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AIR FORCE MANUAL 11-217

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Flying Operations

FLIGHT OPERATIONS

COMPLIANCE WITH THIS PUBLICATION IS MANDATORY

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This Air Force Manual (AFMAN) implements Air Force Policy Directive (AFPD) 11-2, *Aircrew Operations.* This AFMAN applies to individuals at all levels who operate Air Force (AF) aircraft (manned and unmanned), to include civilian and uniformed members of the Regular Air Force, Air Force Reserve and Air National Guard, and pilots assigned to other services or from other nations. Individual aircraft flight manuals should provide detailed instructions required for specific aircraft instrumentation or characteristics. Ensure all records created as a result of processes prescribed in this publication are maintained in accordance with AFMAN 33-363, *Management of Records*, and disposed of in accordance with the Air Force Disposition Schedule located in the Air Force Records Information Management System. Refer recommended changes and questions about this publication to the office of primary responsibility (OPR) using the AF Form 847, *Recommendation for Change of Publication*; route AF Forms 847 from the field through the appropriate functional chain of command. This publication may not be supplemented or further implemented/extended. The authorities to waive wing/unit level requirements in this publication are identified with a Tier ("T-0, T-1, T-2, or T-3") number following the compliance statement. See Air Force Instruction (AFI) 33-360, *Publications and Forms Management*, for a description of the authorities associated with the Tier numbers. Submit requests for waivers through the chain of command in accordance with **paragraph 1.6** of this AFMAN. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

SUMMARY OF CHANGES

This document has been substantially revised and must be completely reviewed. Major changes include: (1) consolidating AFMAN 11-217 Volumes 1 through 3, (2) removing "***bold italic***" formatting throughout, (3) integrating International Civil Aviation Organization (ICAO) guidance throughout, (4) reorganizing chapter order for better information flow, (5) identifying tier compliance items per AFI 33-360, (6) adopting AF Form 679, *Air Force Publication Compliance Item Waiver Request/Approval*, (7) and correcting administrative and grammatical errors.

Chapter 1

OVERVIEW

1.1. General. As a charter member of ICAO, the United States has fully supported the organization's goals from its inception in 1947. ICAO works to achieve the highest level of standards and procedures for aircraft, personnel, airways, and aviation services throughout the world. ICAO oversees the international standards for navigation facilities, airfields, weather, and radio services adhered to by more than 190 Member Nation States. Through active support and participation in ICAO, the Federal Aviation Administration (FAA) strives to improve worldwide safety standards and procedures. ICAO's strategic objectives are to continue to establish and maintain standards and recommended practices (SARP) for the safe and orderly development of international aviation. The 19 ICAO annexes contain more than 10,000 adopted SARPs.

1.2. Scope. This AFMAN is designed to complement AFI 11-202 Volume 3, *General Flight Rules*. AFI 11-202V3 takes precedence when there is conflict with this AFMAN.

1.2.1. AFI 11-202V3 consolidates ICAO SARPs, the U.S. Code of Federal Regulations (CFR), FAA advisory circulars (AC), and United States Air Force (USAF) guidance for pilots.

1.2.1.1. Basic civil aviation information for the national airspace system (NAS) available in the *Aeronautical Information Manual* (AIM) is not duplicated in this AFMAN; additional information available in FAA-H-8083-15, *Instrument Flying Handbook*, FAA-H-8083-16, *Instrument Procedures Handbook*, and FAA-H-8083-25, *Pilot's Handbook of Aeronautical Knowledge*. FAA handbooks and resources may be found on the FAA website at **https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/**.

1.2.1.2. Differences between USAF and FAA aviation information are provided in this AFMAN; important ICAO aviation information is also duplicated for ease of access. This AFMAN has been written to focus on worldwide operations; items that are specific to the NAS are annotated accordingly (e.g., "(NAS only)").

1.2.2. This AFMAN provides broad guidance and cannot address every situation. Pilots should exercise sound judgment to safely conduct flying operations if something is not expressly prohibited in this AFMAN.

1.3. References to Source Material. Pilots must be familiar with the references to the AIM in this AFMAN. (T-1). Pilots should exercise sound judgment when there is conflict between this AFMAN and the AIM. Other references are provided for information only.

1.3.1. All references are provided inside square brackets and listed without any applicable suffix or version (e.g., "[FAA Order 8260.3]"). References at the beginning of a paragraph apply to the entire paragraph; references at the end of a sentence apply only to that sentence.

1.3.2. This AFMAN is current as of its publication date for the references in **Attachment 1**; however, if a newer version is current, then pilots should refer to the current version (e.g., FAA Order 8260.3D is referenced and FAA Order 8260.3E is current).

1.4. Flight Operations outside the NAS. [ICAO Annex 15] ICAO Member Nation States publish their exceptions to ICAO publications in their individual *Aeronautical Information*

Publication (AIP). Flight information publication (FLIP) *Area Planning* (AP) and the *Foreign Clearance Guide* (FCG) should extract pertinent information from these AIPs; however, aircrew may need to refer directly to the appropriate AIP prior to flying in that Nation State's airspace. Note: The United States is a charter Member Nation State of ICAO; the FAA publishes an AIP which lists exceptions that apply within the NAS.

1.5. Flight Operations within the NAS. [FAA Pilot/Controller Glossary; U.S. AIP] The NAS is the airspace, air navigation facilities, and airfields of the United States. It includes components shared jointly with the military and all associated information, services, rules, regulations, policies, procedures, personnel, and equipment. The U.S. territorial airspace is the airspace over the United States, its territories, and possessions, and the airspace over the territorial sea of the United States, which extends 12 nautical miles (NM) from the baselines of the United States, determined in accordance with international law.

1.6. Waivers. Refer to AFI 33-360. The director of operations, AF/A3O, is the approval authority for any non-tiered directive guidance in this AFMAN. Major commands (MAJCOM) (or subordinate units for Tier 2 and Tier 3 waivers) initiate and staff all waiver packages. Coordination through the Air Force Flight Standards Agency flight directives division (AFFSA/XOF), **hqaffsa.xof@us.af.mil**, is required for Tier 0 and Tier 1 waivers and recommended for Tier 2 and Tier 3 waivers.

1.6.1. AFFSA/XOF will pursue external agency concurrence for Tier 0 waivers and provide results to the requesting MAJCOM (e.g., an exemption granted by the FAA Administrator).

1.6.2. The flying MAJCOMs are Air Combat Command, Air Education and Training Command, Air Force District of Washington, Air Force Global Strike Command, Air Force Materiel Command, Air Force Reserve Command, Air Force Special Operations Command, Air Mobility Command, Defense Intelligence Agency, National Guard Bureau, Pacific Air Forces, and United States Air Forces Europe for the purposes of this instruction. Commanders, Air Force forces in the grade of O-8 or higher in combatant commands are considered MAJCOM commanders only for forces under their operational control.

1.6.3. Accomplish all waivers using the AF Form 679. Once approved, wings will send an informational copy to MAJCOM Standardization/Evaluation and AFFSA/XOF within 5 duty days.

Chapter 2

ROLES AND RESPONSIBILITIES

2.1. General. MAJCOMs may reference the following documents when developing training, guidance, and operational execution procedures to comply with the intent of this instruction:

2.1.1. AC 20-131, *Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS-II) and Mode S Transponders*

2.1.2. AC 20-138, *Airworthiness Approval of Positioning and Navigation Systems*

2.1.3. AC 20-140, *Guidelines for Design Approval of Aircraft Data Link Communication Systems Supporting Air Traffic Services (ATS)*

2.1.4. AC 20-150, *Airworthiness Approval of Satellite Voice (SATVOICE) Equipment Supporting Air Traffic Service (ATS) Communication*

2.1.5. AC 20-151, *Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), Versions 7.0 & 7.1 and Associated Mode S Transponders*

2.1.6. AC 20-167, *Airworthiness Approval of Enhanced Vision System, Synthetic Vision System, Combined Vision System, and Enhanced Flight Vision System Equipment*

2.1.7. AC 90-23, *Aircraft Wake Turbulence*

2.1.8. AC 90-91, *North American Route Program*

2.1.9. AC 90-96, *Approval of U.S. Operators and Aircraft to Operate Under Instrument Flight Rules (IFR) in European Airspace Designated for Basic Area Navigation (B-RNAV) and Precision Area Navigation (P-RNAV)*

2.1.10. AC 90-100, *U.S. Terminal and En Route Area Navigation (RNAV) Operations*

2.1.11. AC 90-106, *Enhanced Flight Vision Systems*

2.1.12. AC 90-107, *Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System*

2.1.13. AC 90-114, *Automatic Dependent Surveillance-Broadcast Operations*

2.1.14. AC 91-85, *Authorization of Aircraft and Operators for Flight in Reduced Vertical Separation Minimum (RVSM) Airspace*

2.1.15. AC 120-28, *Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout*

2.1.16. AC 120-29, *Criteria for Approval of Category I and Category II Weather Minima for Approach*

2.1.17. AC 120-42, *Extended Operations (ETOPS and Polar Operations)*

2.1.18. ICAO Doc 8400, *ICAO Abbreviations and Codes*

2.1.19. Title 14, Code of Federal Regulations, Part 1, *Definitions and Abbreviations*

2.1.20. Title 14, Code of Federal Regulations, Part 121, *Operating Requirements: Domestic, Flag, and Supplemental Operations*

2.1.21. Title 14, Code of Federal Regulations, Part 135, *Operating Requirements: Commuter and on Demand Operations and Rules Governing Persons on Board Such Aircraft*

2.2. MAJCOMs. MAJCOMs will:

2.2.1. Provide aircrew training, ensure aircraft certification, and grant operational approval for RNAV operations and Required Navigation Performance (RNP) operations.

2.2.2. Train aircrews, certify aircraft performance-based communication and surveillance (PBCS) systems, and grant operational approval prior to use for PBCS operations in accordance with AFI 11-202V3.

2.2.3. Publish procedures to ensure that aircraft do not exceed protected airspace if allowing aircraft to fly an instrument approach using a lower category.

2.2.4. Develop programs to ensure aircrew are trained, aircraft are certified, and are granted operational approval for operations within reduced vertical separation minimum (RVSM) airspace. Note: Formation flights are non-RVSM if any aircraft in the formation is non-RVSM.

2.2.5. Develop procedures that account for declared distances during touch-and-go operations.

2.2.6. Develop operational guidance on required visual flight rules (VFR) and low-level navigational chart utilization.

2.2.7. Establish acceptable methods for calculating a derived decision altitude (DDA) if aircraft flight manual guidance does not adequately address DDA (e.g., use of demonstrated altitude lost in a go-around, use of industry practice 50 feet above the MDA as the DDA).

2.2.8. Provide aircraft-specific operational approval and training prior to authorizing operations using NAVAIDs oriented to true or grid north.

2.2.9. Determine the highest allowable latitude for aircraft capable of displaying only magnetic heading for areas north of 70 degrees North and south of 60 degrees South that are not officially designated as areas of magnetic unreliability (AMU).

2.2.10. If required, develop departure procedures for use by specific aircraft and MAJCOM-certified aircrews under specific conditions.

2.2.11. Where necessary, develop programs that may authorize pilots to use a suitable RNAV system or RNP system to navigate on the final approach segment of a conventional instrument approach procedure based on a Very High Frequency Omni-directional Range (VOR), Tactical Air Navigation (TACAN), or Nondirectional Radio Beacon (NDB).

2.2.12. Where necessary, at specific airfields, develop their own approach procedures for use by specific aircraft and MAJCOM-certified aircrews under specific conditions. MAJCOM-certified procedures are in accordance with AFI 11-202V3.

2.2.13. Provide training and operational approval in accordance with AFI 11-202V3 for special aircrew and aircraft certification required approaches. Note: Training and approval for one procedure type does not extend to other procedure types (e.g., operational approval for CAT II procedures does not also authorize Special Authorization CAT I procedures).

2.2.14. Where required, authorize SA CAT II authorized aircrew to continue CAT II operations if the installed touch down zone and/or runway centerline lights fail.

Chapter 3

INSTRUMENT FLYING FUNDAMENTALS

3.1. General. [FAA-H-8083-15 **Chapter 6**; FAA-H-8083-25 **Chapter 3**] Instrument flying is defined as the control of an aircraft's spatial position by using instruments rather than outside visual references (**Figure 3.1**). Aircraft are equipped with analog, digital, mechanical, electronic, or a combination of instruments. Proper interpretation of aircraft instruments in instrument flight provides essentially the same information as outside visual references when in visual flight. Aircraft instrumentation falls into three broad categories: control, performance, and navigation.

Figure 3.1. Attitude Instrument Flying.

3.1.1. Control instruments display immediate attitude and power changes and are calibrated to permit adjustments in precise increments (**Figure 3.2**). Control instruments do not indicate aircraft speed or altitude; refer to performance instruments to determine aircraft performance. Aircraft control is determined by reference to attitude and power indicators.

3.1.1.1. The attitude indicator (AI) displays an aircraft's orientation to the Earth's horizon in its pitch and roll axes.

3.1.1.2. Power indicators vary between aircraft; they may include manifold pressure, tachometers, fuel flow, engine pressure ratio, etc.

Figure 3.2. Control Instruments.

3.1.2. Performance instruments indicate the aircraft's actual performance. Performance is determined by reference to the altimeter, airspeed or Mach indicator, vertical velocity indicator (VVI), heading indicator, angle of attack indicator, and turn and slip indicator (**Figure 3.3**). Performance instruments most directly reflect a change in acceleration, which is defined as change in velocity or direction; these instruments indicate if the aircraft is changing airspeed, altitude, or heading, which are horizontal, vertical, or lateral vectors.

Figure 3.3. Performance Instruments.

3.1.3. Navigation instruments indicate the position of the aircraft in relation to a selected navigation facility, fix, or waypoint. This group of instruments includes various course indicators, range indicators, glideslope indicators, and bearing pointers. Aircraft with more technologically advanced instrumentation provide blended information giving the pilot more accurate positional information. Navigation instruments are comprised of indicators that display navigation information from various ground-based and space-based navigation aids (NAVAID) such as very high frequency (VHF) omni-directional radio range (VOR), tactical air navigation system (TACAN), non-directional beacon (NDB), instrument landing system (ILS), distance measuring equipment (DME), global navigation satellite system (GNSS), and other navigation information. These instruments also enable a pilot to maneuver an aircraft along a predetermined path in two or three dimensions relative to ground-based or space-based navigation facilities.

3.2. Control and Performance Method. Aircraft performance is achieved by controlling the aircraft attitude and power. A pilot accomplishes instrument flight by controlling an aircraft's attitude and power to produce controlled and stabilized flight without reference to a visible horizon. This overall process is known as the "control and performance" method of instrument flying. The control and performance method is applied through the use of control, performance, and navigation instruments, resulting in a smooth flight from takeoff to landing.

3.2.1. The control and performance method has four procedural steps:

3.2.1.1. Establish an attitude and power setting on the control instruments that results in the desired performance.

3.2.1.2. Trim (i.e., fine tune the control surfaces) the aircraft until control pressures are neutralized. Trimming for hands-off flight is essential for smooth, precise aircraft control. It allows a pilot to attend to other flight deck duties with minimum deviation from the desired altitude.

3.2.1.3. Cross-check the performance instruments to determine if the established attitude or power setting is providing the desired performance. The cross-check involves both seeing and interpreting. Determine the magnitude and direction of adjustment required to achieve the desired performance if a deviation is noted.

3.2.1.4. Adjust the attitude, power setting, or both on the control instruments as necessary.

3.2.2. Proper control of aircraft attitude results from proper use of the AI, knowing when to change the attitude, and smoothly changing the attitude a precise amount. The AI provides an immediate, direct, and corresponding indication of any change in aircraft pitch or bank attitude.

3.2.2.1. Changing the "pitch attitude" of the aircraft symbol by precise amounts in relation to the artificial horizon makes pitch changes. These changes are measured in degrees or bar widths depending on the type of AI. The amount of deviation from the pilot's desired performance determines the magnitude of the correction.

3.2.2.2. Changing the "bank attitude" of the aircraft symbol by precise amounts in relation to the bank scale makes bank changes. The bank scale is normally graduated at 0 degrees, 10 degrees, 20 degrees, 30 degrees, 60 degrees, and 90 degrees and may be located at the top or bottom of the AI. Bank angles used for instrument turns are normally the desired number of degrees to turn not to exceed 30 degrees (e.g., 20 degrees of bank for a 20 degree turn, 30 degrees of bank for a 30 degree turn, 30 degrees of bank for a 90 degree turn).

3.2.3. Proper power control is the result of smoothly establishing or maintaining desired airspeeds in coordination with attitude changes. Power changes are made by throttle adjustments while referencing power indicators. Power indicators are not affected by factors such as turbulence, improper trim, or inadvertent control pressures. Experience in an aircraft teaches a pilot approximately how far to move the throttle(s) to change the power a given amount. Knowledge of approximate power settings, cross-checking the power indicator(s), and then fine tuning prevents fixating on performance instruments and over-controlling power.

3.3. Trim. An aircraft is correctly trimmed when it is maintaining a desired attitude with all control pressures neutralized. A pilot can devote more attention to navigation instruments and additional flight deck duties when the aircraft is properly trimmed.

3.3.1. An airplane is placed in trim by:

3.3.1.1. Applying control pressure(s) to establish a desired attitude. Then, the trim is adjusted so that the airplane maintains the desired attitude when the pilot releases the flight controls. The aircraft is trimmed for coordinated flight by centering the ball of the turn-and-slip indicator.

3.3.1.2. Changes in attitude, power, or airspeed may require trim adjustments. Use of trim alone to establish a change in attitude usually results in erratic control. Smooth and precise attitude changes are best achieved through a combination of control pressures and subsequent trim adjustments.

3.3.2. A helicopter is placed in trim by continually cross-checking the instruments and performing the following:

3.3.2.1. Use the cyclic-centering button if the helicopter is so equipped; this relieves all possible cyclic pressures.

3.3.2.2. Use the pedal adjustment to center the ball of the turn indicator. Pedal trim is required during all power changes and is used to relieve all control pressures held after a desired attitude has been achieved.

3.3.2.3. Adjust the pitch attitude as airspeed changes to maintain desired attitude for the maneuver being executed. Adjust the bank to maintain a desired rate of turn; use the pedals to maintain coordinated flight. Adjust the trim as control pressures indicate a change is needed.

3.3.3. An improperly trimmed aircraft requires constant control pressures, produces tension and fatigue, distracts attention from cross-checking, and contributes to abrupt and erratic attitude control. The pressures felt on the controls should be only those applied while controlling the aircraft.

3.4. Instrument Cross-Check. The first fundamental instrument flying skill is cross-checking (also called “scanning” or “instrument coverage”). Cross-checking is the continuous and logical observation of instruments for attitude, performance, and navigation information. The “hub and spoke” method is the recommended cross-check technique. A pilot spends 80 to 90 percent of the flight time looking at the AI (i.e., the “hub”) and takes quick glances at the other instruments (i.e., the “spokes”). In general, the cross-check progresses from the AI, out to another instrument, back to the AI and then out again (**Figure 3.4**).

Figure 3.4. "Hub and Spoke" Cross-check.

3.5. Common Instrument Cross-Check Errors. A beginner might cross-check too rapidly, looking at the instruments without knowing exactly what to look for. Pilots learn what to look for, when to look for it, and what corrections to make with increased experience in basic instrument maneuvers and familiarity with the instrument indications associated with these maneuvers. As proficiency increases, a pilot cross-checks primarily from habit, suiting scanning rate and sequence to the demands of the flight situation. Failure to maintain basic instrument proficiency through practice can result in many of the following common scanning errors, both during training and at any subsequent time.

3.5.1. Fixating, or staring at a single instrument, is a common and dangerous error. For example, if one flight parameter, (e.g., altitude) is frequently wandering, the pilot may devote too much time to the corresponding performance instrument (e.g., altimeter) and lose track of other critical parameters (e.g., attitude). While fixated on the instrument, increasing tension may be unconsciously exerted on the controls, which leads to an unnoticed change that may lead to more errors.

3.5.2. Omission of an instrument from the cross-check, may be caused by failure to anticipate significant instrument indications. For example, if the pilot neglects to check the heading indicator for constant heading information when straight-and-level flight is established with reference only to the AI during a roll-out from a 180 degree steep turn. Because of precession error, the AI temporarily shows a slight error, correctable by quick reference to the other flight instruments.

3.5.3. Emphasis on a single instrument, instead of the combination of instruments necessary for attitude information, is an understandable fault during the initial stages of training. It is a natural tendency to rely on the instrument that is most readily understood, even when it provides erroneous or inadequate information. Reliance on a single instrument is a poor technique. For example, a pilot a can maintain reasonably close altitude control with the AI but cannot hold altitude with precision without including the altimeter in the cross-check.

3.6. Instrument Interpretation. The second fundamental skill, instrument interpretation, requires more thorough study and analysis. It begins by understanding each instrument's construction and operating principles. Then, this knowledge is applied to the performance of the aircraft being flown, the maneuvers to be executed, the cross-check and control techniques applicable to that aircraft, and the flight conditions.

3.6.1. As the performance capabilities of the aircraft are learned, a pilot interprets the instrument indications appropriately in relation to the attitude of the aircraft.

3.6.2. If the pitch attitude is to be determined, the airspeed indicator, altimeter, VVI, and AI provide the necessary information.

3.6.3. If the bank attitude is to be determined, the heading indicator, turn coordinator, and AI provide the necessary information.

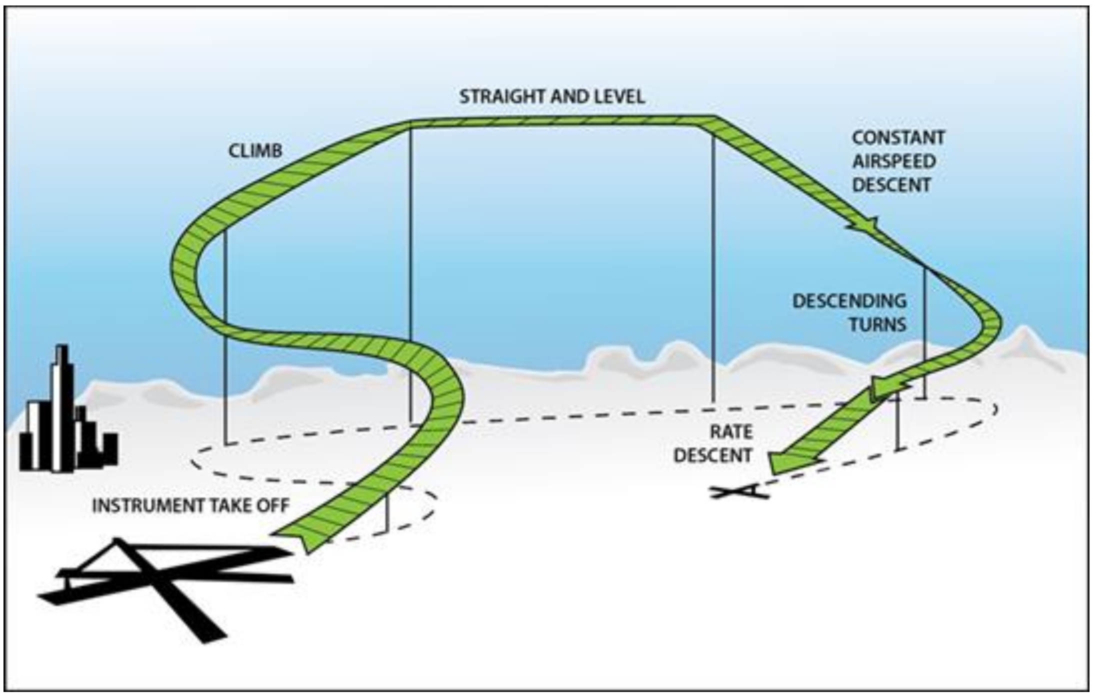
3.6.4. For each maneuver, the pilot learns what performance to expect and the combination of instruments to be interpreted to control aircraft attitude during the maneuver.

Chapter 4

INSTRUMENT MANEUVERS

4.1. General. [FAA-H-8083-15 **Chapter 7** (Fixed Wing)/**Chapter 8** (Helicopter)] Pilots most commonly use the maneuvers in this chapter during instrument flight (**Figure 4.1**). A high level of proficiency employing these maneuvers is necessary to operate safely in instrument conditions. Additional maneuvers may be required for specific training requirements or helicopter operations; refer to applicable sections of the aircraft flight manual for detailed information.

Figure 4.1. Typical Instrument Flight.



4.2. Instrument Takeoff. [FAA-H-8083-15 **Chapter 7**] The instrument takeoff is accomplished by referring to both outside visual references and the flight instruments. The amount of attention given to each reference varies depending on the existing weather conditions. Instrument takeoff procedures and techniques are invaluable aids at night, toward and over water or desolate areas, and during periods of reduced visibility. Immediately transition to instrument references any time disorientation is suspected or when outside visual references become unreliable.

4.3. Instrument Navigation. [FAA-H-8083-15 **Chapter 9**] Understanding navigation systems provides the framework for all instrument procedures. FAA-H-8083-15 provides background information for course intercept, maintaining course, station passage, and arc/radial intercept.

4.4. Proceeding Direct. Pilots will not file a flight plan nor accept a clearance that requires an aircraft to navigate direct to a fix (i.e., radial/DME or radial/radial) unless the primary navigation equipment onboard the aircraft is certified for the appropriate area navigation capability. (T-0). Pilots of aircraft without the appropriate area navigation capability will reply with "unable" when given a clearance to proceed direct to a fix. (T-0). Air traffic control (ATC) should provide radar vectors or an alternate routing under these circumstances.

4.5. Instrument Flying Maneuvers. Detailed descriptions of instrument flying maneuvers may be found in FAA-H-8083-15.

4.5.1. Climbing and descending maneuvers can be performed as constant airspeed or constant rate. The constant airspeed maneuver is accomplished by setting power and varying pitch to maintain a specific airspeed. The constant rate maneuver is accomplished by varying both pitch and power to maintain a specific airspeed and vertical velocity. Either type of climb or descent may be performed while maintaining a constant heading or while turning and should be practiced at airspeeds, configurations, and ascent or descent rates used in actual instrument flight.

4.5.1.1. Most aircraft have a standard set of pitch and power settings for certain airspeeds and configurations. For instance, to maintain 300 knots in a clean configuration, an aircraft might require 10 degrees nose down pitch at idle power. A pilot might also know that for that aircraft, each degree of pitch change at a constant power setting and configuration changes the airspeed 10 knots.

4.5.1.2. To perform a constant airspeed climb or descent, make a smooth and simultaneous change in pitch and power corresponding to the desired airspeed and configuration. Once the initial attitude is established, fine-tune the airspeed by adjusting pitch. Confirm the pitch change by noting a change on the VVI and wait for the airspeed to stabilize. Continue this process until the desired airspeed is attained.

4.5.1.3. Rate climbs and descents are like constant airspeed climbs and descents but require a constant VVI. An effective instrument cross-check and minor power adjustments allow a pilot to fine-tune the descent profile.

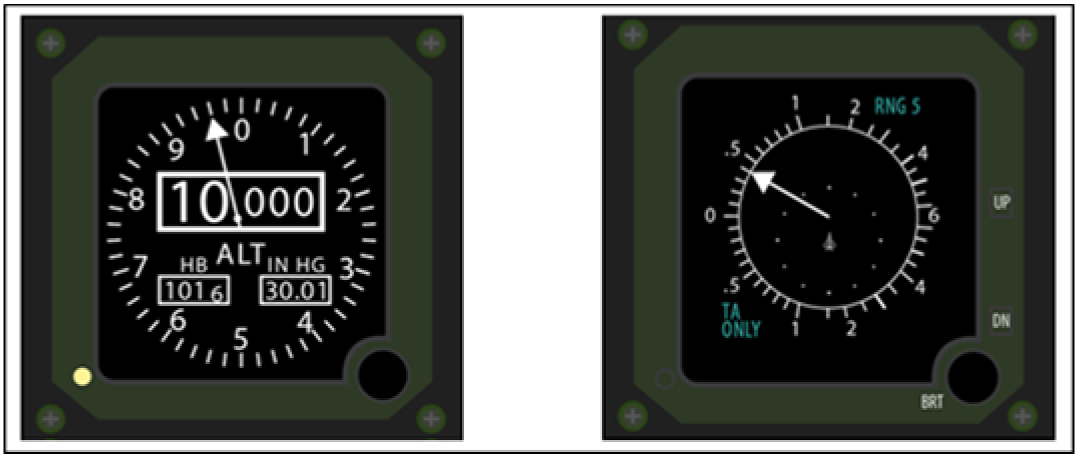
4.5.2. Straight and level un-accelerated flight consists of maintaining desired altitude, heading, and airspeed.

4.5.2.1. Maintain altitude by setting a specific pitch on the AI that maintains the desired altitude. As airspeed decreases, a higher pitch attitude is required to maintain altitude due to the loss of lift. Conversely, higher airspeeds require lower pitch attitudes. Each aircraft has basic pitch and power settings to maintain altitude and airspeed which may change slightly with changes in atmospheric conditions.

