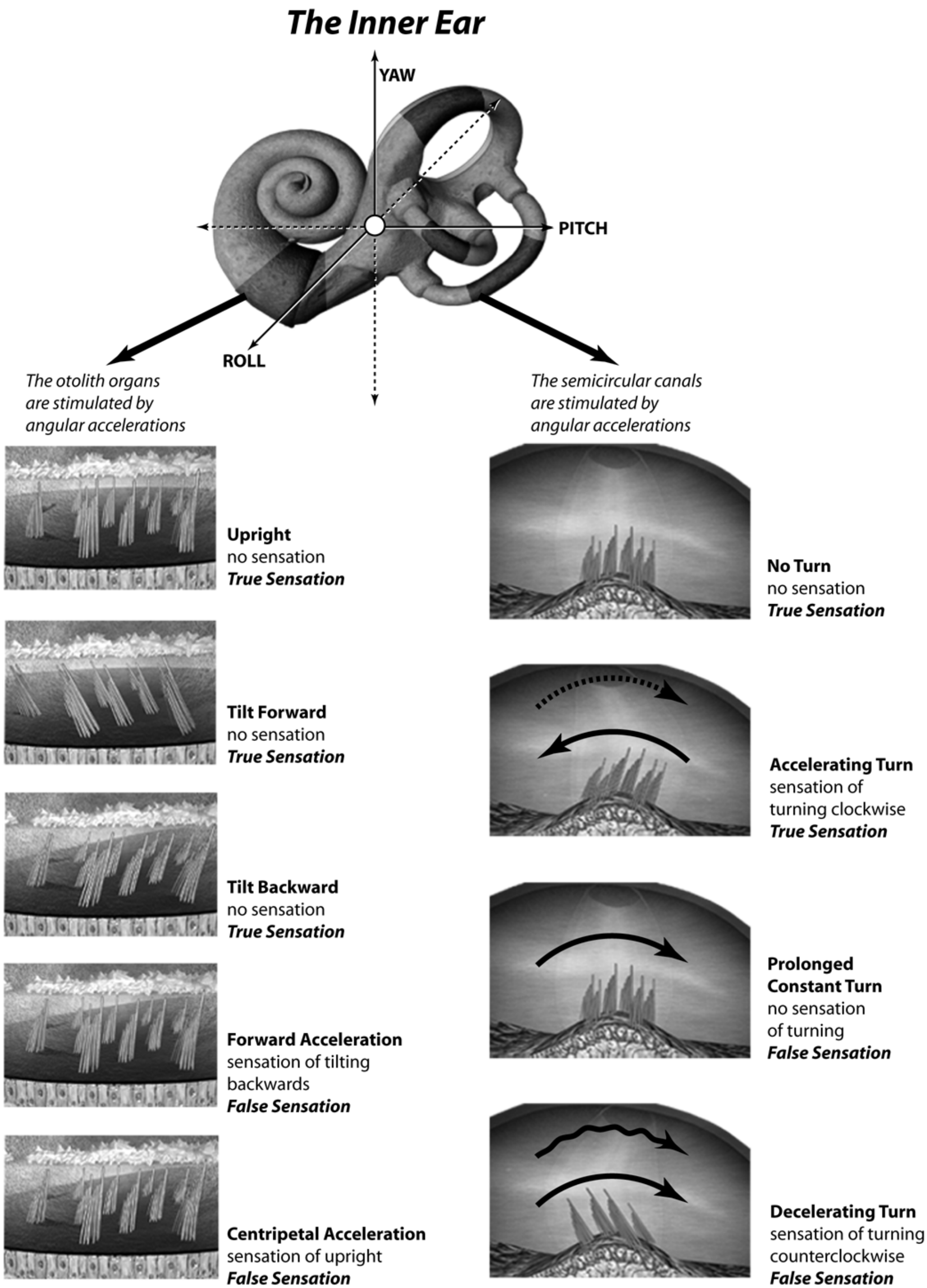
17.2.2.2. Ambient and Focal Vision. The visual system is actually composed of two separate visual modalities, and these two modalities provide different visual functions. The ambient (mainly peripheral) visual modality is primarily concerned with the question of "where," thus providing us an important piece of the spatial orientation mental "picture." Because ambient vision is monitored at the subconscious level, its information is processed automatically at very high rates and without conscious effort. The focal (or central) visual modality is primarily concerned with the question of "what," providing fine detail for recognition. For spatial orientation, focal vision provides visual cues for judgment about distance and depth, and retrieves information from the flight instruments. While focal vision operates with great precision and accuracy, it is processed in the conscious mind relatively slowly, requiring active thought.

17.2.2.3. Visual Conditions in Flight. During flight, the utility of external visual references varies with the quality of available visual information. Because of the dynamic relationship between visual information available and mission requirements, all aviators should be aware that spatial disorientation is possible, under a wide variety of visual and varying workload conditions.

17.2.2.3.1. Adequate External Vision. In the presence of extreme linear and/or angular accelerations and unusual aircraft attitudes, spatial disorientation can occur even on a clear day. Under such circumstances, reference to a distinct horizon in combination with flight instruments should allow the pilot to maintain visual dominance and naturally suppress false vestibular and somatosensory orientation cues.

17.2.2.3.2. Instrument Conditions. At night, in IMC, or in marginal VMC (i.e., when adequate external visual references are not available), the pilot must maintain spatial orientation and a state of visual dominance solely by reference to aircraft instruments, especially the attitude display. The key to success in instrument flying is to develop an effective instrument crosscheck, which provides a continuous source of accurate information related to aircraft attitude, motion, and position. A proficient pilot with an effective crosscheck will have little difficulty in maintaining visual dominance and ignoring other, potentially disorienting, sensory data. The pilot should be aware that what is seen outside the aircraft may be confusing and may lead to visual illusions and sensory conflicts. During times when the aircraft instruments are the sole source of accurate information, pilots can count on becoming disoriented unless they direct their attention to see, correctly interpret, process, and believe the information provided by the instruments – and ultimately "make the instruments read right" regardless of the sensations felt.

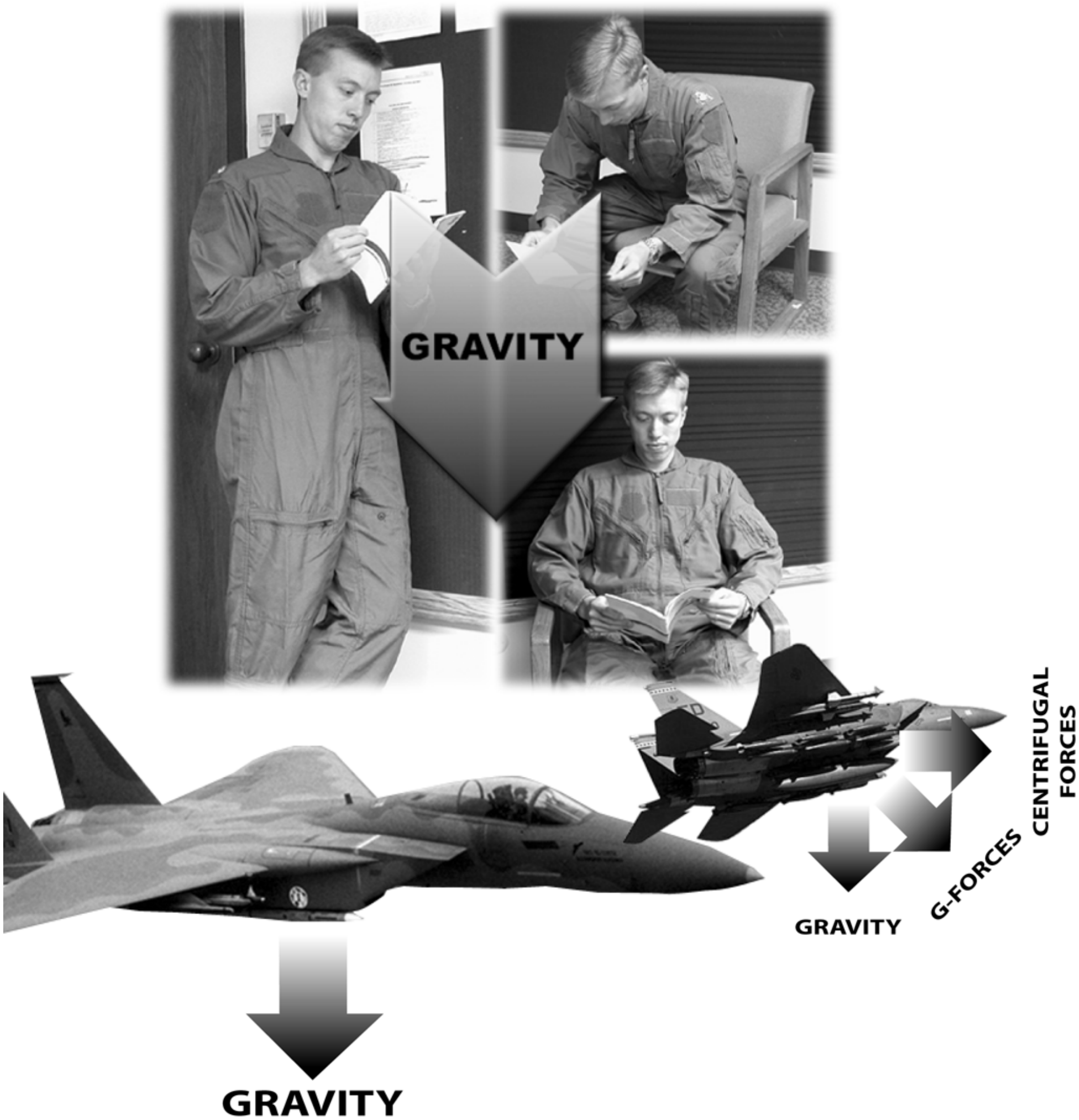
Figure 17.2. Vestibular (Inner Ear) System.



17.2.2.3.3. Aided Night Vision. Night vision goggles (NVG) provide an intensified image of scenes illuminated by ambient energy in the night environment. Although they are a great aid to aviators conducting night operations, NVGs do not turn night into day. The image provided by NVGs places limitations on critical aspects of human visual performance, (i.e. visual acuity, field-of-view, contrast sensitivity, and motion/depth perception). These limitations combine to create a degraded visual environment, increase cognitive workload, and contribute to spatial disorientation. Proper training and extensive experience can help deal with these limitations and reduce the susceptibility to dangerous situations. Spatial orientation at night requires conscious, complex processing of data from cockpit instruments and displays. An aggressive NVG instrument crosscheck should be a part of all NVG operations regardless of illumination levels, flight altitudes or mission profiles. In addition, an effective NVG scan (using constant head movements) compensates for the reduced NVG field-of-view and increases the external field of regard of the aviator. By scanning the horizon during aggressive maneuvering, aircrew can minimize disorientation. Both the instrument crosscheck and an effective scanning technique require concentration and good habit patterns, which should be emphasized and developed during training. When employed under appropriate conditions, NVGs enhance orientation by providing an external visual scene where none is available without the goggles. However, NVG operations are inherently more demanding than comparable day missions and aircrew must fully understand the limitations on human physiology and aircraft systems. AFMAN 11-217, Volume 3 *Supplemental Information*, contains a detailed discussion of NVGs.

17.2.3. Somatosensory System (Figure 17.3). Buried in many body structures, including the skin, joints, and muscles, the somatosensory receptors provide important equilibrium information as they respond to pressure and stretch. The sensations they elicit are the deep pressure feelings that you experience when you sit or the sensations that enable you to know the relative positions of your arms, legs, and body. This system is commonly called the “seat-of-the-pants” sense because some early pilots believed they could determine which way was down by analyzing which portions of their bodies were subject to the greatest amount of pressure. As illustrated in Figure 17.3, the “seat-of-the-pants” sense is completely unreliable as an attitude indicator when moving in the aerial environment.

Figure 17.3. Somatosensory System -- The Seat-Of-The-Pants Sense.



17.2.4. Auditory System. The auditory response in flight is unique in that it is an acquired skill. Pilots learn early in Undergraduate Pilot Training (UPT) that when the aircraft is going fast, there is more airframe/canopy wind noise, and when the aircraft is going slow, the noise level decreases. Thus, the pilot is able to grossly discern airspeed by the noise level in the cockpit. For some pilots, the first clue that they are disoriented is a mismatch between the sounds they expect to hear, based upon their perceived attitude, and the actual "wind" noise present. Although this is not a very precise method, it is often a first clue that something may be out of sync. A quick look at the flight instruments is needed to correctly confirm a possible misperception.

17.3. Physiological Mechanics of Illusions.

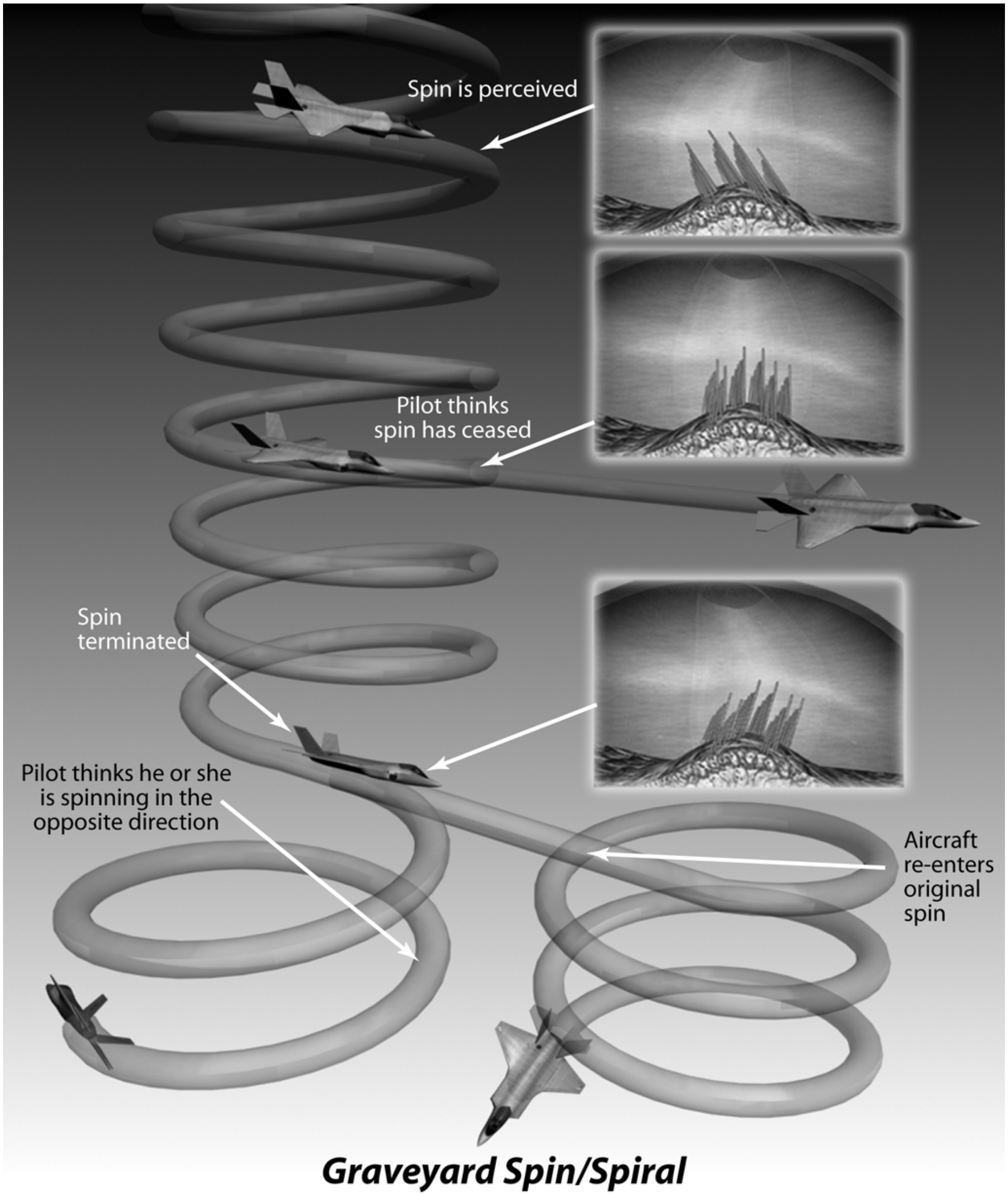
17.3.1. Vestibular Illusions. In the absence of adequate visual orientation cues, the inadequacies of the vestibular and somatosensory systems can, and generally do, result in orientation illusions. It is customary to discuss vestibular illusions in relation to the two components that generate the illusions--the semicircular canals and the otolith organs.

17.3.1.1. Somatogyral Illusion. This set of illusions result from the semicircular canals' inability to register accurately a prolonged rotation, i.e., sustained angular velocity.

17.3.1.1.1. Graveyard Spin (Figure 17.4). This situation begins with the pilot intentionally or unintentionally entering a spin. The pilot's first impression is accurate; that is, a spin is perceived. After about 10 to 20 seconds of constant rotation (no angular acceleration), the fluid in the canals comes to rest with respect to the canal walls and the sensory hairs return to the upright, resting position. The sensation is that of no rotational motion despite the fact that the spin continues. If the spin is then terminated, the angular deceleration produced causes a relative motion between the fluid and the canal walls, thus deviating the sensory hairs in the opposite direction. The pilot erroneously perceives spinning in the opposite direction. If the pilot does not recognize the illusion and acts to correct this false impression, he or she will put the aircraft back into the original spin.