4.5.2.2. While maintaining altitude, continue the instrument cross-check. If the altimeter or VVI indicate an altitude deviation, a pitch change is necessary. For small deviations, use control pressure rather than movement to make smooth and small pitch changes. Use trim to reduce control forces once the desired pitch is set. This allows the performance instruments time to display the new parameter before making an additional correction. Common errors include “chasing” the VVI and making erratic or large control inputs. Make another small and smooth pitch correction on the AI to level off. The attitude should be slightly different than the original pitch setting held when the altitude deviation occurred.

4.5.2.3. When making pitch corrections, a VVI one to two times the amount of the altitude deviation prevents overshoots (e.g., if 100 feet off altitude, set a pitch that produces a 100 to 200 foot per minute climb or descent on the VVI). Approaching the desired altitude, begin the pitch change to level off at approximately 10% of the vertical rate. (**Figure 4.2**).

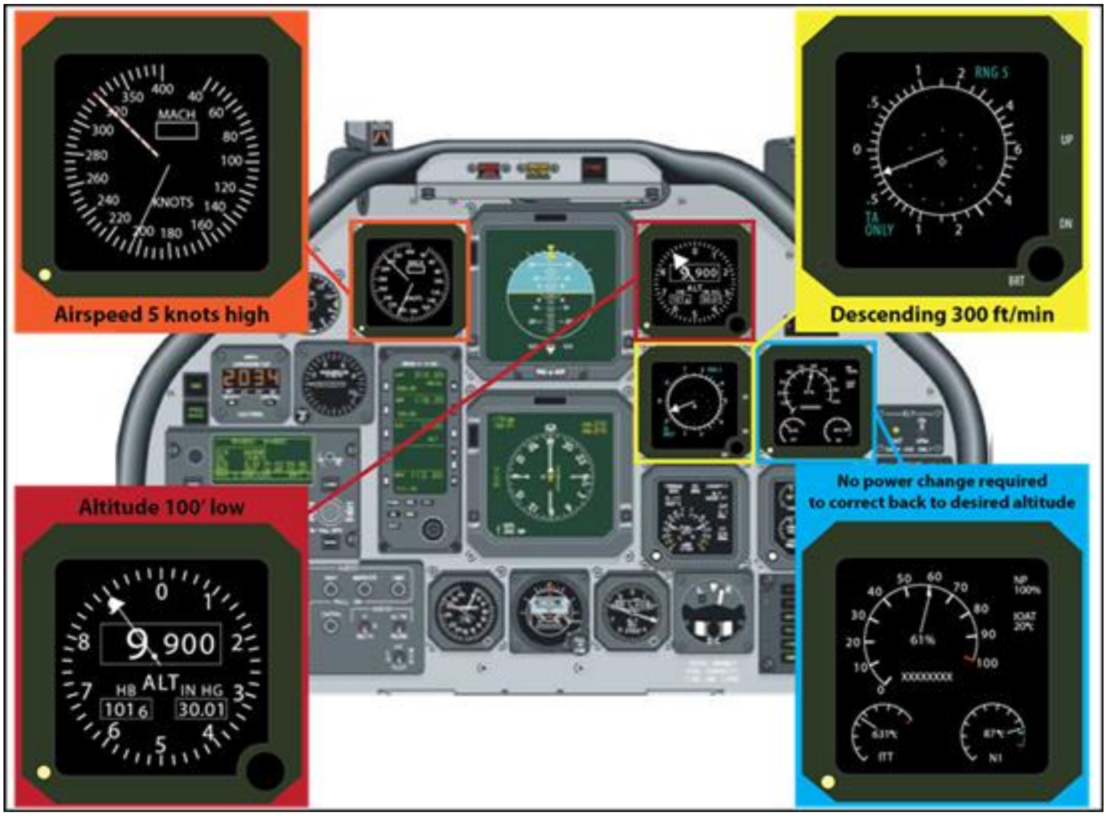
Figure 4.2. Leading the Level Off.



4.5.2.4. Maintaining a desired heading is accomplished by maintaining a zero-bank attitude in coordinated flight. If a heading deviation occurs, make a smooth bank change on the AI to return to the desired heading. As a guide, the bank attitude change on the AI should equal the heading deviation in degrees, not to exceed 30 degrees (e.g., if the heading deviation is 10 degrees, then use 10 degrees of bank). At higher true airspeeds, a larger bank may be needed to prevent an excessive course deviation. **Note:** If maintaining zero bank attitude on the AI and the heading changes, the AI may be "precessing." Confirm this by referencing backup AIs. If precession is noted, it may be necessary to transition to the backup AI depending on the severity of the precession.

4.5.2.5. Maintain airspeed by referring to the airspeed or Mach indicator and adjust the power, drag devices (for large airspeed changes), or aircraft attitude. Known pitch and power settings required for desired airspeed and attitude aid in determining adjustments. An effective instrument cross-check indicates if subsequent power adjustments are required after establishing the approximate initial power setting. **Note:** An airspeed deviation may be the result of a pitch change, not an incorrect power setting (**Figure 4.3**). Check all other flight parameters when an airspeed deviation occurs. Conversely, if in level flight and a power change is necessary to correct airspeed, the new power setting or the employment of drag devices coupled with a change in airspeed may induce a climb or descent and require an attitude correction to maintain level flight. This relationship between airspeed and aircraft attitude requires an effective instrument cross-check.

Figure 4.3. Airspeed Deviation.

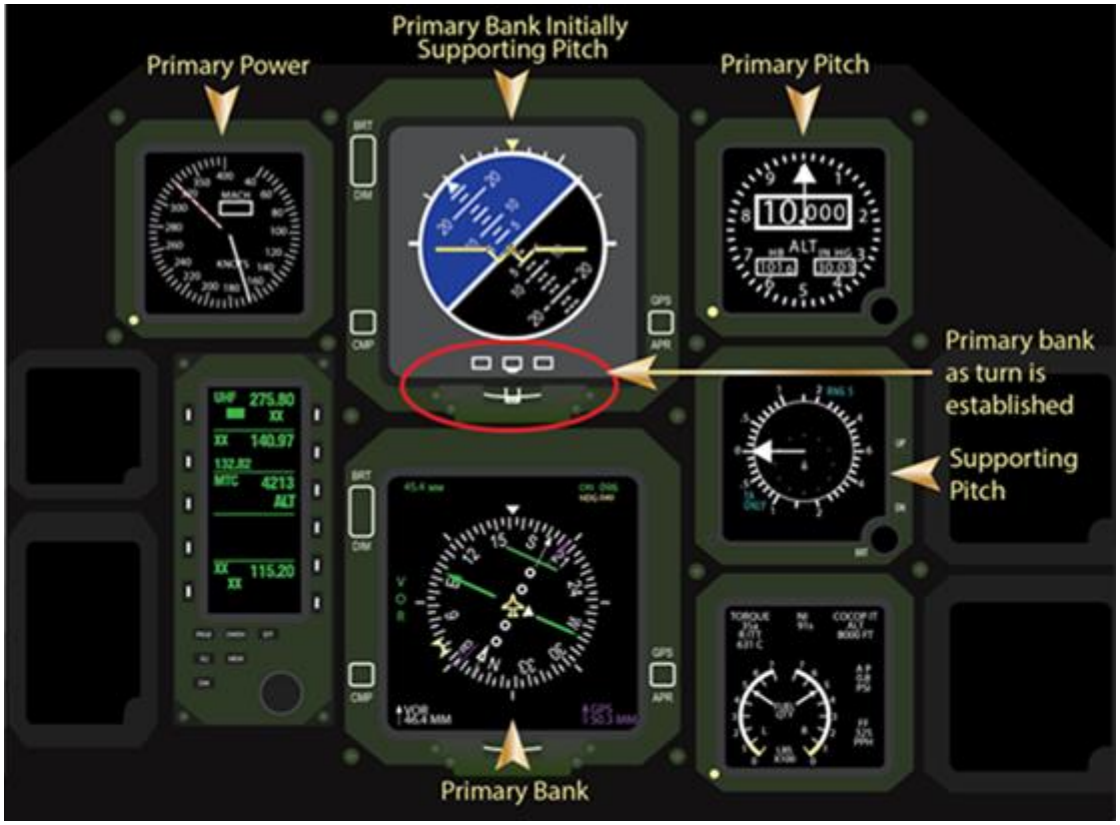


4.5.3. The pitch, bank, and power principles discussed in maintaining straight and level flight apply while performing level turns (**Figure 4.4**). Performing a level turn requires an understanding of several factors: entering the turn; maintaining bank, altitude, and airspeed during the turn; and returning to level flight. A "standard rate turn" is defined as a rate at which the aircraft makes a 360 degree turn in 120 seconds.

4.5.3.1. To prevent heading overshoots, for heading changes of less than 30 degrees, the bank angle should equal the number of degrees to be turned. For heading changes of more than 30 degrees, use a bank angle of 30 degrees. Instrument procedures, high airspeeds, flight manual procedures, or airspace may require other angles of bank. Helicopters should use no more than standard rate turns (15 degrees to 20 degrees) when operating between 80 and 120 knots.

4.5.3.2. To enter a turn, refer to the AI while applying smooth and coordinated control pressures to establish the desired angle of bank. It is normally necessary to increase pitch slightly to counteract the loss of vertical lift due to the bank. The increased pitch in prolonged turns requires consistent back pressure on the elevator control. Trimming off the pressure on the elevator aids in smooth aircraft control and enhance cross-check capability in the turn. Additionally, to maintain airspeed, an increase in power is required to counteract the induced drag produced by the elevator inputs. The bank, pitch change and power increase should all be applied smoothly as the aircraft enters the turn to prevent the need for large corrections during the turn.

Figure 4.4. Level Turns.



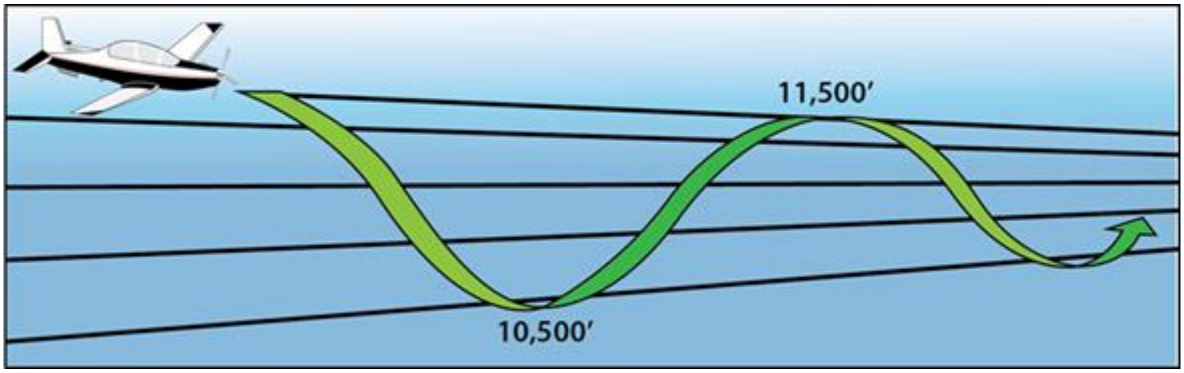
4.5.3.3. To roll out on a desired heading, calculate a lead point that is approximately one-third the angle of bank used in the turn (e.g., if making a 30 degrees bank turn, begin roll out at 10 degrees of heading prior to the desired final heading). Upon reaching the lead point, smoothly and simultaneously reverse the bank, pitch, trim, and power inputs used to roll into the turn. Once on the new heading, check for deviations from straight and level flight and apply corrections as needed.

4.5.4. Steep turns, defined as any turn greater than 30 degrees of bank are practiced in simulated instrument conditions. The control inputs for steep turn entry and exit are identical to a normal turn except all inputs are more pronounced. The increased bank requires more pitch, more back pressure, and more power to counteract the further reduced vertical lift and increased induced drag. The rate of turn is much faster in a steep turn and requires a more aggressive lead point. For helicopters, any rate greater than standard is considered a steep turn; most helicopters practice steep turns using 30 degrees of bank, which is the maximum angle of bank recommended under instrument conditions.

4.6. The "Vertical S". The "Vertical S" maneuvers are proficiency maneuvers designed to improve cross-check and aircraft control necessary for the different phases of instrument flight. Each may be flown utilizing various configurations, airspeeds, rates, etc.

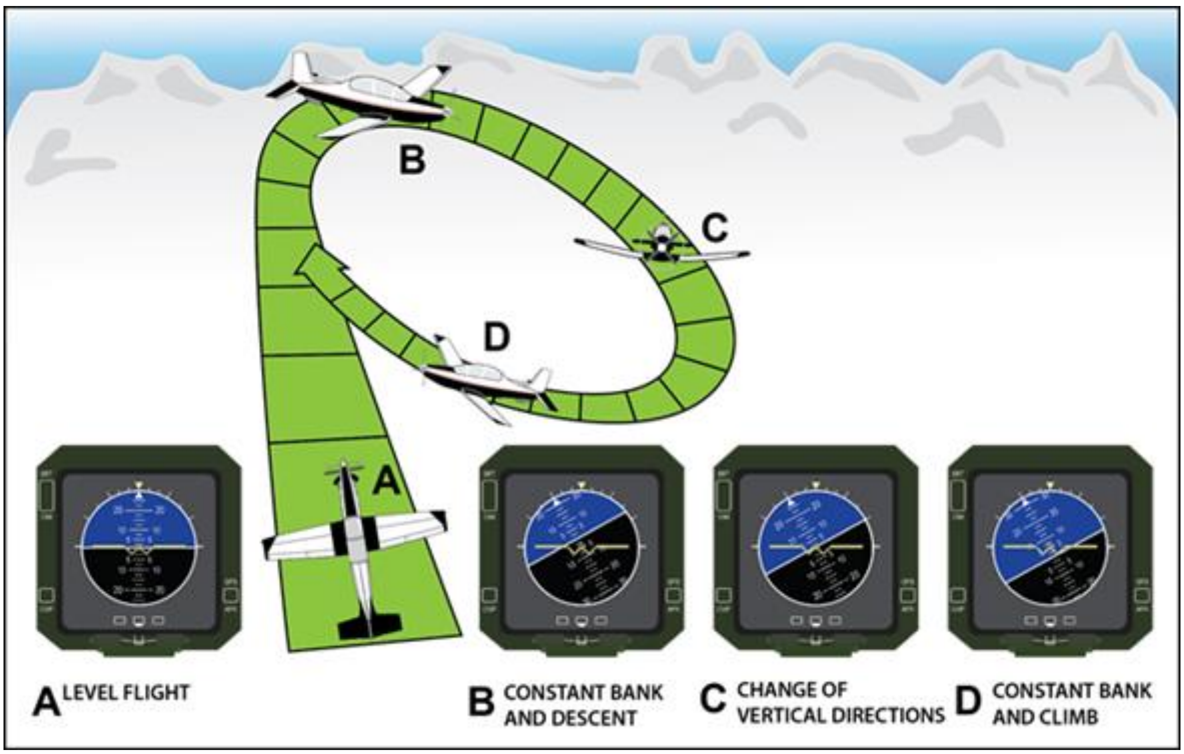
4.6.1. The "Vertical S Alpha" is a continuous series of rate climbs and descents flown on a constant heading utilizing a vertical velocity compatible with aircraft performance (**Figure 4.5**).

Figure 4.5. Vertical S Alpha.



4.6.2. The "Vertical S Bravo" is the same as the Vertical S Alpha except that a constant angle of bank is maintained during the climb and descent (**Figure 4.6**). The angle of bank used should be compatible with aircraft performance (e.g., usually that required for a normal turn). The turn is established simultaneously with the initial climb or descent.

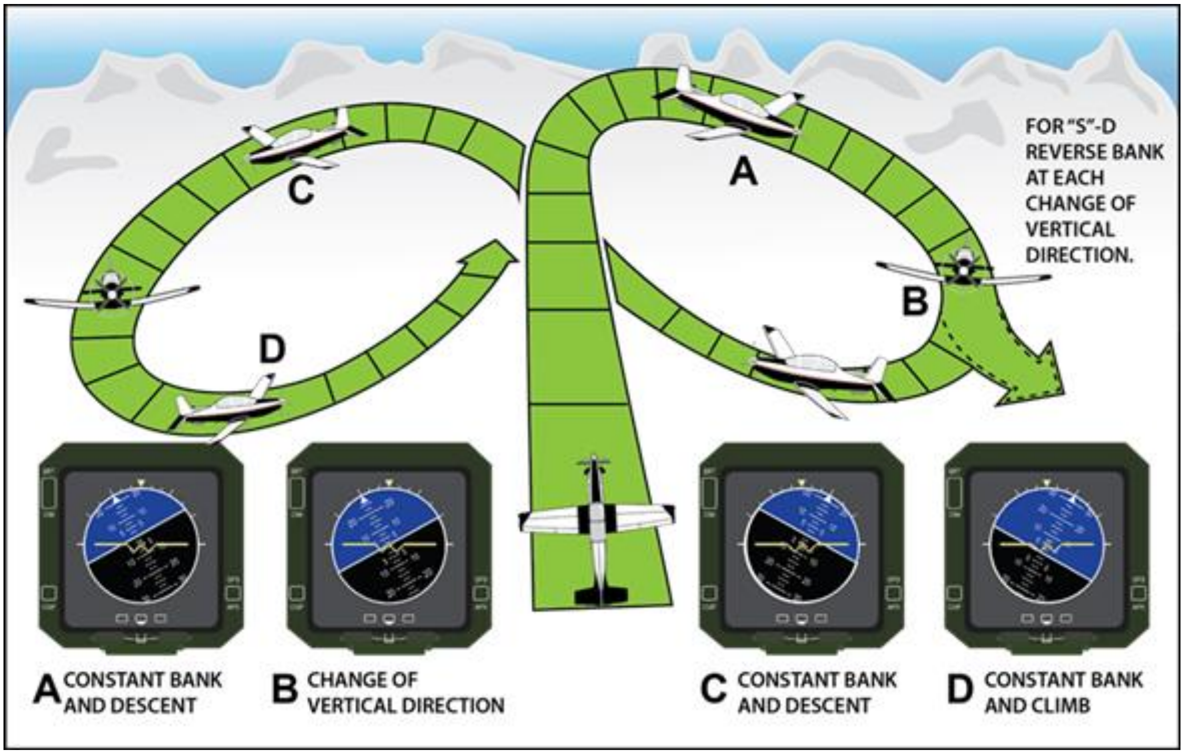
Figure 4.6. Vertical S Bravo.



4.6.3. The "Vertical S Charlie" is the same as Vertical S Bravo, except that the direction of turn is reversed at the beginning of each descent (**Figure 4.7**). Enter the Vertical S Charlie in the same manner as the Vertical S Bravo.

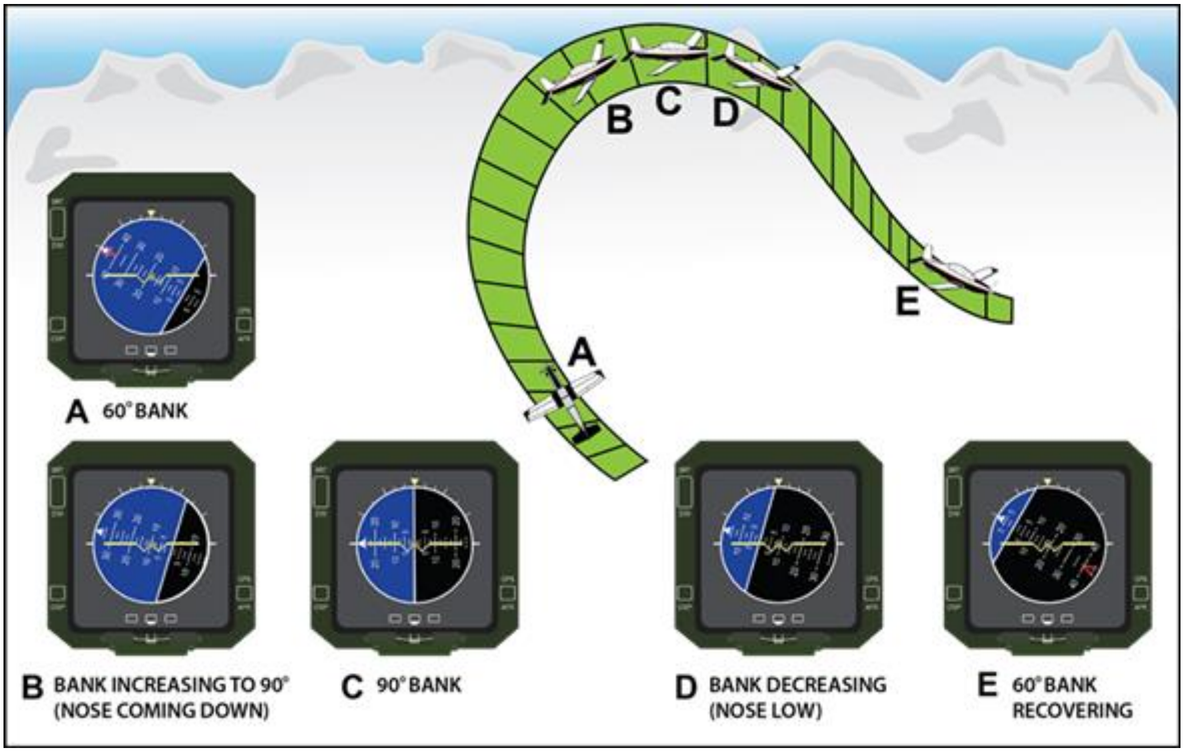
4.6.4. The "Vertical S Delta" is the same as the Vertical S Charlie, except that the direction of turn is reversed simultaneously with each change of vertical direction (**Figure 4.7**). Enter the Vertical S Delta in the same manner as the Vertical S Bravo or Charlie.

Figure 4.7. Vertical S Charlie and Delta.



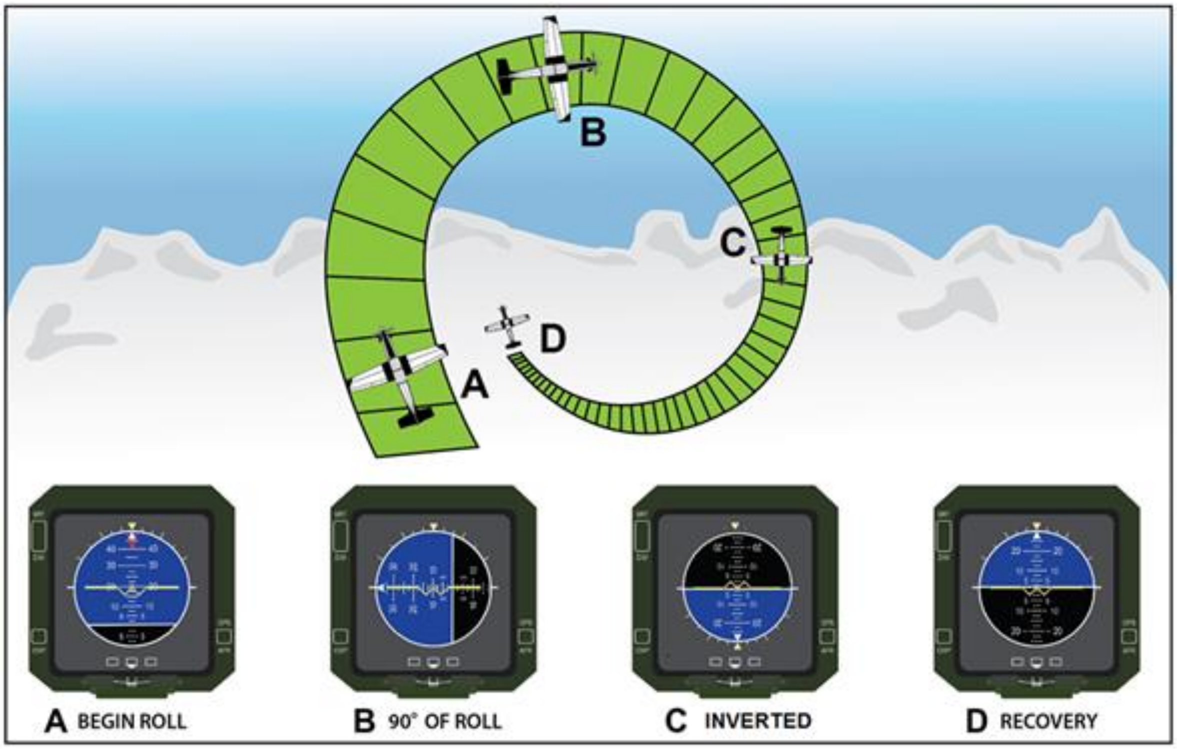
4.7. Wingover. Begin the wingover maneuver from straight and level flight (**Figure 4.8**). After obtaining the desired airspeed, start a climbing turn in either direction while maintaining the wing tip of the miniature aircraft on the horizon bar until reaching 60 degrees of bank. Allow the nose of the aircraft to start down while continuing to increase the angle of bank, planning to arrive at 90 degrees 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 degrees 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 AI.

Figure 4.8. Wingover.



4.8. Aileron Roll. Begin the aileron roll maneuver from straight and level flight (**Figure 4.9**). After obtaining the desired airspeed, smoothly increase the pitch attitude with the wings level 15 degrees to 25 degrees nose up on the AI. Start a roll in either direction and adjust the rate of roll so that, when inverted, the wings are level as the fuselage dot of the miniature aircraft passes through the horizon bar. Continue the roll and recover to level flight. The entire maneuver should be accomplished by reference to the AI. Use sufficient back pressure to maintain normal seat pressures throughout **the maneuver.**

Figure 4.9. Aileron Roll.



4.9. Unusual Attitudes. An unusual attitude is an aircraft attitude which occurs inadvertently, is not normally required for instrument flight, or is not anticipated.

4.9.1. Immediately transition to instrument references if disoriented or when outside visual references become unreliable. Recognizing an unusual attitude is critical to a successful recovery.

4.9.2. Recognize an unusual attitude in one of two ways – an unusual attitude "picture" on the AI or unusual performance on the performance instruments.

4.9.3. Confirm that an unusual attitude exists by comparing control and performance instrument indications prior to initiating recovery on the AI. This precludes entering an unusual attitude because of correcting for erroneous instrument indications. Use additional independent attitude indicating sources (standby AI, copilot's AI, etc.) to verify the actual aircraft attitude. If there is any doubt as to proper AI operation, then recover using AI inoperative procedures.

4.9.4. The recovery actions should be compatible with the severity of the unusual attitude, the characteristics of the aircraft, and the altitude available for the recovery. The following aerodynamic principles and considerations are applicable to the recovery from unusual attitudes:

4.9.4.1. Reducing bank in a dive or increasing bank in a climb aids pitch control.

4.9.4.2. Power and drag devices used properly aid airspeed control if the aircraft flight manual allows their use in unusual attitude situations.

4.9.4.3. During unusual attitude recoveries, unless necessary to avoid a greater emergency, ensure bank and power do not exceed aircraft limitations.

4.9.4.4. For AI with a bank pointer and bank scale at the top, the bank pointer that is always aligned above and perpendicular to the surface of the earth is considered a sky pointer. Rolling towards the sky pointer to place it in the upper half of the case corrects an inverted attitude.

4.9.4.5. For AI with the bank scale at the bottom, rolling in the direction that places the pitch reference scale right side up corrects an inverted attitude.

4.9.5. Night vision devices (NVDs) may be distracting during unusual attitude recoveries. Once transition to instruments has occurred, do not rely on outside NVG cues until the aircraft is recovered.

4.9.6. Spatial disorientation may become severe during the recovery from an unusual attitude with an inoperative AI. Unusual attitudes may result in excess loss of altitude and possible loss of aircraft control.

4.9.7. Due to limited attitude information, recovery from unusual attitudes using a head-up-display (HUD) or a helmet mounted display (HMD) may be difficult or impossible.

4.10. Fixed-wing Unusual Attitudes – AI Operative. For fixed-wing aircraft, use the following procedures if specific unusual attitude recovery procedures are not in the flight manual:

4.10.1. If diving, adjust power and drag devices as appropriate while rolling to a wings level, upright attitude, and correct pitch to level flight on the AI. Do not add back pressure until the aircraft is less than 90 degrees of bank.

4.10.2. If climbing, use power and bank as necessary to assist pitch control and avoid negative loads on the aircraft. As the AI airplane symbol approaches the horizon bar, adjust bank, power, and pitch to complete recovery and establish the desired aircraft attitude. Exercise care when recovering from a steep climb to avoid exceeding bank limitations.

4.11. Fixed-wing Unusual Attitudes – AI Inoperative. Successful recovery from unusual attitudes depends greatly on pilot proficiency and early recognition of AI failure. AI failure should be immediately suspected if control pressures are applied without corresponding AI changes or performance instrument indications contradict the “picture” on the AI. The following procedures are recommended should an unusual attitude be encountered without any functioning AIs:

4.11.1. If the aircraft flight manual allows and an available autopilot is not slaved to gyros of the malfunctioning AI, consideration may be given to engaging the autopilot and setting it to straight and level flight. If airspeed or vertical velocity are excessive, use the procedures below to return the aircraft to acceptable flight parameters before attempting to engage the autopilot.

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

4.11.3. If climbing, use power as required. If the airspeed is low or decreasing rapidly, pitch control may be aided by maintaining or rolling into a turn of approximately standard rate on the turn needle until reaching level flight.

4.11.4. If diving, roll to center the turn needle and recover from the dive. Adjust power and/or drag devices as appropriate. Except for vertical attitudes, rolling “away” from the turn needle or turn coordinator and centering it results in an upright attitude.

4.11.5. 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 through level flight.

4.12. Helicopter Unusual Attitudes – AI 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 aircraft flight manual:

4.12.1. Determine whether the aircraft is in a climb, dive, or hover by referring to the airspeed, altimeter, and VVI.

4.12.2. If climbing, consider pitch attitude and airspeed. If the inadvertent pitch attitude is not extreme (10 degrees or less from level flight), smoothly lower the miniature aircraft back to a level flight indication, level the wings, and resume a normal cross-check using power as required. For extreme pitch attitudes (above 10 degrees), bank the aircraft in the shorter direction toward the nearest 30 degrees bank index. The amount of bank used should be commensurate with the pitch attitude and external conditions, but do not exceed 30 degrees 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.

4.12.3. 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 AI. Adjust power as necessary and resume a normal cross-check.

4.12.4. 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 instrument takeoff, 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.

4.12.5. For helicopters encountering an unusual attitude resulting from blade stall, reduce collective before applying attitude corrections if the aircraft is in a climbing unusual attitude. This aids 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 loading which could lead to additional unusual attitudes or aircraft structural damage.

4.13. Helicopter Unusual Attitudes – AI Inoperative. With an inoperative AI, successful recovery from unusual attitudes depends greatly on pilot proficiency and early recognition of AI failure. For example, AI failure should be immediately suspected if control pressures are applied for a turn without corresponding AI changes or performance instrument indications that contradict the "picture" on the AI. Should an unusual attitude be encountered without an AI, the following procedures are recommended:

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

4.13.2. 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.

4.13.3. 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 results in an upright attitude.

4.13.4. 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

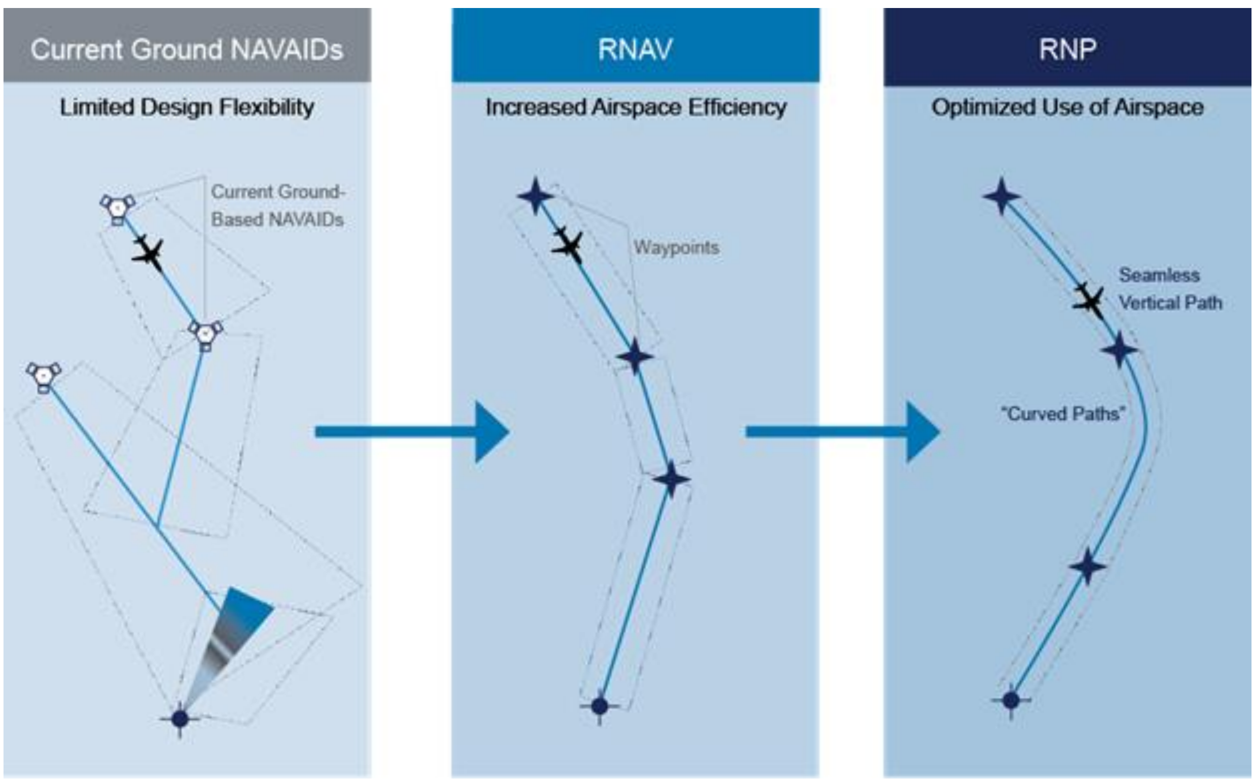
PERFORMANCE-BASED NAVIGATION

5.1. General. [ICAO Doc 9613; AC 90-105; AIM 1-2-2] The performance-based navigation (PBN) concept specifies that aircraft area navigation and required navigation performance (RNP) system performance requirements be defined in terms of the accuracy, integrity, continuity and functionality needed for operations in a defined airspace (**Figure 5.1**). It represents a shift from sensor-based navigation (i.e., the navigation source, such as TACAN, is specified) to performance-based navigation (i.e., the required performance level is specified).

5.1.1. Two fundamental aspects of any PBN operation are the requirements set out in the appropriate navigation specification and the NAVAID infrastructure (both ground-based and space-based) allowing the system to operate.

5.1.2. Performance requirements are identified in navigation specifications. Navigation specifications identify the choice of sensors and equipment that may be used to meet performance requirements. These navigation specifications are defined at a sufficient level of detail to facilitate global harmonization by providing specific implementation guidance.

Figure 5.1. Progression from Sensor-based to Performance-based Navigation.



5.2. Area Navigation (RNAV) Operations and RNP Operations. [AIM 1-2-1 through AIM 1-2-4; AIM 5-1-16; AIM 5-5-16] MAJCOMs will provide aircrew training, ensure aircraft certification, and grant operational approval for RNAV operations and RNP operations.

5.3. PBN Context. PBN is one of several enablers of an airspace concept. Communications, air traffic services (ATS) surveillance, and air traffic management are also essential elements of an airspace concept.

5.3.1. PBN relies on area navigation and includes three components:

5.3.1.1. The NAVAID infrastructure;

5.3.1.2. The navigation specification; and

5.3.1.3. The navigation application.

5.3.2. The navigation application results from applying the NAVAID infrastructure and navigation specification to routes and instrument procedures within an airspace concept.

5.4. Fundamental PBN Concepts. The following concepts are fundamental to a solid understanding of PBN:

5.4.1. **RNAV specification** – a navigation specification based on area navigation that does not include the requirement for on-board performance monitoring and alerting, designated by the prefix “RNAV” (e.g., RNAV 5, RNAV 1).

5.4.2. **RNP specification** – a navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting, designated by the prefix “RNP” (e.g., RNP 4, RNP 0.3).

5.5. Navigation Functional Requirements. Both RNAV specifications and RNP specifications include requirements for certain navigation functionalities. More sophisticated navigation specifications include the requirement for navigation databases and the capability to execute database procedures. At the basic level, these functional requirements may include:

5.5.1. Continuous indication of aircraft position relative to track displayed to the pilot flying on a navigation display situated in the primary field of view;

5.5.2. Display of distance and bearing to the active TO waypoint;

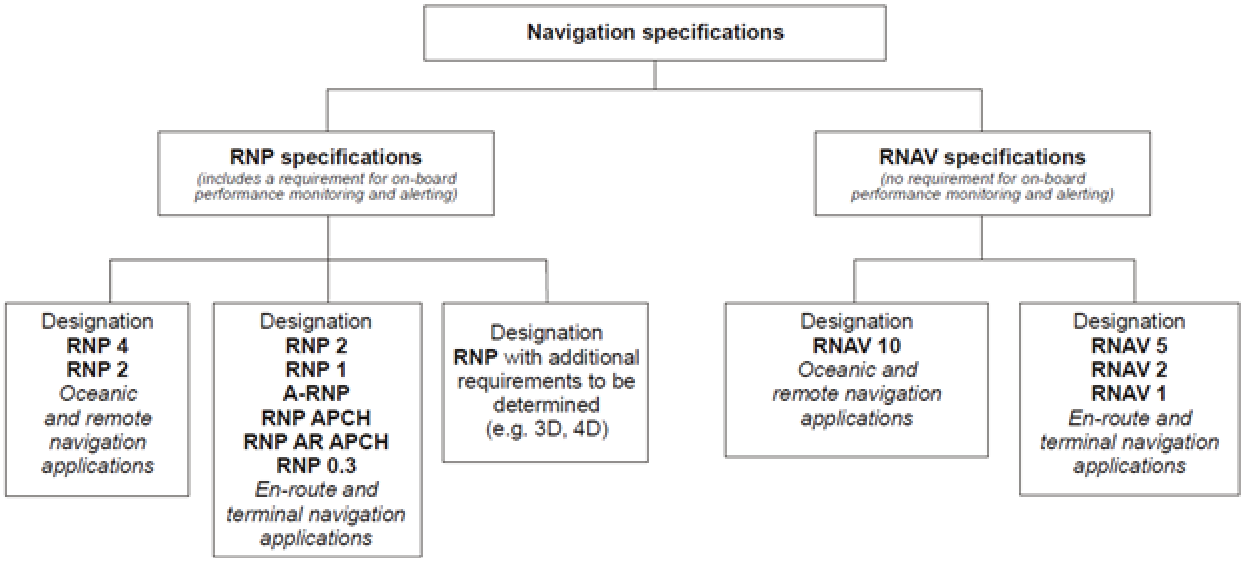
5.5.3. Display of ground speed or time to the active TO waypoint;

5.5.4. Navigation data storage function; and

5.5.5. Failure indication of the RNAV system or RNP system, including the sensors.

5.6. Designation of RNAV Specifications and RNP Specifications. “RNP X” designates an RNP specification (e.g., RNP 4); “RNAV X” designates an RNAV specification (e.g., RNAV 1). A prefix is used without a suffix where a navigation specification covers various phases of flight and permits different lateral navigation (LNAV) accuracy during various flight phases (e.g., A-RNP) (**Figure 5.2**). Note: “RNP APCH” and “RNP AR APCH” are the designations for approaches that use RNP specifications. See **paragraph 5.6.1**

Figure 5.2. Navigation Specification Designations.



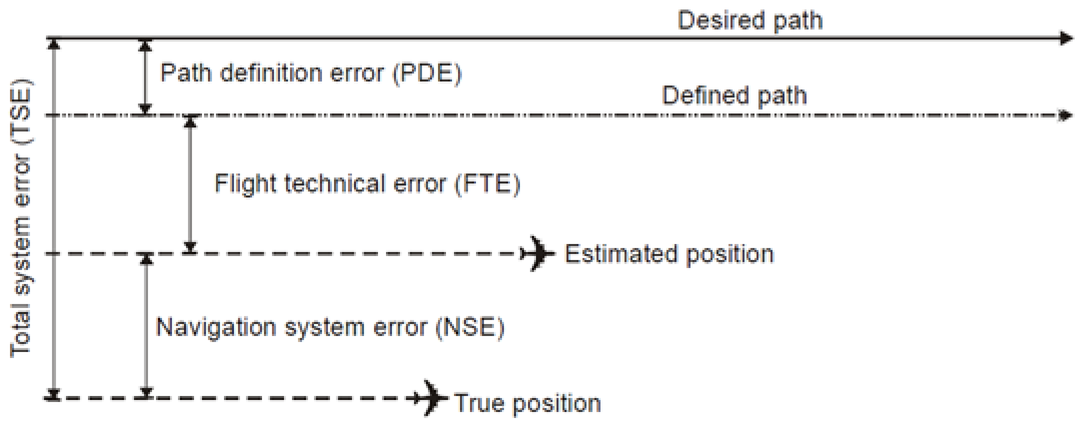
5.6.1. For RNAV designations and RNP designations, the "X" refers to the LNAV accuracy, or total system error (TSE), in nautical miles, expected to be achieved at least 95% of the flight time by the aircraft operating within the airspace, route, or procedure (**Figure 5.3**). TSE is composed of:

5.6.1.1. Path definition error (PDE) is the difference between the defined path on a navigation system and the desired path at a specific point. PDE is considered negligible due to the database integrity process.

5.6.1.2. Flight technical error (FTE) is the accuracy with which the aircraft is controlled as measured by the indicated aircraft position with respect to the indicated command or desired position. This functions as a combination of aircraft performance and the aircrew flying. It does not include pilot errors.

5.6.1.3. Navigation system error (NSE) is the difference between true position and estimated position. NSE is contained through integrity monitoring within the system itself. The NSE is largely independent of the aircraft on which the system is installed. **Note:** In sensor-based navigation, the NSE and PDE were built into the design; therefore, aircrew focused on resolving FTE only. In contrast to sensor-based navigation, PBN can now specifically target the NSE.

Figure 5.3. Lateral Navigation Errors.



5.6.2. Approach navigation specifications cover all segments of the instrument approach. RNP specifications are designated using RNP as a prefix and an abbreviated textual suffix (e.g., RNP APCH or RNP AR APCH). **Note:** Conventional approaches with PBN segments may include RNAV specifications or RNP specifications specific to defined segments of the approach.

5.6.2.1. (NAS only) "RNAV (GPS)" is equivalent to (ICAO) "RNP APCH".

5.6.2.2. (NAS only) "RNAV (RNP)" is equivalent to (ICAO) "RNP AR APCH".

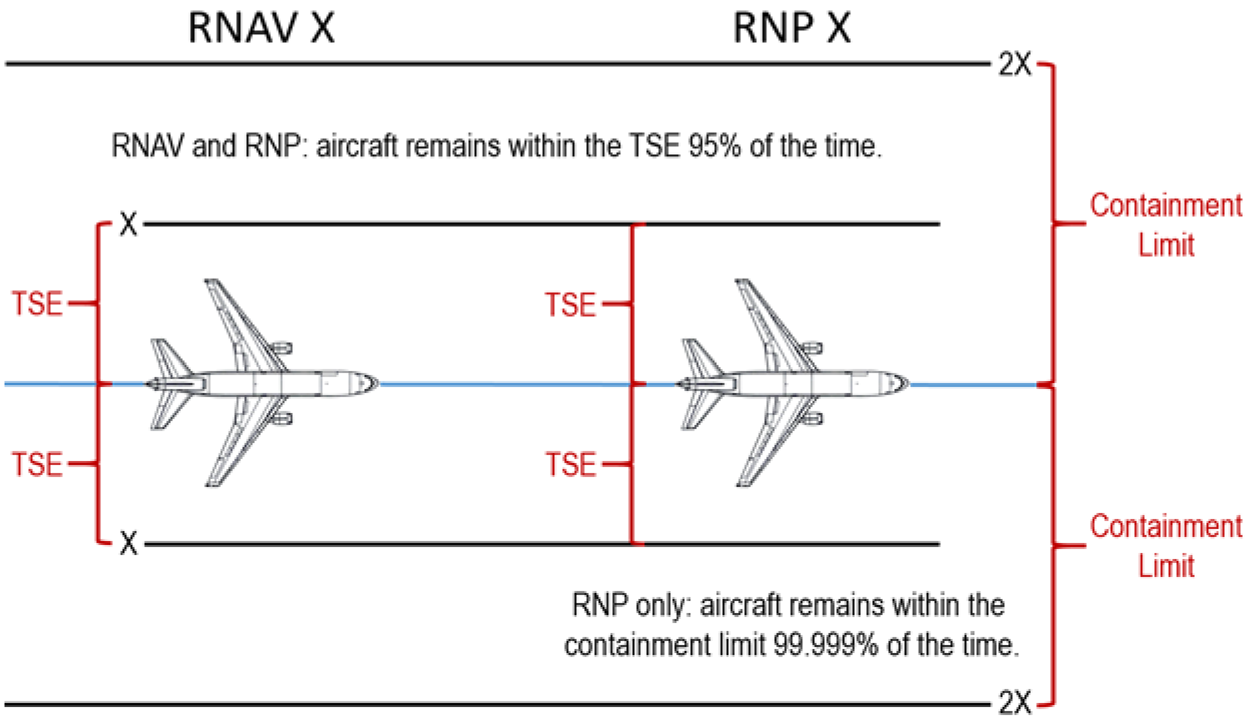
5.7. RNAV Designations and RNP Designations. In cases where navigation accuracy is used as part of the designation of a navigation specification, it is only one of the functional and performance requirements included in a navigation specification (**Figure 5.4**).

5.7.1. Functional and performance requirements are defined for each navigation specification; therefore, an aircraft approved for an RNP specification is not automatically approved for all RNAV specifications.

5.7.2. Similarly, an aircraft approved for an RNAV specification or RNP specification having a stringent accuracy requirement (e.g., RNP 0.3) is not automatically approved for a navigation specification having a less stringent accuracy requirement (e.g., RNP 1, RNP 4).

5.7.3. It may seem logical, for example, that an aircraft approved for RNP 1 be automatically approved for RNP 4; however, this is not the case. Aircraft approved to the more stringent accuracy requirements may not necessarily meet some of the functional requirements of the navigation specification having a less stringent accuracy requirement.

Figure 5.4. RNAV Designations vs RNP Designations.



5.8. On-board Performance Monitoring and Alerting. On-board performance monitoring and alerting is the main element that determines if the navigation system complies with the necessary safety level associated with an RNP application (versus an RNAV application). Additionally, it determines if the navigation system relates to lateral and longitudinal navigation performance. Finally, it determines if the navigation system allows the aircrew to detect that the navigation system is not achieving or cannot guarantee the navigation performance required with 10^{-5} integrity (i.e., less than a 0.001% chance).

5.8.1. RNP systems provide improvements on the integrity of operations; this may permit closer route spacing and can provide sufficient integrity to allow only RNP systems to be used for navigation in a specific airspace. The use of RNP systems may therefore offer significant safety, operational, and efficiency benefits over RNAV systems.

5.8.2. Both RNAV systems and RNP systems are required to meet an accuracy requirement 95% of the time (i.e., with a 95% confidence). Normally, RNAV systems do not include on-board performance monitoring and alerting; aircrew will monitor a lateral deviation display (e.g., course deviation indicator (CDI)) for course errors. **(T-0).**

5.8.3. RNP systems are required to alert the aircrew if the accuracy requirement is not met or the probability that lateral TSE exceeds 2X is greater than 10^{-5} (i.e., the performance monitoring and alerting requirement contains the aircraft within 2X at a 99.999% level of confidence). Compliance with the performance monitoring and alerting requirement does not imply automatic monitoring of FTE. Therefore, the on-board monitoring and alerting function should consist at least of an NSE monitoring and alerting algorithm and a lateral deviation display enabling the crew to monitor the FTE.

Chapter 6

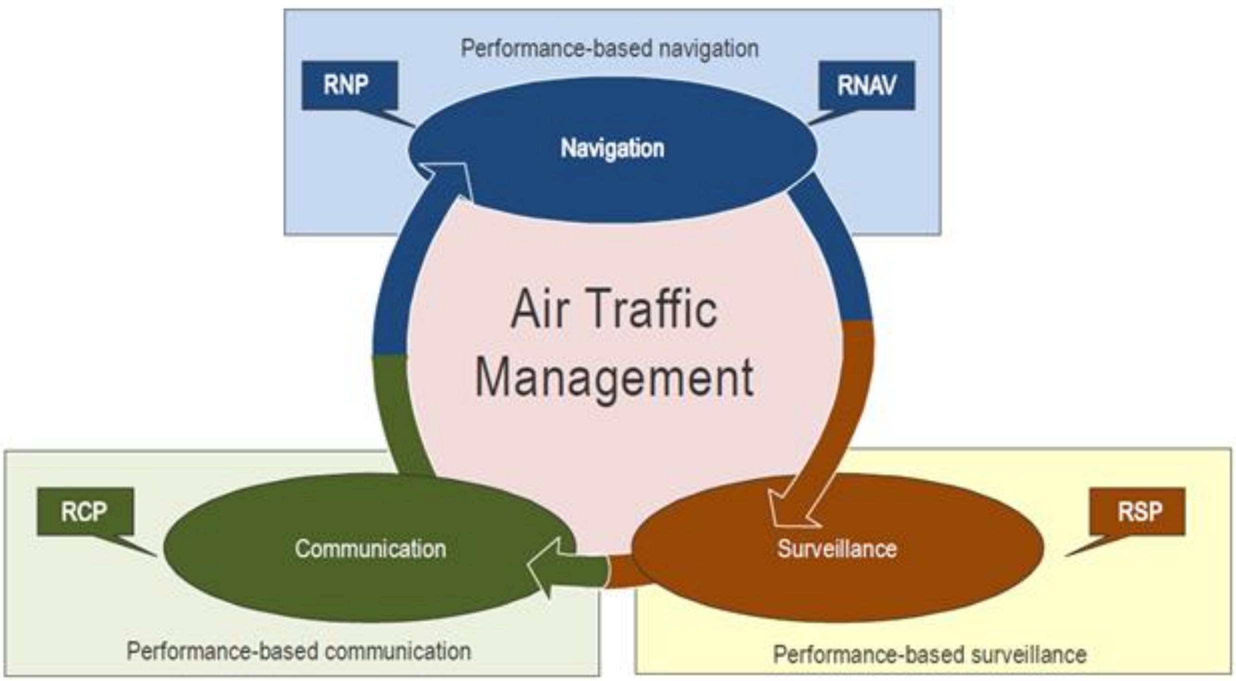
PERFORMANCE-BASED COMMUNICATIONS AND SURVEILLANCE

6.1. General. [ICAO Doc 9869; AC 90-117] The performance-based communication and surveillance (PBCS) concept provides objective operational criteria to evaluate different and emerging communication and surveillance technologies intended for evolving air traffic management (ATM) operations.

6.2. PBCS Operations. MAJCOMs will train aircrews, certify aircraft PBCS systems, and grant operational approval prior to use for PBCS operations in accordance with AFI 11-202V3. Note: This requirement does not prohibit aircrews from operating in airspace where PBCS is implemented; however, such aircraft would not be eligible for reduced separation minima requiring PBCS capability (e.g., North Atlantic High Level Airspace).

6.3. PBCS Context. The PBCS concept is aligned with that of PBN (**Figure 6.1**). While the PBN concept applies RNAV specifications and RNP specifications to the navigation element, the PBCS concept applies required communication performance (RCP) and required surveillance performance (RSP) specifications to communication and surveillance elements, respectively. Each RCP or RSP specification includes allocated criteria among the components of the communication and surveillance systems involved.

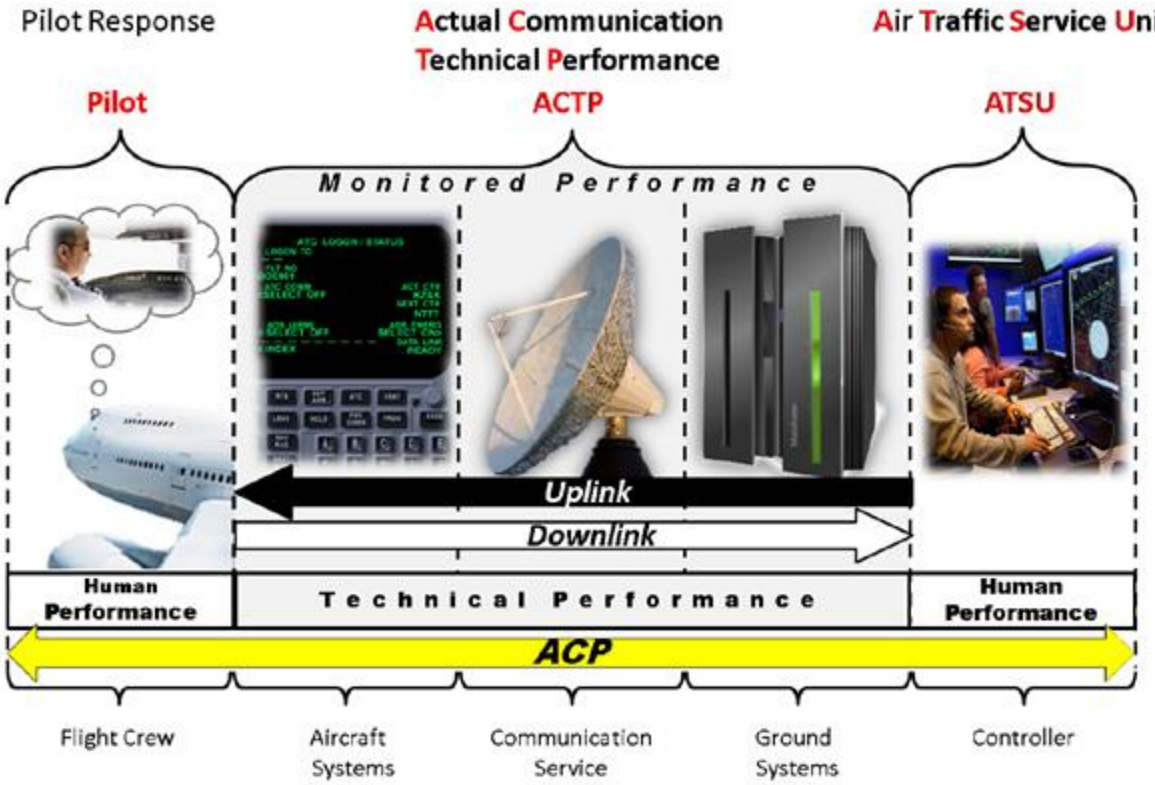
Figure 6.1. Performance-based ATM Model.



6.4. RCP Specifications. An RCP specification represents operational parameters for the complete communication transaction. “RCP X” designates an RCP specification and makes RCP expiration time clear to airspace planners, aircraft manufacturers, and operators (e.g., RCP 240). RCP specifications are applied to achieve required communication performance and may support specific aircraft separation minima.

6.5. Actual Communication Performance (ACP). ACP is the combined uplink and downlink performance of ground systems, communication service, and aircraft systems (**Figure 6.2**). ACP is an indicator of the operational performance of a communication system which includes human and technical components.

Figure 6.2. Actual Communications Performance (ACP).



6.6. RSP Specifications. An RSP specification represents operational parameters for the complete surveillance transaction. "RSP X" designates an RSP specification and makes RSP overdue delivery time clear to airspace planners, aircraft manufacturers, and operators (e.g., RSP 180). RSP specifications are applied to airspace based on specific objectives (e.g., the surveillance performance required to support specific separation minima).

Chapter 7

GROUND-BASED NAVIGATION AIDS

7.1. General. Various NAVAIDs are in use today, each serving a specific purpose. This chapter builds on the concepts introduced in FAA handbooks and manuals.

7.1.1. Refer to AIM 1-1-1 through AIM 1-1-20 for basic NAVAID information.

7.1.2. Additional detailed information may be found in FAA-H-8083-15, FAA-H-8083-16, and FAA-H-8083-25.

7.2. Reporting Malfunctions. [AIM 1-1-13] Pilots should notify ATC of any NAVAID malfunction or deteriorating performance.

7.3. Using Ground-based NAVAIDs.

7.3.1. Tune the desired frequency or channel.

7.3.2. Identify the NAVAID via aural (Morse code) or visual (alphanumeric) signal.

7.3.3. Monitor the station identification (either aural or visual) to ensure a reliable signal is being transmitted.

7.3.3.1. Removal of station identification warns pilots that the facility is officially off the air for tune-up or repairs and may be unreliable even though signals are received.

7.3.3.2. There is a direct correlation between the strength of an NDB identifier and the strength and reliability of its signal; there are no off flags to indicate loss of signal. Therefore, monitor the NDB for the entire procedure when procedures require an NDB.

7.3.4. Select proper position for the navigation system switches.

7.3.5. Display the desired information on the navigation instruments.

7.3.6. Check the appropriate instrument indicators for proper operation.

7.4. VOR Minimum Operational Network (MON). [AIM 1-1-3] The FAA plans to remove selected VORs from service as flight procedures and the enroute structure are gradually being replaced with PBN procedures.

7.4.1. PBN procedures are primarily reliant on GNSS. Aircraft equipped with DME/DME systems may continue flying PBN procedures during a GNSS disruption.

7.4.2. The FAA plans to retain a limited network of VORs for aircraft not equipped with a DME/DME system; the MON provides basic navigation service for these aircraft if GNSS becomes unavailable. During a GNSS disruption, the MON enables aircraft to navigate through the affected area or to a safe landing at an airfield without reliance on GNSS.

7.4.3. Navigation using the MON may not be as efficient as the new PBN route structure; however, use of the MON should provide nearly continuous VOR signal coverage at 5,000 feet above ground level (AGL) across the NAS, outside of the western U.S. mountainous area.