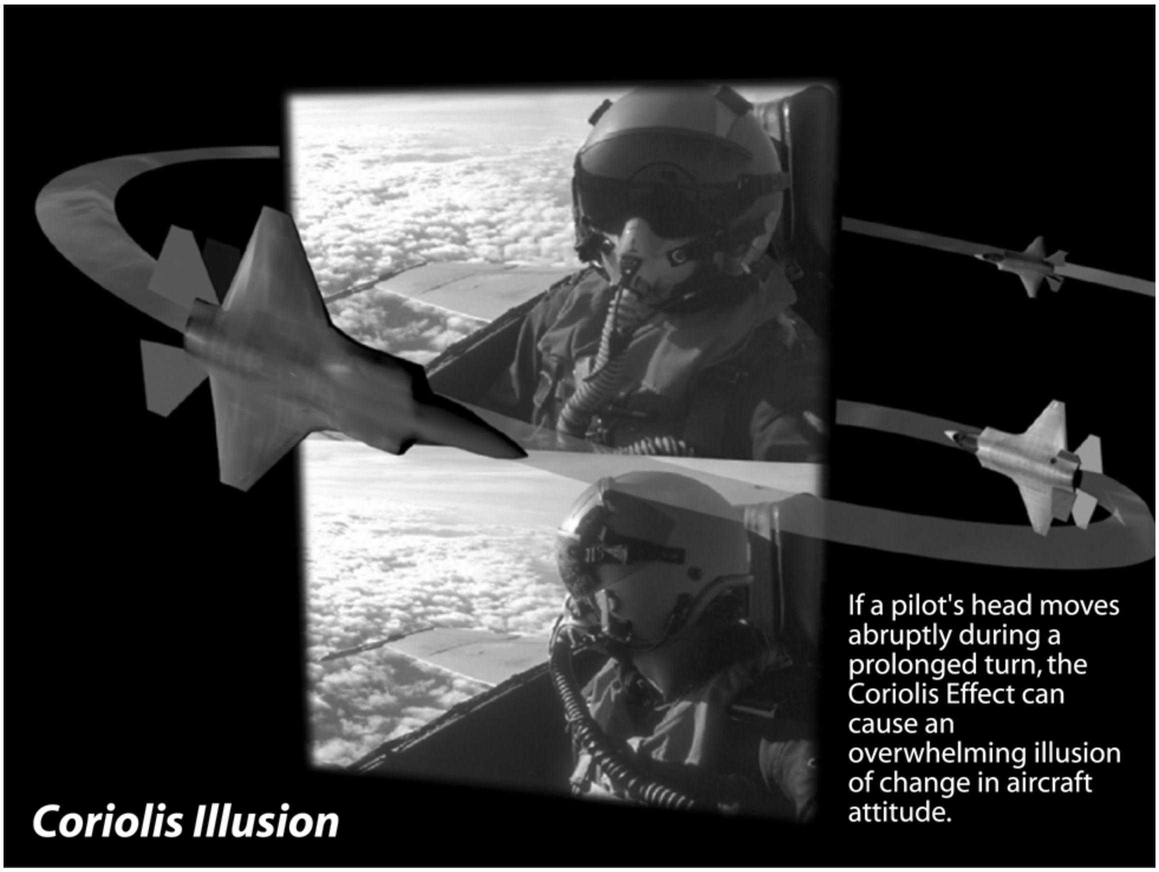
17.3.1.1.2. Graveyard Spiral. In this maneuver the pilot has intentionally or unintentionally put the aircraft into a prolonged turn with a moderate or steep bank. The constant rate of turn causes the pilot to lose the sensation of turning after a period of time. Noting a loss of altitude, the pilot may pull back on the controls or perhaps add power in an attempt to regain the lost altitude without checking that an increase in bank has occurred. Unless the incorrectly perceived bank attitude is corrected, such actions only serve to tighten a downward spiral. Once the spiral has been established, the pilot sometimes experiences the illusion of turning in the opposite direction after the turning motion of the aircraft has stopped. Under these circumstances, if the pilot fails to suppress all sensory data except the visual, vestibular illusions may cause inappropriate inputs, resulting in re-establishment of the spiral.

Figure 17.4. Graveyard Spin/Spiral.



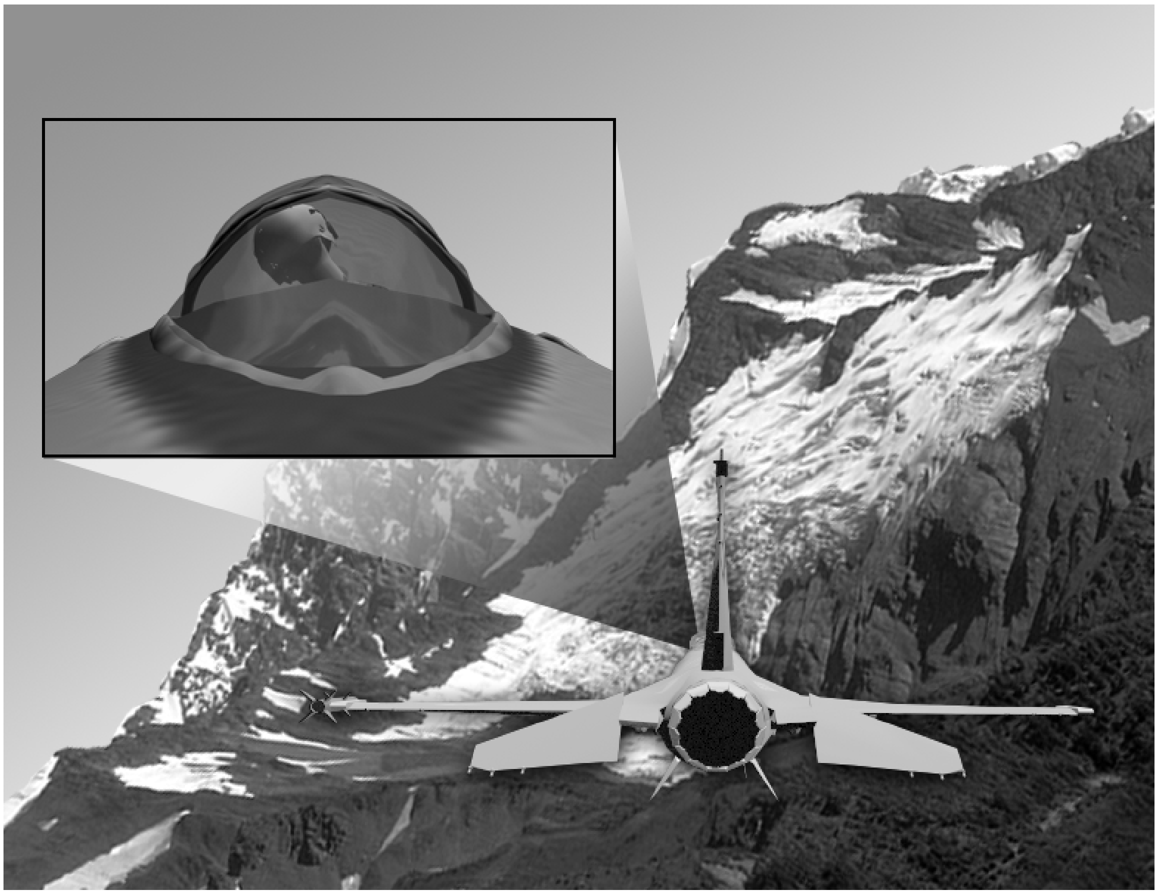
17.3.1.2. Coriolis Illusion (Figure 17.5). During high turn rates, abrupt head movements may cause pilots to perceive motions they are not actually doing. When the body is in a prolonged turn in one plane, the fluid in those canals stimulated by the onset of the turn eventually comes up to speed with the canal walls. If the head is then tilted in another plane, the angular momentum of the fluid causes it to move again relative to the canal walls. The resulting sensation is one of rotation in a third plane. This has also been called a "cross-coupling" sensation. If pilots try to correct for the illusion without referencing their flight instruments, they may put the aircraft in a dangerous attitude. The coriolis illusion is probably not as important in fixed wing aircraft because the relatively low turn rates of instrument flight make coriolis illusion very difficult to generate. However, care should be used during rotary-wing flight. These aircraft have the ability to generate significant yaw rates.

Figure 17.5. The Coriolis Illusion and the Leans.



17.3.1.3. The Leans. This is the most common vestibular illusion and is caused by rolling or banking the aircraft after the pilot has a false impression of the true vertical. After a prolonged turn has ceased, the pilot may perceive the roll to wings level as a bank and turn in the opposite direction. This can cause pilots to lean in an attempt to assume what they think is a vertical posture. If they establish a very slow roll to the left that does not stimulate the vestibular apparatus and then roll rapidly to the right to level flight, they may generate the false impression of only having rolled to the right, and the leans may result. The leans are most commonly felt when flying formation on the wing in and out of the weather or at night. Since the wingman's attention is on the flight lead and not on the attitude display, it becomes easy for the vestibular or somatosensory system to provide false orientation cues, often reinforced by false ambient visual cues. These false orientation cues can quickly convince the wingman of being in an "unusual" attitude and cause a strong case of the leans. To minimize the effects of the leans while on the wing, it is important for the wingman to occasionally cross-reference the attitude display, without making a head movement if possible. Thus, the pilot must use focal vision to overcome the false cues and to acquire accurate spatial orientation information.

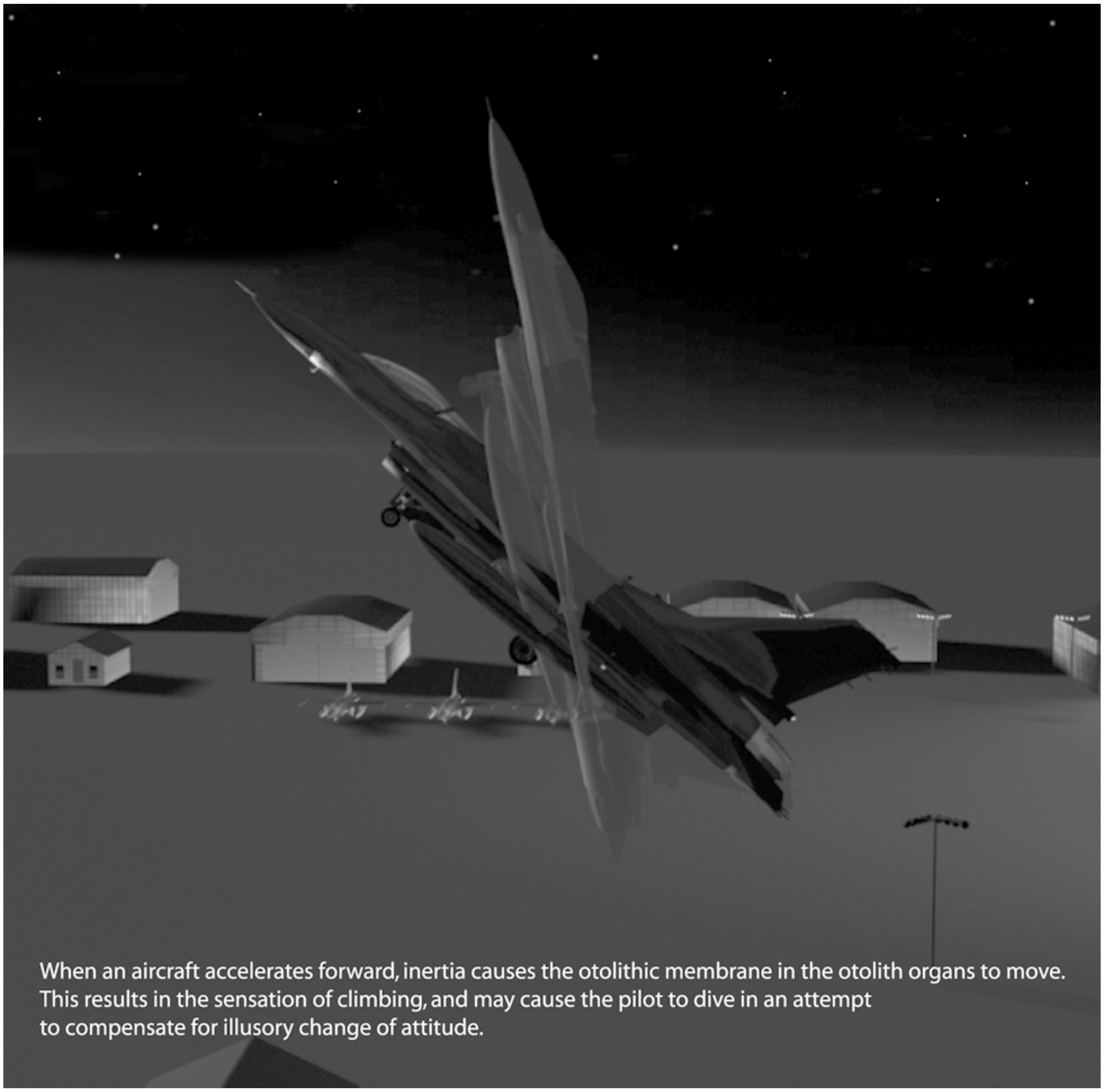
Figure 17.6. The Leans.



17.3.1.4. Somatogravic Illusion. The otolith organs are responsible for a set of illusions known as somatogravic illusions. This type of illusion is the sensation of change in attitude when the otolith organs are stimulated by linear acceleration. This illusion was first noted in the US Navy during aircraft carrier launch operations. A false nose high sensation can occur when an aircraft accelerates forward in level flight. This somatogravic illusion may be unrecognized during an IMC takeoff or missed approach acceleration if the pilot is not concentrating on flying instruments. Correcting for this illusion during climbout could cause the pilot to dive the aircraft into the ground. A false nose-down sensation can occur as a result of rapid deceleration in the weather.

17.3.1.4.1. Inversion illusion. A variant of somatogravic illusion is the inversion illusion, in which G forces act on the otolith organs to give the pilot transitioning from an upright position to one of feeling upside down. Although the inversion illusion is of greatest magnitude in high-performance aircraft, it can occur in any aircraft. The pilot can overcome the illusion by paying attention to valid external visual references or to aircraft attitude instruments.

Figure 17.7. The Somatogravic Illusion.



17.3.1.4.2. G-excess illusion. The G-excess illusion depends on otolith-organ mechanisms. The G-excess illusion is an exaggerated sensation of body tilt caused by a greater that 1-G force on the otolith organs. The additional G force (that amount greater than 1 G) increases the response of the otolith organs, causing the false perception (illusion) of an excessive amount of pitch or bank. When a pilot's head is facing forward in a G-pulling turn, the G-excess effect causes a false percept the aircraft has tilted backwards (pitched up). In the absence of overriding visual cues, the pilot can make dangerous attitude control errors to correct for the G-excess illusion. If the pilot is looking at the "9 o'clock level" position while in a left turn, the G-excess effect would create the illusion the pilot's direction of gaze is above the actual direction; i.e., the aircraft is in less of a bank than is actually the case. The pilot would compensate for the illusion by overbanking. Because of the G-excess illusion, the pilot may be in a bank somewhat greater than the perceived bank angle, and feel comfortable in it. The G-excess effect and the illusion of underbank do not necessarily disappear as a result of the compensatory overbank. The same phenomenon can occur repeatedly as long as the G-load is maintained. Thus, even though the initial perceptual error may be small, the accumulation of erroneous compensatory control input can result in a rapidly developing severe overbank and the accompanying earthward velocity vector. Remember, the prime time for the G-excess illusion to happen is during any turning and looking maneuver.

17.3.1.5. Nystagmus. During and immediately after maneuvers resulting from particularly violent angular accelerations, such as spins and rapid aileron rolls, the vestibular system can fail to stabilize vision. The eyes can exhibit an uncontrollable oscillatory movement called nystagmus. This eye movement generally results in an inability to focus on either flight instruments or outside visual references. Rolling maneuvers are especially likely to result in visual blurring because of nystagmus. Normally, nystagmus ceases several seconds after termination of angular acceleration; but under conditions of vestibular dominance and high task loading, nystagmus and blurring of vision can persist much longer, even long enough to prevent recovery.

17.3.2. Visual Illusions (Figure 17.8). A wide variety of visual misperceptions are known to occur during flight, and the most common illusions are described here. When flying with NVGs, pilots should be aware that they are susceptible to the same visual illusions but with additional variations. The image intensification process of the goggles can intensify the illusion as well as the ambient light.

Figure 17.8. Visual Illusions.

17.3.2.1. Blending of Earth and Sky. At night with both aided and unaided vision, pilots may confuse ground lights with stars. In doing so, the possibility exists of flying into the ground because the perceived horizon is below the actual horizon. Pilots may also confuse unlighted areas of the earth with an overcast night sky. If pilots erroneously perceive ground features (such as the seashore) as the horizon, they are in danger of flying into the unlighted water or terrain above it. A pilot flying with aided night vision may see a fairly bright light source and mistake it for an aircraft or ground light, when in fact it is a distant star with high near infrared energy that is barely visible with unaided vision.

17.3.2.2. NVG Flight Over Water. Flight over water is particularly dangerous with NVGs due to the significantly reduced contrast, absence of features, and lack of motion cues in the NVG image. Also, a frequent cause of spatial disorientation with NVGs has been the reflection of stars by water surfaces. Hazy conditions over water can cause disorientation and force almost total reliance on flight instruments. Therefore, NVG flight over water must be conducted with an increased reliance on instruments as if the aircraft were in IMC. Because of the number of illusions that can occur, extraordinary vigilance must be maintained in the aircrew's crosscheck between outside visual references and instrument references to prevent misinterpretation of the NVG scene.

17.3.2.3. False Vertical and Horizontal Cues. Flying over sloping cloud decks or land that slopes gradually upward into mountainous terrain often compels pilots to fly with their wings parallel to the slope, rather than wings-level, or to climb or descend with the slope. A related phenomenon is the disorientation caused by the aurora borealis in which false vertical and horizontal cues generated by the aurora result in attitude confusion in pilots trying to fly formation or refuel at night in northern regions. This illusion has been called the visual form of the Leans. The other form of the Leans is primarily the result of semicircular canal stimulation.

17.3.2.4. No Vertical or Horizontal Cues. This situation is especially hazardous during night formation flights when the only outside reference is the lights of the lead aircraft. Frequent cockpit instrument scans, to include altitude, are essential when taking "spacing." Keeping the leader's lights in the same relative position on the windscreen does not ensure adequate horizontal or vertical spacing, nor does it ensure adequate height above the terrain. Especially during deceleration, when aircraft pitch attitude increases, keeping lead in the same position on the windscreen can cause a substantial loss of altitude. Night intercepts are especially dangerous without frequent instrument crosschecks. An overshoot and subsequent pullback toward lead can be confusing if you think that you are below the lights when in reality you are level (altitude-wise) with the lights but in a 90-degree bank. A maneuver to offset yourself to one side or the other, or below, could have disastrous results. When displacement is behind and below the lead aircraft, the misperception of actual altitude has been termed the DIP Illusion.

17.3.2.5. Undetected IMC. A particularly hazardous regime exists when flying with NVGs in weather conditions conducive to the formation of thin clouds or fog. NVGs are primarily sensitive to near infrared energy, and near infrared energy is poorly reflected by moisture. Aircrew using NVGs will be able to detect dense clouds or fog, especially clouds silhouetted against a clear sky. However, thin clouds or fog may actually be invisible with NVGs, because not enough energy is reflected from their surface to create an image. Of more significance is the situation where thin clouds are obscuring slightly thicker clouds, which are themselves obscuring somewhat more dense clouds. There may not be enough contrast between succeeding cloud banks to alert aviators to IMC conditions prior to inadvertent entry. It is possible to enter IMC without ever detecting its presence while utilizing NVGs. To combat this phenomenon, NVG aircrew must be aware of the increase in scintillation in the NVG image, indicating a decrease in the level of brightness of the NVG image. As the illumination level decreases with the increasing cloud cover, the automatic brightness control in the goggle adjusts to maintain constant image luminance. However, as illumination conditions worsen, NVG image luminance can gradually decrease. The NVG user may continuously adapt to decreases in image luminance and fail to notice the subtle changes in scene brightness. In these conditions the NVG aircrew must interpret the increase in scintillation in the NVG image as the primary warning that environmental conditions may be deteriorating.

17.3.2.6. Vection Illusions. A sensation of self-motion induced by relative movement of viewed objects is called vection. Such sensations are frequently illusory, and can be of linear (translational) or angular (rotational) movement. An example of a linear vection illusion is that of an adjacent automobile creeping forward at a stoplight and creating the sensation that one's own vehicle is creeping backwards. In formation flying, such illusions are common. An example of an angular vection illusion is the feeling of rotation one can experience when the revolving reflection of a rotating anti-collision light is viewed in fog or clouds.

17.3.2.7. Visual Autokinesis. A stationary light stared at for 6 to 12 seconds in the dark will appear to move. This phenomenon can cause considerable confusion in pilots flying formation or rejoining on a tanker at night. To minimize or overcome this phenomenon: (a) shift your gaze frequently to avoid prolonged fixation on the light, (b) view the target beside or through, and in reference to, a relatively stationary structure such as a canopy bow, (c) make eye, head, and body movements to try to destroy the illusion, and (d) as always, monitor the flight instruments to prevent or resolve any perceptual conflict. Increasing the brilliance, size, and number of lights, or causing the lights to flash, will diminish the effect of the autokinesis phenomenon.

17.3.2.8. Flicker Vertigo. Rare individuals are susceptible to flickering lights, and can experience unusual sensations caused by the passage of light through propellers or rotor blades or by flashing strobe lights. Light flickering at frequencies from 4 to 20 times per second can produce nausea, dizziness, convulsions, and even unconsciousness in those individuals.

17.3.2.9. Black-Hole Conditions. Black-hole conditions are encountered when flying on a dark night over water or unlighted terrain with an indiscernible horizon. Pilots without peripheral visual cues needed for orientation develop a sense of stability and misperceive their reference (e.g., flight lead or a lighted runway) is moving about or is malpositioned. This same condition exists in white-out, brown-out and any other time the visual environment is degraded to the point of poor peripheral cues. It is often most serious during the approach to landing without VGSI lighting.

17.3.2.10. Induced Motion Illusion. Induced motion illusion is the perceived motion of objects that are not actually moving, when other objects are physically moving instead. Induced motion is most vivid with indiscernible backgrounds such as "black-hole" conditions (e.g., the illusion of rising light can be an undetected descent).

17.3.2.11. Moth Illusion. The visual illusion experienced when trying to stay oriented with a descending light source. The misperception is the result of failing to detect the actual downward motion because attention is centered on keeping the intensity of the light constant and failing to detect the downward movement.

17.3.3. Somatosensory Illusions.

17.3.3.1. The Seat-of-the-Pants Sense. Pilots can be deceived if they interpret the pressure sensations experienced during flight as meaning the same thing they would in an earth bound situation (i.e., pressure on the seat-of-the-pants indicates down). In flight, this pressure sensation is misleading because during coordinated flight, the force resulting from centripetal acceleration and gravity are always toward the floor of the aircraft. Thus, pilots can never tell through the pressure sensors which direction is the true vertical.

17.3.3.2. Giant Hand Illusion. The giant hand phenomenon is a subconscious reflex behavior, generated by vestibular or somatosensory inputs that interfere with the pilot's conscious control of the aircraft. This illusion gives the impression that some external force is pushing on the aircraft or holding it in a certain attitude. When disorientation is primarily about the roll axis, as with the leans or graveyard spiral, the pilot may see deviation from the desired attitude on the attitude indicator, apply the appropriate stick pressure to roll the aircraft to reduce the unwanted bank angle, and discover that efforts to roll the aircraft appear to be resisted. The aircraft either seems to not let the pilot roll or, once the airplane has been rolled to the proper attitude, it seems to roll back to the original attitude as if a giant hand were pushing a wing down. When the disorientation is about the pitch axis, as it is when a somatogravic illusion of pitch-up occurs during forward acceleration, the pilot may experience what feels as excessive nose down trim and the aircraft appears to resist efforts by the pilot to pull the nose up, as if a giant hand were pushing the nose down. There is little research relating to our understanding of the Giant Hand Illusion. To date it has not been satisfactorily reproduced on the ground. It appears to be most commonly experienced during night air refueling operations.

17.3.3.2.1. Reflex Actions. The giant-hand phenomenon is thought to occur as a result of pilot reflex actions during disorientation. Remember, our reflexes are geared to a ground-based environment and, therefore, rely on vestibular and somatosensory inputs to determine which way is up. During disorientation, the desired control input is in conflict with the reflex input, giving the illusion of some external force acting on the aircraft.

17.3.3.2.2. Overcoming the Giant Hand. To overcome the giant hand illusion, the pilot should momentarily remove his or her hand from the control stick to interrupt the reflex response. A positive effort must then be made on the controls to move the attitude indicator to the proper attitude. Some pilots have reported that they used their fingertips or knees to move the controls to keep the illusion dispelled. When they gripped the controls in the usual manner, the apparent control anomaly returned. Clearly, the pilot must be sufficiently knowledgeable about the giant hand illusion to suspect it when the possibility of spatial disorientation exists.

17.4. Types of Spatial Disorientation. There are three distinct types of spatial disorientation. Type I is unrecognized spatial disorientation; the pilot is unaware that anything is wrong and controls the aircraft in response to the false sensations of attitude and motion. Type II is recognized disorientation; the pilot is aware that something is wrong, but may not realize that the source of the problem is spatial disorientation. The pilot usually suspects an instrument malfunction, and in a few cases it has been reported that the pilot will "tap" on the display glass to see if it is stuck (even with Cathode Ray Tubes (CRTs)). Type III is incapacitating spatial disorientation; the pilot knows something is wrong, but the physiological or emotional responses to the disorientation are so great that the pilot is unable to recover the aircraft. This may result from the pilot's inability to obtain visual information due to blurring of vision (nystagmus), however, there have been several reports of this occurring during air refueling or flying fingertip. An example of each type of disorientation follows:

17.4.1. Example of Type I SD. The last of four aircraft took off on a daytime sortie in the weather, intending to follow the other three in a radar in-trail departure. Because of a navigational error shortly after takeoff, the pilot was unable to acquire the other aircraft on radar. Frustrated, the pilot elected to intercept the other aircraft knowing they would be on the arc of the Standard Instrument Departure. The pilot proceeded directly to that point, scanning the radar diligently for the blips that should be appearing at any time. Meanwhile, after climbing to 4,000 feet above ground level, the pilot entered a 2,000-3,000 foot per minute descent as the result of an unrecognized, 3-degree nose-low attitude. After receiving requested position information from another member of the flight, the mishap pilot suddenly made a steeply banked turn, either to avoid a perceived threat of collision or to join up with the rest of the flight. Unfortunately, the pilot had already descended far below the other aircraft and was going too fast to avoid the ground. This mishap resulted from unrecognized, or Type I, disorientation. The specific illusion responsible was the somatogravic illusion created by the forward acceleration of the aircraft during takeoff and climbout. Preoccupation with the radar scanning compromised the pilot's instrument crosscheck to the point where the false vestibular cues were able to dominate orientation information processing. Having accepted this inaccurate spatial orientation "feeling," the pilot controlled the aircraft accordingly until it was too late to recover.

17.4.2. Example of Type II SD. On a clear day with unlimited visibility and a distinct horizon, the pilot was flying a two-on-two air combat training mission over water. After a series of roll reversals during the engagement, the pilot thought the aircraft was straight and level when the pilot acquired the bandits slightly low and to the right. In reality, the pilot was in a 90-degree left bank looking up at the other aircraft. To ensure a successful separation, the pilot rolled to the left and pulled to raise the nose slightly. Actually, the pilot had rolled almost inverted and pulled down. What alerted the pilot to being disoriented was that the aircraft sounded as if it was going very fast (this is the beginning of Type II—the pilot suspects something to be wrong, in this case it was an aural cue).

When the pilot looked inside and checked, the instruments showed the pilot was in an inverted 60-70 degree dive accelerating through Mach. The recovery was all instinct: roll to the nearest horizon and pull. The pilot pulled 12.5 G during the recovery and bottomed out at 2,000 feet above the water. This incident of recognized, or Type II, spatial disorientation occurred because of channelized attention on the second bandit, a breakdown of crosscheck, and subsequent loss of attitude awareness. Type II SD happens more often than mishap reporting would indicate and is a known hazard associated with employing an aircraft as a weapons platform.

17.4.3. Example of Type III SD. On a clear day three aircraft were engaged in vigorous air combat tactics training. One pilot initiated a hard left turn at 17,000 feet above ground level. For reasons that have not been established with certainty, the pilot's aircraft began to roll to the left at a rate estimated at 150 to 220 degrees/second. The pilot transmitted, "out-of-control autoroll," while descending through 15,000 feet. The pilot made at least one successful attempt to stop the roll as evidenced by the momentary cessation of the roll at 8,000 feet; then the aircraft began to roll again to the left. Forty seconds elapsed between when the rolling began and when the pilot ejected--but too late. Regardless of whether the rolling was caused by a mechanical malfunction or was induced by the pilot, the certain result of this extreme motion was vestibulo-ocular disorganization, which not only prevented the pilot from reading the instruments but also kept the pilot from orienting with the natural horizon. Thus, incapacitating, or Type III, disorientation probably prevented the pilot from taking corrective action to stop the roll and keep it stopped; if not that, it certainly compromised the pilot's ability to assess accurately the level to which the situation had deteriorated.

17.5. Causes of Spatial Disorientation. There are a number of conditions or factors that will increase the potential for spatial disorientation. Some of these situations are physiological in nature (human factors) while others are external factors related to the environment in which the pilot must fly (psychological). Awareness on the part of the pilot is required to reduce the risks associated with these situations and factors. Although SD episodes are found throughout the experience range of pilots, it is most commonly noticed within the first 500 hours of learning to fly a new type of aircraft.

17.5.1. Personal Factors. Mental stress, fatigue, hypoxia, various medicines, G stress, temperature stresses, and emotional problems can reduce the pilot's ability to resist spatial disorientation. A pilot who is proficient at accomplishing and prioritizing mission tasks (with an efficient instrument crosscheck), is mentally alert, and is physically and emotionally qualified to fly will have significantly less difficulty maintaining orientation. On the other hand, a pilot who becomes task-saturated easily; fails to properly prioritize tasks; is mentally stressed; is preoccupied with personal problems; or is fatigued, ill, or taking non-prescribed medication is at increased risk of becoming disoriented.

17.5.2. Workload. A pilot's proficiency on instruments and formation flying is decreased when he or she is busy manipulating cockpit controls; and either anxious, mentally stressed, or fatigued. When the pilot is distracted from crosschecking the instruments during task intensive phases of flight in marginal weather or reduced visibility conditions, the pilot's ability to recognize and resist spatial disorientation is severely diminished.

17.5.3. Inexperience. Inexperienced pilots with little instrument time are particularly susceptible to spatial disorientation. It takes time and experience to "feel" comfortable in a new aircraft system and develop a solid, effective instrument crosscheck. A pilot who still must search for switches, knobs, and controls in the cockpit has less time to concentrate on flight instruments and may be distracted during a critical phase of instrument flight. The cockpit workload associated with complex aircraft is particularly significant for the recent pilot graduate or pilots new to these systems. A second crewmember is not always available to change radio channels, set up navigation aids, and share other cockpit chores. Therefore, it is essential for an effective instrument crosscheck to be developed early and established during all phases of flight. Other cockpit duties, like radio changes, radar operation, etc., must not be allowed to distract the pilot from basic instrument flying.

17.5.4. Proficiency. Total flying time does not protect an experienced pilot from spatial disorientation. More important is current proficiency and the number of flying hours or sorties in the past 30 days. Aircraft mishaps due to spatial disorientation generally involve a pilot who has had limited flying experience in the past 30 days. Flying proficiency begins to deteriorate rapidly after 3 or 4 weeks out of the cockpit. Vulnerability to spatial disorientation is high for the first few flights following a significant break in flying duties.

17.5.5. Instrument Time. Pilots with less instrument time are more susceptible to spatial disorientation than more experienced pilots. Many spatial disorientation incidents have been reported during the penetration turn, final approach, climbout after takeoff, trail departures, and while performing high-performance flight maneuvers. This is when the vestibular illusions are the most devastating. Other very critical times are at night and during weather formation flights, when the wingman loses sight of the lead or when a pilot flying in VMC suddenly enters IMC.

17.5.6. Phases of Flight. Although distraction, channelized attention, and task saturation are not the same as spatial disorientation, they precipitate it by keeping the pilot from maintaining an effective instrument crosscheck. Spatial disorientation incidents have occurred during all phases of flight. During the following critical phases pilots are particularly susceptible to becoming spatially disoriented because of the extra potential for distraction, channelized attention, and task saturation.

17.5.6.1. Takeoff and Landing. The takeoff and landing phase of flight is a dynamic and demanding environment. Aircraft acceleration, speed, trim requirements, rate of climb or descent, and rate of turn are all undergoing frequent changes. The aircraft may pass in and out of VMC and IMC. At night, ground lights may add confusion. Radio channel or IFF/SIF changes may be directed during a critical phase of flight while close to the ground. Unexpected changes in climbout or approach clearance may increase workload and interrupt an efficient instrument crosscheck. An unexpected requirement to make a missed approach or circling approach at night or in IMC is particularly demanding, and at a strange field with poor runway lighting, even more demanding.

17.5.6.2. Air-to-Ground. Another critical phase of flight, with a high potential for spatial disorientation, is the maneuvering associated with air-to-ground ordnance deliveries during night or periods of reduced visibility and air combat maneuvers. Again, under such conditions the only completely reliable information related to aircraft attitude is provided to the pilot by the flight instruments. Because of the nature of the mission, the pilot's attention is directed outside the cockpit. Potential for distraction is great. What the pilot sees outside the cockpit may be misleading or the pilot may fail to scan an important instrument parameter (such as attitude, airspeed, altitude, or vertical velocity) during a critical phase of the weapons delivery. These factors easily can lead to an unrecognized spatial disorientation or "lack of attitude awareness" in which the pilot inadvertently places the aircraft in a position from which recovery is impossible.

17.5.6.3. Formation Flying. A demanding situation with a high potential for creating spatial disorientation is night or weather formation flying. Formation flying presents special problems to the pilot in maintaining spatial orientation. First and most important, pilots flying on the wing cannot maintain appropriate visual dominance. They are deprived of any reliable visual information concerning aircraft attitude related to the earth's surface. They cannot see the true horizon and have little or no time to scan their own instruments. Under these conditions, it becomes difficult to suppress information provided by unreliable sources such as the vestibular system. Illusions of various kinds are almost inevitable. A pilot's concentration on maintaining proper wing position may be compromised by what the pilot "feels" the aircraft attitude to be. Lack of confidence in lead will increase tension and anxiety. An inexperienced, rough, flight lead will most certainly aggravate the situation. Poor in-flight communications and the lack of specific procedures (properly briefed) to recover a disoriented wingman will increase the potential for an aircraft mishap.

17.6. Prevention of Spatial Disorientation Mishaps. The pilot's role in preventing mishaps due to spatial disorientation essentially involves three things: training, good flight planning, and knowledge of procedures. It must be emphasized that the key to success in instrument flying is an efficient instrument crosscheck. The flight instruments provide the only reliable aircraft orientation information, at night or in IMC. Any situation or factor that interferes with this flow of information, directly or indirectly, increases the potential for disorientation.

17.6.1. Training. The training and education of the pilot about the dangers of spatial disorientation begin with the information in this chapter. Additional information is provided by flight surgeons, aerospace physiologists, IRC instructors, and flying safety officers through lectures, slide presentations, films, videotapes, and safety journals. Experienced pilots can pass on valuable information to new crewmembers in flight briefings and squadron meetings.

17.6.1.1. Basic Knowledge. The effects of spatial disorientation can be minimized through an understanding of the physiological mechanisms that cause various illusions, the phases of flight where the illusions can be expected, and a plan of action (procedure) to follow in dealing with sensory conflicts once they occur.

17.6.1.2. Flight Simulators and Trainers to Prevent SD. Aircraft simulators are excellent training devices for learning instrument flight procedures. These devices are not typically used for specific SD trainers. However, some special-purpose devices exist and are used in physiological training.

17.6.1.3. Actual Aircraft. Regular and frequent instrument flight in the aircraft either under the hood (if available), at night, or in actual weather conditions is necessary to provide the pilot the experience and confidence needed to fly safely in instrument conditions.

17.6.2. Flight Planning. Thorough preflight planning is important in reducing the potential for spatial disorientation incidents, particularly in fighter-type aircraft. It is difficult for a pilot to fly the airplane and maintain an effective instrument crosscheck while searching for information in the IFR supplement.

17.6.2.1. General information. Before takeoff acquire all of the information needed to safely complete an instrument flight. This is particularly important for cross-country flights to strange fields in night weather conditions. The remarks section of the IFR Supplement Airport/Facility Directory and FLIP AP/l should be checked for known approach illusions. Attention should be directed during flight planning to events that may be unexpected. What are the missed approach procedures? What is the circling minimum descent altitude (MDA)? What type of runway lighting system is installed at the alternate airfield?

17.6.2.2. Specific situation. If available at the base of intended landing, pilots flying single-seat aircraft should plan to make a single frequency, en route descent to a radar monitored, precision approach during night or IMC.

17.6.3. Procedures. It is important that aviators have an established set of recommended procedures to follow in the event they experience spatial disorientation. The general procedures put forth here may differ depending on type of aircraft (such as single-seat, dual-seat, or crew-type aircraft) or type of mission (formation flight or NVG flight). Additionally, commands normally establish specific procedures for aircraft under their control. A few general principles can be stated here.

17.6.3.1. General Principles. Any pilot who does not continually monitor the flight instruments during IMC, night, and other conditions of reduced visibility will become spatially disoriented in a matter of seconds. The pilot may divert attention from the instruments just long enough to study an approach plate, look for a wingman, or assess the effect of a weapons drop, and feel perfectly comfortable while Type I disorientation develops. The pilot may either fly the aircraft into the ground without realizing the error, may look back at the instruments and regain orientation immediately but too late to prevent a mishap, or may develop Type II disorientation and have to struggle with a sensory conflict to maintain control of the aircraft. The general procedure for dealing with spatial disorientation is the same for all aircraft.

17.6.3.1.1. Recognize Problem. If a pilot begins to feel disoriented, the key is to recognize and confirm the problem early. Then take immediate corrective actions before aircraft control is compromised.

17.6.3.1.2. Reestablish Visual Dominance. The pilot must reestablish accurate visual dominance. To do this, keep the head in the cockpit, defer all cockpit chores that are not essential, and concentrate solely on flying basic instruments. Make frequent reference to the attitude display that is the primary reference needed to establish and maintain visual dominance. The pilot must make the instruments “read right.” Apply the necessary control inputs to make the attitude indicator display the desired orientation and adjust that display to make the other flight parameters fall into line.

17.6.3.1.3. Beware of Persistent Symptoms. If the symptoms do not improve immediately, or if they get worse, the pilot should bring the aircraft to straight-and-level flight using the attitude display. Maintain straight-and-level flight until the symptoms abate. Declare an emergency if necessary, and advise ATC of the problem.

17.6.3.1.4. Resolve Sensory Conflict. If action is not taken early, the pilot may not be able to resolve the sensory conflict. It is possible for spatial disorientation to proceed to a point (a true state of panic) where the pilot is unable to see, interpret, or process information from the flight instruments. Further, it may not be possible to hear or respond to verbal instructions. Aircraft control in such a situation may be impossible. The pilot must admit that physiological limits have been exceeded and the only alternative may be to abandon the aircraft.

17.6.3.1.5. Transfer Aircraft Control. If the pilot experiences spatial disorientation to a degree that it interferes with maintaining aircraft control, then control of the aircraft should be transferred to the second crewmember, if qualified. If an autopilot is available, consideration should be given to using it to control the aircraft.