7.5. TACAN. A TACAN consists of a rotating antenna for transmitting azimuth information and a receiver-transmitter for transmitting range information. Aircrew will not navigate using a

TACAN unless valid azimuth and range information are available (i.e., a TACAN broadcasting range with no valid azimuth or a TACAN broadcasting azimuth with no valid range must be considered unusable). (T-0).

7.5.1. Like the VOR, the receipt of a TACAN signal is dependent on the line-of-sight principle. Therefore, aircraft altitude, distance from station, terrain and obstructions are principal factors that affect TACAN signals.

7.5.2. The TACAN may also have an "X" or "Y" setting. Pilots may assume the TACAN is set to "X" unless the letter "Y" appears in parenthesis after the TACAN frequency.

7.5.3. The ground equipment responsible for providing DME is only capable of responding to 100 simultaneous interrogations before saturation occurs. TACANs are designed to disregard weaker signals when more than 100 DME interrogations are received.

7.6. Instrument Landing System (ILS). [ICAO Annex 10 Volume 1] ICAO procedures for air navigation services – aircraft operations (PANS-OPS) criteria defines the standard service volume for a localizer (LOC) as 25 nautical miles within 10 degrees of the front course centerline, 17 nautical miles between 10 degrees and 35 degrees of the front course centerline, and 10 nautical miles outside of 35 degrees from the front course centerline.

7.6.1. Where topographical features dictate, or operational requirements permit, this service volume may be reduced to 18 nautical miles within the 10-degree sector and 10 nautical miles for the remainder of the coverage when alternative navigation means provide satisfactory coverage within the intermediate approach area.

7.6.2. (NAS only) FAA criteria defines the standard service volume for a localizer in accordance with the reduced localizer service volume of 18 nautical miles within the 10-degree sector and 10 nautical miles for the remainder of the coverage [AIM 1-1-9].

7.7. Localizer (LOC). [ICAO Annex 10 Volume 1] The ICAO abbreviation for a localizer facility on an instrument procedure is " LLZ"; however, the abbreviation "LOC" may also be used. ICAO PANS-OPS criteria require localizer final approach track alignment within 5 degrees of runway centerline; U.S. terminal instrument procedure (TERPS) criteria requires localizer final approach track within 3 degrees of runway centerline.

7.7.1. A localizer offset more than 5 degrees from runway centerline is considered an instrument guidance system (IGS).

7.7.2. (NAS only) A localizer offset more than 3 degrees from runway centerline is considered a localizer type directional aid (LDA) [FAA Order 6750.24].

Chapter 8

SPACE-BASED NAVIGATION AIDS

8.1. General. [ICAO Doc 9849; AIM 1-1-18] The term GNSS refers to any satellite constellation that provides positioning, navigation, and timing services. Theoretically, a GNSS receiver can calculate its three-dimensional position by knowing its range from three satellites if the receiver clock is perfectly synchronized with the satellite clocks. In practice, the GNSS receiver calculates the "pseudo-range" to at least four satellites and their positions to calculate the clock offset via the pseudo-range of the fourth satellite.

8.1.1. There are only two fully operational GNSS constellations providing global services: the U.S. global positioning system (GPS) and the Russian Federation *globalnaya navigazionnaya sputnikovaya sistema* (GLONASS).

8.1.1.1. The European Union (EU) Galileo constellation currently includes 17 operational satellites and 5 satellites under commissioning; the full 30-satellite system is expected to be complete in 2020.

8.1.1.2. The Chinese BeiDou navigation satellite system (BDS) constellation currently has 15 operational satellites in orbit; it is expected to achieve full global coverage in 2020.

8.1.2. GNSS constellations are not necessarily interoperable; therefore, GNSS receivers require specific hardware to receive, decode, and use services from each constellation.

8.1.3. GNSS navigation is referenced to the world geodetic system 1984 (WGS-84) coordinate system. GNSS-based navigation should only be used where the Nation State conforms to WGS-84 or equivalent systems.

8.2. Reporting Malfunctions. [AIM 1-1-13] Pilots should notify ATC of any GNSS malfunction or deteriorating performance. Additionally, GNSS problems should be reported via the FAA's *GPS Anomaly Reporting Form* at **http://www.faa.gov/air_traffic/nas/gps_reports/**.

8.3. Global Positioning System (GPS). The USAF operates GPS for the U.S. Government. In 2007, the U.S. Government re-committed to providing GPS signals on a continuous worldwide basis in support of international civil aviation. The nominal GPS space segment is comprised of 24 operational satellites in orbit.

8.3.1. The GPS navigation message is made up of three major components. The first contains the GPS date and time, the satellite's status, and an indication of its health. The second contains orbital information that allows the receiver to calculate the position of the satellite. The third, called the almanac, provides the locations and pseudo-random noise codes of all the satellites, which allows the receiver to determine which satellites are in view. **Note:** The pseudo-random noise code is used to identify GPS satellites in U.S. notice to airmen (NOTAM) system and many GPS receivers.

8.3.2. GPS status information is also available from the United States Coast Guard navigation information service: (703) 313-5907 or **http://www.navcen.uscg.gov/**. Additionally, satellite status is available through the NOTAM system via the DoD Aeronautical Information Portal (DAIP) website at **https://www.daip.jcs.mil/**. Pilots may retrieve GPS and wide area augmentation system (WAAS) NOTAMs by selecting “GPS/WAAS” under “Advanced Search” after logging in to DAIP.

8.4. *Globalnaya Navigazionnaya Sputnikovaya Sistema* (GLONASS). The Ministry of Defence of the Russian Federation operates GLONASS. The nominal GLONASS space segment consists of 24 operational satellites and several spares. A navigation message transmitted from each satellite consists of satellite coordinates, velocity and acceleration vector components, satellite health information, and corrections to GLONASS system time. The navigation message provides information regarding the status of the transmitting satellite along with information on the remainder of the constellation.

8.5. Aircraft-based Augmentation System (ABAS). ABAS is an avionics implementation that processes core constellation signals with information available on board the aircraft. Many ICAO Nation States have taken advantage of GPS with ABAS to improve service without incurring any expenditure on infrastructure.

8.5.1. There are two general classes of integrity monitoring: receiver autonomous integrity monitoring (RAIM), which uses GNSS information exclusively; and aircraft autonomous integrity monitoring, which also uses information from additional on-board sensors such as inertial reference units (IRU).

8.5.2. ABAS provides integrity monitoring using redundant range measurements to support fault detection (FD) or fault detection and exclusion (FDE). The purpose of FD is to detect a potential position error caused by a satellite exceeding its tolerances. Upon detection, the GNSS navigation function is lost. Avionics with FDE identify and exclude the faulty satellite, thereby allowing GNSS navigation to continue without interruption, provided that sufficient healthy satellites with good geometry remain in view.

8.6. RAIM. [ICAO Doc 9849; AIM 1-1-17] RAIM requires at least five satellites with good geometry to detect a faulty signal and alert the aircrew; FDE requires six. The availability of RAIM and FDE is slightly lower for mid-latitude operations and slightly higher for equatorial and high-latitude operations due to the nature of core constellation orbits. The requirement for redundant signals means that navigation guidance with RAIM may not be available 100% of the time.

8.6.1. A barometric altimeter may be used to provide an additional measurement that reduces the number of satellites in view required by one for RAIM and FDE. Barometric aiding can also help to increase RAIM and FDE availability when there are enough visible satellites, but their geometry is not adequate to support the integrity function. **Note:** Barometric aiding is different from the barometric vertical navigation (Baro-VNAV) function used to support some non-precision approaches with vertical guidance.

8.6.2. There are two types of RAIM alert: when there is poor satellite geometry, during which the ability to detect a failed satellite is lost; and when the RAIM algorithm detects a satellite fault, which results in the loss of GNSS navigation capability unless the receiver includes FDE.

8.6.3. Some ICAO Nation States have approved the use of GNSS as the only navigation service in domestic airspace and in oceanic and remote areas; the avionics require FDE in these cases. Under such approvals, aircraft may require dual systems and pilots may be required to perform preflight predictions to make certain that enough satellites will be in view to support service throughout the flight.

8.6.4. Predictive RAIM information for the NAS may be obtained by contacting an FAA flight service station (FSS) or visiting the FAA RAIM Prediction Tool website at **http://sapt.faa.gov/**. Within Europe, predictive RAIM information may be obtained by visiting the AUGUR GPS RAIM Prediction Tool website at **http://augur.eurocontrol.int/**.

8.7. Satellite-Based Augmentation System (SBAS). SBAS augments core satellite constellations by providing integrity and correction information; some systems also provide additional ranging signals. SBAS reference stations monitor core constellation satellite signals and continuously provide data to master stations. Master stations use these data to assess satellite signal validity and compute corrections to the broadcast orbital information and clock data for each satellite.

8.7.1. The GNSS SARPs allow for three levels of SBAS capability that provide:

8.7.1.1. Core satellite status and geostationary earth orbit (GEO) satellite ranging;

8.7.1.2. Clock and orbital information corrections; and

8.7.1.3. Clock, orbital information, and ionospheric corrections.

8.7.2. The first two levels support PBN enroute through non-precision approach operations; the third level also supports non-precision approach with vertical guidance operations.

8.8. SBAS Avionics. "SBAS receiver" designates GNSS avionics that meet the minimum requirements outlined in ICAO Annex 10 and relevant specifications, such as Technical Standard Order (TSO)-C145, *Airborne Navigation Sensors Using the Global Positioning System Augmented by The Satellite Based Augmentation System (SBAS)* or TSO-C146a, *Stand-Alone Airborne Navigation Equipment Using The Global Positioning System Augmented By the Satellite Based Augmentation System (SBAS)*.

8.8.1. There are four classes of SBAS avionics that support different performance capabilities. Class I equipment supports enroute, terminal, and LNAV approach operations. Class II equipment supports enroute, terminal, LNAV/vertical navigation (VNAV) approach operations, and LNAV approach operations. Class III and IV equipment support enroute, terminal, and four approach minima levels: localizer performance with vertical guidance (LPV), localizer performance (LP), LNAV/VNAV, and LNAV.

8.8.2. SBAS avionics are required to annunciate the highest level of service supported by the combination of the SBAS signal integrity level and the receiver certification using the naming conventions on the approach procedure chart lines of minima. SBAS avionics support flying the complete procedure and can operate in a vector-to-final mode.

8.8.3. SBAS avionics may provide advisory vertical guidance when flying NDB or VOR approaches and GNSS non-precision approaches in areas where an SBAS supports this level of service, thus providing the benefits of a stabilized descent. In this case, the aircrew is responsible for complying with all minimum altitudes specified on the approach chart.

8.9. SBAS Coverage and Service Areas. GEO satellite footprints define the coverage area of an SBAS. Within this coverage area, ICAO Nation States can establish service areas where SBAS supports approved operations. Other ICAO Nation States within the coverage area could also establish service areas either by installing integrated reference and monitoring stations in cooperation with the SBAS provider or by approving the use of SBAS signals. An ICAO Nation State that has established an SBAS service area is responsible for the SBAS signals within that service area.

8.9.1. Current SBAS implementations include the U.S. wide area augmentation system (WAAS), European geostationary navigation overlay system (EGNOS), Indian GPS and geo-augmented navigation system (GAGAN), and the Japanese multi-function satellite augmentation system (MSAS).

8.9.1.1. WAAS, EGNOS, and GAGAN augment GPS but not GLONASS; they allow for LPV operations down to 200 feet height above touchdown (HAT).

8.9.1.2. MSAS does not currently support LPV operations.

8.9.2. The Russian Federation is currently developing the system for differential corrections and monitoring (SDCM). SDCM is designed to provide corrections and integrity for GPS and GLONASS.

8.9.3. Although SBAS architectures are different, they broadcast an ICAO standard message format on the same frequency; they are interoperable from the aircraft perspective. When SBAS coverage areas overlap, it is possible for an SBAS operator to monitor and broadcast integrity and correction messages for the GEO satellites of another SBAS, thus improving availability by adding ranging sources.

8.9.4. SBAS coverage for the NAS may be obtained by visiting the FAA WAAS Performance website at **http://www.nstb.tc.faa.gov/**. SBAS coverage for Europe may be obtained by visiting the EGNOS User Support website at **https://egnos-user-support.essp-sas.eu/new_egnos_ops/**.

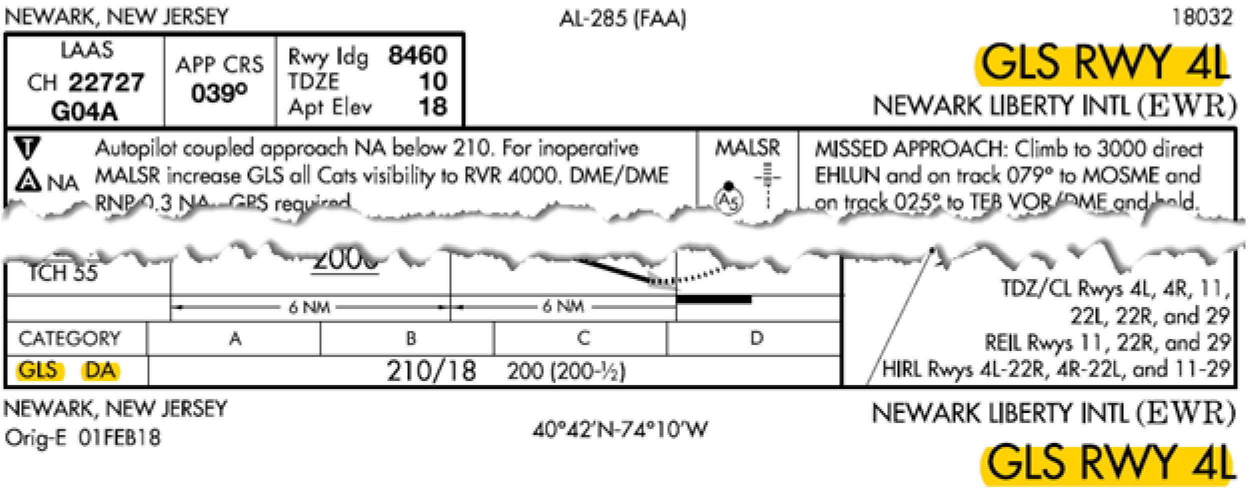
8.10. Ground Based Augmentation System (GBAS). A GBAS ground station is located at or near the airfield served. The ground station monitors core constellation signals and broadcasts locally relevant pseudo-range corrections, integrity parameters, and approach definition data to aircraft in the terminal area via a VHF data broadcast (VDB). GBAS supports CAT I precision approaches; in the future GBAS may support CAT II and III precision approaches. **Note:** Some documents refer to local area augmentation system (LAAS) which is an outdated term for GBAS.

8.10.1. GBAS precision approach service provides lateral and vertical deviation guidance for the final approach segment. The optional GBAS positioning service supports two-dimensional PBN operations in terminal areas.

8.10.2. GBAS can provide multiple approaches to the same runway end with a unique channel number identifying each one. These approaches may have different glide path angles or displaced thresholds.

8.10.3. The term "GBAS landing system (GLS)" is used in the charting of GBAS approaches, both for the chart title and the GBAS minima line (**Figure 8.1**).

Figure 8.1. GBAS Landing System (GLS) Approach.



8.11. GBAS Avionics. The term GBAS receiver designates the GNSS avionics that meet the minimum requirements for a GBAS receiver as outlined in ICAO Annex 10 and relevant specifications.

8.11.1. Like ILS, the GBAS receiver provides lateral and vertical guidance relative to the defined final approach course and glide path. The receiver selects the VDB frequency and identifies the specific data block that defines the approach.

8.11.2. GBAS avionics standards have been developed to mimic ILS to simplify the integration of GBAS with existing avionics. Display scaling and deviation outputs are equivalent to ILS to reduce aircrew training requirements. All avionics provide final approach course and glide path guidance to all configurations of ground stations.

Chapter 9

MISSION PLANNING

9.1. General. [FAA Pilot/Controller Glossary] It is important not to confuse or use terms inappropriately. Flight conditions do not always correspond to the type of flight plan filed.

9.1.1. Instrument flight rules (IFR) are a set of rules governing the conduct of instrument flight. In the NAS it is also used by pilots and controllers to indicate a type of flight plan.

9.1.2. Instrument meteorological conditions (IMC) are meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling less than the minima specified for visual meteorological conditions.

9.1.3. Visual flight rules (VFR) govern the procedures for conducting flight under visual conditions. (NAS only) The term "VFR" is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements; in addition, it is also used by pilots and controllers to indicate type of flight plan.

9.1.4. Visual meteorological conditions (VMC) are meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than specified minima.

9.2. NOTAMs. [AIM 5-1-3; AFI 11-208; FAA Order 7930.2; ICAO Annex 15] Time-critical aeronautical information is distributed via the NOTAM system. NOTAMs typically include information of a temporary nature or not sufficiently known in advance to permit publication on aeronautical charts or in other operational publications. NOTAM information is available via the DAIP website at **https://www.daip.jcs.mil/**.

9.2.1. If the airfield is not covered by DAIP, a plain language notice in red font is displayed advising the user of that fact. In this case, contact the airfield manager or associated FSS directly for NOTAM information.

9.2.2. Abbreviations are explained in the *Flight Information Handbook* (FIH) and the FAA *Notices to Airmen Publication* (NTAP). **Note:** The NTAP is available on the DAIP website.

9.2.3. Special interest NOTAMs for VFR flight in the NAS:

9.2.3.1. Tethered balloons are depicted as restricted areas on IFR enroute low-altitude charts and FAA sectional charts.

9.2.3.2. Glider and parachute operations are depicted with symbols on FAA sectional charts. Operations may be announced via NOTAM or listed in the enroute supplements.

9.3. Critical DME NOTAMs. [FAA Aeronautical Information Services] A critical DME is a DME facility that, when not available, results in navigation service which is not sufficient for DME/DME/IRU operations along a specific route or procedure. The required performance assumes an aircraft's navigation system meets the minimum standard for DME/DME area navigation systems or the minimum standard for DME/DME/IRU area navigation systems. Critical DME facilities are identified on the appropriate instrument procedure. Pilots of DME/DME/IRU-equipped aircraft should check NOTAMs to verify the operation of critical DME facilities. The current list of critical DME facilities may be found on the FAA website at **https://www.faa.gov/air_traffic/flight_info/aeronav/criticaldme/**.

9.4. Digital Product Updates.

9.4.1. Update National Geospatial-Intelligence Agency (NGA) digital products via application-specific update procedures or the NGA's Aeronautical Content Exploitation System (ACES) website at **https://aerodata.nga.mil/AeroBrowser/**.

9.4.2. Update FAA digital products via the FAA's Digital Products website at **https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/**.

9.4.3. Update commercial digital products as required by the publisher.

9.5. Aircraft Category. [ICAO Doc 8168V1] Aircraft approach category is equal to the stall speed (V^{so}) multiplied by 1.3 or stall speed (V^{s1g}) multiplied by 1.23 in the landing configuration at the maximum certificated landing mass. If both V^{so} and V^{s1g} are available, the higher resulting speed is used. (**Table 9.1**). Use the minima corresponding to the category determined during aircraft certification or higher.

9.5.1. If it is necessary to maneuver at a speed exceeding the upper limit of the speed range for an aircraft category, pilots will use the minimums for the higher category unless otherwise authorized by AFI or MAJCOM directive. **(T-2).** MAJCOMs will publish procedures to ensure that aircraft do not exceed protected airspace if allowing aircraft to fly an instrument approach using a lower category.

9.5.2. PANS-OPS criteria establish maximum speeds by aircraft category for departures, holding, circling, and all approach segments; refer to the appropriate chapter for these maximum speeds.

Table 9.1. Aircraft Category.

Category	Speed Range in Knots Indicated Airspeed
A	Less than 91 knots
B	91 knots – 120 knots
C	121 knots – 140 knots
D	141 knots – 165 knots
E	166 knots or more
H	Helicopters
Note: Helicopters may use CAT A minima.	

9.6. Automation Management. Pilots should be proficient at operating all levels of automation available on the aircraft. The level of automation used at any time should be that most appropriate for the circumstances to enhance safety and passenger comfort.

9.6.1. The lowest level of automation (i.e. "hand flying") may be necessary until a situation is resolved when an immediate change of aircraft path is required (e.g., escape or avoidance maneuvers, unusual attitude recovery). Regaining aircraft control should never be delayed to maintain a specific level of automation.

9.6.2. Proper execution of flight guidance panel inputs should be verified by checking that the resulting flight mode annunciations correctly correspond to the commanded inputs. Pilots should continually scan control, performance, and navigation instruments to ensure that the aircraft performs as expected in all modes of flight.

9.7. Operations in International Airspace.

9.7.1. Pilots operating in international airspace will file an international flight plan unless MAJCOM or contingency guidance specifies otherwise. **(T-2).** International airspace exists over the high seas at any point greater than 12 nautical miles offshore of a coastal state. Refer to diplomatic clearances and the FCG for specific guidance on sovereign territory avoidance procedures. Refer to DoD FLIP *General Planning* for further information.

9.8. Transitioning Airspace Classes.

9.8.1. When operating under IFR, transition from one type of airspace to another is generally transparent to the pilot. The IFR clearance is clearance to enter each type of airspace as it is encountered; typically, no specific clearances are issued. When operating under VFR, it is up to the pilot to determine the airspace type, operating rules, and equipment requirements, and comply accordingly. Under VFR, transitions from one type of airspace to another are not transparent to the pilot, and in many cases, require a specific clearance.

9.8.2. [AIM 3-2-4] Two-way radio contact means the pilot is talking to ATC but may or may not have a clearance. An aircraft is considered in two-way radio contact if a controller responds to a radio call with, "[call sign] standby." **Note:** If a controller responds with "Aircraft calling approach, standby" then two-way radio contact has not been established.

9.9. VFR Flight in Controlled Airspace. [AIM 3-2] In the NAS, ATC provides traffic advisories to all aircraft as the controller's work situation permits. Safety alerts (terrain, obstruction, aircraft conflict, Mode C intruder) are mandatory services and provided to all aircraft.

9.10. IFR Flight in Uncontrolled Airspace. [ICAO Annex 11; AIM 3-3-3*]* IFR operations are permitted in uncontrolled airspace. All normal IFR equipment requirements and rules apply to include minimum altitude and flight levels (FL). While operating in VMC, pilots are solely responsible to see and avoid other traffic, terrain, and obstacles. ATC only provides separation between aircraft in controlled airspace. Therefore, caution should be exercised when operating in IMC under IFR in uncontrolled airspace.

9.11. Airspace and Airspace Classification. [AIM **Chapter 3**; ICAO Annex 11; FAA-H-8083-15 **Chapter 1**] Pilots should be familiar with the operational requirements for the airspace in which they operate (**Figure 9.1** and **Figure 9.2**). **Note:** Failure of equipment required for a specific airspace may render the aircraft unable to remain in that airspace.

Figure 9.1. NAS Airspace Classification.

	Class A	Class B	Class C	Class D	Class E	Class G
Entry Requirements	ATC clearance	ATC clearance	Prior two-way communications	Prior two-way communications	Prior two-way communications*	None
Minimum Pilot Qualifications	Instrument Rating	Private or Student certification—local restrictions apply.	Student certificate	Student certificate	Student certificate	Student certificate
Two-Way Radio Communications	Yes	Yes	Yes	Yes	Yes, under IFR flight plan*	None
Special VFR Allowed	No	Yes	Yes	Yes	Yes	N/A
VFR Visibility Minimum	N/A	3 statute miles	3 statute miles	3 statute miles	3 statute miles**	1 statute mile†
VFR Minimum Distance from Clouds	N/A	Clear of clouds	500' below, 1,000' above, 2,000' horizontal	500' below, 1,000' above, 2,000' horizontal	500' below,** 1,000' above, 2,000' horizontal	Clear of clouds†
VFR Aircraft Separation	N/A	All	IFR aircraft	Runway operations	None	None
Traffic Advisories	Yes	Yes	Yes	Workload permitting	Workload permitting	Workload permitting
Airport Application	N/A	• Radar • Instrument approaches • Weather • Control tower • High density	• Radar • Instrument approaches • Weather • Control tower	• Instrument approaches • Weather • Control tower	• Instrument approaches • Weather	• Control tower

*Exception: temporary tower or control tower present
**True only below 10,000 feet
† True only during day at or below 1,200 feet AGL (see 14 CFR part 91)

AGL—above ground level
FL—flight level
MSL—mean sea level

Figure 9.2. ICAO Airspace Classification.

Class	Type of flight	Separation provided	Service provided	Speed limitation*	Radio communication requirement	Subject to an ATC clearance
A	IFR only	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
B	IFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
	VFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
C	IFR	IFR from IFR IFR from VFR	Air traffic control service	Not applicable	Continuous two-way	Yes
	VFR	VFR from IFR	1) Air traffic control service for separation from IFR; 2) VFR/VFR traffic information (and traffic avoidance advice on request)	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
D	IFR	IFR from IFR	Air traffic control service, traffic information about VFR flights (and traffic avoidance advice on request)	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
	VFR	Nil	IFR/VFR and VFR/VFR traffic information (and traffic avoidance advice on request)	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
E	IFR	IFR from IFR	Air traffic control service and, as far as practical, traffic information about VFR flights	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
	VFR	Nil	Traffic information as far as practical	250 kt IAS below 3 050 m (10 000 ft) AMSL	No	No
F	IFR	IFR from IFR as far as practical	Air traffic advisory service; flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	No
	VFR	Nil	Flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	No	No
G	IFR	Nil	Flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	No
	VFR	Nil	Flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	No	No

* When the height of the transition altitude is lower than 3 050 m (10 000 ft) AMSL, FL 100 should be used in lieu of 10 000 ft.

9.11.1. Pilots will apply the operating rules associated with the more restrictive airspace designation when overlapping airspace designations exist. **(T-0).**

9.11.2. Pilots will not plan to transit airspace without the required minimum equipment unless authorized by ATC. **(T-0).**

9.11.3. [FAA JO 7110.65; FAA Pilot/Controller Glossary] In a non-radar environment, ATC does not have a radio detection device to provide information on range, azimuth and elevation of objects. ATC relies on information relayed from flight crews to determine the actual geographic position and altitude (e.g., voice position reports, data link). **Note:** Aircraft in controlled airspace can be in a non-radar environment.

9.11.4. Radar service may be provided in a radar environment. **Note:** An aircraft can be VFR and not in two-way radio contact with ATC and still be operating in a radar environment.

9.11.5. Controlled airspace is a generic term that covers the different classifications of airspace (Classes A through E) and defined dimensions within which ATC service is provided in accordance with the airspace classification.

9.11.6. Uncontrolled airspace is a term that covers all airspace (Classes F through G) not designated as controlled airspace. **Note:** Class F airspace is not used in the NAS.

9.11.7. Prohibited areas are airspace of defined dimensions, above the land areas or territorial waters of a Nation State, within which aircraft flight is prohibited [ICAO Annex 2; AIM 3-4-2].

9.11.8. Restricted areas are airspace of defined dimensions, above the land areas or territorial waters of a Nation State, within which aircraft flight is restricted in accordance with certain specified conditions [ICAO Annex 2; AIM 3-4-3].

9.11.9. Danger areas or (NAS only) warning areas are airspace of defined dimensions within which activities dangerous to aircraft flight may exist at specified times [ICAO Annex 2].

9.11.10. [AIM **Chapter 3** Section 4] (NAS only) Special use airspace includes prohibited, restricted, and warning areas. **Note:** Prohibited and restricted areas are regulatory special use airspace; military operations areas, warning areas, controlled firing areas, and national security areas (NSA) are non-regulatory special use airspace.

9.11.11. (NAS only) The FAA may impose temporary flight restrictions (TFR) for many reasons (e.g., imminent hazards, disaster relief) [14 CFR Part 91; AIM 3-5-3]. The current list of TFRs may be found at **http://tfr.faa.gov/**.

9.11.12. Military training routes (MTR) allow the military to train in a wide range of airborne tactics. MTRs may be either IFR MTRs (IR) or VFR MTRs (VR) [AIM 3-5-2; FLIP AP/1B]. **Note:** Unlike IRs and VRs, slow speed low altitude training routes (SR) are not part of the MTR system and therefore have no directive guidance in the AIM or FAA Order JO 7610.4, *Special Operations*. Slow routes are low-level routes at or below 1,500 feet AGL and are published in AP/1B. Flight above 1,500 feet AGL does not meet the criteria of the SR system. [FLIP AP/1B]

9.11.13. (NAS only) Tabulations of parachute jump areas in the United States are contained in the *Chart Supplement U.S.* [AIM 3-5-4].