17.6.3.2. Single-Seat/Solo Aircraft. A pilot alone in an aircraft is more limited in applying these general principles to deal with spatial disorientation. In this situation, the pilot obviously does not have the option to transfer aircraft control, except possibly to the autopilot.

17.6.3.3. Dual-Seat Aircraft. The same general principles stated above apply to a dual-seat aircraft. However, a second crewmember is generally available to share the cockpit workload.

17.6.3.3.1. Division of Workload. The other crewmember can assist the pilot by copying clearances, changing radio/IFF channels, and acquiring information from flight information publications. The division of workload between the crewmembers should be clearly understood and covered in the preflight briefing.

17.6.3.3.2. Critical Phases. During departures, penetrations/en route descents, or critical phases of flight, the second crewmember should closely monitor and call out altimeter settings, altitudes, airspeeds, and other appropriate information.

17.6.3.4. Crew-Type Aircraft. The same general principles stated above plus the comments for dual-seat aircraft apply to crew-type aircraft. Although additional crewmembers are available to reduce pilot workload, illusions and sensory conflicts are possible and do occur. Illusions experienced here are more likely to be visual in origin than vestibular.

17.6.3.4.1. Causes of Disorientation. Weather- and night-related incidents of spatial disorientation occur in these aircraft. The causes are varied but can be related to distractions, poor runway lighting, fatigue, and circadian rhythm problems.

17.6.3.4.2. Crew Coordination. Specific procedures concerning division of workload and crew coordination should be clearly understood and covered in the preflight briefing.

17.6.3.5. Flying Formation. All of the general principles for dealing with spatial disorientation apply to formation flights. Additional procedures are necessary since the potential for spatial disorientation is greatest for formation flights during night or weather conditions.

17.6.3.5.1. Proficiency. Pilots scheduled for formation flights in night/IMC should be current and proficient in instrument, night, and formation flying. Particular attention should be directed to the number of sorties and flying hours in the past 30 days.

17.6.3.5.2. Safe Formation Flight. There are two essential requirements for safe formation flight. First, the flight leader must be experienced, competent, and smooth. Second, the wingman must be proficient in formation flying. The wingman must have total confidence in lead and concentrate primarily on maintaining a proper wing position.

17.6.3.5.3. Night Join-ups. Night join-ups are inherently difficult, particularly when conducted at low altitude over water or dark terrain. Alternative profiles, such as a trail departure and climbout, should be considered.

17.6.3.5.4. Deteriorating Weather. If the weather encountered during a formation flight is either too dense or turbulent to ensure safe flight, the flight leader should separate the aircraft under controlled conditions. This may be better than having a wingman initiate lost wingman procedures at a time that may be dangerous or, worse yet, when the wingman is severely disoriented.

17.6.3.5.5. Disoriented Wingman. In the preflight briefing, the flight leader should cover specific procedures to manage a disoriented wingman.

17.6.3.5.6. NOTE: Lost wingman procedures are designed to ensure safe separation between aircraft in a flight when a wingman loses sight of lead. Lost wingman procedures are not designed to recover a wingman with severe spatial disorientation. Precise execution is required to perform lost wingman procedures; a severely disoriented pilot may not be able to accomplish this.

17.6.3.5.7. Communication. The flight lead should encourage a wingman to verbalize a feeling of disorientation. A few words from lead may reassure the wingman and may help form a mental picture of the flight's position in space. For example: "Two, we are level at 20,000 feet in a 30 degree left bank at 300 knots."

17.6.3.5.8. Persistent Problem. If the wingman continues to have problems, the lead should bring the flight to straight-and-level and advise the wingman. If possible, maintain straight-and-level for at least 30 seconds and up to 60 seconds. Generally, the wingman's symptoms will subside in 30 to 60 seconds. Advise ATC if an amended clearance is necessary.

17.6.3.5.9. Lead Transfer. If the above procedures are not effective, then lead should consider transferring the flight lead position to the wingman while straight-and-level.

17.6.3.5.9.1. NOTE: Once assuming lead, maintain straight-and-level flight for 60 seconds before initiating turns, climbs, or descents. The objective is for the disoriented pilot to reestablish visual dominance as quickly as possible. Again, a wingman that is severely disoriented should normally not elect or be directed to execute lost wingman procedures. At this point, consideration should be given to terminating the mission and recovering the flight by the simplest and safest means possible. Under exceptional circumstances, however, when the above procedures are ineffective and the disoriented wingman cannot continue to fly formation safely, the lost wingman procedure and single ship recovery are a viable last resort.

17.6.3.5.10. Lost Wingman. Spatial disorientation may not be experienced until the pilot executes lost wingman procedures. Sudden vestibular and other erroneous sensory inputs may not agree with instrument indications. It is most important at that moment for the pilot to believe and trust the attitude display and to make the attitude display reflect the desired aircraft orientation.

Chapter 18

INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) PROCEDURES

18.1. Introduction. The ICAO is composed of over 180 member nations and is a part of the United Nations. Unlike the FAA, whose regulations are directive, ICAO is an advisory organization that jointly agrees on procedural criteria. Although the ICAO does not have any enforcement authority, ICAO member nations do undertake an obligation to adopt the annexes and procedures adopted as standard by the ICAO. These are published in a document called Procedures for Air Navigation Services-Aircraft Operations (PANS-OPS), in the Annexes to the Convention, and Standards and Recommended Practices (SARPS). Member nations are required to publish their exceptions to PANS-OPS and SARPS in their individual Aeronautical Information Publication (AIP). Most nations do this and follow the ICAO publication of aeronautical information SARPS in Annex 15. These procedures are intended to be strictly adhered to by flight crews in order to achieve and maintain an acceptable level of safety in flight operations. USAF aircrews will find pertinent information extracted from the AIPs in FLIP AP and the Foreign Clearance Guide (FCG).

18.1.1. The ICAO Convention does contain an exemption for state aircraft. However, there should be a due regard exercised for the safety of navigation of civil aircraft. ***USAF crews shall comply with guidance in AFI 11-202 Volume 3, General Flight Rules regarding compliance with ICAO procedures.***

18.1.1.1. NOTE: Although an ICAO signatory, the United States uses none of the PANS-OPS procedures. We use the Federal Aviation Regulations for procedural guidance instead as an equivalent to an AIP.

18.1.2. The Continuum of Safety. Even more so than in the United States, international flying requires good judgment on the part of the pilot. The Air Force expects and encourages you to apply it. No book of hard and fast rules could ever hope to cover all the various situations you may encounter everywhere in the world. The global mission of the USAF means that you may well be required to operate in countries without a well-developed aviation system, or into airfields where the ICAO rules have been ignored, replaced or poorly applied. The PIC must necessarily be the final judge of what is safe and prudent for any given mission on any given day. A thorough review of all flight planning documents prior to departure is critical.

18.1.3. Applicability. Procedures described in this chapter apply only in airspace not under FAA control. These procedures are ICAO standard procedures and may be modified by each country (as the U.S. has).

18.1.3.1. When determining whether to apply FAA or ICAO procedures in flying an instrument procedure, the nationality of the air traffic controller or who produced the procedure is not relevant. The geographic location of the aircraft is the determining factor, unless local procedures (detailed in FLIP and/or local directives) are in place. Regardless of the nationality of the air traffic controller and/or the origin of the instrument procedure you are using, ***if you are flying outside US National Airspace, apply ICAO instrument procedures unless otherwise published***.

18.1.3.2. US National Airspace is defined as airspace controlled by the FAA. This airspace is defined geographically as overlying the 50 United States, the District of Columbia, the Commonwealth of Puerto Rico, and the several territories and possessions (ex. Marianas Islands, etc.) of the United States. By Presidential proclamation in December 1988, this airspace also overlies the waters up to 12 miles from the coast.

18.1.3.2.1. IAW ICAO Article 12 and Annexes 2 and 11, the United States has accepted responsibility for providing air traffic services within airspace overlying the high seas beyond 12 miles from the coast (also known as international airspace). These flight information regions of international airspace are: Oakland Oceanic, Anchorage Oceanic, Anchorage Continental, Anchorage Arctic, Miami Oceanic, Houston Oceanic, and New York Oceanic. Although the FAA in these areas is providing air traffic services, they are considered international airspace and ICAO rules apply.

18.1.4. Finding Current Information and Procedures. Changes to ICAO standard procedures can be numerous and may even vary from airfield to airfield within a country. FLIP Area Planning (AP) generally contains a comprehensive consolidation of procedural requirements, but a thorough review of all applicable preflight planning sources is essential to ensuring compliance with ICAO, host nation, and USAF requirements. Other preflight planning sources include, but are not limited to: NOTAMS, The ASRR, Specific Theatre Information Files (STIF), and MAJCOM/Unit Flight Crew Information File (FCIF).

18.1.5. Terminal IAPs. There are many different kinds of approaches published in the DoD FLIP books for regions outside the United States. You may find approaches designed using U.S. TERPS at overseas bases. You may also find approaches designed under the civil PANS-OPS criteria. Or you may find procedures that use host nation criteria that are different from PANS-OPS. Aircraft executing maneuvers other than those intended by the host nation approach design could exceed the boundaries of the protected airspace or may cause overflight of unauthorized areas. ***All ICAO procedures must be flown as they are depicted***.

18.1.5.1. NOTE: For procedures designed in accordance with host nation or PANS-OPS criteria, the original foreign procedures may have been modified or edited as a result of the DoD TERPS review, which is conducted before these procedures are published in DoD FLIP.

18.2. Definitions. Here are a few ICAO definitions that differ from those commonly used in the United States.

18.2.1. PANS-OPS. PANS-OPS is a two-part document. The first volume is for pilots, and is similar to the FAA's AIM. The second volume contains the ICAO "TERPS." The document is intended for the use of the international civilian aviation community, not the military. There have been a number of editions of PANS-OPS published since the creation of the ICAO, each with significant changes in the details of instrument approach procedure design. This means that you may find approaches in different parts of the world that have been designed with entirely different rules.

18.2.2. Aircraft Categories. Aircraft approach categories play a much bigger role in the design of ICAO instrument procedures than they do in the U. S. In addition to affecting final approach minimums, PANS-OPS references maximum speeds by category for such operations as holding, departures, and the intermediate segments of instrument approaches. To make matters even more confusing, these additional "category" restrictions specify speeds that are completely different from the familiar approach speeds on final. The appropriate PANS-OPS "category" speeds appear in tables later in this chapter.

18.2.3. Track. The projection on the earth's surface of the path of an aircraft, the direction of which path at any point is usually expressed in degrees from North, specifying true or magnetic. This means you must apply any known winds/drift to maintain the ground path. Obstacle clearance in ICAO procedures is provided under the assumption that pilots will maintain the depicted track.

18.2.4. Bank Angle. Procedures are based on average achieved bank angle of 25 degrees, or the bank angle giving a rate of turn of 3 degrees per second, whichever is less.

18.2.5. Established on Course. The ICAO defines "established on course" as being within half full-scale deflection for an ILS or VOR/DME and within ± 5° of the required bearing for the NDB. Although ICAO does not formally define "established on course" for a TACAN, ***the same definition for VOR/DME applies***. ***Do not consider yourself "established on course" until you are within these limits.*** ICAO obstacle clearance surfaces assume that the pilot does not normally deviate from the centerline more than one-half scale deflection after being established on track. Despite the fact that there is a range of "acceptable" variation, make every attempt to fly the aircraft on the course centerline and on the glide path. Allowing a more than half-scale deflection (or a more than half-scale fly-up deflection on glideslope) combined with other system tolerances could place the aircraft near the edge or at the bottom of the protected airspace where loss of protection from obstacles can occur.

18.3. Departure Procedures.

18.3.1. Screen Heights. It may be difficult or impossible to accurately determine screen height used for a particular departure procedure. For PANS-OPS, the origin of the OIS begins at 16 ft (5 m) above the DER. See Chapter 9 for guidelines to determine screen height.

18.3.2. Climb Gradient. ICAO does not apply the FAA 24% ROC formula and has retained the traditional 48 ft/nm (0.8%) ROC for both departures and missed approaches. ICAO obstacle clearance during departures is based on a 2.5% gradient obstacle clearance (152 feet/NM) and an increasing 0.8% obstacle clearance (48 feet/NM). This equates to a minimum climb gradient of 3.3% (200 feet/NM). Minimum climb gradients exceeding 3.3% will be specified to an altitude/height after which the 3.3% will be used.

18.3.3. Basic Rules for All Departures. Unless the procedure specifies otherwise, ***you must climb on runway heading at a minimum of 200 feet/NM (3.3%) until reaching 400 feet above the DER. Continue to climb at a minimum of 200 feet/NM until reaching a safe enroute altitude.***

18.3.4. Omnidirectional Departures. The PANS-OPS "Omnidirectional Departure" is somewhat similar to the FAA's "Diverse Departure." It is a departure procedure without any track guidance provided. There are some very important differences, though, because an Omnidirectional Departure may be published even though obstacles penetrate the 40:1 Obstacle Identification Surface. If this is the case, PANS-OPS gives the departure designer a number of ways to publish departure restrictions. These restrictions may be published singly, or in any combination.

18.3.4.1. Standard case. Where no obstacles penetrate the 40:1 OIS, then no departure restrictions will be published. Upon reaching 400 feet above DER, you may turn in any direction.

18.3.4.2. Specified turn altitude. The procedure may specify a 3.3% climb to an altitude where a safe omnidirectional turn can be made.

18.3.4.3. Specified climb gradient. The procedure may specify a minimum climb gradient of more than 3.3% to an altitude before turns are permitted.

18.3.4.4. Sector departure. The procedure may identify sectors for which either a minimum turn altitude or a minimum climb gradient is specified. (For example, "Climb straight ahead to 2000 feet before commencing a turn to the east/sector 180°-270°).

18.3.5. Departures with Track Guidance (SIDs). PANS-OPS uses the term Standard Instrument Departure (SID) to refer to departures using track guidance. Minimum climb gradients may apply. There are two basic types: straight and turning.

18.3.5.1. Straight departures. Whenever possible, a straight departure will be specified. A departure is considered "straight" if the track is aligned within 15° of the runway centerline.

18.3.5.2. Turning departures. Where a departure route requires a turn of more than 15°, a turning departure may be constructed. Turns may be specified at an altitude/height, at a fix or at a facility. If an obstacle prohibits turning before the departure end of the runway or prior to reaching an altitude/height, an earliest turning point or a minimum turning altitude/height will be specified. When it is necessary, after a turn, to fly a heading to intercept a specified radial/bearing, the procedure will specify the turning point, the track to be made good and the radial/bearing to be intercepted.

18.3.5.2.1. Turning departures are designed with maximum speed limits. These maximum speeds may be published by category or by a note. For example, these procedures may be annotated, "Departure limited to CAT C Aircraft" or "Departure turn limited to 220 KIAS maximum." ***You must comply with the speed limit published on the departure to remain within protected airspace. If you require a higher speed, ATC may approve the higher speed or assign an alternative departure procedure.***

18.3.5.2.2. If the departure is limited to specific aircraft categories, these are the applicable speeds:

Table 18.1. Maximum Airspeed on Departure.

Aircraft Category	Max Airspeed (KIAS)
A	120
B	165
C	265
D	290
E	300

18.4. Low Altitude Approach Procedures.

18.4.1. Procedural Tracks. Procedural Track approaches are the most common way of transitioning from the enroute structure. These approaches are often much more complicated than a comparable U. S. approach, and may include multiple NAVAIDs, fixes and course changes, but they are flown essentially the same as described in Chapter 13.

18.4.2. Reversal Procedures and Racetrack Procedures. If the instrument approach cannot be designed as a procedural track arrival, then a reversal procedure or a racetrack or a holding pattern is required.

18.4.2.1. Reversal Procedures. ICAO "Reversal Procedures" are similar in concept to FAA "Procedure Turns." The ICAO recognizes three distinctly different methods of performing a "reversal procedure," each with its own airspace characteristics: the 45°/180° Procedure Turn (Figure 18.1), the 80°/260° Procedure Turn (Figure 18.2), and the Base Turn (Figure 18.3).

18.4.2.1.1. Entry is restricted to a specific direction or sector. To remain within the airspace provided requires strict adherence to the directions and timing specified.

18.4.2.1.1.1. NOTE: The protected airspace for "reversal procedures" does not permit a racetrack or holding maneuver to be conducted unless so specified. ***You may not enter an ICAO procedure turn using the "Holding Technique" described in Chapter 13.*** Instead, refer to the entry procedures below.

18.4.2.1.2. The 45°/180° Procedure Turn. This procedure starts at a facility or fix and consists of:

18.4.2.1.2.1. A straight leg with track guidance; this straight leg may be timed or limited by a radial or DME distance;

18.4.2.1.2.2. A 45° turn; commenced at the designated radial or DME fix, or at the completion of the published timing requirement;

18.4.2.1.2.3. A straight leg without track guidance. This straight leg is timed; it is 1 minute from the start of the turn for categories A and B aircraft and 1 minute 15 seconds from the start of the turn for categories C, D and E aircraft;

18.4.2.1.2.4. A 180° turn in the opposite direction to intercept the inbound track.

18.4.2.1.2.4.1. NOTE: You must adjust the time or distance on the outbound track to ensure the reversal is initiated at a point specified on the IAP if so depicted, or the maneuver is completed within the specified “remain within” distance.

18.4.2.1.3. The 80°/260° Procedure Turn. This procedure starts at a facility or fix and consists of:

18.4.2.1.3.1**.** A straight leg with track guidance; this straight leg may be timed or limited by a radial or DME distance;

18.4.2.1.3.2**.** An 80° turn; commenced at the designated radial or DME fix, or at the completion of the published timing requirement, followed immediately by;

18.4.2.1.3.3**.** A 260° turn in the opposite direction to intercept the inbound track.

18.4.2.1.3.3.1. NOTE: You must adjust the time or distance on the outbound track to ensure the reversal is initiated at a point specified on the IAP if so depicted, or the maneuver is completed within the specified “remain within” distance.

18.4.2.1.3.4. While executing this procedure, comply with the speeds in paragraph 18.4.2.2.8.1 or as published on the procedure. Also, comply with the bank angle restrictions of paragraph 18.2.4.

18.4.2.1.4. The Base Turn. This procedure consists of intercepting and maintaining a specified outbound track, timing from the facility or proceeding to a specified fix, followed by a turn to intercept the inbound track.

18.4.2.1.4.1. NOTE: The base turn procedure is not optional. ***You may not fly one of the “procedure turns” described above instead of the depicted base turn.*** More than one track may be depicted depending on aircraft category.

Figure 18.1. 45°/180° Course Reversal.

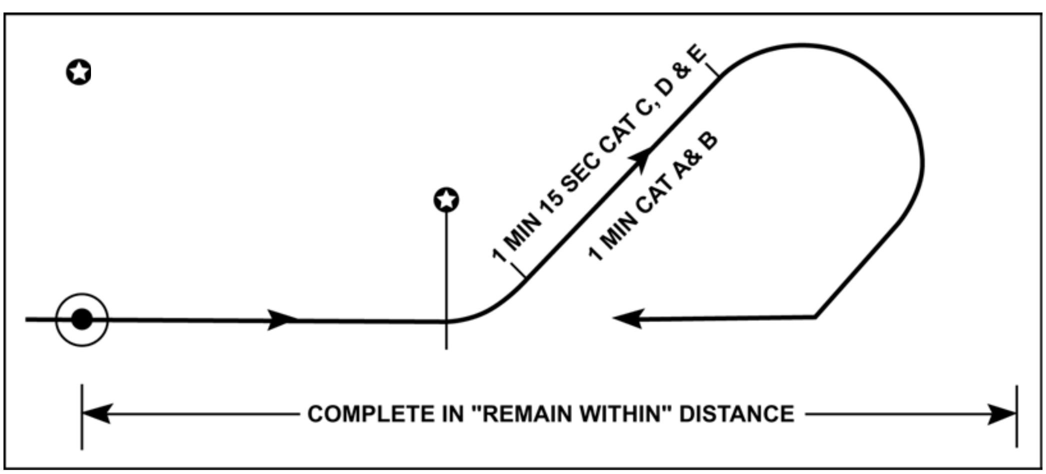


Figure 18.2. 80°/260° Course Reversal.

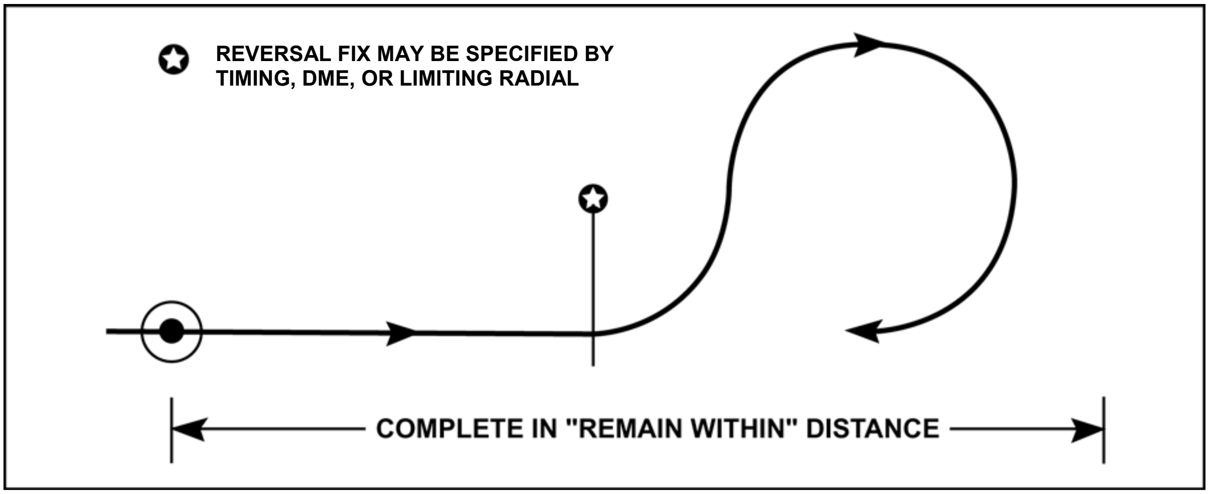
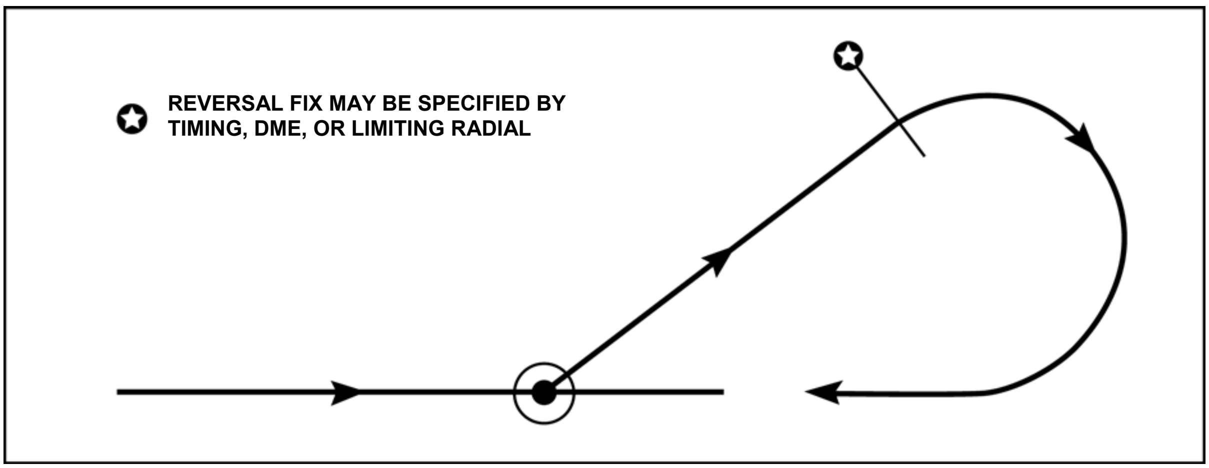


Figure 18.3. Base Turns.



18.4.2.2. Reversal Procedure Entry. Of all the differences between FAA and ICAO procedures, the entry into the three course reversal maneuvers has historically been the area of greatest confusion for USAF pilots. A short discussion is in order:

18.4.2.2.1. The 30° Entry Sector. The reason PANS-OPS specifies this entry sector is because, unlike in the U. S., the course reversal protected airspace may not include <u>any</u> airspace except that on the outbound side of the procedure turn fix. In the U. S., protected airspace includes a large "entry zone" surrounding the fix.

18.4.2.2.2. ***Unless the procedure specifies particular entry restrictions, the 45°/180°, 80°/260°, and base turn reversal procedures must be entered from a track within ± 30° of the outbound reversal track*** (Figure 18.5). There is a special rule for base turns: for base turns where the ± 30° entry sector does not include the reciprocal of the inbound track, the entry sector is expanded to include the reciprocal. (Figure 18.6). If the aircraft's arrival track is not within the entry sector:

18.4.2.2.2.1. Comply with the published entry restrictions or arrival routing; or

18.4.2.2.2.2. If there is a suitable arrival holding pattern published, enter holding prior to the reversal procedure; or

18.4.2.2.2.3. If there is no published routing or suitable holding pattern, use good judgment while maneuvering the aircraft into the entry sector.

18.4.2.2.2.4. For racetrack entry, see paragraph 18.4.2.3.

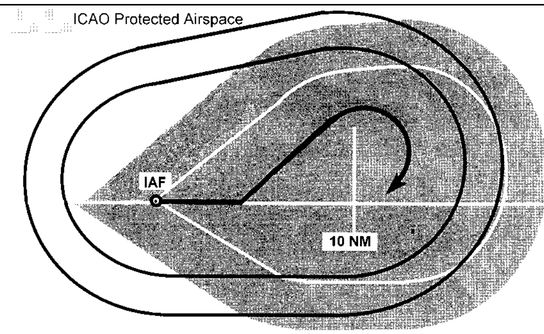
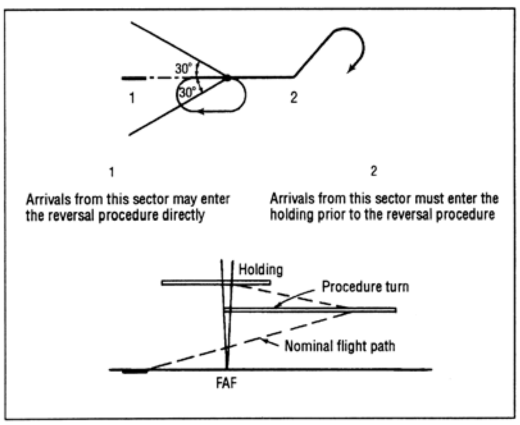
18.4.2.2.3. What if you Arrive From Outside the Entry Sector?

18.4.2.2.3.1. Arrival Routing. There is often some form of published arrival routing into the course reversal IAF, such as a STAR, feeder routing, or arrival airway. This arrival routing may not fall into the 30-degree entry sector. Such arrival routes will be blended into the reversal approach, and protected airspace is provided to allow the pilot to turn onto the outbound reversal track. Pilots need not request "maneuvering airspace" to perform an alignment maneuver. Such requests are often met with confusion by ATC. You should remain within protected airspace on the published arrival routing, whether or not that happens to align you with the 30° entry sector.

18.4.2.2.3.2. Using the Arrival Holding Pattern. On most ICAO course reversals, a holding pattern is published at or near the IAF to accommodate arrivals from outside the 30-degree sector and not on a published arrival routing. PANS-OPS directs pilots arriving from outside the entry sector to enter holding prior to the reversal procedure. In most cases, the holding pattern will align you for the approach.

18.4.2.2.3.3. Off-airway Arrivals. What if there is no suitable Holding Pattern? The danger arises when attempting to perform the course reversal when arriving into the IAF from a direction not anticipated by the approach designer, such as when you request to proceed direct to the fix from a point off the arrival airway. Sometimes there is no holding pattern published for your alignment, or there is a holding pattern that does not turn you into the entry sector. In this case, you will need to maneuver into the entry sector somehow. You must understand how small the protected airspace is, especially when compared to an FAA procedure turn. You may be operating completely outside of protected airspace while proceeding to the IAF, and terrain and obstacle clearance may be totally up to you. Use good judgment, consider the published minimum safe/sector altitudes, and do not rely solely on ATC to keep you safe.

Figure 18.4. Comparison of FAA and ICAO Protected Airspace for a Procedure Turn.

<table>
<tr><td>FAA protected airspace for a procedure turn is shown in white, with the ICAO airspace in gray. Note that there is no primary protected airspace to the West of the IAF under PANS-OPS criteria.</td><td></td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">ICAO Course Reversal Entry Sector.</td></tr>
<tr><td></td><td>1. Arrivals from within the entry sector will be in protected airspace immediately upon passing the IAF.

2. If there is a suitable holding pattern, you can arrive from outside the entry sector and use a turn in holding to align with the entry sector.</td></tr>
</table>

Figure 18.5. Procedure Turn Entry (45°/180° or 80°/260°).

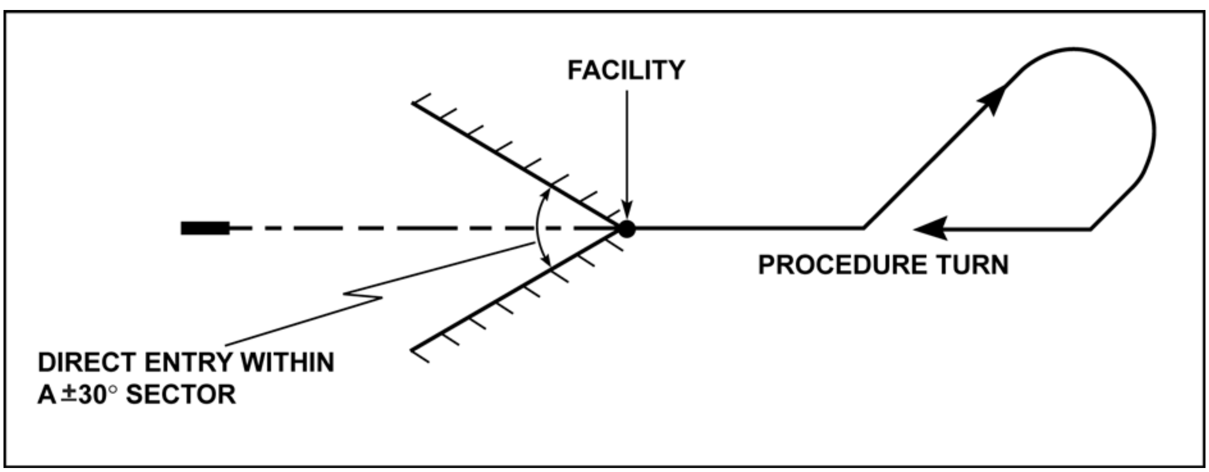
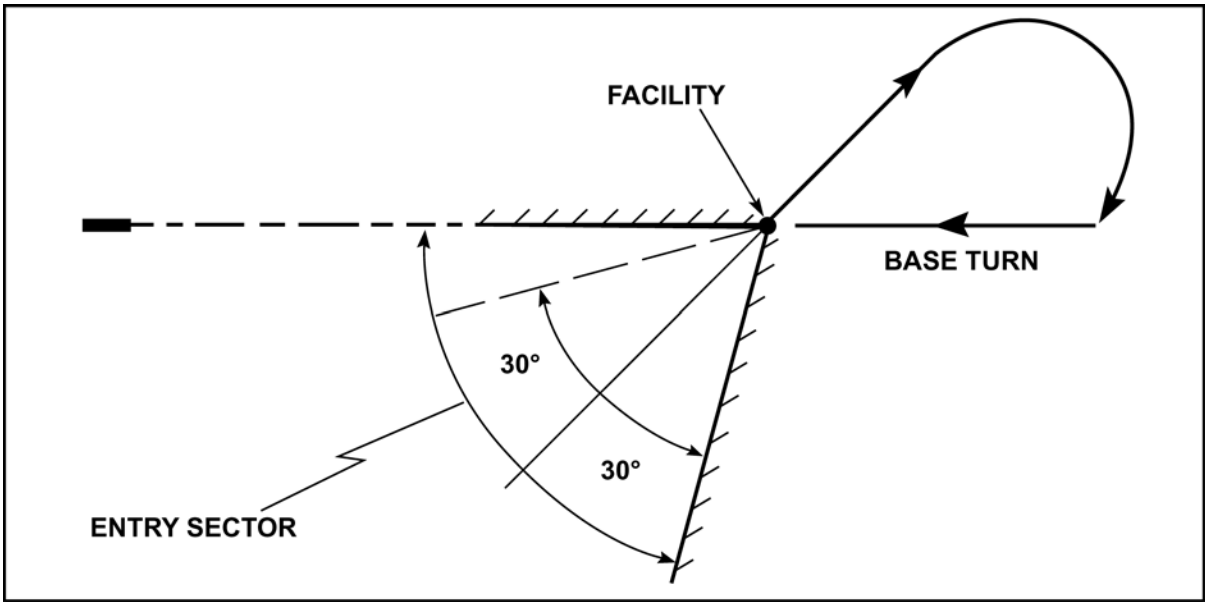


Figure 18.6. Base Turn Entry.



18.4.2.2.4. Timing. Begin timing to comply with published times or "remain within" distances when outbound abeam the facility or fix. If the abeam position cannot be determined while in a turn, start timing after completing the turn.

18.4.2.2.5. Descent. A descent can be depicted at any point along a course reversal. When a descent is depicted at the IAF, start descent when abeam or past the IAF and on a parallel or intercept heading to the depicted outbound track. For descents past the IAF, be established on a segment of the IAP before beginning a descent to the altitude associated with that segment.

18.4.2.2.6. NOTE: According to the ICAO's definition, "established on a segment" is considered being within half full-scale deflection for an ILS or VOR and within ± 5° of the required bearing for the NDB.

18.4.2.2.7. Remaining Within Protected Airspace. To ensure that you remain within protected airspace while executing ICAO course reversals, you must ***comply with the following***:

18.4.2.2.7.1. Fly no faster than the maximum speed for your category in paragraph 18.4.2.2.8.1, or the maximum airspeed published on the procedure, whichever is lower;

18.4.2.2.7.2. Comply with the entry sector requirements of paragraph 18.4.2.2 (i.e. 30° entry sector);

18.4.2.2.7.3. Begin the course reversal at the fix specified in the procedure;

18.4.2.2.7.4. Comply with the bank angle restrictions in paragraph 18.2.4;

18.4.2.2.7.5. Begin required timing at the appropriate location;

18.4.2.2.7.6. Apply drift corrections to track the published ground track.

18.4.2.2.8. ***Airspeed Restrictions. Before reaching the IAF, reduce to maneuvering airspeed. Use holding speed if maneuvering speed is not specified for your aircraft.***

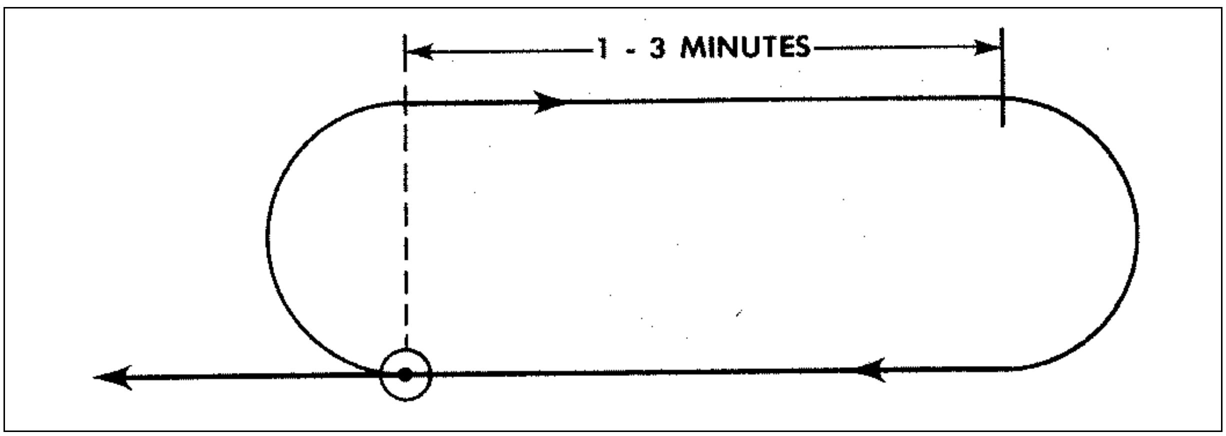
18.4.2.2.8.1. If the procedure is limited to specific aircraft categories, these are the applicable speeds for the initial approach segment:

Table 18.2. Maximum Approach Speeds.

Category	Max Speed
A	110 KIAS
B	140 KIAS
C	240 KIAS
D	250 KIAS
E	250 KIAS

18.4.2.2.8.2. Additional speed restrictions may be charted on individual IAPs and must be complied with. ***However, the maximum speeds by category, as shown above, will not be exceeded without approval of the appropriate ATC agency.***

Figure 18.7. Racetrack Procedure.



18.4.2.3. The Racetrack (Figure 18.7). The ICAO "Racetrack Procedure" is similar in concept to an FAA "Holding In Lieu of Procedure Turn." This maneuver consists of a holding pattern with outbound leg lengths of 1 to 3 minutes, specified in 30-second increments. As an alternative to timing, a DME distance or an intersecting radial or bearing may limit the outbound leg.

18.4.2.3.1. Racetrack Entry Procedure. Normally a racetrack procedure is used when aircraft arrive overhead the fix from various directions. Entry procedures for a racetrack are the same as entry procedures for holding patterns with several exceptions:

18.4.2.3.1.1. The teardrop offset should be planned using 30° from the inbound course.

18.4.2.3.1.2. The teardrop entry from sector 2 is limited to 1 1/2 minutes wings level on the 30-degree teardrop track, after which the pilot is expected to turn to a heading to parallel the outbound track for the remainder of the outbound time. If the outbound time is only 1 minute, the time on the 30-degree teardrop track will be 1 minute also.