9.11.14. [AIM 5-6] The air defense identification zone (ADIZ) is special designated airspace of defined dimensions within which aircraft are required to comply with special identification and reporting procedures additional to those related to ATS provisions. **Note:** Pilots will adhere to ADIZ procedures unless approved for a specific mission exception. **(T-0).**

9.11.15. (NAS only) Certain areas are prescribed special air traffic rules areas and pilots must adhere to Title 14, Code of Federal Regulations, Part 93, *Special Air Traffic Rules*, unless otherwise authorized by ATC [AIM 3-5-7; 14 CFR Part 93; FAA JO 7210.3]. **(T-0).**

9.12. Adherence to ATC Clearances and Instructions. [14 CFR Part 91.123; AIM 4-4-10; ICAO Doc 4444 4.5; ICAO Annex 11] Include aircraft identification (call sign) in all read backs. Read back ATC clearances and instructions containing altitude assignments, restrictions, vectors, headings, altimeter settings, and runway assignments in the same sequence they are given. Initial read back of a taxi, departure, or landing clearance should include the runway assignment including left, right, or center as applicable. The read back of the “numbers” reduces communication errors that occur when a number is either misheard or incorrect. If the ATC clearance or instructions are unclear, query the controller.

9.13. Descent Gradients. Descent gradients in excess of 10 degrees (1,000 feet per nautical mile) in IMC may induce spatial disorientation when descending “at pilot’s discretion.” Exceeding a 10-degree descent gradient below 15,000 feet AGL substantially decreases margin for error in avoiding obstacles and terrain, and may not provide effective radar monitoring.

9.14. Airspeed Adjustments.

9.14.1. [AIM 4-4-12] ATC issues speed adjustments to pilots of radar-controlled aircraft to achieve or maintain required or desired spacing. Speed adjustments are indicated airspeed expressed in 10 knot increments; speeds may be Mach numbers expressed in 0.01 increments at or above FL 240. Pilots complying with speed adjustments must maintain a speed within +/- 10 knots (0.02 Mach) of the specified speed. **(T-0).**

9.14.2. If ATC determines, before an approach clearance is issued, that it is no longer necessary to apply speed adjustment procedures, they may advise the pilot to “resume normal speed” or “resume published speed.” Normal speed is used to terminate ATC assigned speed adjustments on segments where no published speed restrictions apply. It does not cancel published restrictions on instrument procedures and does not relieve the pilot of those speed restrictions.

9.15. Transponder Operations. [ICAO Doc 8168V1 Part III Section 3] Aircraft will squawk 2000 in the absence of any ATC directions or regional air navigation agreements. **(T-0).**

9.15.1. (NAS only) VFR aircraft normally squawk either 1200 or an ATC assigned flight following code (including SRs) [AIM 4-1-20].

9.15.2. (NAS only) Aircraft operating VFR or IFR in restricted areas, warning areas, or VFR on VR routes normally squawk 4000 unless another code has been assigned by ATC [AIM 4-1-20; JO 7110.65].

9.15.3. (NAS only) VFR aircraft which fly authorized search and rescue missions may be advised to squawk 1277 in lieu of 1200 while enroute to, from, and within the designated search area.

9.15.4. (NAS only) Aircraft operating in or near the Washington DC Special Flight Rules Area (SFRA), or Flight Restricted Zone (FRZ) must refer to the appropriate publication for transponder procedures to prevent intercept. **(T-0).**

9.16. Automatic Dependent Surveillance – Broadcast (ADS-B). [AC 20-165; AC 20-172] ADS-B Out refers to an aircraft broadcasting its position and other information. ADS-B In refers to an aircraft receiving the broadcasts and messages from the ground network.

9.16.1. Pilots should refer to Nation State AIPs and the FLIP AP series for ADS-B Out requirements outside the NAS; failure to meet requirements may result in denied access to airspace.

9.16.2. [14 CFR Part 91.225; 14 CFR Part 91.227] (NAS only) Effective January 1, 2020, aircraft operating in airspace defined in 14 CFR Part 91.225 are required to have an ADS-B Out system that includes a certified position source capable of meeting the requirements as defined in 14 CFR Part 91.227. These regulations set a minimum performance standard for the ADS-B Out transmitter and integrated position source installed on an aircraft.

9.16.2.1. ADS-B Out requirements apply to the airspace defined in 14 CFR Part 91.225 regardless of whether the operation is conducted under VFR or IFR.

9.16.2.2. On January 1, 2020, aircraft not complying with the requirements may be denied access to this airspace. ADS-B Out will be required to operate in:

9.16.2.2.1. Class A, B, and C airspace; **(T-0).**

9.16.2.2.2. Class E airspace within the 48 contiguous states and the District of Columbia at or above 10,000 feet mean sea level (MSL), excluding the airspace at and below 2,500 feet AGL; **(T-0).**

9.16.2.2.3. Class E airspace at or above 3,000 feet MSL over the Gulf of Mexico from the coastline of the United States out to 12 nautical miles; **(T-0).** and

9.16.2.2.4. Around those airfields identified in 14 CFR Part 91 Appendix D. **(T-0).**

9.16.3. ADS-B In is not currently mandated; however, a compatible display is necessary to view ADS-B In information if an operator chooses to equip an aircraft with ADS-B In.

9.17. Reduced Vertical Separation Minimum (RVSM). [14 CFR Part 91 Appendix G] Within RVSM airspace, ATC separates aircraft by a minimum of 1,000 feet vertically between FL290 and FL410 inclusive. RVSM airspace is special certification airspace; MAJCOMs will ensure aircrew are trained, aircraft are certified, and are granted operational approval for RVSM airspace. **Note:** Formation flights are non-RVSM if any aircraft in the formation is non-RVSM.

9.18. Procedures for Accommodation of Non-RVSM Aircraft in RVSM Airspace. [AIM 4-6-10; 14 CFR Part 91.180; 14 CFR Part 91 Appendix G] If the aircraft is not certified and operationally approved for RVSM operations, the aircraft is referred to as a “non-RVSM” aircraft. **Note:** Failure of equipment required for RVSM airspace may make an aircraft non-RVSM.

9.18.1. Non-RVSM aircraft are handled on a workload permitting basis. The vertical separation standard applied between non-RVSM aircraft and all other aircraft is 2,000 feet.

9.18.2. Pilots will inform controllers of the lack of RVSM approval. **(T-0).**

9.18.3. The transponder must be operational to fly in RVSM airspace. **(T-0).**

9.18.4. [AIM 4-6-11] In order for the PIC to request a climb to or descent from FL above RVSM airspace without intermediate level off the aircraft must:

9.18.4.1. Be capable of a continuous climb/descent and not need to level off at an intermediate altitude for any operational consideration. **(T-0).**

9.18.4.2. Be capable of climbing and descending at the normal rate for the aircraft. **(T-0).**

9.19. Level Off Operating Practices. Operational experience, monitoring studies and pilot/controller reports have shown incompatibilities between traffic collision avoidance system (TCAS) and ATC systems.

9.19.1. When safe, practical, and in accordance with aircraft flight manual operating procedures, pilots should limit vertical speed to 1,500 feet per minute or less when within 1,000 feet of assigned altitudes. This should reduce unnecessary resolution advisories (RA) and is in line with AIM and ICAO guidance.

9.19.2. Aircraft leveling off at 1,000 feet above or below level conflicting traffic may result in RAs being issued to the level aircraft. These RAs are triggered because the climbing or descending aircraft maintains high vertical speeds when approaching the cleared altitude or flight level. The collision logic contains algorithms that recognize this encounter geometry and delays the issuance of a traffic advisory to the level aircraft by up to 5 seconds to allow TCAS to detect the initiation of the level off maneuver by the intruder.

9.20. Air Traffic Services (ATS). [ICAO Annex 11 **Chapter 2**] Air traffic services comprise of:

9.20.1. Air traffic control service is provided to prevent collisions between aircraft or between aircraft and obstructions within the maneuvering area, and expediting and maintaining an orderly flow of traffic; it is divided into three parts:

9.20.1.1. Area control service provides air traffic control services for controlled flights.

9.20.1.2. Approach control service provides air traffic control services for those parts of controlled flights associated with arrival or departure.

9.20.1.3. Aerodrome control service provides air traffic control services for airfield traffic except those under approach control service.

9.20.2. Flight information service provides advice and information useful for the safe and efficient conduct of flights.

9.20.3. Alerting service notifies appropriate organizations regarding aircraft in need of search and rescue aid and assist such organizations as required.

9.21. Emergency Frequencies. Emergency frequencies are 121.5 megahertz (MHz) and 243.0 MHz. These frequencies are to be used when not in radio contact with ATC and aircrew need to make emergency contact or to contact ATC when no other means are available.

9.22. Flight Service Station (FSS). [FAA Pilot/Controller Glossary] An FSS is an air traffic facility which provides preflight briefings, flight plan processing, enroute flight advisories, search and rescue services, and assistance to lost aircraft and aircraft in emergency situations. An FSS may also relay ATC clearances, process NOTAMS, broadcast aviation weather and aeronautical information, and advise U.S. Customs and Immigration of trans-border flights. In Alaska, an FSS may provide airfield advisory services.

9.22.1. [FAA General Aviation Pilot's Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision Making] An FSS may be reached by phone at 1-800-WX-BRIEF or by radio on frequencies published on FAA sectionals and enroute charts. **Note:** When dialing the standard number, 1-800-WX-BRIEF from a cell phone, this number connects to the FSS associated with the cell phone area code, not necessarily the nearest FSS.

If using a cell phone outside its calling area, check the *Chart Supplement U.S.* to find the specific telephone number for the nearest FSS.

9.22.2. [FAA JO 7110.10; FAA Pilot/Controller Glossary] An FSS may be equipped with remote communication outlets and can transmit and receive on more than one frequency at more than one location. Broadcast “ANY RADIO” with aircraft call sign and the nearest NAVAID to ensure FSS personnel use the correct transmitter.

9.23. Hazardous Inflight Weather Advisory Service (HIWAS). [AIM 7-1-10, AFH 11-203V1] HIWAS is a continuous recorded inflight weather forecast broadcasted over selected VOR frequencies. VORs with HIWAS service are identified by a small solid square inside the VOR frequency identification box. To listen to HIWAS information, turn up the volume on the VOR receiver just as if monitoring the VOR for identification.

9.24. Local Airport Advisory. [AIM 3-5-1] Local airport advisory service is available only in Alaska and is operated within 10 statute miles of an airfield where an FSS is at the airfield.

9.24.1. The FSS automatically provides “Final Guard” during periods of fast-changing weather as part of the service from the time the aircraft reports “on final” or “taking the active runway” until the aircraft reports “on the ground” or “airborne.”

9.24.2. “Final Guard” is a value-added wind and altimeter monitoring service which provides an automatic wind and altimeter check during active weather situations when the pilot reports “on final” or “taking the active runway.”

9.25. Remote Airport Information Service. [AIM 3-5-1] Remote airport information service is provided in support of short-term special events like small to medium fly-ins. The service is advertised by “D” NOTAM only from the NTAP.

9.26. VFR Radar Assistance. [FAA JO 7110.10] ATC may provide vectoring services to VFR aircraft. ATC may have limited vectoring capability for weather avoidance, but the responsibility to remain in VMC rests with the pilot.

9.27. VFR Flight Following. [FAA JO 7110.10] Flight following services are provided if requested by the pilot and ATC workload and equipment capability permits. ATC should provide separation from IFR traffic and participating VFR traffic. The ultimate responsibility for traffic separation still rests with the pilot while participating in flight following.

9.28. VFR Cruising Altitudes and Flight Levels. [ICAO Annex 2 **Chapter 4**] Except where otherwise indicated in air traffic control clearances or specified by the appropriate ATS authority, VFR flights in level cruising flight operated above 3,000 feet AGL or higher as specified by the appropriate ATS authority will be conducted at a cruising level appropriate to the track as specified in **Table 9.2**. **(T-0).**

Table 9.2. VFR Cruising Altitudes and Flight Levels.

From 000 degrees to 179 degrees magnetic			From 180 degrees to 359 degrees magnetic	
Altitude	**Flight Level**		**Altitude**	**Flight Level**
3500	FL035		4500	FL045
5500	FL055		6500	FL065
7500	FL075		8500	FL085
9500	FL095		10500	FL105
11500	FL115		12500	FL125
13500	FL135		14500	FL145
15500	FL155		16500	FL165
17500	FL175		*18500*	*FL185*
19500	*FL195*		*20500*	*FL205*
21500	*FL215*		*22500*	*FL225*
23500	*FL235*		*24500*	*FL245*
25500	*FL255*		*26500*	*FL265*
27500	*FL275*		*28500*	*FL285*
VFR Cruising Altitudes and Flight Levels (non-RVSM airspace only)				
30000	*FL300*		*32000*	*FL320*
34000	*FL340*		*36000*	*FL360*
38000	*FL380*		*40000*	*FL400*
etc.	*etc.*		*etc.*	*etc.*

Note:
1) VFR flights will not be operated above FL200 or at transonic and supersonic speeds unless authorized by the appropriate ATS authority *[ICAO Annex 2 Chapter 4]*. **(T-0).**
2) (NAS only) Pilots will maintain the altitude or flight level assigned by air traffic control when operating VFR above 18,000 MSL *[14 CFR Part 91.159]*. **(T-0).**

9.29. Composite Flight Plan (IFR/VFR Flights). [AIM 5-1-7] Procedures for filing a composite flight plan are in FLIP *General Planning* **Chapter 4**.

9.29.1. Prior to transitioning to the IFR segment, maintain VMC and contact the nearest FSS and request an IFR clearance. Once cleared by ATC to operate IFR, either request ATC "close VFR flight plan" or cancel the VFR portion with an FSS. Ensure the VFR flight plan is closed to prevent unnecessary search and rescue operations.

9.29.2. Cancel IFR with ATC and contact an FSS to activate the VFR portion of the flight plan.

9.30. (ICAO) Transitioning IFR to VFR. [ICAO Doc 4444 4.8] Pilots must specifically request "cancelling my IFR flight" and any changes to the current flight plan. **(T-0).** ATC should respond with "IFR flight cancelled at… (time)."

9.31. VFR Helicopter Operations. Helicopters should avoid the flow of fixed wing aircraft traffic patterns, unless able to maintain a compatible speed.

9.32. VFR-on-top. [AIM 4-4-8] A pilot on an IFR flight plan in VMC may request VFR-on-top in lieu of an assigned altitude. This permits a pilot to select an altitude or FL of their choice (subject to ATC restriction). When operating in VMC with ATC authorization to "maintain VFR-on-top/maintain VFR conditions" pilots must:

9.32.1. Fly at the appropriate VFR altitude. **(T-0).**

9.32.2. Comply with VFR visibility and distance from cloud criteria. **(T-0).**

9.32.3. Comply with IFR as applicable to the flight (e.g., minimum IFR altitudes, radio communications, course to be flown, adherence to ATC clearances). **(T-0).**

9.33. Special VFR. [ICAO Doc 4444 **Chapter 7**; AIM 4-4-6] Special VFR (SVFR) allow aircraft to operate under VFR when meteorological conditions are less than those required for VFR flight in Class B, C, D, or E airspace. Helicopters may request SVFR, where applicable, when the weather is below that required for the given airspace but above mission design series (MDS)-specific weather requirements. Limit the use of SVFR to mission essential as these procedures limit the traffic the ATC tower can allow in its airspace.

9.34. Defense VFR (DVFR). [14 CFR Part 99; AIM 5-6-4] Allows aircraft to operate under VFR in the ADIZ.

9.34.1. PIC must maintain two-way radio communications and aircraft must have an operable transponder unless specifically cleared by ATC. **(T-0).**

9.34.2. If the pilot is unable to maintain two-way radio communication, the pilot may proceed in accordance with the original DVFR flight plan or land as soon as practicable. The pilot must report radio failure to an appropriate aeronautical facility as soon as possible. **(T-0).**

9.34.3. DVFR flight plans must contain the time and point of ADIZ penetration and the aircraft must depart within five minutes of the estimated departure time. **(T-0).**

9.34.4. No pilot may deviate from an ATC clearance or the filed DVFR flight plan unless that pilot notifies an appropriate aeronautical facility before deviating. **(T-0).**

9.34.5. In controlled airspace, pilots must make the required position report. **(T-0).**

9.34.6. In uncontrolled airspace, pilots must:

9.34.6.1. Report the time, position, and altitude at which the aircraft passed the last reporting point before entering the ADIZ and the estimated time of arrival (ETA) over the next appropriate reporting point along the route. **(T-0).**

9.34.6.2. If there is no appropriate reporting point along the route, the pilot reports at least 15 minutes before entering the ADIZ, the estimated time, position and altitude at which the aircraft will enter the ADIZ. **(T-0).**

9.34.6.3. If the departure airfield is within ADIZ or so close to the ADIZ boundary that it prevents the pilot from complying with the previous paragraphs, then the pilot must report immediately after departure, the time of departure, the altitude, and the ETA over the first reporting point along the route. **(T-0)**

9.35. Inadvertent Flight into IMC While Operating Under VFR. Anticipate IMC and alter route of flight to maintain VMC unless safety dictates otherwise. If unable to maintain VMC, immediately transition to instruments, coordinate an IFR clearance, and cancel the VFR flight plan.

9.36. Declared Distances. [AIM 4-3-6] Declared distances are marked on instrument approach plates or airfield diagrams with an “inverse D” symbol (**Figure 9.3**). Declared distances for a runway represent the maximum distances available and suitable for meeting takeoff and landing distance performance requirements (**Figure 9.4** and **Figure 9.5**). These distances are determined in accordance with FAA runway design standards. A declared distance program has four defined distances:

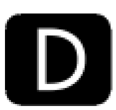
9.36.1. Takeoff run available (TORA) is the runway length declared available and suitable for the ground run of an airplane taking off. The TORA is typically the physical length of the runway, but it may be shorter than the runway length if necessary to satisfy runway design standards.

9.36.2. Takeoff distance available (TODA) is the takeoff run available plus the length of any remaining runway or clearway beyond the far end of the takeoff run available. The TODA is the distance declared available for satisfying takeoff distance requirements for aircraft where certification, operating rules, and available performance data allow for the consideration of a clearway in takeoff performance calculations. **Note:** Pilots will not use TODA for takeoff performance calculations without specific MAJCOM authorization and training. **(T-2).**

9.36.3. Accelerate-stop distance available (ASDA) is the runway plus stopway length declared available and suitable for the acceleration and deceleration of an airplane aborting a takeoff. The ASDA may be longer than the physical length of the runway when a stopway has been designated available by the airfield operator, or it may be shorter than the physical length of the runway if necessary to use a portion of the runway to satisfy runway design standards.

9.36.4. Landing distance available (LDA) is the runway length declared available and suitable for a landing airplane. The LDA may be less than the physical length of the runway or the length of the runway remaining beyond a displaced threshold if necessary to satisfy runway design standards; for example, where the airfield operator uses a portion of the runway to achieve the runway safety area requirement.

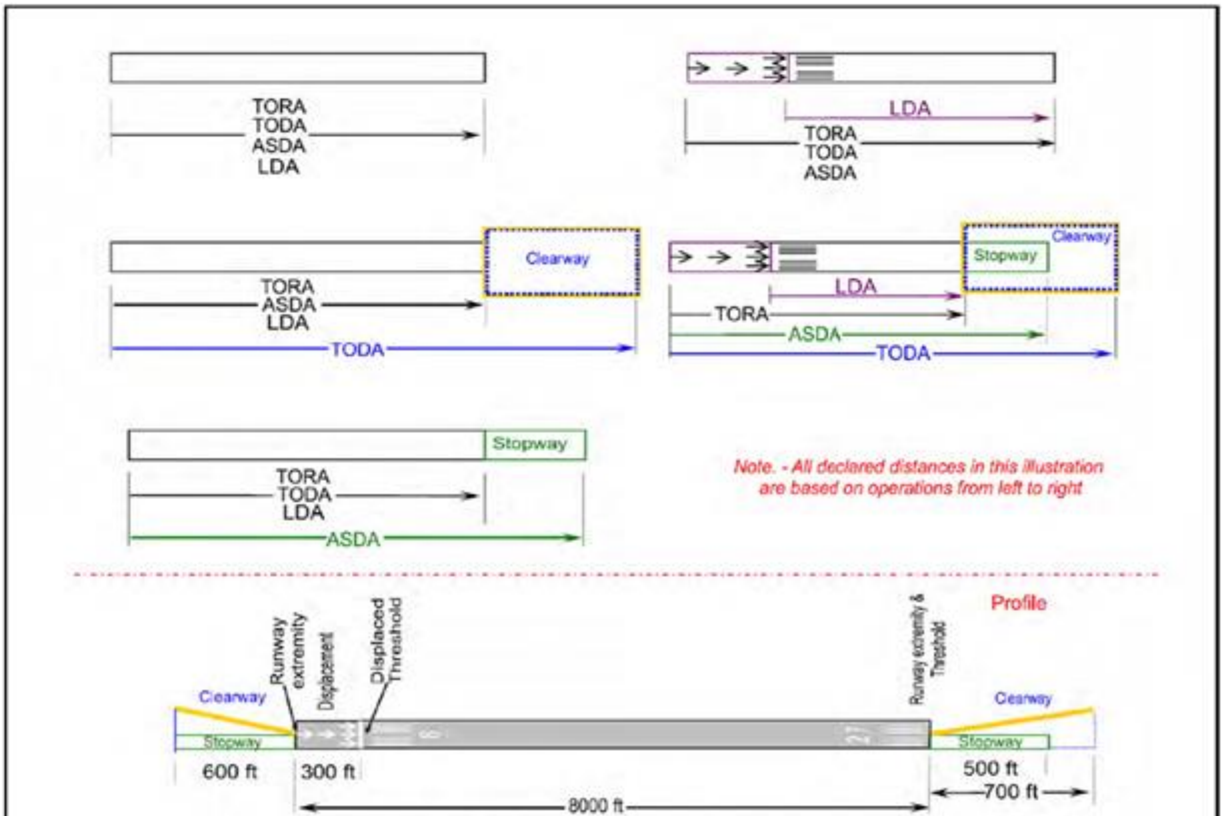
Figure 9.3. Declared Distance Symbol.



9.36.5. Operations are not bound by declared distances as long as the takeoff and landing performance calculations fall within the published distances. An aircraft is not prohibited from operating beyond a declared distance during takeoff, landing, or taxi provided the runway surface is appropriately marked as usable.

9.36.6. Declared distances are not designed with consideration for touch-and-go operations. MAJCOMs will establish procedures that account for declared distances during touch-and-go operations.

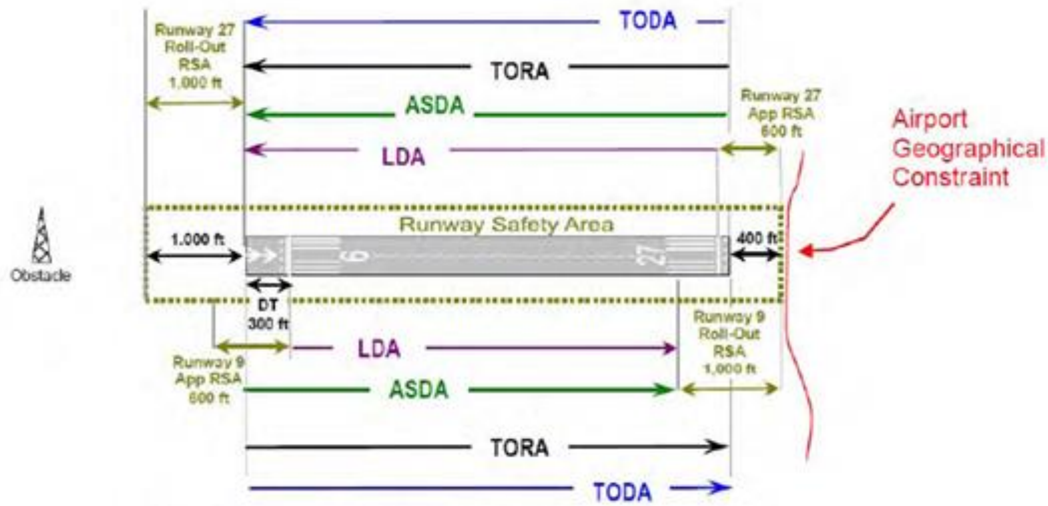
Figure 9.4. Declared Distances.



Runway	Length (feet)	TORA	ASDA	TODA	LDA
9	8000	8000	8500	8700	7700
27		8000	8600	8600	8000

Figure 9.5. Effects of a Geographical Constraint on Runway Declared Distances.

Runway 27 operations: Runway 27 threshold displaced to provide the required RSA at the approach end of the runway. As a result, the LDA is reduced 200 ft.



Runway 9 operations: The ASDA is reduced by 600 ft to achieve the required RSA at the roll-out end of the runway. The LDA is reduced by 900 ft because, 1) the 300 ft displaced threshold located at the approach end of the runway (due to an approach obstacle), and 2) as result of the 600 ft of runway needed to achieve the required RSA at the roll-out end of the runway.

Runway	Length (feet)	TORA	TODA	ASDA	LDA
9	8000	8000	8000	7400	7100
27		8000	8000	8000	7800

NOTE–

A runway's RSA begins a set distance prior to the threshold and will extend a set distance beyond the end of the runway depending on the runway's design criteria. If these required lengths cannot be achieved, the ASDA and/or LDA will be reduced as necessary to obtain the required lengths to the extent practicable.

9.37. Altimeter Settings. [AIM 7-2; FAA-H-8083-16; ICAO Doc 8168 Volume 1] The units of measure for altimeter settings are hectopascals (hPa), millibars (mbar), inches of mercury (in Hg), and millimeters of mercury (mm Hg). **Note:** Hectopascals and millibars may be used interchangeably.

9.37.1. Many sensitive altimeters can display two different barometric scales in the Kollsman window of the altimeter. Use the proper scale to set the altimeter setting. For aircraft that have only one type of altimeter scale, or for areas where the altimeter setting is not converted by aircraft systems, the FIH section D contains the appropriate conversion table.

9.37.2. In some areas, controllers use shorthand to issue an altimeter setting, which can cause confusion for crews. For example, "992" could mean "29.92 in Hg" or "992 mbar." Always confirm the correct units of measure when setting the altimeter.

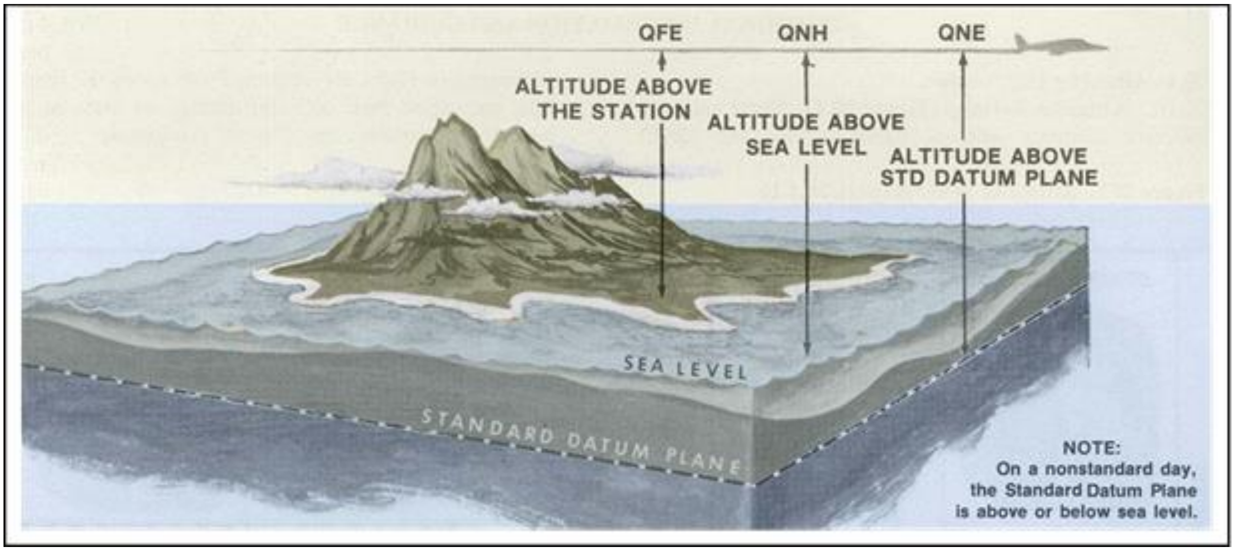
9.37.3. The types of altimeter settings are QNH, QNE, and QFE (**Figure 9.6**). Refer to Nation State AIPs and the FLIP AP series for altimeter setting procedures and units used for each Nation State from which a pilot operates. (NAS only) QNH is used exclusively for altimeter settings.

9.37.3.1. QNH indicates aircraft height in MSL. **Note:** All DoD design criteria are based upon QNH altimeter settings but may provide QFE altitudes in parenthesis.

9.37.3.2. QNE indicates aircraft height above an imaginary plane called the "standard datum plane" (i.e., FL0). The altimeter setting at FL0 is 29.92 in Hg or 1013.25 mbar.

9.37.3.3. QFE indicates aircraft height in AGL. The altimeter should indicate zero on the ground with the proper QFE set.

Figure 9.6. Types of Altimeter Settings.



9.37.4. Transition altitude (TA) is the altitude near an airfield at or below which the vertical position of an aircraft is determined from an altimeter set to QNH or QFE as appropriate. TA is normally specified for each airfield by the Nation State in which the airfield exists. TA should not normally be below 3,000 feet height above airfield (HAA) and is published on the appropriate charts. (NAS only) The TA is always 18,000 feet.