18.4.2.3.1.3. Parallel entries may not return directly to the facility without first intercepting the inbound track.

18.4.2.3.1.4. All maneuvering will be done as much as practical on the maneuvering side of the inbound track.

18.4.2.3.1.4.1. NOTE: When necessary due to airspace limitations, entry into the racetrack procedure may be restricted to specified routes. When so restricted, the entry routes will be depicted on the IAP. Racetrack procedures are used where sufficient distance is not available in a straight segment to accommodate the required loss of altitude and when entry into a reversal maneuver is not practical. They may also be specified as alternatives to reversal procedures to increase operational flexibility.

18.4.2.3.2. Shuttle Procedure. A "Shuttle" is a descent or climb conducted in a holding pattern. A shuttle is normally specified where the descent required between the end of the initial approach and the beginning of the final approach exceeds standard ICAO approach design limits.

18.4.2.3.3. Alternate Procedures*:* There may be alternate procedures specified to any of the procedures described above. IAPs will contain the appropriate depiction and the words "alternative procedure." Pilots should be prepared to execute either procedure. ***Prior to accepting clearance for an approach that depicts an alternative procedure, determine which procedure the controlling agency expects****.*

18.4.2.3.4. Circling Procedures. ICAO circling protected airspace is typically larger than US TERPS and the ROC is higher. One important distinction to make is between the terms "runway environment" and "airport environment***." While circling using an ICAO-designed procedure, you must maintain visual contact with the runway environment (as defined in paragraph 14.2.1.2.6) throughout the entire circling maneuver.*** In the United States, you are only required to maintain visual contact with the airport environment while circling to land, but cannot descend out of the circling MDA until the runway environment is in sight.

18.4.2.3.4.1. Use the following table to determine maximum airspeeds for circling.

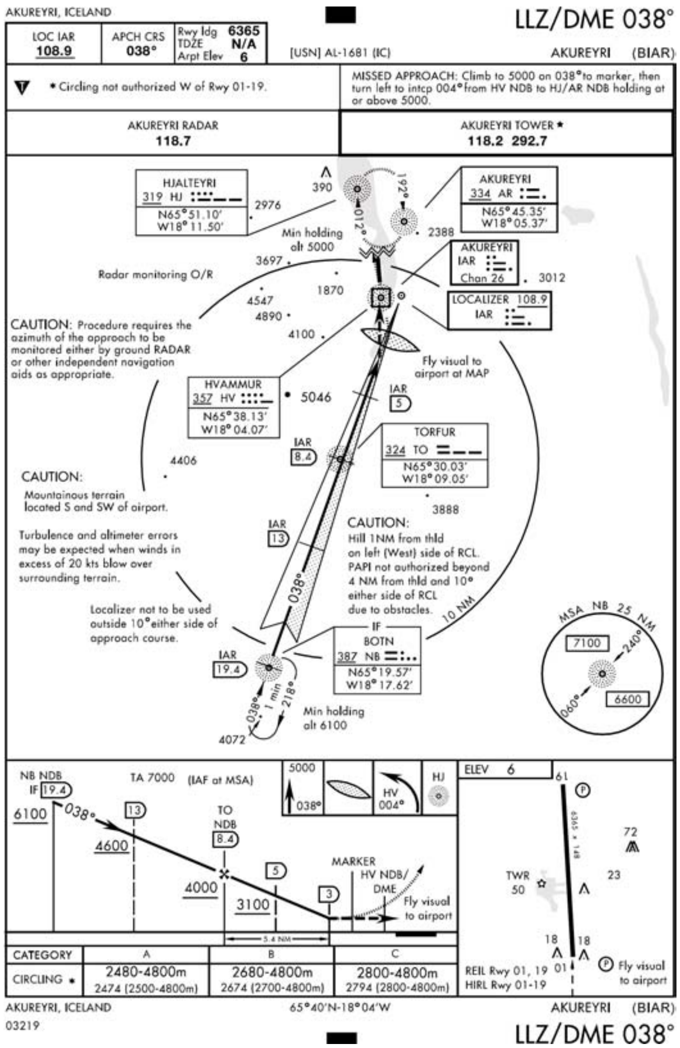
Table 18.3. Maximum Airspeeds for Circling Approaches.

Approach Category	Maximum Speed
A	100 KIAS
B	135 KIAS
C	180 KIAS
D	205 KIAS
E	240 KIAS

18.4.3. Localizer (LLZ). PANS-OPS abbreviates the localizer facility as LLZ. The accuracy of the signal generated by the LZZ is the same as a LOC. PANS-OPS normally requires the LLZ final approach track alignment to remain within 5° of the runway centerline. However, in certain cases, the alignment can exceed 5°. Where required, PANS-OPS allows an increase of the final approach track to 15° for categories C, D, and E. For aircraft categories A and B, the maximum angle formed by the final approach track and the runway centerline is 30°.

18.4.3.1. NOTE: Prior to flying a LDA or LLZ, compare the final approach course with the runway heading. The airdrome sketch should provide a visual indication of the angle formed between the final approach track and the runway centerline.

Figure 18.8. LLZ Approach.



18.4.4. Timing for Missed Approach and FAF to MAP. Some host nations use non-standard timing for determining the MAP on a procedure. This means timing may go from the FAF to the runway threshold or from a step-down fix to the runway threshold. When these host nation procedures are published in DoD FLIP, these non-standard timing blocks will be converted to the US standard of FAF to MAP. This can induce some errors due to rounding of numbers. For this reason, when using timing to determine the MAP on a DoD procedure produced by a host nation, it is imperative that crews correctly determine the timing based on groundspeed, and then fly that groundspeed to avoid exaggerating errors already induced due to the conversion from host nation to DoD format.

18.5. Holding.

18.5.1. Bank Angle. Make all turns at a bank angle IAW paragraph 18.2.4. ICAO procedures do not allow correcting for winds by adjusting bank angle. The "triple-drift" technique described in Chapter 10 is a good way to correct for winds without varying your bank angle.

18.5.2. Tracks. All procedures depict tracks. ***Attempt to maintain the track by allowing for known winds and applying corrections to heading and timing during entry and while flying in the holding pattern.***

18.5.3. Limiting Radial. When holding away from a NAVAID, where the distance from the holding fix to the NAVAID is short, a limiting radial may be specified. A limiting radial may also be specified where airspace conservation is essential. If you encounter the limiting radial first, initiate a turn onto the radial until you turn inbound. Do not exceed the limiting DME distance, if published.

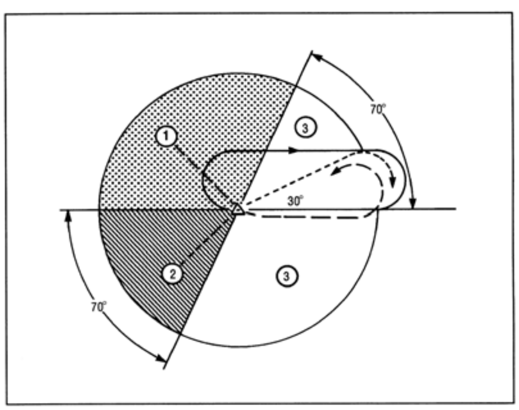
18.5.4. Holding Entry Procedure. ***The ICAO holding entry procedure is a mandatory procedure. All timing, distances, and limiting radials must be complied with. Enter the holding pattern based on your heading (±5°) relative to the three entry sectors depicted in Figure 18.9. Upon reaching the holding fix, follow the appropriate procedure for your entry sector:***

18.5.4.1. Sector 1 (Parallel). Turn onto an outbound heading for the appropriate time or distance, and then turn towards the holding side to intercept the inbound track or to return to the fix.

18.5.4.2. Sector 2 (Offset). Turn to a heading to make good a track making an angle of 30° from the reciprocal of the inbound track on the holding side. Fly outbound for the appropriate period of time described in paragraph 18.4.2.3.1.2, until the appropriate limiting DME is attained, or where a limiting radial (paragraph 18.5.3) is also specified, either until the limiting DME is attained or until the limiting radial is encountered, whichever occurs first, then turn right to intercept the inbound holding track.

18.5.4.3. Sector 3 (Direct). Turn and follow the holding pattern.

Figure 18.9. ICAO Holding Pattern Entry Sectors.



1. Sector 1: make a parallel entry.
2. Sector 2: make a teardrop entry. The teardrop is defined as the 30° offset track.
3. Sector 3: make a direct entry.

18.5.5. Airspeeds. There is little standardization of maximum holding airspeeds in PANS-OPS. There are three completely different tables of holding airspeeds that an approach designer could have used, depending on which edition of PANS-OPS was used when the holding pattern was constructed. Many countries publish their own holding pattern airspeeds. This information is supposed to be published in FLIP, but it may be quite difficult or impossible for to you to actually find it. Some holding pattern airspeeds are published on IAPs. You must understand, though, that the concept is the same as in the United States: maximum holding airspeeds are defined by PANS-OPS (or the host country) and have no relation to the holding speed specified in the aircraft flight manual. If you cannot, (or do not want to) find the precise maximum holding speed, you may use the table below as a recommendation. The table reproduces the airspeeds from PANS-OPS, and is the most common table used.

Table 18.4. ICAO Holding Airspeeds.

ALTITUDE	AIRSPEED	AIRSPEED
	Normal Conditions	Turbulence*
Up to 14,000 Feet Inclusive (CAT A and B)	170	170
Up to 14,000 Feet Inclusive (CAT C thru E)	230	280
Above 14,000-20,000	240	280 or 0.8 Mach, whichever is less
Above 20,000-34,000	265	280 or 0.8 Mach, whichever is less
Above 34,000	0.83 Mach	0.83 Mach

18.5.5.1. NOTE: *The speeds published for turbulence conditions shall be used for holding only after prior clearance with ATC, unless the relevant publications indicate that the holding area can accommodate aircraft flying at these high holding speeds.

18.5.6. Holding Pattern Lengths. On the second and subsequent arrivals over the fix, turn and fly an outbound track that will most appropriately position the aircraft for the turn onto the inbound track. Continue outbound until the appropriate limiting distance or time. ICAO outbound legs are the limiting factor for both timed and fixed distance holding patterns. The standard times are: 1 minute outbound at or below 14,000 feet MSL, or 1 1/2 minutes outbound above 14,000 feet MSL.

18.5.7. Wind Corrections. Attempt to correct both heading and timing to compensate for the effects of wind to ensure the inbound track is regained before passing the holding fix inbound. Indications available from the NAVAID and estimated or known winds should be used in making these corrections. If a limiting radial is published and encountered prior to the outbound limits, it must be followed until a turn inbound is initiated at the appropriate distance/time.

18.6. ICAO Altimeter Setting Procedures. There are three different methods of reporting the altimeter measurements and four different units of measure used to express altimeter settings. For aircraft that have only one type of altimeter scale, or for areas where the altimeter setting is not converted for you, the FIH contains conversion tables. It is critical that crewmembers understand how to apply the conversions prior to flight into airspace using other than inches of mercury QNH for altimeter settings. Refer to FLIP AP for specific altimeter setting procedures for each country.

18.6.1. Methods of Reporting Altimeter Settings.

18.6.1.1. QNH Settings. A QNH altimeter setting represents the pressure that would, in theory, exist at sea level at that location by measuring the surface pressure and correcting it to sea level pressure for a standard day. ***Set the reported QNH when descending through, or operating below, the published MSL Transition Level***. With the proper QNH set, the altimeter will indicate your height above MSL. All DOD approach criteria are based upon using QNH altimeter settings. Some also provide QFE altitudes in parenthesis.

18.6.1.2. QNE Settings. QNE is used to indicate your height above an imaginary plane called the "standard datum plane," also known as "FL 0". The established altimeter setting at FL 0 is 29.92 inches of Mercury (IN HG), or 1013.2 millibars or hectopascals. ***Set QNE (29.92) when climbing through, or operating above the Transition Altitude.***

18.6.1.3. QFE Settings. QFE is the altimeter setting issued to aircraft to indicate the AGL height above the airport. With the proper QFE set, your altimeter should indicate "0" on the ground. The Royal Air Force and the Royal Navy in the United Kingdom, and in many parts of the Pacific and Eastern Europe commonly use QFE.

18.6.2. Units of Measure for Altimeter Settings.

18.6.2.1. Inches of Mercury. The unit of measure used in the US is inches of mercury.

18.6.2.1.1. WARNING: In some areas, controllers will use shorthand to issue an altimeter setting, which can cause confusion for crews. For example, "992" could mean 29.92 inches or 992 mb. Insure you are using the correct units of measure when setting your altimeter.

18.6.2.1.2. NOTE: Most USAF altimeters have the ability to display either inches of mercury or millibars/hectopascals by use of two different barometric scales in the window of the altimeter. Insure you are using the proper scale to set the altimeter setting.

18.6.2.2. Millibars and Hectopascals. In most other parts of the world, the metric system is used and you will hear the term "millibars (MB)" or "hectopascals (HPa)." Both MB and HPa equal the same unit of pressure per square centimeter, and thus can be used interchangeably.

18.6.2.3. Millimeters of Mercury. This is primarily used in Eastern Europe and nations of the former USSR, and is not to be confused with millibars, which is a different unit of measure.

18.6.2.3.1. WARNING: Do not set a millimeters value from ATC on your altimeter using the millibars scale that is part of your altimeter because they are NOT equivalent.

18.6.3. Transition Altitude. The altitude in the vicinity of an airport at or below which the vertical position of an aircraft is determined from an altimeter set to QNH or QFE as appropriate. Transition altitude is normally specified for each airfield by the country in which the airfield exists. Transition altitude will not normally be below 3,000 feet HAA and must be published on the appropriate charts.

18.6.4. Transition Level. The lowest flight level available for use above the transition altitude. Transition level is usually passed to the aircraft during the approach or landing clearances. The transition layer may be published, or it may be supplied by ATC via the ATIS or during arrival. Half flight levels may be used: for example, "FL 45."

18.6.5. Transition Layer. That area between the transition altitude and transition level. Aircraft are not normally assigned altitudes within the transition layer.

18.6.6. Transition Between Flight Levels and Altitudes. The vertical position of an aircraft at or below transition altitude shall be expressed in altitude (QNH or QFE as appropriate). Vertical position at or above the transition level shall be expressed in terms of flight levels (QNE). When passing through the transition layer, vertical position shall be expressed in terms of flight levels (QNE) when climbing and in terms of altitudes (QNH or QFE as appropriate) when descending. After an approach clearance has been issued and the descent to land is commenced, the vertical positioning of an aircraft above the transition level may be by reference to altitude (QNH or QFE as appropriate) provided that level flight above the transition altitude is not indicated or anticipated. This is intended for turbo jet aircraft where an uninterrupted descent from high altitude is desired and for airfields equipped to reference altitudes throughout the descent.

18.6.7. Altimeter Errors. The allowable altimeter errors at a ground checkpoint in ICAO are different than in the US and vary by airport elevation and atmospheric pressure. ***Use the following tables to determine allowable altimeter errors. If your aircraft flight manual is more restrictive than the values shown in these tables, comply with the guidance in your aircraft flight manual.***

Table 18.5. Allowable Altimeter Errors at Ground Checkpoint for Airports Up to 3500 Feet Elevation With Atmospheric Pressure at or Above Standard.

Airport Elevation	Atmospheric Pressure	Altimeter Range	Allowable Difference
3500 Feet or Below	At or Above Standard	0-30,000 Feet	±60 Feet
3500 Feet or Below	At or Above Standard	0-50,000 Feet	±80 Feet

Table 18.6. Allowable Altimeter Errors at Ground Checkpoint for Airports Above 3500 Feet Elevation or Atmospheric Pressure Lower Than Standard (Altimeter Range 0-30,000 Feet).

Airport Elevation	Allowable Difference
2000 Feet	±60 Feet
3000 Feet	±70 Feet
4000 Feet	±75 Feet
5000 Feet	±80 Feet
6000 Feet	±85 Feet
7000 Feet	±95 Feet
8000 Feet	±105 Feet
9000 Feet	±115 Feet
10000 Feet	±125 Feet
11000 Feet	±135 Feet
12000 Feet	±145 Feet
13000 Feet	±155 Feet
14000 Feet	±165 Feet
15000 Feet	±175 Feet

Table 18.7. Allowable Altimeter Errors at Ground Checkpoint for Airports Above 3500 Feet Elevation or Atmospheric Pressure Lower Than Standard (Altimeter Range 0-50,000 Feet).

Airport Elevation	Allowable Difference
2000 Feet	±100 Feet
3000 Feet	±105 Feet
4000 Feet	±115 Feet
5000 Feet	±125 Feet
6000 Feet	±135 Feet
7000 Feet	±145 Feet
8000 Feet	±155 Feet
9000 Feet	±165 Feet
10000 Feet	±175 Feet
11000 Feet	±185 Feet
12000 Feet	±195 Feet
13000 Feet	±205 Feet
14000 Feet	±215 Feet
15000 Feet	±225 Feet

18.6.8. Altimeter Use in Flight. ***Prior to take-off at least one altimeter will be set to the latest QNH/QFE altimeter setting. Set the altimeter to QNE (29.92) climbing through transition altitude. Prior to commencing the initial approach to an airfield, the number of the transition level should be obtained from the appropriate air traffic services unit. Obtain the latest QNH/QFE before descending below the transition level.***

18.7. Units of Measure for Altitudes.

18.7.1. Some countries, particularly in Eastern Europe and nations of the former USSR, use meters to define altitudes. Most USAF aircraft do not have altimeters that can display meters. FLIP AP contains information on units of measure for each country. The FIH has a conversion chart for feet to meters. It is imperative to correctly convert from feet to meters when flying in these areas.

18.7.1.1. WARNING: In some areas you may be required to fly altitudes or flight levels in meters and use an altimeter setting other than inches of mercury QNH. For example, altitude in meters using millibars QFE. Misapplication of conversions in these areas can cause mid-air collision or collision with the ground. Crews must insure they are thoroughly familiar with their aircraft system limitations and conversions prior to flight in these areas.

Chapter 19

CATEGORY II AND III ILS

19.1. Category II ILS Approach (Airport, Aircraft, and Aircrew Certification Required). A Category II ILS approach provides the capability of flying to minima as low as a DH of 100 feet and an RVR of 1200. The DH for a Category II approach is identified by a pre-selected height on the aircraft radar altimeter. This figure is enclosed in parentheses on the IAP and is prefaced by RA (Radar Altimeter), example: (RA 113).

19.1.1. Checks. Check flight directors, barometric and radar altimeters, and any other Category II equipment. Set the DH on the radar altimeter (if required for the approach).

19.1.1.1. On certain Category II ILS approaches, the terminology “RA-NA” will be annotated in the minimums section of the procedure. This indictes that the DH must be determined solely from the barometric altimeter, not the radar altimeter.

19.1.2. Brief. Brief Category I procedures as a backup approach if appropriate.

19.1.3. Faults. Announce the illumination of any Category II system fault identification light.

19.1.3.1 NOTE: Depending on the Category II equipment installed, a fault indication below 300 feet AGL may require an immediate go-around command.

19.1.3.2. Failures Prior to 300 feet AGL. If any required Category II component fails prior to 300 feet AGL, the system is capable of a Category I approach only unless the failure can be corrected prior to 300 feet AGL.

19.1.3.3. Failures Below 300 feet AGL. Any failure of a required Category II component below 300 feet AGL requires the pilot to execute an immediate missed approach unless visual cues are sufficient to complete the approach and landing.