9.37.5. Transition level (TLv) is the lowest FL available for use above the TA. TLv is usually passed to the aircraft during the approach or landing clearance. The TLv may be published or available via automatic terminal information service (ATIS). Half FLs may be used (e.g., FL45). **Note:** (NAS only) The TLv is FL180 unless the QNH altimeter setting is less than 29.92 in Hg; refer to the FIH section B for further information.

9.37.6. The transition layer is that area between the TA and TLv. Aircraft are not normally assigned altitudes within the transition layer.

9.38. Altimeter Use in Flight. The vertical position of an aircraft at or below TA is expressed in altitude (QNH or QFE as appropriate). Vertical position at or above the TLv is expressed in terms of FL (QNE).

9.38.1. When passing through the transition layer, vertical position is expressed in terms of FL (QNE) when climbing and in terms of altitudes or height (QNH or QFE as appropriate) when descending.

9.38.2. After an approach clearance has been issued and the descent to land is commenced, the vertical positioning of an aircraft above the TLv 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.

9.38.3. Set QNE when climbing through or operating above the TA. Set the reported QNH or QFE, as appropriate, when descending through or operating below the TLv.

9.38.4. Pilots may be required to fly altitudes or FLs in meters and use an altimeter setting other than inches of mercury QNH. For example, altitude in meters, using a QFE altimeter setting in mbar. **Note:** Misapplication of conversions in these areas can cause mid-air collision or collision with the ground.

9.38.5. When operating at non-towered or austere locations, use all means available to obtain a local altimeter setting prior to departure. Some non-towered airfields have automated weather reporting capability that includes altimeter setting.

9.38.5.1. At certain locations it may be possible to obtain a nearby altimeter setting. However, use caution as bodies of water, terrain, or meteorological phenomena can cause significant local differences in altimeter settings over a short distance.

9.38.5.2. If no other means are available to obtain a local altimeter setting, set the airfield elevation in the altimeter.

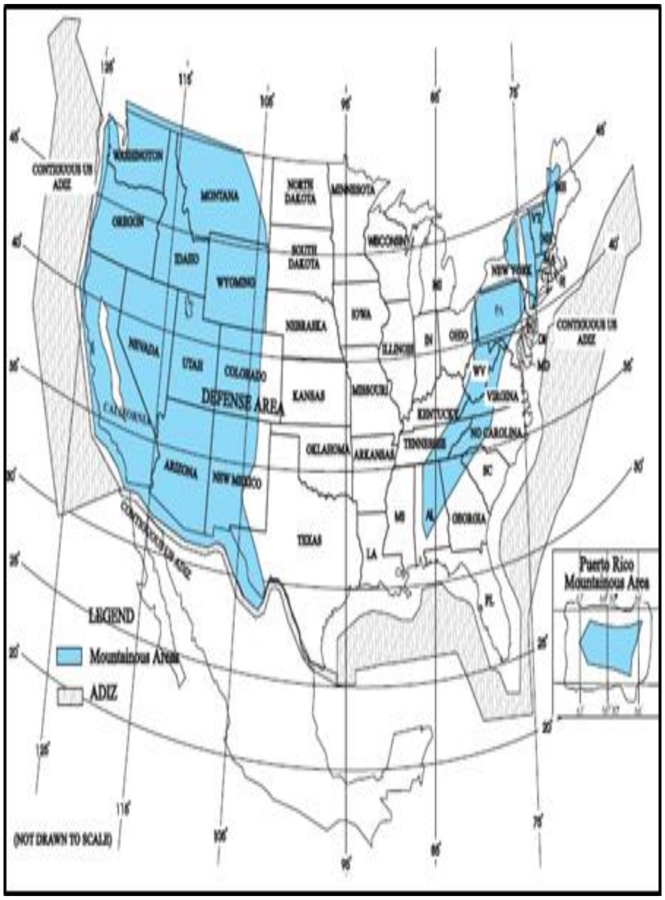
9.38.6. Refer to AIM 7-2-2 in accordance with AFI 11-202V3 when barometric pressure is less than 28.00 in Hg or more than 31.00 in Hg.

9.39. Cold Weather Altimeter Corrections. Pressure altimeters are calibrated to indicate true altitude under International Standard Atmospheric (ISA) conditions. Any deviation from ISA results in an erroneous reading on the altimeter. The altimeter error becomes extremely important when considering obstacle clearances in temperatures lower than standard since the aircraft's true altitude is lower than 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. Height above altimeter setting source is the altitude AGL at the airfield where the altimeter source is located. The amount of error is approximately 4 feet per thousand feet for each degree Celsius of difference from ISA. Cold weather altimeter correction procedures are in accordance with the FIH and AFI 11-202V3.

9.39.1. (ICAO) Minimum vectoring altitudes include a correction for cold temperatures; refer to the applicable AIP for exceptions. Mountainous areas are defined as an area of changing terrain where the changes of terrain elevation exceed 3,000 feet within 10 nautical miles.

9.39.2. (NAS only) Radar minimum vectoring altitudes are not corrected for cold temperatures. Mountainous areas are in accordance with 14 CFR Part 95.11 (**Figure 9.7**).

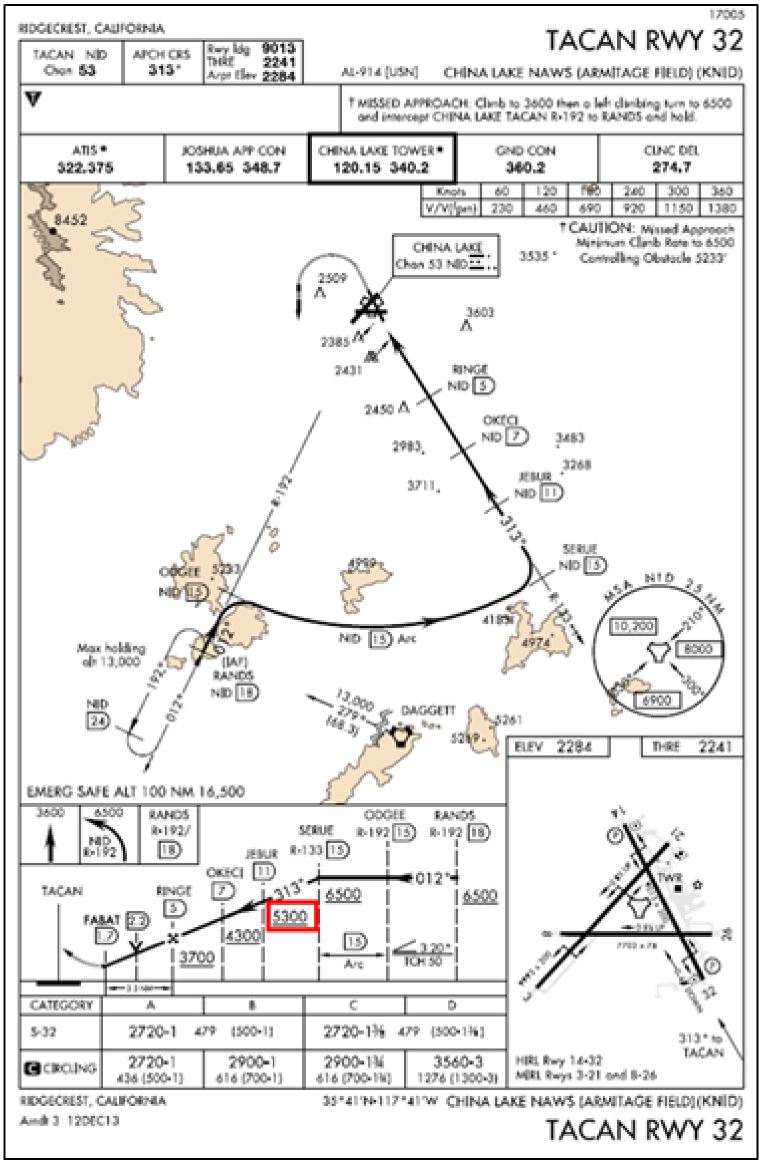
Figure 9.7. NAS Designated Mountainous Areas.



9.40. Calculating Cold Temperature Corrections. The table in the FIH is linear and allows for interpolation to determine the required altimeter correction.

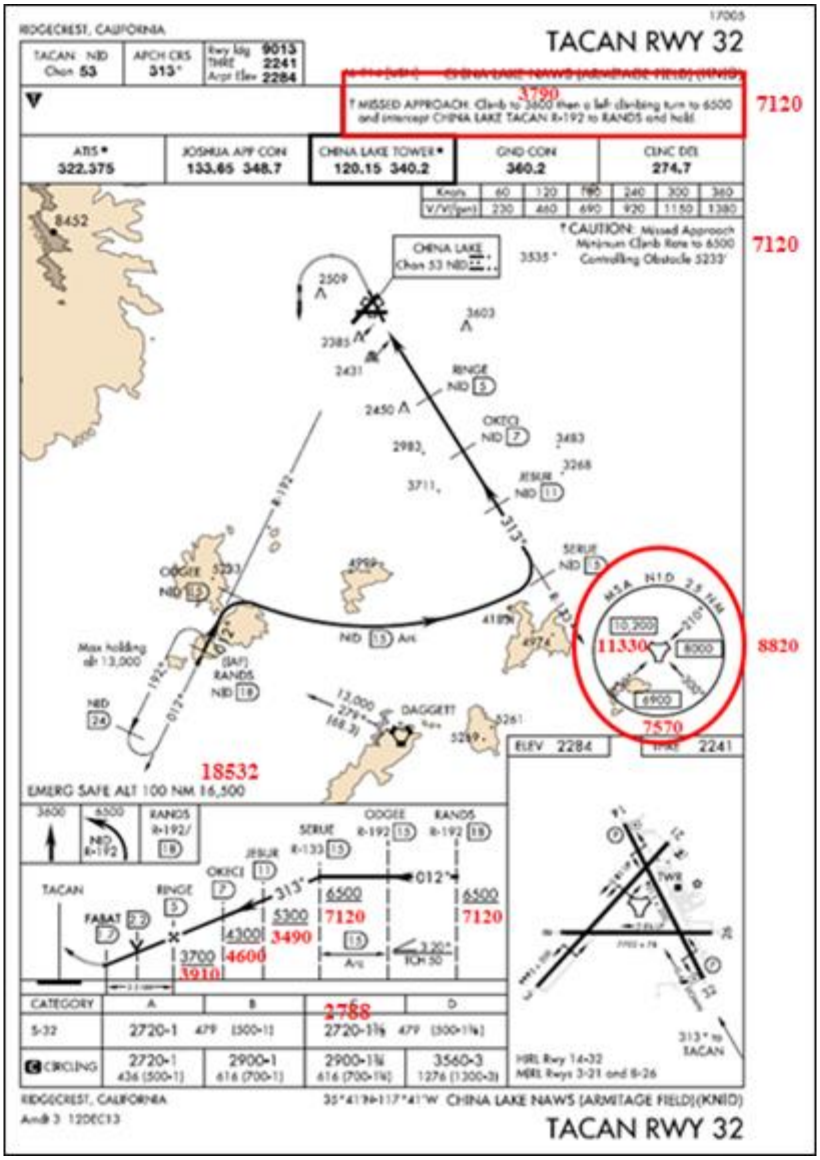
9.40.1. For example, assume KNID TACAN runway (RWY) 32, a CAT C aircraft, and -20 degrees Celsius (**Figure 9.8**). All altitudes on the approach plate need to be corrected since an intermediate approach altitude is greater than or equal to 3,000 above the altimeter setting source.

Figure 9.8. Temperature Correction Example, KNID, TACAN RWY 32.



9.40.2. To calculate the altitude correction for the initial approach fix (IAF) RANDS, determine the HAT at the IAF. In this example, the HAT at the IAF is 4259 feet (6500 – 2241 = 4259). From the temperature correction chart, the altitude correction is (570 + 50) + 6500 = 7120 MSL. Altitude correction is normally rounded up to the nearest 10. Follow the same calculation procedures for all altitudes on the approach plate (**Figure 9.9**).

Figure 9.9. Example Temperature Correction.



9.41. Calculating Cold Temperature Corrections – Remote Altimeter Setting. Follow the remote altimeter setting guidance published on the approach plate. Use the field elevation from the altimeter setting source. Subtract the remote altimeter source field elevation from the approach altitude to get the height above the altimeter setting source. Determine the temperature corrections in accordance with **paragraph 9.39** Using KATW ILS or LOC RWY 3 (**Figure 9.10** and **Figure 9.11**) and -20 degrees Celsius, the first step is to apply the remote altimeter setting published guidance. In this example, add 81 feet to the decision altitude (DA) (1088 + 81), the new DA is 1169. The next step is to determine the height above the altimeter setting source. In this example, the height above the altimeter source is (1169 – 695) 474 feet. Finally, determine the temperature correction. In this example, the new cold weather corrected DA is 1240.

Figure 9.10. KATW ILS or LOC RWY 3.

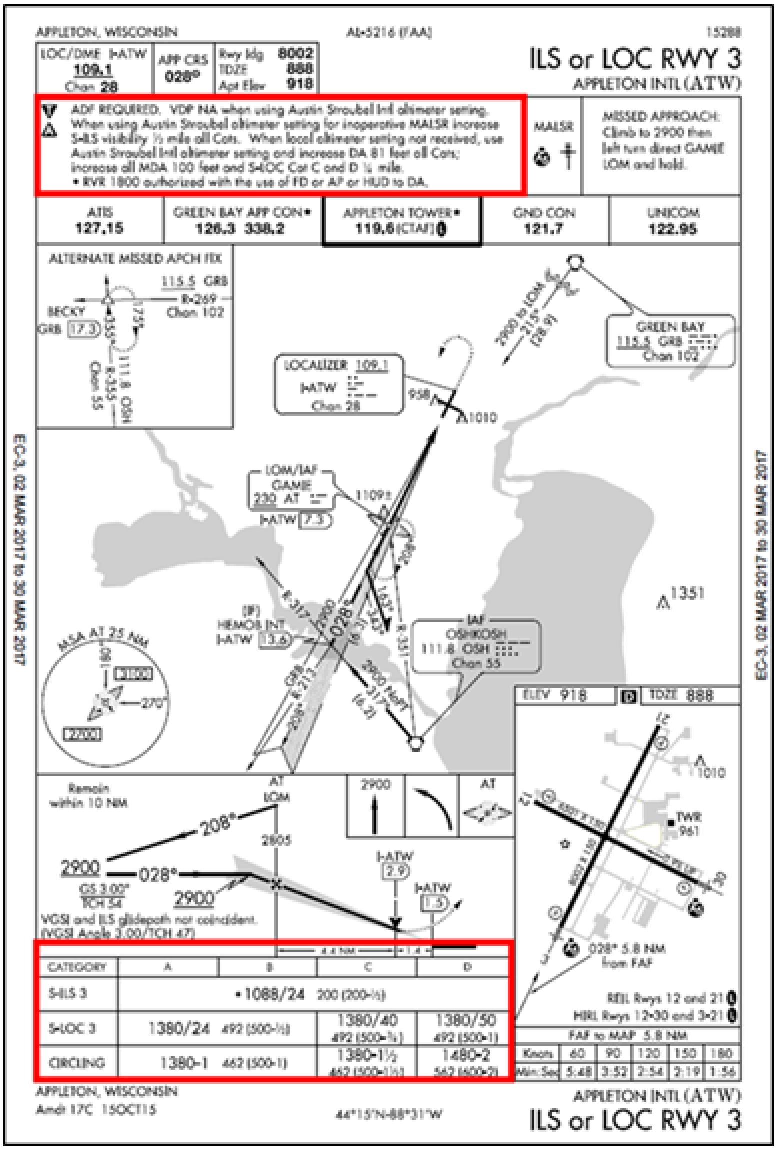
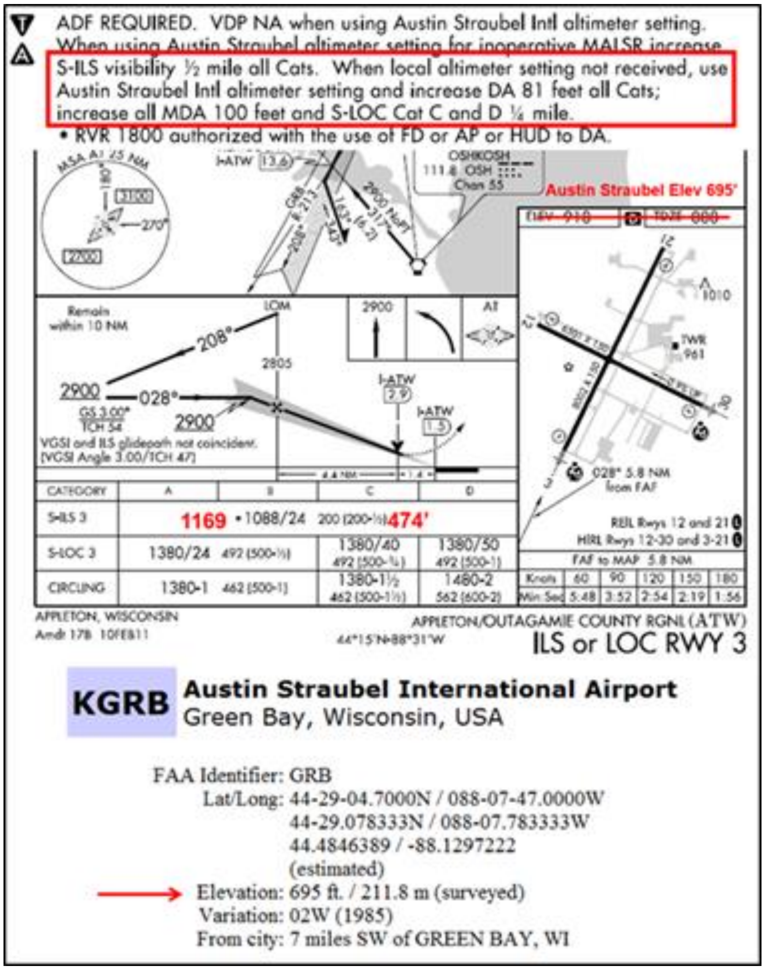


Figure 9.11. Cold Temperature Corrections – Remote Altimeter Setting.



9.42. FAA Cold Temperature Restricted Airports. [NTAP] In 2015, the FAA released a NOTAM implementing cold temperature altitude corrections at airfields with a published cold temperature restriction. FAA cold temperature restricted airports are identified by the "snowflake" icon and associated temperature limit published on U.S. Government instrument approach plates (**Figure 9.12**). The FAA procedures differ from AFI 11-202V3 procedures.

Figure 9.12. Snowflake Icon.

9.42.1. The main difference between the two procedures are the temperature limits set by each procedure and which approach altitudes are corrected. AFI 11-202V3 applies a standard set of criteria to all airfields to determine which altitudes need to be corrected. The FAA procedure requires cold weather altitude corrections only at airfields, temperatures, and approach segments listed in the NTAP.

9.42.2. Aircrew will correct all altitudes on the approach plate if there is a "snowflake" and the actual airfield temperature is at or below the published "snowflake" temperature. **(T-1).**

9.43. IFR Alternate Minimums. [DoD Publication Product Specifications paragraph 303] Some civil and foreign approaches may have alternate minimums (**Figure 9.13)** or alternate not authorized (NA) (**Figure 9.14)** in the remarks.

9.43.1. The alternate minimums symbol informs pilots that the alternate weather minimums for an airfield are non-standard. Air Force alternate weather minimums are listed in AFI 11-202V3 and Air Force pilots are not required to comply with the weather minimums listed in the IFR ALTERNATE MINIMUMS section of the Terminal Procedures Publication (TPP). **Note:** There may be other requirements that do apply to Air Force pilots. Therefore, pilots must review the IFR ALTERNATE MINIMUMS for pertinent information (e.g., “NA when local weather not available”, “NA when control tower closed”). **(T-0).**

Figure 9.13. IFR Alternate Minimums Symbol.

9.43.2. The alternate NA symbol informs pilots that the specific approach cannot be used to qualify the field as an alternate due to an unmonitored NAVAID or the lack of a weather reporting service.

Figure 9.14. Alternate Not Authorized Symbol.

9.44. PBN Alternate Airfield Considerations. [AC 90-108] For the purposes of flight planning, any required alternate airfield must have an available instrument approach procedure that does not require the use of GNSS. **(T-2).** This restriction includes conducting a conventional approach at the alternate airfield using a substitute means of navigation that is based upon the use of GNSS. For example, these restrictions would apply when planning to use GNSS equipment as a substitute means of navigation for an out-of-service VOR that supports an ILS missed approach procedure at an alternate airfield. In this case, some other approach not reliant upon the use of GPS must be available. **(T-2).** This restriction does not apply to TSO-C145 or TSO-C146 SBAS receivers.

9.44.1. [AIM 1-1-17] For flight planning purposes, properly equipped GNSS users whose navigation systems have FDE capability, who perform a preflight RAIM prediction at the airfield where the RNAV (GPS) approach is planned, have proper knowledge, required training, and approval to conduct a GNSS-based instrument approach, may file based on a GNSS-based instrument approach at either the destination or the alternate airfield, but not at both locations. At the alternate airfield, pilots may plan for:

9.44.1.1. LNAV or circling minimum descent altitude (MDA);

9.44.1.2. LNAV/VNAV DA, if equipped with and using approved Baro-VNAV equipment; or

9.44.1.3. RNP 0.3 DA on an RNAV (RNP) instrument approach, if they are specifically authorized users with approved Baro-VNAV equipment and the pilot has verified RNP availability through an approved prediction program.

9.44.1.4. If the above conditions cannot be met, any required alternate airfield must have an approved instrument approach procedure other than GNSS-based that is anticipated to be operational and available at the ETA, and for which the aircraft is equipped to fly. **(T-2).**

9.44.2. [AIM 1-1-18] Pilots with SBAS receivers may plan to use any instrument approach procedure authorized for use with their SBAS avionics as the planned approach at a required alternate, with the following restrictions:

9.44.2.1. When using SBAS at an alternate airfield, flight planning must be based on flying the RNAV (GPS) LNAV or circling line of minima on a GPS approach procedure or a conventional approach procedure with "or GPS" in the title. **(T-2).**

9.44.2.2. Non-precision weather requirements must be used for planning. **(T-2). Note:** Properly trained and approved, as required, TSO-C145 and TSO-C146 equipped SBAS users using approved Baro-VNAV equipment may plan for LNAV/VNAV DA at an alternate airfield. Specifically authorized SBAS users using approved Baro-VNAV equipment may also plan for RNP 0.3 DA at the alternate airfield as long as the pilot has verified RNP availability through an approved prediction program.

9.44.2.3. Upon arrival at an alternate airfield, when the SBAS navigation system indicates that LNAV/VNAV or LPV service is available, then vertical guidance may be used to complete the approach using the displayed level of service.

Chapter 10

INSTRUMENT CHARTS

10.1. General. The geographic location of the aircraft is the determining factor for which instrument chart procedural criteria to use unless local procedures detailed in FLIP or local directives are in place. If flying outside of the NAS, apply ICAO procedures unless otherwise published. **Note:** The nationality of ATC or the agency that produced a given procedure is not relevant.

10.1.1. A current copy of the appropriate instrument procedure chart will be available in the aircraft for the departure, destination, and all planned alternates. **(T-3).**

10.1.2. Instrument charts retrieved from MAJCOM-approved FAA or NGA electronic delivery systems are identical to those in the printed TPP.

10.1.2.1. If printing instrument procedures distributed by a commercial vendor, ensure the license agreement is current. Do not use the instrument procedure if the license agreement is unknown.

10.1.2.2. Pilots will annotate the effective dates from the NGA ACES website banner on any printed or photocopied NGA instrument procedure. **(T-2). Note:** Comparing amendment numbers or Julian dates on new plates against previously printed plates is not a valid way of determining currency. Information on a plate can change without an amendment number or Julian date change.

10.1.3. Refer to the appropriate Terminal Change Notice (TCN) on the front of the TPP to ensure an instrument procedure is current when using NGA-printed products.

10.2. Ground Track. [ICAO Doc 8168V1 Section 2 **Chapter 1**] All instrument procedures are based on a ground track. Obstruction clearance assumes that pilots apply appropriate corrections to maintain the published path across the ground.

10.3. Instrument Procedure Design Criteria. [DoD Publication Product Specifications; IACC-4; FAA Order 8260.3] Knowing what design criteria was used to create an instrument procedure is essential to determining protected airspace requirements. Criteria used to develop published instrument procedures are not determined by the physical location of the airfield but by the protected airspace allowances used in the procedure design.

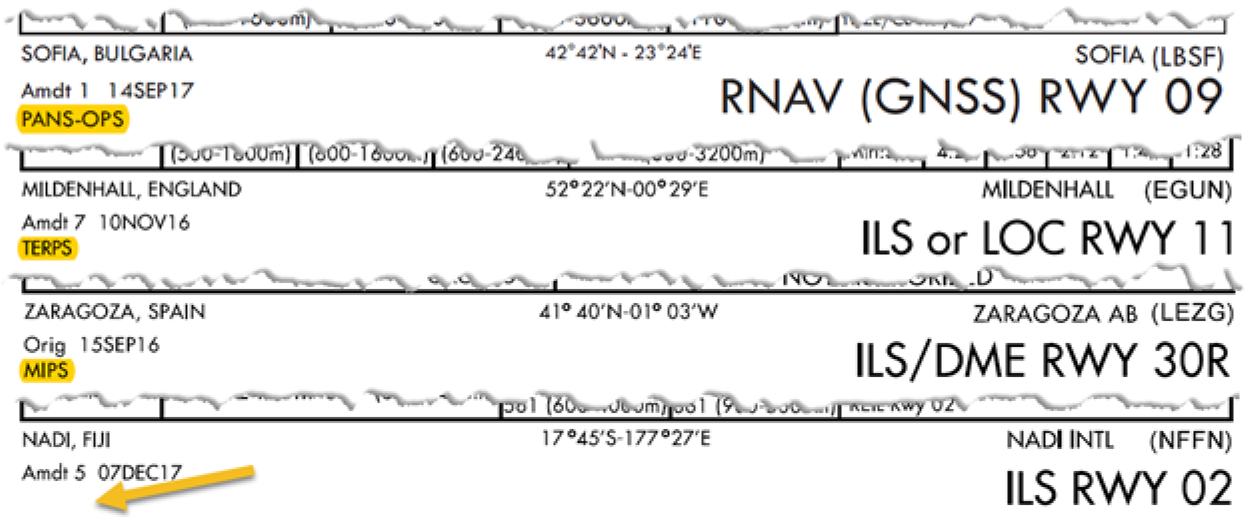
10.3.1. The U.S. Government applies U.S. TERPS design criteria within the United States and its territories in accordance with FAA Order 8260.3. A DoD or FAA designed terminal instrument procedure must pass through a stringent quality control process, culminating in a flight inspection, prior to being published in U.S. Government FLIP. **Note:** Outside the NAS, the USAF may apply U.S., ICAO, or North Atlantic Treaty Organization (NATO) Military Instrument Procedure Standardization (MIPS) design criteria as authorized by AFI 11-230, *Instrument Procedures*, or as directed by the host nation.

10.3.2. Other Nation States may use U.S. TERPS, ICAO PANS-OPS, NATO MIPS, their own criteria, or a combination of criteria when designing instrument procedures (e.g., Japan primarily uses ICAO PANS-OPS but publishes different circling area calculations). **Note:**

NATO MIPS (i.e., NATO Standard AATCP-1) lists NATO supplemental procedures to ICAO PANS-OPS for instrument departure and approach procedures.

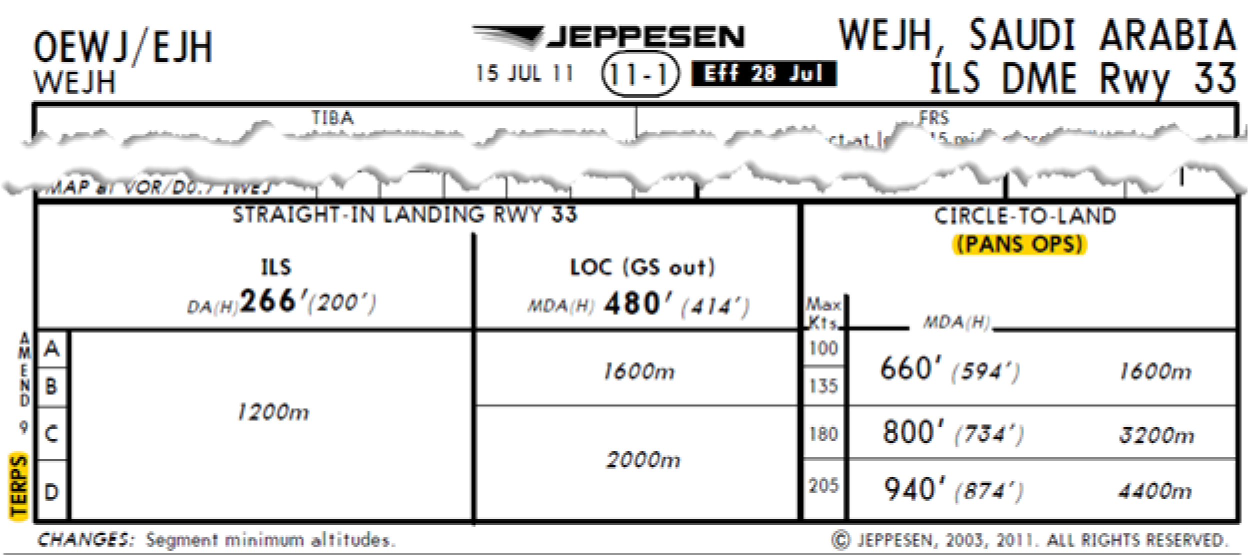
10.3.3. On Foreign Terminal Instrument Procedures (FTIP) published in DoD FLIP, the design criteria used to develop the procedure is published in the bottom left margin below the amendment number and procedure revision date; pilots may infer that U.S. TERPS design criteria is applied when no criteria is published as it is more restrictive (**Figure 10.1**).

Figure 10.1. Instrument Procedure Design Criteria – U.S. Government.



10.3.4. The design criteria is published on the bottom left margin of the instrument procedure on Jeppesen®-published procedures; it is published on the approach if multiple design criteria are used to create the instrument procedure. For example, the ILS DME RWY 33 at Wejh, Saudi Arabia is designed in accordance with U.S. TERPS criteria, yet the circling area is designed based on PANS-OPS criteria (**Figure 10.2**).

Figure 10.2. Instrument Procedure Design Criteria – Jeppesen®.



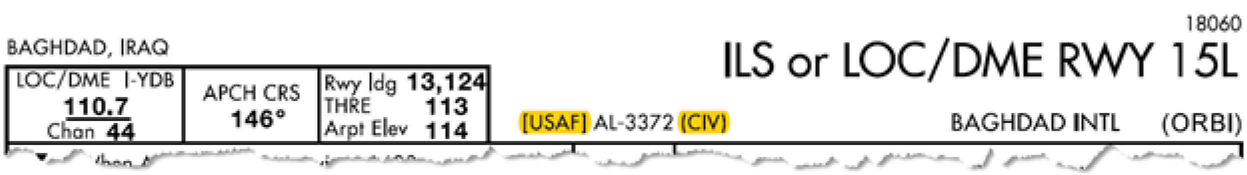
10.4. High Performance Military Aircraft (HPMA) Criteria. [NATO Standard AATCP-1; AFI 11-230] HPMA criteria are military unique criteria for instrument procedures that are normally flown by military-type aircraft (i.e., fighter aircraft) serving a specific operational requirement. HPMA criteria introduce a new aircraft category that does not align with existing ICAO aircraft categories. Pilots will not fly HMPA departures or approaches, nor will pilots utilize HPMA lines of minima on an instrument approach without MAJCOM training and approval. **(T-2).**

10.5. Chart Reference Number. [DoD Publication Product Specifications paragraph 303; FAA IACC-4 **Chapter 3**] The chart legend number at the top of U.S. Government-developed instrument procedures is preceded by the series "AL" (i.e., low instrument procedure) or "JAL" (i.e., high instrument procedure) and dash followed by the chart reference number and the abbreviated name of the appropriate authority who requested the instrument procedure be published, placed inside parentheses. Brackets indicate the procedure is captured digitally (e.g., AL-000 [USA]; JAL-0000 [USAF]; AL-0000 [USN]; AL-000 [FAA]).

10.5.1. The notation at the top of a DoD-published instrument procedure cannot be used to determine what design criteria was used to develop the procedure; departure end crossing restrictions are not consistently published in Terminal Procedure Publications.

10.5.2. On DoD-published FTIP, the chart legend number is preceded by the OPR who requested the procedure publication and followed by the Nation State authority who developed the procedure in parentheses or brackets (**Figure 10.3**). These procedures are developed by the Nation State's procedure development authority and are published in DoD FLIP. The Nation State identifier may be a 2-letter code (e.g., "IZ"); "CIV" or "MIL" indicates the Nation State has more than one procedure design authority. DoD-published FTIP procedures are verified and validated as safe by a DoD procedure specialist. The DoD procedure specialist assumes responsibility for maintaining the currency and accuracy of the DoD-published procedure until it is removed from the Terminal Procedure Publication.

Figure 10.3. DoD Published Foreign Terminal Instrument Procedure.



10.6. FTIP Policy. On 7 June 1996 (last updated 2000), the Secretary of Defense issued the "*DoD Instrument Flight Procedures Policy*" memo, establishing the requirement for the Services to validate any terminal instrument procedures not developed by the FAA or DoD. This review validates whether the instrument procedure meets an equivalent level of safety as U.S. TERPS, ICAO PANS-OPS, or NATO design criteria, when required, prior to use in flight. AFI 11-230 outlines this evaluation process for the Air Force. AFI 11-202V3 provides aircrew-specific guidance regarding the use of FTIP published by sources other than the FAA or NGA. Each MAJCOM has specific guidance and training requirements for the use of FTIP.

10.7. FTIP Review. A thorough evaluation of FTIP is the only way to ensure procedures are safe for aircrew use outside the NAS when compatible procedures are not published in DoD FLIP. An FTIP review, conducted in accordance with AFI 11-230, consists of an instrument procedure criteria compliance evaluation (commonly called a "TERPS review"). Non-U.S. Government published FLIP must meet the standards prescribed in U.S. TERPS, ICAO PANS-OPS, or NATO design criteria.

10.7.1. An instrument procedure evaluation validates FTIP for compliance with accepted criteria or standards prior to use in flight. This "TERPS review" is accomplished by the responsible MAJCOM procedure specialist and is provided to aircrew via the "Giant Report" found on Air Mobility Command's Global Decision Support System (GDSS) website located at **https://gdss.maf.ustranscom.mil/**.

10.7.1.1. Aircrew should check the "Approach/Departure Information" section of the Giant Report for availability of DoD/FAA and Nation State terminal instrument procedures (**Figure 10.4**). DoD/FAA approaches are listed by FLIP volume under the "DoD/FAA/SA Approaches" header; the letter "Y" indicates an approach is published in DoD FLIP. **Note:** Under the "Jeppesen®/Host Approaches" header (**Figure 10.5**), the letter "Y" for a particular Nation State terminal instrument procedure does not indicate the procedure is approved for use; it only indicates the procedure exists.

Figure 10.4. FTIP Published in DoD FLIP.

Approach/Departure Information

SID Source: DOD, HN, JEP **Airfield Diagram Source:** DOD, HN, JEP [LIRN-Airfield Docs]

Top

DoD/FAA/SA Approaches

DOD/NOAA Volume: ENAME

Effective Date: 02-NOV-2015

RWY	ILS	PAR	ASR	TAC	VOR	NDB	LOC|LLZ	RNAV	LCTR	LDA	SDF	MLS	LOC|BC	REMARKS
06					Y									
24	Y						Y							

Figure 10.5. FTIP Approaches Published by Nation State or Commercial Vender.

Top

JEP/Host Approaches

Jeppesen Airfield Name: NAPLES, ITALY

Effective Date: 02-NOV-2015

RWY	ILS	PAR	ASR	TAC	VOR	NDB	LOC|LLZ	RNAV	LCTR	LDA	SDF	MLS	LOC|BC	REMARKS
06	Y				Y		Y							
24	Y						Y							

10.7.1.2. Aircrew should check the status of terminal instrument procedure reviews for availability and currency under the "TERPS Reviews" header (**Figure 10.6**). Aircrew will not fly terminal instrument procedures that have an expired FTIP review. **(T-2). Note:** Aircrew may request new or re-accomplished FTIP reviews through the appropriate MAJCOM in accordance with FLIP *General Planning* and AFI 11-230.

Figure 10.6. FTIP Review.

Top

TERPS Reviews

Approved by MAJCOM

AMC☐ AFRC☐ ANG☐ USAFE☑ PACAF☐ AETC☐ AFMC☐ AFSOC☐ ACC☐ AFSPC☐

Comments:

THE FOLLOWING PROCEDURES ARE APPROVED FOR USE THROUGH THIS DATE: Additional restrictions and/or authorizations are listed in each specific procedure review.	07-FEB-2017

10.7.2. Instrument procedure specialists and MAJCOM/A3V provide additional notes, corrections, and types of conditions (e.g., day, night) under which a crew has been approved to fly a specific instrument procedure. Aircrew should thoroughly study all comments on the FTIP review during preflight planning. While an FTIP review includes an evaluation of the FTIP for compliance with accepted instrument procedure criteria or standards, it does not absolve aircrew from ensuring their aircraft can maneuver appropriately while flying the procedure.

10.8. Comparison Evaluation. A comparison evaluation validates the reproduction accuracy of a commercially produced instrument procedure (e.g., Jeppesen®, Lido®) against the source Nation State instrument procedure. A comparison evaluation is not included in an FTIP review unless specifically requested.

10.8.1. FTIP published by a commercial vendor are published directly from data provided by the Nation State. Unlike DoD/FAA published procedures, the commercial vendor may not compare the Nation State data to any accepted standards of terminal instrument procedure design or the Nation State may not flight check the procedure. The procedure may not guarantee obstacle clearance or it may have other design issues which make it unsafe to fly. In comparison, a terminal instrument procedure published by the DoD/FAA guarantees obstacle clearance when properly flown. Commercial vendors normally publish a legal disclaimer assuming no responsibility for obstacle clearance.

10.8.2. All commercially published FTIPs must have a current FTIP review and comparison evaluation prior to use in flight. **(T-2). Exception:** Procedures published by Jeppesen® may be used in accordance with AFI 11-202V3 without a comparison evaluation if a current FTIP review exists for the source Nation State instrument procedures.

10.9. Non-U.S. Government Published Instrument Procedures. Other Nation States do not always publish their procedures in English. Additionally, they do not use the same charting standards as the DoD/FAA. Aircrew may be completely unfamiliar with the symbology, wording, abbreviations, or other information on Nation State terminal instrument procedures. Commercially published FTIPs may present some of the same challenges to aircrew.

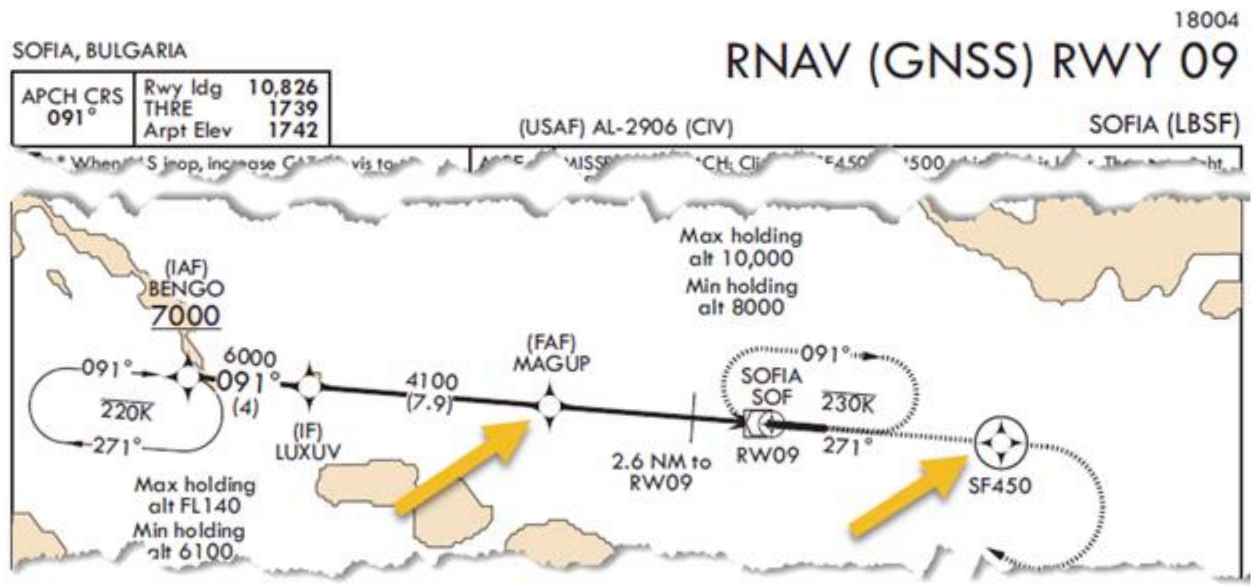
10.10. FTIP Flyability Checks. Flyability checks may be required; they are another means for MAJCOM instrument procedure specialists to ensure FTIPs are safe, practical, and consistent with good procedure design prior to publication in DoD FLIP. Usually, a flyability check is the single incomplete requirement preventing MAJCOM procedure specialists from submitting FTIPs to the NGA for inclusion in DoD-published FLIP. Flyability checks are not official flight inspections; aircrew procedures may be found in AFI 11-230.

10.11. Waypoints. [FAA-H-8083-16 **Chapter 4**; ICAO Doc 8168V1 Part I Section 4 **Chapter 8**] Two types of waypoints appear in area navigation procedures: fly-over and fly-by (**Figure 10.7**). Fly-over waypoints are indicated by the standard waypoint symbol enclosed in a circle. For a fly-over waypoint, turn anticipation is not allowed. No turn may be accomplished until the aircraft passes over the waypoint. Fly-by waypoints are depicted using the standard waypoint symbol. Turn anticipation is allowed for fly-by waypoints.

10.11.1. A fly-by vertical waypoint is a waypoint for which an aircraft may initiate a vertical rate change and depart the specified vertical path to the active waypoint prior to reaching that waypoint, in order to capture the next vertical path. A fly-over vertical waypoint is a waypoint for which an aircraft remains on the defined vertical path until passing the active waypoint, and may not initiate the necessary vertical rate change to capture the next vertical path until after passing the active waypoint.

10.11.2. Approach waypoints are normally fly-by waypoints; the missed approach waypoint and the missed approach holding waypoint are normally fly-over waypoints. Overlay approach charts and some early stand-alone GPS approach charts may not reflect this convention. The missed approach holding waypoint is normally a fly-over waypoint; however, if it also serves another purpose (e.g., serves as an IAF), it is charted as a fly-by waypoint on the approach plate even though it is a fly-over waypoint for entry into holding.

Figure 10.7. Fly-by versus Fly-over Waypoint.



10.12. Radius-to-Fix (RF). [ICAO Doc 9613; AC 90-105] RF legs are intended to be applied where accurate, repeatable, and predictable navigation performance is required in a constant radius turn. This functionality can be used in departures, arrivals, initial approach segments, intermediate approach segments, and the final phase of the missed approach. Procedures with RF legs are identified on the appropriate chart (**Figure 10.8**).

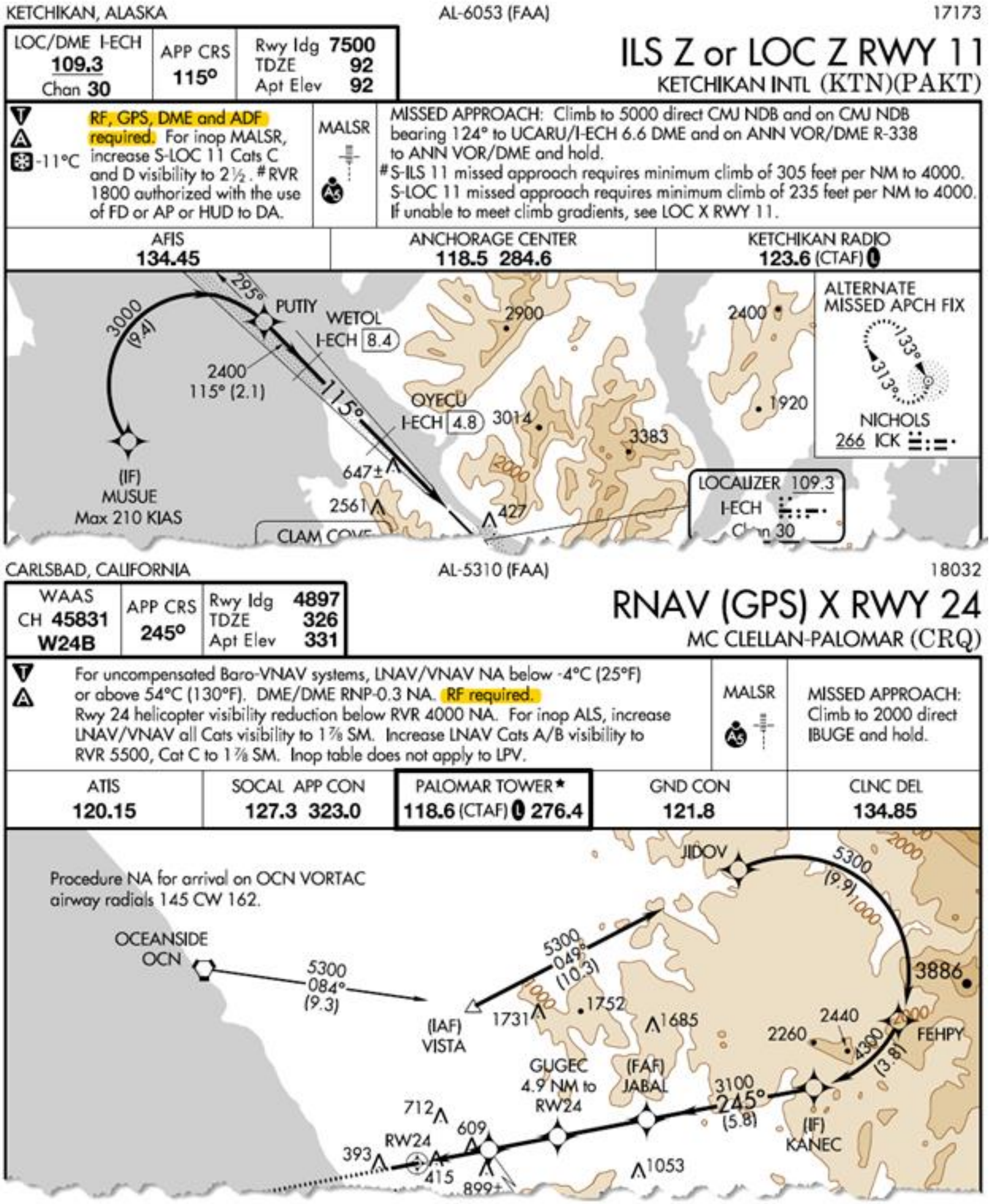
10.12.1. RF legs in the final approach, initial or intermediate phases of the missed approach are prohibited unless the approach is designed under the RNP Authorization Required (RNP AR) specification. Refer to **Chapter 19** for RNP AR approach details.

10.12.2. ATC should not issue a “Direct-To” clearance to a waypoint beginning an RF leg or a vector to intercept an RF leg. The aircraft flight manual should document limitations if:

10.12.2.1. The aircraft cannot proceed “Direct-To” the initial fix defining an RF leg segment; or

10.12.2.2. The aircraft cannot accept a radar vector to the middle of an RF leg segment for intercepting and completing the RF leg segment from that point while sustaining the desired level of performance.

Figure 10.8. Radius-to-Fix (RF) Legs.



10.12.3. An autopilot or flight director with at least "roll-steering" capability coupled to the RNP system is required. The autopilot and flight director must operate with suitable accuracy to track the lateral and vertical paths as required by a specific RNP procedure. **(T-0).**

10.12.3.1. An electronic map display depicting the RNP computed path of the selected procedure is required. **(T-0).**

10.12.3.2. The flight management computer, the flight director system, and the autopilot must be capable of commanding and achieving a bank angle up to 25 degrees above 400 feet AGL. **(T-0).**

10.12.4. The flight guidance mode should remain in LNAV when abandoning a procedure while on an RF leg to enable display of deviation and positive course guidance during the RF leg. Crew procedures must be used to assure the aircraft will respond to the specified flightpath during the RF leg in the event that the aircraft does not provide this capability. **(T-0).**

10.12.5. When a flight is predicated on flying an RNP procedure with an RF leg, the pilot must determine that the installed autopilot or flight director is operational. **(T-0).**

10.12.6. The aircraft must be established on the procedure prior to starting the RF leg. **(T-0).**

10.12.7. The pilot is expected to maintain the centerline of the desired path on RF legs. FTE should be limited to half the navigation accuracy associated with the procedure for normal operations (e.g., 0.5 nautical miles for RNP 1).

10.12.8. The pilot must not exceed maximum airspeeds associated with the RF leg. **(T-0).**

10.12.9. If an aircraft system failure results in the loss of capability to follow an RF turn, the pilot should maintain the current bank and roll out on the charted RF exit course. The pilot should advise ATC as soon as possible of the system failure.

Chapter 11

WAKE TURBULENCE

11.1. General. Every aircraft generates a wake while in flight. Wake turbulence is caused by a pair of counter-rotating vortices trailing from the wing tips and pose problems to other aircraft. This chapter builds on the concepts introduced in FAA handbooks and manuals. Refer to AIM 7-3 for basic wake turbulence information unless otherwise noted.

11.2. Aircraft Weight Classes.

11.2.1. [ICAO Doc 4444 Chapter 4.9] Wake turbulence separation minima is based on a grouping of aircraft types into three categories according to the maximum certificated take-off mass as follows:

11.2.1.1. Super (J) – A380-800

11.2.1.2. Heavy (H) – all aircraft types of 300,000 pounds or more;

11.2.1.3. Medium (M) – aircraft types less than 300,000 pounds but more than 15,500 pounds; and

11.2.1.4. Light (L) – aircraft types of 15,500 pounds or less.

11.2.1.5. Helicopters should be kept well clear of light aircraft when hovering or while air taxiing.

11.2.2. [FAA Pilot/Controller Glossary] For the purposes of wake turbulence separation minima, ATC classifies aircraft as super, heavy, large, and small as follows:

11.2.2.1. Super – The Airbus A-380-800 (A388) and the Antonov An-225 (A225) are classified as super.

11.2.2.2. Heavy – Aircraft capable of takeoff weights of 300,000 pounds or more whether or not they are operating at this weight during a particular phase of flight.

11.2.2.3. Large – Aircraft of more than 41,000 pounds, maximum certificated takeoff weight, up to but not including 300,000 pounds.

11.2.2.4. Small – Aircraft of 41,000 pounds or less maximum certificated takeoff weight.

11.3. (ICAO) Wake Turbulence Separation. [ICAO Doc 4444] Distance-based wake turbulence separation minima in **Table 11.1** is applied when:

11.3.1. An aircraft is operating directly behind another aircraft at the same altitude or less than 1,000 feet;

11.3.2. Both aircraft are using the same runway, or parallel runways separated by less than 2,500 feet; or

11.3.3. An aircraft is crossing behind another aircraft, at the same altitude or less than 1,000 feet below.

Table 11.1. ICAO Distance-based Wake Turbulence Minima.

Preceding Aircraft	Succeeding Aircraft	Distance-based Wake Turbulence Separation Minima in Nautical Miles
SUPER	HEAVY	6
	MEDIUM	7
	LIGHT	8
HEAVY	HEAVY	4
	MEDIUM	5
	LIGHT	6
MEDIUM	LIGHT	5

11.3.4. Wake turbulence separation is not required for arriving VFR flights landing on the same runway as a preceding landing HEAVY or MEDIUM aircraft and between arriving IFR flights executing visual approach when the aircraft has reported the preceding aircraft in sight and has been instructed to follow and maintain own separation from that aircraft. ATC should issue a caution of possible wake turbulence. The pilot in command is responsible for wake turbulence spacing. Minimum wake turbulence for landing aircraft is in **Table 11.2**.

Table 11.2. ICAO Time-based Wake Turbulence Minima.

	Landing Behind	Time-based Wake Turbulence Separation Minima
MEDIUM	HEAVY	2
LIGHT	HEAVY	3
	MEDIUM	
Note: Time in minutes.		

11.3.5. A minimum separation of 2 minutes is applied between a LIGHT or MEDIUM aircraft taking off behind a HEAVY aircraft or a LIGHT aircraft taking off behind a MEDIUM aircraft when the aircraft are using:

11.3.5.1. The same runway;

11.3.5.2. Parallel runways separated by less than 760 meters (2,500 feet);

11.3.5.3. Crossing runways if the projected flight path of the second aircraft crosses the projected flight path of the first aircraft at the same altitude or less than 300 meters (1,000 feet) below;

11.3.5.4. Parallel runways separated by 760 meters (2,500 feet) or more if the projected flight path of the second aircraft crosses the projected flight path of the first aircraft at the same altitude or less than 300 meters (1,000 feet) below.

11.3.6. A separation minimum of 3 minutes is applied between a LIGHT or MEDIUM aircraft when taking off behind a HEAVY aircraft or a LIGHT aircraft when taking off behind a MEDIUM aircraft from:

11.3.6.1. An intermediate part of the same runway; or

11.3.6.2. An intermediate part of a parallel runway separated by less than 760 meters (2,500 feet).

11.3.7. A separation minimum of 2 minutes is applied between a LIGHT or MEDIUM aircraft and a HEAVY aircraft and between a LIGHT aircraft and a MEDIUM aircraft when operating on a runway with a displaced landing threshold when:

11.3.7.1. A departing LIGHT or MEDIUM aircraft follows a HEAVY aircraft arrival and a departing LIGHT aircraft follows a MEDIUM aircraft arrival; or

11.3.7.2. An arriving LIGHT or MEDIUM aircraft follows a HEAVY aircraft departure and an arriving LIGHT aircraft follows a MEDIUM aircraft departure if the projected flight paths are expected to cross.

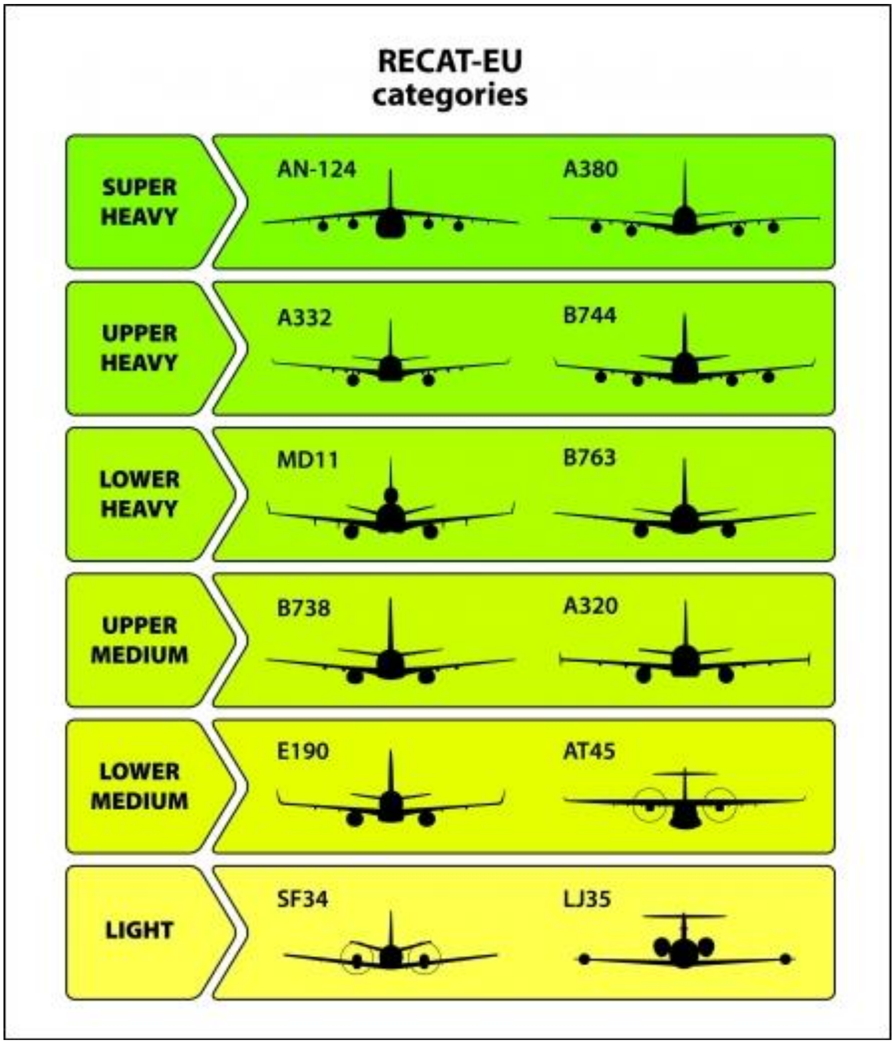
11.3.8. A separation minimum of 2 minutes is applied between a LIGHT or MEDIUM aircraft and a HEAVY aircraft and between a LIGHT aircraft and a MEDIUM aircraft when the heavier aircraft is making a low or missed approach and the lighter aircraft is:

11.3.8.1. Utilizing an opposite-direction runway for take-off; or

11.3.8.2. Landing on the same runway in the opposite direction, or on a parallel opposite-direction runway separated by less than 760 meters (2,500 feet).

11.4. European Wake Vortex Re-categorization (RECAT-EU). [Eurocontrol RECAT-EU] RECAT-EU is a new, much more precise categorization of aircraft than the traditional ICAO wake categories (**Figure 11.1**). It aims at safely increasing airfield capacity by redefining wake turbulence categories and their associated separation minima. It divides the current Heavy and Medium categories into two sub-categories and creates a new Super Heavy category which includes the Airbus A380 and AN-124.

Figure 11.1. RECAT-EU Categories.