19.1.4. Advisory Calls. Make appropriate advisory altitude calls on the approach, including a call 100 feet above the DH.

19.1.4.1. NOTE: Tolerances for continuing the approach from 100 feet above DH are: airspeed ±5 knots of computed final approach speed or the speed directed by the flight manual for Category II approaches, and deviation from glide slope and localizer not to exceed one-half dot.

19.1.5. Visual Cues. From 100 feet above the DH to the Category II DH, the pilot not flying the aircraft will concentrate primarily on outside references to determine if visual cues are sufficient to complete the landing visually.

19.1.6. Continue. ***Continue the approach at DH only if the following conditions are met:***

19.1.6.1. Runway. Runway environment (as defined in para 14.1.1.2.6) is in sight.

19.1.6.2. Airspeed. Airspeed is within ± 5 knots of the computed final approach speed or as directed by the flight manual.

19.1.6.3. Deviations. Localizer or glide slope deviations do not exceed one-half dot.

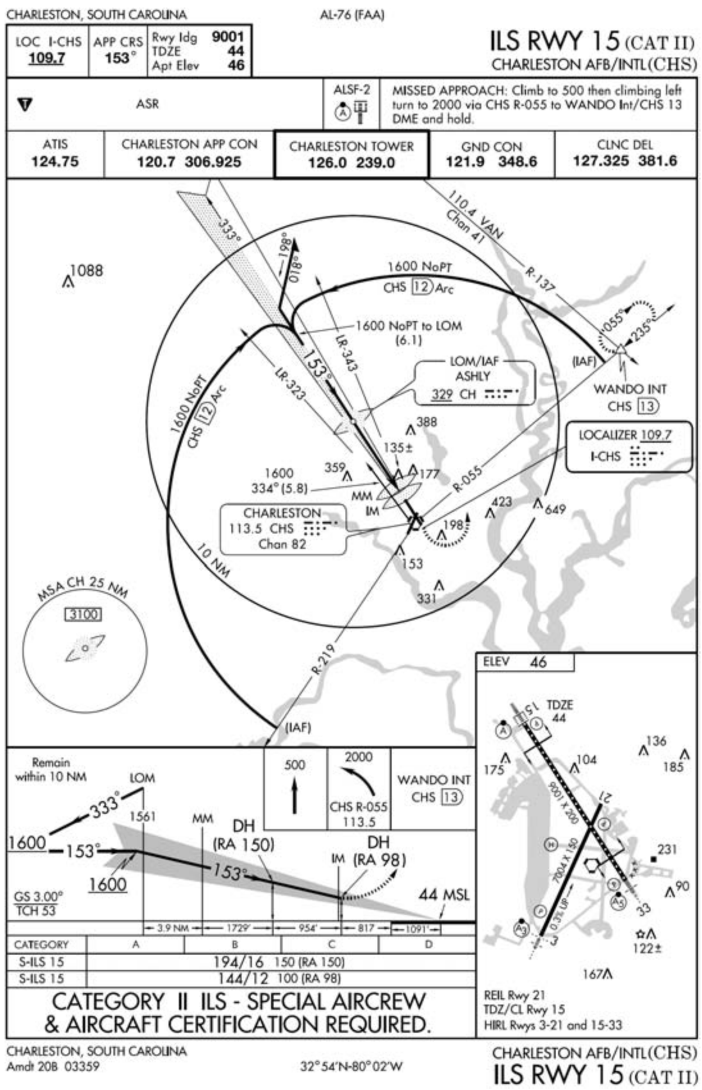
19.1.6.4. Aircraft position. The aircraft's position is within, and tracking to remain within, the extended lateral confines of the runway.

19.1.6.5. Stabilized. The aircraft is stabilized with reference to attitude and airspeed.

19.1.7. Go Around. Go around at DH if the runway environment is not in sight or if any of the above tolerances are exceeded.

19.1.7.1. NOTE: These procedures are intended for use by Category II ILS certified aircrews only. ***Individual MAJCOM directives and aircraft manuals have established minimum equipment requirements and restrictions that must be complied with prior to initiating a Category II ILS approach***.

Figure 19.1. Category II ILS.



19.2. Category III ILS (Airport, Aircraft, and Aircrew Certification Required).

19.2.1. Definitions.

19.2.1.1. ILS Category III. A precision instrument approach and landing without a DH, or a DH below 100 feet (30 meters) and controlling runway visual range not less than 700 feet (240 meters).

19.2.1.1.1. ILS Category IIIa. An ILS approach procedure that provides for approach without a DH or RVR not less than 700 feet.

19.2.1.1.2. ILS Category IIIb. An ILS approach procedure that provides for approach without DH and with RVR not less than 150 feet.

19.2.1.1.3. ILS Category IIIc. An ILS approach procedure that provides for approach without DH and without RVR minimum.

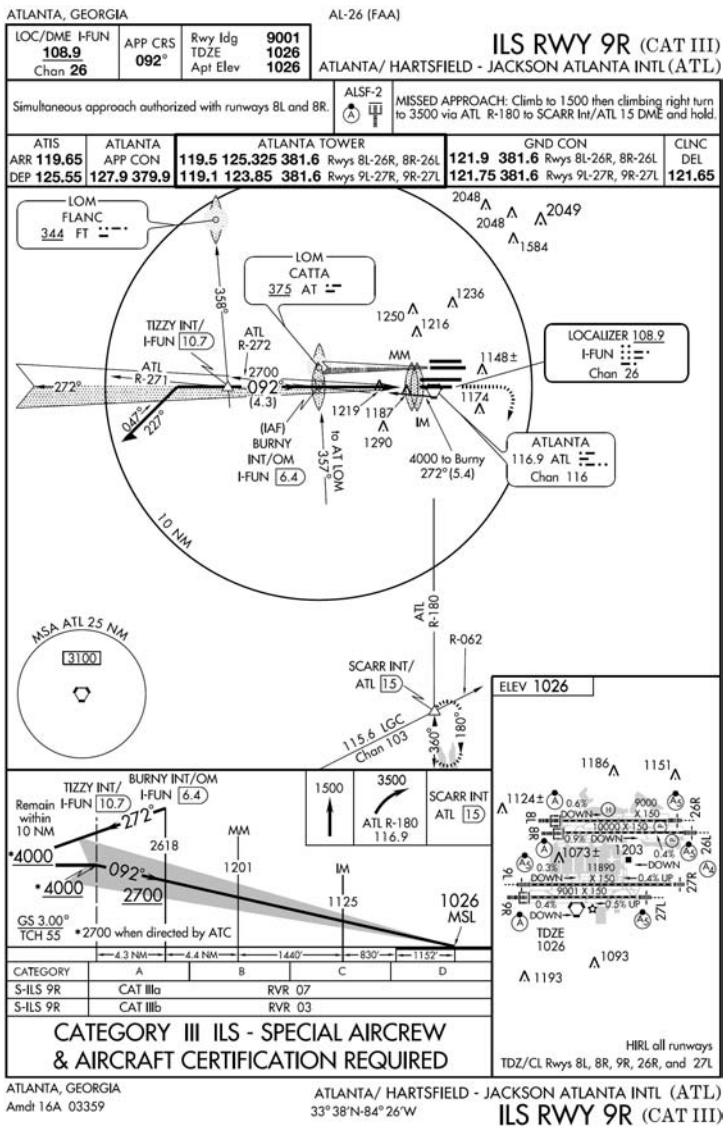
19.2.1.2. Alert Height (AH). A height defined as 100 feet above the highest elevation in the touchdown zone, above which a Category III approach would be discontinued and a missed approach initiated if a failure occurred in one of the required redundant operational systems in the airplane or in the relevant ground equipment. Below this height, the approach, flare, touchdown, and rollout may be safely accomplished following any individual failure in the associated Category III systems.

19.2.2. Operational Concepts. The weather conditions encountered in Category III operations range from adequate visual references for manual rollout in Category IIIa, to inadequate visual references even for taxi operations in Category IIIc. To maintain a high level of safety during approach and landing operations in very low visibilities, the airborne system and ground support system requirements established for Category III operations should be compatible with the limited visual references that are available. The primary mode of Category III operations is automatic approach to touchdown using automatic landing systems that does not require pilot intervention. However, pilot intervention should be anticipated in the unlikely event that the pilot detects or strongly suspects inadequate aircraft performance as well as when it is determined that an automatic touchdown cannot be safely accomplished within the touchdown zone.

19.2.2.1. Fail Operational Category III Operations. Aircraft certification is based on the total airborne system being operative down to AH height of 100 feet. The aircraft will accomplish an automatic landing and rollout using the remaining automatic systems following failure of one system below AH. Equipment failures above AH must result in a go-around or reversion to another approach if those requirements can be met. For Category IIIa fail-operational approach and landing without a rollout control system, visual reference with the touchdown zone is required and should be verified prior to the minimum height specified by the operator for the particular aircraft type. These visual cues combined with controlling transmissometer RVR report of visibility at or above minima are necessary to verify that the initial landing rollout can be accomplished visually. A go-around should be accomplished if there is no visual reference prior to the specified minimum height or upon receiving a report of controlling RVR below minima prior to this height. For Category IIIa fail-operational approach and landing with a rollout control system, the availability of visual reference is not a specific requirement for continuation of an approach to touchdown. The design of the cockpit instrumentation, system comparators, and warning systems should be adequate in combination to assure that the pilot can verify that the aircraft will safely touchdown within the touchdown zone and safely rollout if the controlling RVR is reported at or above approved minima. The aircraft may go-around safely from any altitude to touchdown. Use manual go-around after touchdown.

19.2.3. Procedures. See individual MAJCOM directives and aircraft manuals for minimum equipment requirements, restrictions, and procedures used when initiating Category III ILS approaches.

Figure 19.2. Category III ILS.

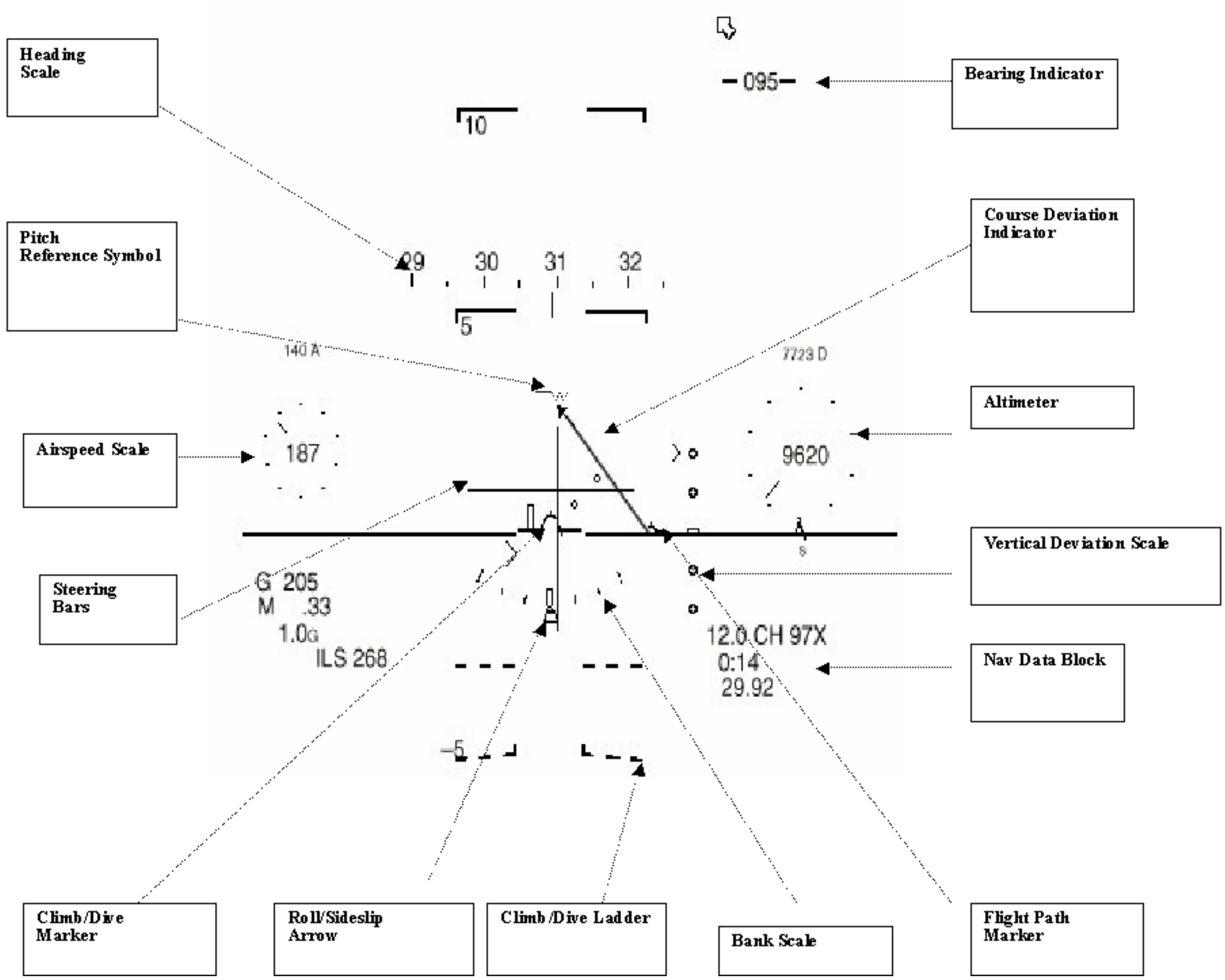


Chapter 20

THE HEAD-UP DISPLAY (HUD)

20.1. General Use of HUDs. HUDs currently in use vary in field-of-view, symbology, and operation. However, most HUDs provide similar displays for instrument flight. Figure 20.1 shows a typical HUD configuration and some of the terms for its symbology. Refer to your aircraft flight manual for specific information on HUD operation, symbology, and failure indications.

Figure 20.1. Typical HUD Configuration (Instrument Approach Mode) (paragraph 20.1).



20.2. Use of HUDs in Instrument Flight.

20.2.1. Part of Normal Crosscheck. ***A HUD not endorsed as a Primary Flight Reference (PFR) according to AFI 11-202, Volume 3 General Flight Rules, should not be used as a sole-source instrument reference.*** HUDs not endorsed as a PFR may be integrated into the normal instrument crosscheck. Improvements in information integrity and failure indications have increased confidence in the HUD's reliability; however, the combination of symbology and mechanization enabling its use as a sole-source attitude reference has not been incorporated into all HUDs. It is important for pilots to know the HUD's capabilities and limitations so they can take full advantage of its strengths and learn to work with its weaknesses.

20.2.2. Format. The format of the HUDs scales and references may differ greatly from their head-down counterparts but their content and sources of origin are usually similar if not identical.

20.2.2.1. Command Symbol. The flight path marker (FPM), or velocity vector (VV), as it is referred to on some HUDs, in conjunction with the flight path scale, is the HUD feature most used during instrument flight. Simply put, the FPM is a symbol that displays pitch compensated for angle of attack, drift, and yaw. It shows where the aircraft is actually going, assuming a properly functioning INS, and may be used to set a precise climb or dive angle relative to the HUD's flight path scale. This ability to show the actual flight path of the aircraft makes the FPM a unique control and performance element. The major advantage of vector (FPM) flying over conventional attitude flying is the ease of setting a precise glide path instead of using the ADI, VVI, and airspeed to approximate a glide path. The FPM can also be used to determine where the aircraft will touchdown. Drawbacks to vector flying include the tendency of the display to float around the combining glass, especially in crosswinds, the bobbing motion of the FPM as it lags behind the movement of the nose of the aircraft, and the degraded usefulness of the FPM when it exceeds the limits of the field-of-view at high angles of attack and in large drift or yaw situations. Some aircraft address these drawbacks with a "drift cutout mode" which maintains the lateral position of the FPM on the HUD centerline. Other aircraft simultaneously display a climb/dive marker (CDM) with the FPM. The CDM displays the current climb/dive angle while remaining horizontally fixed to the centerline of the HUD.

20.2.2.2. Flight Path Scale. Typically, the flight path scale is displayed in a 1:1 angular relationship with the "real world," though some HUDs gradually compress the scale at steeper climb/dive angles to reduce movement of the symbols and create a global display similar to that found on an attitude indicator. The HUD's expanded flight path scale allows the pilot to make smaller, more precise corrections than is possible using conventional head-down displays. Like the FPM, the flight path scale can be of limited use when it approaches the limits of the HUD's field-of-view.

20.2.2.3. Other Scales. HUD scales (except for the flight path scale) are essentially repeaters of the head-down performance instruments. They provide information such as airspeed, altitude, heading, vertical velocity, and angle of attack. These scales are often direct readouts of pitot static or air data computer information and are as reliable as the primary instruments. An important difference between the head-up and head-down scales is the formats they employ. Digital displays of airspeed and altitude are very precise but they do not show trends or rate of change very well. Vertical scales show trend but they are not intuitive (that is, should the altitude scale move downward when the altitude is decreasing or should the higher numbers always be at the top of the scale) and they are not as precise as digital scales. The HUD heading scale is easier to use than the head-down heading indicator for small heading changes, such as on final approach, because of its expanded scaling, but it is cumbersome when used to determine angular relationships with a desired course or other traffic. Vertical velocity, an indispensable element in flying a precision glide path using conventional pitch reference techniques, becomes extraneous data when flying a glide path with a valid FPM. It is apparent then that proficiency in HUD flying requires the development of an integrated crosscheck that encompasses the most useful information available. Always confirm the HUD data before using it and continue to crosscheck it against the head-down data to confirm its accuracy.

20.2.2.4. Navigation Information. Navigation information displayed on the HUD varies from aircraft to aircraft both in symbology and format. Sources (INS, TACAN, ILS) may be selectable, so it is important to remember which source has been selected and whether the display is raw data or steering information. The ILS mode may display either course guidance or course deviation. As in flying command steering bars on an attitude indicator, the pilot must not fixate on HUD steering commands but continue to reference raw data to determine aircraft position and to verify the HUD commands. Chasing the steering commands with the FPM may result in over-controlling, especially if raw data is not provided on the HUD.

20.2.2.5. Information Missing. The lack of power indicators and bearing information prevents most current HUDs from providing complete “control” or “navigation” information and reinforces the need for the pilot to use the HUD as only part of an integrated crosscheck.

20.2.3. Instrument Flight Use. To effectively use the HUD for instrument flight, the pilot must first understand basic attitude flying procedures and techniques and be proficient in flying instruments using various elements of HUD information to complement the instrument crosscheck.

20.2.3.1. Instrument Takeoff and Climb. Prior to takeoff, ensure that information displayed on the HUD agrees with that on the conventional instruments. Rotation is accomplished by establishing the initial pitch attitude using a combination of outside visual cues and the attitude reference. The initial pitch attitude may be set on the HUD if it contains a pitch reference symbol, otherwise, use the head down attitude reference. When the FPM becomes active and a stabilized pitch is established, use the FPM for precise adjustments. Continue to crosscheck the airspeed and VVI to ensure the climb angle is correct, making adjustments using the FPM as necessary.

20.2.3.2. Level Off. Begin the level off at a predetermined lead point. Fly the FPM smoothly to the level flight path line, adjusting the rate of movement so that level flight occurs at the desired altitude. When the FPM is stabilized on the horizon line of the HUD, the altimeter and VVI should be steady. The HUD information should be considered unreliable if indications of a climb or dive persist.

20.2.3.3. Penetration/Descent. Determine the descent gradient (altitude to lose/[distance to travel in NM x 100] = descent gradient) required to meet any altitude restrictions and fly the FPM to the corresponding angle on the flight path scale. Crosscheck the actual altitude with the desired altitude at intermediate points during the descent to ensure the proper dive angle is set.

20.2.3.4. Approach. Set the illumination intensity. At night or in dense weather the runway or approach lighting may wash out low illumination levels in the HUD. Ensure the approach angle of attack corresponds to the computed final approach airspeed. If the angle of attack is in the appropriate range but the airspeed is higher than expected, the aircraft may not be properly configured for landing.

20.2.3.4.1. Non-precision. Compute the descent angle from the FAF to the VDP. At the FAF fly the FPM to the desired angle and crosscheck the airspeed, vertical velocity, and angle of attack. If the MDA is reached prior to the VDP, wait until the dive line corresponding to the desired visual glide path is over the desired touchdown zone and then lower the FPM to the touchdown zone.

20.2.3.4.2. Precision. The FPM can be used very effectively for establishing and maintaining precision glide paths. From stabilized, level flight adjust the FPM to the desired glide path angle at the glide slope intercept point. Crosscheck the airspeed, vertical velocity, and angle of attack, to confirm proper performance. Using a combination of FPM and the expanded heading scale in the HUD, make small bank corrections to correct to the final course. Continue to crosscheck the head-down raw data to ensure approach tolerances are not exceeded.

20.2.3.4.3. Transition from Instrument Flight. Because of the HUD's location within the pilot's forward field-of-view, it can facilitate the transition from instrument flight to visual acquisition of the runway. Immediately upon visual acquisition of the runway, ensure the FPM/CDM is coincident with the intended touchdown zone. If it is not, smoothly correct the flight path or discontinue the approach. If the FPM is on the touchdown zone at a descent angle less than 2.5°, the aircraft is on a low, flat approach; discontinue the descent until the proper glide path can be acquired. If the FPM is used to maintain precise glide path control, once established on the ILS glide slope, it should closely coincide with the runway point of intercept (RPI) when the instrument to visual transition occurs. Current HUDs are designed to have as many as three different symbols overlay the touchdown zone when the aircraft is on the proper course and glide slope.

20.2.3.4.3.1. CAUTION: These symbols may tend to obscure the external visual scene so fly instruments down to the flare looking through the HUD, not at it.

20.2.3.4.3.2. WARNING: Any abrupt attitude changes to attempt to bring the projected touchdown point into your visual segment may produce high sink rates and thrust or lift problems at a critical time. Those so-called-duck-under maneuvers must be avoided during any transition to landing, particularly at night and in low visibility.

20.3. HUD Limitations.

20.3.1. Global Orientation. Many HUDs are incapable of providing intuitive global orientation information because of the small sections of space that they represent. Also, since many HUDs provide only a partial picture of the aircraft's attitude, a pilot who tries to use the HUD to confirm an unusual attitude may see only a blur of lines and numbers. In a fast moving environment, the pilot may not be able to differentiate or recognize the difference between the solid climb lines from the identical, but dashed, dive lines in the flight path scale. Any confusion or delay in initiating proper recovery inputs may make recovery impossible.

20.3.1.1. NOTE: Unless your HUD is endorsed as a PFR, do not use it when spatially disoriented, for recovery from an unusual attitude, or during lost wingman situations; use the head down display anytime an immediate attitude reference is required. Typically, head down displays are inherently easier to use in these situations due to the larger attitude coverage, color asymmetry between the ground and sky, and reduced interference from the outside visual scene (glare, optical illusions, etc.). For this reason, even if your HUD is endorsed as a PFR, current Air Force guidance requires the head down display be available to the pilot with not more than one hands-on switch action.

20.3.2. Flight path information. Most HUD flight path information is based on an INS. Many INSs have the capability to compute and display different types of airspeed (calibrated, true, or ground) and heading (magnetic or ground track). Though the INS and HUD have become increasingly more reliable, they can fail insidiously and with little or no warning. If such a failure occurs the pilot must realize that the types of airspeed and heading selected may change as the displays revert to a different mode of operation, and the FPM may disappear, leaving the pilot with a fixed pitch reference at a surprisingly different climb or dive angle. Be prepared for any such failure by constantly cross-checking the head-down attitude reference and other performance instruments.

20.3.3. Interpretation. Remember that the HUD picture is only a small piece of the "big picture," so what the pilot sees on the HUD must be accurately interpreted. That is to say, you may be on-speed with the FPM at the correct flight path angle but aiming well short of the runway, or you may be on-speed with the FPM on the desired aim point, but at too high a descent angle, resulting in an unacceptably high sink rate, or at too low a descent angle resulting in a dragged-in final and short touchdown.

20.3.4. Fixation. Fixation on HUD information can cause a breakdown in a proper instrument crosscheck and contribute to poor situational awareness. Information displayed on the HUD can be very compelling to the pilot. The tendency for the pilot to fixate on the HUD is increased by the display of excessive and unnecessary information or when the HUD brightness level is not adjusted properly for the background contrast. Minimize the tendency to fixate on the HUD by maintaining an efficient composite crosscheck and ensuring the HUD brightness level is properly adjusted.

20.3.5. HUD Field of View. HUD symbology may also obscure objects within the HUD field of view. When non-essential HUD information is displayed or when the HUD brightness level is excessive, the probability of obscuration is dramatically increased. Proper HUD settings (including elimination of non-task-essential information and adjusting the brightness to the proper level) are imperative to prevent potential hazards to safe flight.

20.3.6. Conventional Crosscheck. Finally, pilots should remain proficient in the conventional instrument crosscheck for their specific aircraft. Regardless of the type HUD you have (endorsed as a PFR or not), it is important to occasionally fly an instrument approach or accomplish a level-off without using the HUD so you retain your proficiency in the event of a HUD malfunction. The results may indicate a need to practice your conventional instrument crosscheck. Using HUD information incorrectly or at the wrong time can actually increase pilot workload, but timely, proper use of it can help you fly more precise instruments on a routine basis.

20.3.6.1. WARNING: Even under the best of conditions, practice HUD out approaches can result in increased pilot workload and possible approach deviations. During approaches in known weather conditions or reduced visibility, it is recommended that all available situational awareness tools be utilized (to include the HUD) to ensure the aircraft is successfully landed.

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Air & Space Operations

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

Number	Title
	Aeronautical Information Manual (AIM)
AC 00-62	Internet Communications of Aviation Weather and NOTAMs
AC 20-130A	Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors
AC 20-138	Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Supplemental Navigation System
AC 25-4	Inertial Navigation Systems
AC 61-27C	Instrument Flying Handbook
AC 90-45A	Approval of Area Navigation Systems for Use in the U.S. National Airspace System
AC 90-66A	Recommended Standard Traffic Patterns and Practices for Aeronautical Operations at Airport Without Operating Control Towers
AC 90-79	Recommended Practices and Procedures for the Use of Electronic Long-Range Navigation Equipment
AC 90-91G	National Route Program (NRP)
AC 90-94	Guidelines for Using Global Positioning System Equipment for IFR Enroute and Terminal Operations and for Nonprecision Instrument Approaches in the US National Airspace System
AC 90-96	Approval of US Operators and Aircraft to Operate Under Instrument Flight Rules (IFR) in European Airspace Designated for Basic Area Navigation (BRNAV/RNP-5)
AC 90-97	Use of Barometric Vertical Navigation (VNAV) for Instrument Approach Operations Using Decision Altitude
AC 90-98	Simultaneous Closely Spaced Parallel Operations at Airports Using Precision Runway Monitor (PRM) Systems
AC 90-99	High Altitude Airspace Redesign Phase 1
AC 91-63C	Temporary Flight Restrictions (TFR)
AC 91-70	Oceanic Operations
AC 91-73A	Part 91 and Part 135 Single-Pilot Procedures During Taxi Operations
AC 91-75	Attitude Indicator
AC 97-1A	Runway Visual Range (RVR)
AC 97-2	Database Standardization for the Global Positioning System (GPS) Overlay Program
AFI 11-201	Flight Information Publications
AFI 11-202 Volume 3	General Flight Rules
AFI 11-210	Instrument Refresher Course (IRC) Program

Number	Title
AFI 11-218	Aircraft Operations and Movement on the Ground
AFI 11-230	Instrument Procedures
AFI 33-360 Volume 1	Publications Management
AFJMAN 11-208 (I)	Department of Defense Notice to Airmen (NOTAM) System
AFMAN 11-217 Volume 2	Visual Flight Procedures
AFMAN 11-217 Volume 3	Supplemental Information
AFMAN 11-225	United States Standard Flight Inspection Manual
AFMAN 11-226	United States Standard for Terminal Instrument Procedures (TERPS)
AFPAM 11-216	Air Navigation
AFPD 10-9	Lead Operating Command Weapon System Management
AFPD 11-2	Aircraft Rules and Procedures
FAAN 8400.71	Flying of Non-RNAV/FMS SIDs and STARs with RNAV/FMS Navigation Equipment
FAAO 6750.24C	Instrument Landing Systems (ILS) and Ancillary Electronic Component Configuration and Performance Requirements
FAAO 7100.9C	Standard Terminal Arrival
FAAO 7130.3A	Holding Pattern Criteria
FAAO 8260.3B	United States Standard for Terminal Instrument Procedures (TERPS)
FAAO 8260.31B	Foreign Terminal Instrument Procedures
FAAO 8260.46B	Departure Procedure Program
FAR Part 1	Definitions and Abbreviations
FAR Part 121	Operational Requirements: Domestic, Flag and Supplemental Operations
FAR Part 135	Operational Requirements: Commercial and On-Demand Operations and Rules Governing Persons on Board Such Aircraft
FAR Part 91	General Operations and Flight Rules
MSO C-129A	Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)/Precise Positioning Service (PPS)
MSO C-145	Airborne Navigation Sensors Using the Global Positioning System (GPS)/Precise Positioning Service (PPS) for Area Navigation (RNAV) in Required Navigation Performance (RNP) Airspace; RNP-20 RNAV Through RNP-0.3 RNAV
TSO C-129A	Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
TSO C-145A	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
TSO C-146A	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
TSO C-147	Traffic Advisory System (TAS) Airborne Equipment
TSO C-151B	Terrain Awareness and Warning System

Abbreviations and Acronyms

AC	Advisory Circular
ACT	Approach Clearance Time
ADF	Automatic Direction Finding
ADI	Attitude Director Indicator
AFFSA	Air Force Flight Standards Agency
AFOD	US Army Flight Operations Detachment Europe
AFRL	Air Force Research Labs
AGL	Above Ground Level
AH	Alert Height
AIM	Aeronautical Information Manual
AIP	Aeronautical Information Publication
ALTRV	Altitude Reservation
AMI	Airspeed Mach Indicator
AMU	Areas of Magnetic Unreliability
ANG	Air National Guard
ANP	Actual Navigation Performance
AP	Area Planning
AQP	Airport Qualification Program
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal Systems
ASR	Aircraft Surveillance Radar
ASRR	Airfield Suitability Report
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
ATD	Along Track Distance
ATIS	Automatic Terminal Information Service
AVVI	Altitude Vertical Velocity Indicator
AZ	Azimuth
BARO-VNAV	Barometric Vertical Navigation
BC	Back Course
BDHI	Bearing Distance Heading Indicator
BIRDTAM	Bird Activity Notices to Airmen
BRNAV	Basic Area Navigation
BAZ	Back Azimuth
C/A	Course Acquisition
CADC	Central Air Data Computer
CAS	Calibrated Airspeed
CDI	Course Deviation Indicator
CDM	Climb Dive Marker
CDU	Control Display Unit
CFIT	Controller Flight Into Terrain
CI	Course Indicator
CLC	Course Line Computer

CNS/ATM	Communication Navigation Systems / Air Traffic Management
CONUS	Continental United States
CRT	Cathode Ray Tube
CSW	Course Selector Window
CTAF	Common Traffic Advisory Frequency
CVFP	Charted Visual Flight Procedure
DA	Decision Altitude
DAFIF	Digital Aeronautical Flight Information File
DER	Departure End of Runway
DF	Direct to Fix
DG	Directional Gyro
DH	Decision Height
DINS	DoD Internet NOTAM System
DME	Distance Measuring Equipment
DME/P	Precision Distance Measuring Equipment
DoD	Department of Defense
DP	Departure Procedure
DR	Dead Reckoning
DVA	Diverse Vector Area
EAS	Equivalent Airspeed
EFC	Expect Further Clearance
EL	Elevation Angle
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
ETE	Estimated Time En Route
ETL	Effective Translational Lift
EUCARF	European Central Altitude Reservation Facility
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAR	Federal Aviation Regulations
FAS	Final Approach Speed
FAWP	Final Approach Way Point
FBO	Fixed Base Operator
FCG	Foreign Clearance Guide
FCIF	Flight Crew Information File
FDC	Flight Data Center
FDE	Fault Detection and Exclusion
FDS	Flight Director System
FIH	Flight Information Handbook
FIR	Flight Information Region
FL	Flight Level
FLIP	Flight Information Publication
FMA	Final Monitor Aids
FMS	Flight Management System

FMSP	Flight Management System Procedure
FOV	Field of View
fpm	Feet Per Minute
FPM	Flight Path Marker
FSS	Flight Service Station
GCA	Ground Controlled Approach
GCCS	Global Command and Control System
GEO	Geostationary Satellite
GLONASS	Global Orbiting Navigation Satellite System
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
GP	General Planning
GPS	Global Positioning System
GS	Groundspeed
GSI	Glide Slope Indicator
GSP	Glide Slope Pointer
GUS	Ground Uplink Station
HAA	Height Above Aerodrome
HAT	Height Above Touchdown
HDD	Head Down Display
Hg	Mercury
HILO	Holding In Lieu of Procedure Turn
HIRL	High Intensity Runway Lighting
HMD	Helmet Mounted Display
HSI	Horizontal Situation Indicator
HSIAC	Human Systems Information Analysis Center
HUD	Head-Up-Display
Hz	Hertz (cycles per second)
IAF	Initial Approach Fix
IAP	Instrument Approach Procedure
IAS	Indicated Airspeed
IAW	In Accordance With
IAWP	Initial Approach Way Point
ICAO	International Civil Aviation Organization
IF	Intermediate Fix
IFF	Identification, Friend or Foe
IFIS	Integrated Flight Instrument System
IFR	Instrument Flight Rules
IFRB	International Frequency Registration Board
ILS	Instrument Landing System
ILS/PRM	ILS Precision Runway Monitor
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IMN	Indicated Mach Number
INS	Inertial Navigation System

IRC	Instrument Refresher Course
IRU	Inertial Reference Unit
ISA	International Standard Atmospheric
ITO	Instrument Takeoff
JCS	Joint Chiefs of Staff
kHz	Kilohertz
KIAS	Knots Indicated Airspeed
KTAS	Knots True Airspeed
LAAS	Local Area Augmentation System
LDA	Localizer Type Directional Aid
LLZ	Localizer (ICAO)
LNAV	Lateral Navigation
LOC	Localizer
LOM	Locator Outer Marker
LORAN	Long-Range Aid to Navigation
MAHWP	Missed Approach Holding Way Point
MAJCOM	Major Command
MAP	Missed Approach Point
MAWP	Mission Approach Waypoint
MCA	Minimum Crossing Altitude
MCS	Master Control Station
MDA	Minimum Descent Altitude
MDS	Mission Design Series
MEA	Minimum En Route Altitude
mHz	MilliHertz
MHz	Megahertz
MIRL	Medium Intensity Runway Lighting
MLS	Microwave Landing System
MM	Middle Marker
MMLS	Mobile Microwave Landing System
MOA	Military Operations Area
MOCA	Minimum Obstruction Clearance Altitude
MRA	Minimum Reception Altitude
MSL	Mean Sea Level
MVA	Minimum Vectoring Altitude
NACO	National Aeronautical Charting Office
NAS	National Airspace System
NATS	North Atlantic Track System
NATO	North Atlantic Treaty Organization
NAVAID	Navigational Aid
NDB	Nondirectional Beacon
NGA	National Geospatial-Intelligence Agency
NM	Nautical Miles
NoPT	No Procedure Turn Required
NOTAM	Notices to Airmen

NRP	National Route Plan
NRS	Navigation Reference System
NTAP	Notices to Airmen Publication
NTZ	No Transgression Zone
NVG	Night Vision Goggles
ODP	Obstacle Departure Procedure
OBS	Omni Bearing Selector
OIS	Obstacle Identification Surface
OM	Outer Marker
PANS-OPS	Procedures for Air Navigation Services-Aircraft Operations
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PFR	Primary Flight Reference
PIC	Pilot in Command
PPS	Precise Porsitioning
PRN	Pseudo Random Noise
PT	Procedure Turn
P (y)	Precision Global Positioning System Code
RA	Resolution Advisory
Radar	Radio Detecting and Ranging
RAIM	Random Autonomous Integrity Monitoring
REIL	Runway End Identifier Lights
RMI	Radio Magnetic Indicator
RNAV	Area Navigation
RNP	Required Navigation Performance
ROA	Remotely Operated Aircraft
ROC	Required Obstacle Clearance
RPI	Runway Point of Intercept
rpm	Revolutions per minute
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimums
SARPS	Standards and Recommended Practices
SAS	Stability Augmentation System
SD	Spatial Disorientation
SDF	Simplified Directional Facility
SDP	Special Departure Procedure
SDP	Standard Datum Plane
SID	Standard Instrument Departure
SIF	Selective Identification Feature
SM	Statute Miles
SNOWTAM	Snow/Ice Notices to Airmen
SOIA	Simultaneous Offset Instrument Approaches
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival

STIF	Special Theater Information Files
SVN	Satellite Vehicle Number
TAA	Terminal Arrival Areas
TACAN	Tactical Air Navigation
TAS	True Airspeed
TCAS	Traffic Collision Alert System
TCH	Threshold Crossing Height
TCN	Terminal Change Notice
TDZE	Touchdown Zone Elevation
TERPs	Terminal Instrument Procedures
TF	Track to Fix
TFR	Temporary Flight Restriction
TLS	Transponder Landing System
TMN	True Mach Number
TO	Technical Order
TSO	Technical Standard Order
TWEB	Transcribed Weather Broadcast
UE	User Equipment
UHF	Ultra High Frequency
UIR	Upper Information Regions
UPT	Undergraduate Pilot Training
USA	United States Army
USAF	United States Air Force
USN	United States Navy
USNS	US NOTAM System
UTC	Universal Time Coordinated
VA	Heading to Altitude
VASI	Visual Approach Slope Indicator
VDP	Visual Descent Point
VFR	Visual Flight Rules
VGSI	Vertical Glide Slope Information
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VORTAC	VHF Omnidirectional Range/Tactical Air Navigation
VOT	VOR Test Facility
VV	Velocity Vector
VVI	Vertical Velocity Indicator
WAAS	Wide-Area Augmentation System
WP	Waypoint
WRS	Wide-Area Ground Reference Station
WMS	Wide area Master Station

Attachment 2

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