11.4.1. RECAT-EU distanced-based separation minima on approach and departure is shown in **Table 11.3**

Table 11.3. RECAT-EU Distance-based Wake Turbulence Minima.

Leader/Follower	**SUPER HEAVY**	**UPPER HEAVY**	**LOWER HEAVY**	**UPPER MEDIUM**	**LOWER MEDIUM**	**LIGHT**
SUPER HEAVY	3	4	5	5	6	8
UPPER HEAVY		3	4	4	5	7
LOWER HEAVY		(*)	3	3	4	6
UPPER MEDIUM						5
LOWER MEDIUM						4
LIGHT						3
Note: Distance in nautical miles. (*) means "minimum radar separation," set at 2.5 nautical miles, is applicable as per ICAO Doc 4444 provisions.						

11.4.2. RECAT-EU time-based separation minima on departure is shown in **Table 11.4**

Table 11.4. RECAT-EU Time-based Wake Turbulence Minima.

Leader/Follower	SUPER HEAVY	UPPER HEAVY	LOWER HEAVY	UPPER MEDIUM	LOWER MEDIUM	LIGHT
SUPER HEAVY		100	120	140	160	180
UPPER HEAVY				100	120	140
LOWER HEAVY				80	100	120
UPPER MEDIUM						120
LOWER MEDIUM						100
LIGHT						80
Note: Time in seconds.						

11.5. (NAS only)Wake Turbulence Separation. [AIM 7-3-9] Because of the possible effects of wake turbulence, controllers are required to apply no less than specified minimum separation to all IFR aircraft, to all VFR aircraft receiving Class B or Class C airspace services when operating behind super or heavy aircraft, and to small aircraft operating behind a C-32 / Boeing 757 (B757).

11.5.1. Separation is applied to aircraft operating directly behind a super or heavy at the same altitude or less than 1,000 feet below, and to small aircraft operating directly behind a B757 at the same altitude or less than 500 feet below:

11.5.1.1. Heavy behind super − 6 miles.

11.5.1.2. Large behind super − 7 miles.

11.5.1.3. Small behind super − 8 miles.

11.5.1.4. Heavy behind heavy −4 miles.

11.5.1.5. Small/large behind heavy − 5 miles.

11.5.1.6. Small behind B757 − 4 miles.

11.5.2. Separation is provided to small aircraft measured from the time the preceding aircraft is over the landing threshold:

11.5.2.1. Small landing behind heavy − 6 miles.

11.5.2.2. Small landing behind large, non-B757 − 4 miles.

11.5.3. Appropriate time or distance intervals are provided to departing aircraft when the departure is from the same threshold, a parallel runway separated by less than 2,500 feet with less than 500 feet threshold stagger, or on a crossing runway and projected flight paths cross:

11.5.3.1. Three minutes or the appropriate radar separation when takeoff is behind a super aircraft;

11.5.3.2. Two minutes or the appropriate radar separation when takeoff is behind a heavy aircraft.

11.5.3.3. Two minutes or the appropriate radar separation when a small aircraft takeoff is behind a B757. **Note:** Controllers may not reduce or waive these intervals.

11.5.4. A 3-minute interval is provided when a small aircraft takeoff is:

11.5.4.1. From an intersection on the same runway (same or opposite direction) behind a departing large aircraft or B757, or

11.5.4.2. In the opposite direction on the same runway behind a large aircraft or B757 takeoff or low/missed approach. **Note:** This 3-minute interval may be waived upon specific pilot request; it may not be waived behind a B757.

11.5.5. A 4-minute interval is provided for all aircraft taking off behind a super aircraft, and a 3-minute interval is provided for all aircraft taking off behind a heavy aircraft when the operations are as described above and are conducted on either the same runway or parallel runways separated by less than 2,500 feet. Controllers may not reduce or waive this interval.

11.5.6. Pilots may request additional separation (i.e., 2 minutes instead of 4 or 5 miles) for wake turbulence avoidance. This request should be made as soon as practical on the ground control frequency and at least before taxiing onto the runway. **Note:** The pilot-in-command of an aircraft is directly responsible for and is the final authority as to the operation of that aircraft.

11.5.7. Controllers may anticipate separation and need not withhold a takeoff clearance for an aircraft departing behind a large, heavy, or super aircraft if there is reasonable assurance the required separation exists when the departing aircraft starts takeoff roll.

Chapter 12

DEPARTURE

12.1. General. Planning a safe departure normally consists of three steps: selecting a valid departure method, determining the required climb gradient, and ensuring performance meets or exceeds that climb gradient. Reference AIM 5-2-8, FAA-H-8083-15, and ICAO Doc 8168V1 for more detailed explanations and examples of departure procedures (DP).

12.2. VFR Communication. [14 CFR Part 91.123] Pilots departing VFR must comply with ATC instructions when participating in radar services or flight following. **(T-0).**

12.2.1. It is important when departing from non-towered airfields for pilots to be vigilant for other aircraft both on the ground and in the air as well as other hazards to aircraft. When ready to depart, utilize the airfield common traffic advisory frequency (CTAF) or universal communication (UNICOM) frequency to announce aircraft location, departure runway, intentions, and direction of flight after departure.

12.2.2. Radio contact with ATC may not always be possible on the ground. In those instances, aircrew may either activate the VFR flight plan or obtain an IFR release through a ground communications relay station or with an FSS via telephone or radio once airborne.

12.3. VFR Departure. The ability to "see and avoid" obstacles and terrain is inherent to VFR departures. Pilots must adhere to AFI 11-202V3 procedures for VFR climb performance. **(T-2).**

12.4. IFR Departure. Authorized IFR departure methods may be found in AFI 11-202V3.

12.5. IFR Departure Climb Gradients. [ICAO Doc 8168V2 Part I Section 3 **Chapter 2**] The standard IFR departure climb gradient is 3.3% (200 feet per nautical mile); it begins at 16 feet above the departure end of the runway (DER). Standard IFR DER crossing restrictions are listed in **Table 12.1**; pilots under IFR must plan to cross the DER at or above these restrictions unless otherwise published or MAJCOM-directed procedures are followed (e.g., Special Departure Procedures). **(T-0).**

Table 12.1. IFR DER Crossing Restrictions (Unless Published Otherwise).

Design Criteria	Crossing Restriction
USAF / USN	0 feet
ICAO / NATO	16 feet
FAA / USA	0 – 35 feet

12.5.1. [FAA Order 8260.3] The departure climb gradient begins at 0 feet above the DER elevation under current U.S. TERPS criteria; however, many procedures developed under older U.S. TERPS criteria still have an unpublished DER crossing restriction of 35 feet.

12.5.1.1. All USAF and United States Navy (USN) departure climb gradients begin at 0 feet above the DER elevation unless published otherwise.

12.5.1.2. FAA and United States Army (USA) departure climb gradients begin between 0 feet and 35 feet above the DER elevation. There is no consistent method for a pilot to determine the required DER crossing restriction for an FAA or USA departure procedure.

12.5.1.2.1. [AIM 5-2-8] Unless specified otherwise, the required obstacle clearance for all FAA and USA departures, including diverse departures, is based on the pilot crossing the DER at least 35 feet above the DER elevation, climbing to 400 feet above the DER elevation before making the initial turn, and maintaining a minimum climb gradient of 200 feet per nautical mile, unless required to level off by a crossing restriction, until the minimum IFR altitude.

12.5.1.2.2. The FAA is the Senior Airfield Authority at joint-use airfields and is responsible for all instrument procedures; therefore, pilots should plan to cross the DER at least 35 feet above the DER elevation at joint-use airfields.

12.5.1.2.3. If in doubt, or the 35-foot restriction limits mission capability, contact the MAJCOM TERPS office for the actual DER crossing restriction.

12.5.2. ICAO departure bank angle is 15 degrees until 1,000 feet, 20 degrees between 1,000 and 3,000 feet, and above 3,000 feet is 25 degrees or standard rate (3 degrees per second) whichever requires less bank.

12.5.3. ICAO design criteria is based on the maximum departure airspeeds in **Table 12.2**.

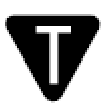
Table 12.2. ICAO Maximum Allowable Departure Speeds.

Aircraft Category	Max Indicated Airspeed
A	120
B	165
C	265
D	290
E	300
H	90

12.6. IFR Departure Procedures. Airfields with IFR departure procedures designed to assist pilots in avoiding obstacles during the climb to the minimum enroute altitude (MEA), or airfields that have civil IFR takeoff minimums other than standard, are listed in the "IFR TAKEOFF MINIMUMS, OBSTACLE DEPARTURE PROCEDURES, AND DIVERSE VECTOR AREAS (RADAR VECTORS)" of the TPP, commonly called the "Trouble T" section.

12.6.1. The "Trouble T" symbol on all published instrument procedures for an airfield notifies pilots that departure procedures exist (**Figure 12.1**).

Figure 12.1. "Trouble T" Symbol.



12.6.2. Takeoff minimums and departure procedures apply to specific runways unless otherwise stated. An entry may also be listed that contains only takeoff obstacle notes. Altitudes, unless otherwise indicated, are minimum MSL altitudes.

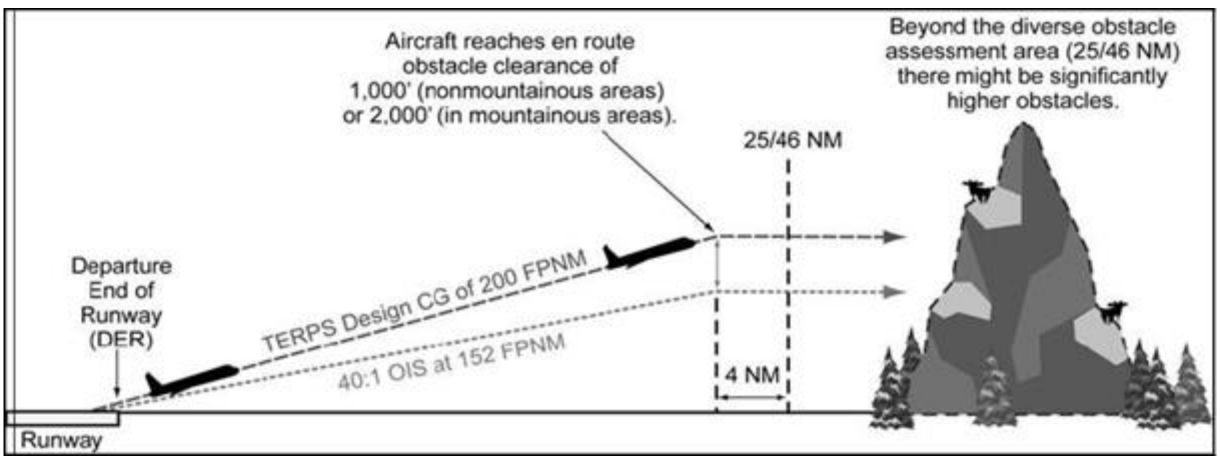
12.6.3. IFR DPs specifically designed for obstacle avoidance are referred to as obstacle departure procedures (ODP) and are textually described in the "Trouble T" section of the TPP or published separately as a graphic procedure. Pilots may recognize graphic ODPs by the term “(OBSTACLE)” included in the procedure title (e.g., “TETON TWO (OBSTACLE)”).

12.7. Diverse Departure. [FAA Order 8260.46] An instrument procedure specialist conducts a diverse departure assessment to determine if an obstacle penetrates the 40:1 obstacle identification surface (OIS). The 40:1 OIS is equivalent to 152 feet per nautical mile; an additional 48 feet per nautical mile or more of required obstacle clearance is added to the 40:1 OIS, making the standard IFR departure climb gradient 200 feet per nautical mile.

12.7.1. A diverse departure may be authorized if no obstacles, other than low close-in obstacles, penetrate the 40:1 OIS. ATC does not specifically clear pilots for a diverse departure nor can pilots file it on a flight plan.

12.7.2. The diverse departure obstacle assessment area is limited to 25 nautical miles from the airfield in non-mountainous terrain and 46 nautical miles in designated mountainous areas (**Figure 12.2**). Beyond this distance, the pilot is responsible for obstacle clearance if not operating on a published route, below the MEA or minimum obstruction clearance altitude (MOCA) of a published route, or below an ATC-assigned altitude. Pilots should check terrain and obstacle information for areas surrounding the immediate terminal area when planning any instrument departure.

Figure 12.2. Diverse Departure Obstacle Assessment.



12.7.3. A diverse departure is an acceptable IFR departure method for a specific runway unless that runway has a published ODP listed in the “Trouble T” section of the TPP (**Figure 12.3**).

Figure 12.3. Diverse Departure Not Authorized (Runway 36R).

HUNTSVILLE, AL

HUNTSVILLE INTL-CARL T JONES FIELD (HSV)

TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES

AMDT 4A 18032 (FAA)

DEPARTURE PROCEDURE: **Rwy 36R,** climb heading 005° to 1600 before turning right.

TAKEOFF OBSTACLE NOTES: **Rwy 18L,** trees

12.7.4. Sector diverse departures only allow for diverse departures within specific sector requirements (**Figure 12.4**).

Figure 12.4. Sector Diverse Departure.

JACKSONVILLE NAS (TOWERS FIELD) (KNIP)

JACKSONVILLE, FL

TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES

AMDT 2 16203

DEPARTURE PROCEDURE: **Rwy 10,** Diverse departures only between 116° through 276° CW. **Rwy 14,** Diverse departures only between 095° through 320° CW. **Rwy 32,** Diverse departures only between 351° through 141° CCW.

TAKEOFF OBSTACLE NOTES: **Rwy 10,** windsock 341'

12.8. ICAO Omnidirectional Departure. [ICAO Doc 8168V1 **Chapter 3**] The omnidirectional departure is a departure procedure without any track guidance provided or available (**Figure 12.5**). It's like the FAA's diverse departure with a very important difference: the omnidirectional departure may be published even with OIS penetrations. The instrument procedure specialist may design the omnidirectional departure procedure using any combination of the following:

12.8.1. Departure restrictions are not published when obstacles do not penetrate the 40:1 OIS and an additional 246 feet of required obstacle clearance exists. Pilots may turn in any direction upon reaching 400 feet above DER elevation.

12.8.2. The procedure specifies a 200 foot per nautical mile climb to an altitude at which omnidirectional turns may be made when obstacles preclude turns at 400 feet.

12.8.3. The procedure may define a minimum climb gradient of more than 200 feet per nautical mile to a specified altitude before turns are permitted.

12.8.4. The procedure may identify sectors for which either a minimum climb gradient or a minimum turn altitude is specified (e.g., "Climb straight ahead to 2,000 feet before commencing a turn to the east/sector 0 degrees to 179 degrees and climb to 1,800 feet before commencing a turn to the west/sector 180 degrees to 359 degrees").

12.8.5. Pilots must maintain at least the standard IFR climb gradient from the altitude at which turns in any direction are allowed until reaching a minimum IFR altitude. **(T-0).**

Figure 12.5. Omnidirectional Departure.

Military	TAKE OFF & DEPARTURE PROCEDURE
	All Rwys
	STD
1 & 2 Eng	1
3 & 4 Eng	½

OMNIDIRECTIONAL DEPARTURE PROCEDURE

RWY 08: Cross DER at least 210'. Climb on track 086° until passing 1200', then proceed on course.

RWY 26: Cross DER at least 194'. Climb on track 261° until passing 700', then proceed on course.

CHANGES: None. © JEPPESEN, 2000, 2012. ALL RIGHTS RESERVED.

12.9. Non-standard IFR Takeoff Minimums. Non-standard IFR takeoff minimums are provided for civil pilots to "see and avoid" obstacles during departure when obstacles penetrate the 40:1 OIS within 3 statute miles from the DER (**Figure 12.6**).

Figure 12.6. IFR Takeoff Minimums – Non-standard.

ANDREWS, SC
ROBERT F. SWINE (PHH)
TAKEOFF MINIMUMS AND (OBSTACLE)
DEPARTURE PROCEDURES
ORIG 02276 (FAA)
TAKEOFF MINIMUMS: **Rwy 18,** 300-1. **Rwy 36,** 400-1.

12.9.1. A minimum climb gradient is published when obstacles penetrate the 40:1 OIS beyond 3 statute miles from the DER. Some non-standard takeoff weather minima list a specific climb gradient that may be used with "standard" weather minima or alternate procedures for a standard climb gradient (**Figure 12.7**).

Figure 12.7. IFR Takeoff Minimums – "Or Standard".

CLARKSVILLE, TN
OUTLAW FIELD (CKV)
TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES
AMDT 2 06271 (FAA)
TAKEOFF MINIMUMS: **Rwy 35,** 300-1 or std. w/ min. climb of 240' per NM to 800. Alternatively, with standard takeoff minimums and a normal 200'/NM climb gradient, takeoff must occur no later than 1900' prior to DER.

12.9.2. Occasionally, IFR takeoff minimums are published that are specific to a certain category of aircraft (**Figure 12.8**). Pilots will use the aircraft approach category from the aircraft flight manual for procedures that specify an aircraft category. **(T-0).**

Figure 12.8. IFR Takeoff Minimums – Specific Aircraft Category.

GALLUP, NM
GALLUP MUNI (GUP)
TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES
AMDT 2 94230 (FAA)
TAKEOFF MINIMUMS: **Rwy 6,** CAT A,B 1300-2 or std. with a min. climb of 300' per NM until passing 8000. CAT C,D 1600-3 or std. with a min. climb of 320' per NM until passing 8500. **Rwy 24,** 700-2 or std. with a min. climb of 370' per NM until passing 8000.

12.10. ODP – Specific Routing. The instrument procedure specialist may publish specific routing to avoid obstacles under the "departure procedure" section of the ODP (**Figure 12.9**).

Figure 12.9. ODP – Specific Routing.

LA JUNTA, CO
LA JUNTA MUNI (LHX)
TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES
AMDT 3A 16091 (FAA)
DEPARTURE PROCEDURE: **Rwy 8,** climb via heading 080°. **Rwy 12,** climb via heading 120°. **Rwy 26,** turn left heading 160°. **Rwy 30,** turn left heading 140°. **All aircraft,** intercept LAA R-238 (V210) to LAA VOR/DME. When at or above 8000 proceed on course.
NOTE: **Rwy 26,** rod 196' from DER, 445' left of centerline, 10' AGL/4241' MSL. fence 224' from DER, 198' right of centerline, 7' AGL/4235' MSL.

12.11. ODP – Visual Climb Over Airport (VCOA). A VCOA procedure is a departure option for an IFR aircraft, operating in visual meteorological conditions equal to or greater than the specified visibility and ceiling, to visually conduct climbing turns over the airfield to the published "climb-to" altitude from which to proceed with the instrument portion of the departure. VCOA procedures are developed to avoid obstacles greater than 3 statute miles from the DER but still require at least the standard IFR climb gradient while executing the VCOA. Pilots are responsible to advise ATC as early as possible of the intent to fly the VCOA procedure prior to departure.

12.11.1. USAF pilots are prohibited from constructing their own VCOA. **(T-0).**

12.11.2. VCOA procedures are normally published as a textual ODP; however a VCOA may appear as a note on a graphical ODP.

12.11.2.1. A VCOA procedure has a published non-standard ceiling and visibility directly associated with the words "for VCOA" in the "TAKEOFF MINIMUMS" section of the ODP (**Figure 12.10**). It also includes the instructions "obtain ATC approval for VCOA when requesting IFR clearance" and "climb in visual conditions" to cross a specified airfield, NAVAID, or fix at or above a specified altitude before proceeding on course in the "VCOA" section of the ODP.

Figure 12.10. ODP – VCOA Format.

CEDAR CITY, UT
CEDAR CITY RGNL (CDC)
TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES
AMDT 3 17005 (FAA)
TAKEOFF MINIMUMS: **Rwy 8**, 4200-3 for VCOA. **Rwy 20,** std. w/ min. climb of 290' per NM to 7300 or 4200-3 for VCOA. **Rwy 26,** std. w/min. climb of 255' per NM to 7000 or 4200-3 for VCOA.
DEPARTURE PROCEDURE: **Rwys 2, 8,** climbing left turn direct EHK VOR/DME, thence... **Rwy 20, 26,** climbing right turn direct EHK VOR/DME, thence... ...continue climb on EHK VOR/DME R-287 until reaching the MEA/MCA for direction of flight.
VCOA: **Rwys 8, 20, 26,** obtain ATC approval for VCOA when requesting IFR clearance. Climb in visual conditions to cross Cedar City Rgnl airport at or above 9700, then proceed on EHK VOR/ DME, then on EHK VOR/DME R-287 until reaching the MEA MCA for direction of flight.

12.11.2.2. A VCOA procedure published under old standards that is not updated has a published non-standard ceiling and visibility directly associated with the words "for climb in visual conditions" in the "TAKEOFF MINIMUMS" section of the ODP (**Figure 12.11**). It also includes the instructions "for climb in visual conditions" to cross a specified airfield, NAVAID, or fix at or above a specified altitude before proceeding on course in the "DEPARTURE PROCEDURE" section of the ODP.

Figure 12.11. ODP – Legacy VCOA Format.

BULLHEAD CITY, AZ
LAUGHLIN/BULLHEAD INTL (IFP)
TAKEOFF MINIMUMS AND (OBSTACLE)
DEPARTURE PROCEDURES
AMDT 1 09183 (FAA)
TAKEOFF MINIMUMS: **Rwy 16,** std. w/ a min. climb of 370' per NM to 1800, or 1700-3 for climb in visual conditions. **Rwy 34,** std. w/ a min. climb of 495' per NM to 5500, or 1700-3 for climb in visual conditions.
DEPARTURE PROCEDURE: **Rwy 16,** climb via heading 164° and EED VORTAC R-334 to EED VORTAC, or for climb in visual conditions: cross Laughlin/Bullhead Intl airport at or above 2300, then continue climbing via heading 155° and EED VORTAC R-335 to EED VORTAC. **Rwy 34,** climb via heading 344° to 1600, then climbing right turn direct EED VORTAC, or for climb in visual conditions: cross Laughlin/Bullhead Intl airport at or above 2300, then continue climbing via heading 155° and EED VORTAC R-335 to EED VORTAC. **All Aircraft** climb in EED VORTAC holding pattern (East, right turn, 257° inbound) to cross EED VORTAC at or above MEA for direction of flight before proceeding on course.

12.11.2.3. Some VCOA procedures may not conform to either format listed above. Contact the MAJCOM TERPS office to determine if a VCOA is authorized (**Figure 12.12**).

Figure 12.12. ODP – Non-Conforming VCOA Format.

AMEDEE AAF (KAHC),
HERLONG, CA . . . . Amdt 1, 09239
Rwy 8, 26: 4000-3 for climb in visual conditions.
Rwy 8, 26: Cross Amedee AAF at or above 7900 before proceeding on course.

12.12. ODP – Reduced Takeoff Runway Length Procedure (RTRL). If all obstacles penetrate the OIS by 35 feet or less, the instrument procedure specialist may artificially limit the takeoff runway length available to achieve a standard climb gradient of 200 feet per nautical mile (**Figure 12.13**). An RTRL procedure requires the aircraft to lift off the runway at or prior to a specified distance from the DER. In the example below, subtract the value in the RTRL procedure from the usable runway length to determine the reduced runway length. If the reduced length is equal to or greater than the aircraft's calculated ground run, the procedure may be flown using a standard climb gradient of 200 feet per nautical mile.

Figure 12.13. ODP – RTRL Procedure.

ANTIGO, WI
LANGLADE COUNTY (AIG)
TAKEOFF MINIMUMS AND (OBSTACLE)
DEPARTURE PROCEDURES
AMDT 1 13206 (FAA)
TAKEOFF MINIMUMS: **Rwy 9,** 300-2¼ or std. w/min. climb gradient of 215' per NM to 1900, or alternatively, with standard takeoff minimums and a normal 200' per NM climb gradient, takeoff must occur no later than 1700' prior to DER.

12.13. ODP – Combination of Methods. The instrument procedure specialist may use a combination of the previously described methods to construct an ODP. In **Figure 12.14**, the pilot has to comply with required climb gradient in the "TAKEOFF MINIMUMS" and the routing in the "DEPARTURE PROCEDURE," or request the VCOA, for runways 6, 16, and 24; an IFR departure from runway 34 is not allowed.

Figure 12.14. ODP – Combination of Methods.

ROANOKE, VA
ROANOKE-BLACKSBURG RGNL/
WOODRUM FIELD (ROA)
TAKEOFF MINIMUMS AND (OBSTACLE)
DEPARTURE PROCEDURES
AMDT 11 15344 (FAA)
TAKEOFF MINIMUMS: **Rwy 6,** std. w/ min. climb of 585' per NM to 3000, or 2600-3 for climb in visual conditions. **Rwy 16,** std. w/ min. climb of 340' per NM to 3000, or 2600-3 for climb in visual conditions. **Rwy 24,** std. w/ min. climb of 242' per NM to 2800, or 2600-3 for climb in visual conditions. **Rwy 34,** NA-Obstacles.
DEPARTURE PROCEDURE: **Rwy 6,** climb on heading 058° to 3200 before proceeding on course. **Rwy 16,** climb on heading 156° to 3000 before proceeding on course. **Rwy 24,** climb on heading 238° and on I-SZK LDA localizer west course to 4200 to DIXXY INT/I-SZK 15.25 DME before proceeding on course.
VISUAL CLIMB: Obtain ATC approval for VCOA when requesting IFR clearance. Climb in visual conditions to cross Roanoke-Blacksburg Rgnl/Woodrum Field at or above 3600 before proceeding on course.

12.14. Takeoff Obstacle Notes. Obstacles within 3 statute miles of the DER identified during the diverse departure obstacle assessment that require a climb gradient greater than 200 feet per nautical mile are published under "TAKE-OFF OBSTACLE NOTES" in the "Trouble T" section (**Figure 12.15**). The purpose of this section is to identify the obstacles and alert the pilot to the height and location of the obstacles so they can be seen and avoided.

12.15. Low Close-in Obstacles. Obstacles that require a climb gradient greater than 200 feet per nautical mile for a very short distance, only until the aircraft is 200 feet above the DER, are referred to as "low, close-in obstacles."

Figure 12.15. Low Close-in Obstacles.

AMARILLO, TX

RICK HUSBAND AMARILLO INTL (AMA)

TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES

AMDT 1 07242 (FAA)

DEPARTURE PROCEDURE: **Rwy 22,** climb heading 218° to 4100 before turning northbound. **Rwy 31,** climbing right turn heading 360° to 5400 before turning westbound.

TAKEOFF OBSTACLE NOTES: **Rwy 31,** sign 23' from DER, 257' right of centerline, 6' AGL/3605' MSL.

12.16. Diverse Vector Area (DVA). [FAA-H-8083-16] A DVA may be created to allow radar vectors to be used in lieu of an ODP at some locations where an ODP has been established. DVA information states that headings are as assigned by ATC and climb gradients, when applicable, are published immediately following the specified departure procedure (**Figure 12.16**). DVAs have been assessed for departures which do not follow a specific ground track.

12.16.1. DVAs require the standard IFR departure climb gradient unless a higher than standard IFR climb gradient is published under "DIVERSE VECTOR AREA (RADAR VECTORS)" in the "Trouble T" section of the TPP or ATC issues a required climb gradient.

12.16.2. IFR departure climb gradients published under the "TAKEOFF MINIMUMS" or "DEPARTURE PROCEDURE" in the "Trouble T" section of the TPP do not apply to DVAs.

Figure 12.16. Diverse Vector Area.

ALBUQUERQUE, NM

ALBUQUERQUE INTL SUNPORT (ABQ)

TAKEOFF MINIMUMS AND (OBSTACLE)
DEPARTURE PROCEDURES
AMDT 7 14149 (FAA)

TAKEOFF MINIMUMS: **Rwy 8,** std. w/min. climb of 515' per NM to 7800.

DEPARTURE PROCEDURE: **Rwys 3, 30,** climbing left turn direct ABQ VORTAC. If required, continue climb in ABQ

DIVERSE VECTOR AREA (RADAR VECTORS)
ORIG 16203 (FAA)

Rwy 3, 12, 21, 26, 30, Heading as assigned by ATC.
Rwy 8, Heading as assigned by ATC; requires minimum climb of 470' per NM to 7600. Do not exceed 240Kts until established on assigned heading.

12.17. Specific ATC Departure Instructions.

12.17.1. Specific ATC departure instructions include a heading and an altitude. Do not apply wind drift corrections.

12.17.2. [FAA JO 7110.65] ATC may vector an aircraft on departure or a missed approach in accordance with the following:

12.17.2.1. If the aircraft is climbing to an altitude at least 1,000 feet above an obstacle, ATC may vector an aircraft to maintain at least 3 miles separation from the obstacle.

12.17.2.2. If an obstacle is on the flight path, ATC will provide a crossing restriction.

12.18. Standard Instrument Departure (SID). A SID is a departure procedure established at certain airfields to simplify clearance delivery procedures and assist in meeting environmental, capacity, and ATC requirements. SIDs may be requested by specific ATC facilities, military services, or other users to enhance operations. SIDs also provide protection from obstacles; however, they are not ODPs and may not be flown unless approved by ATC.

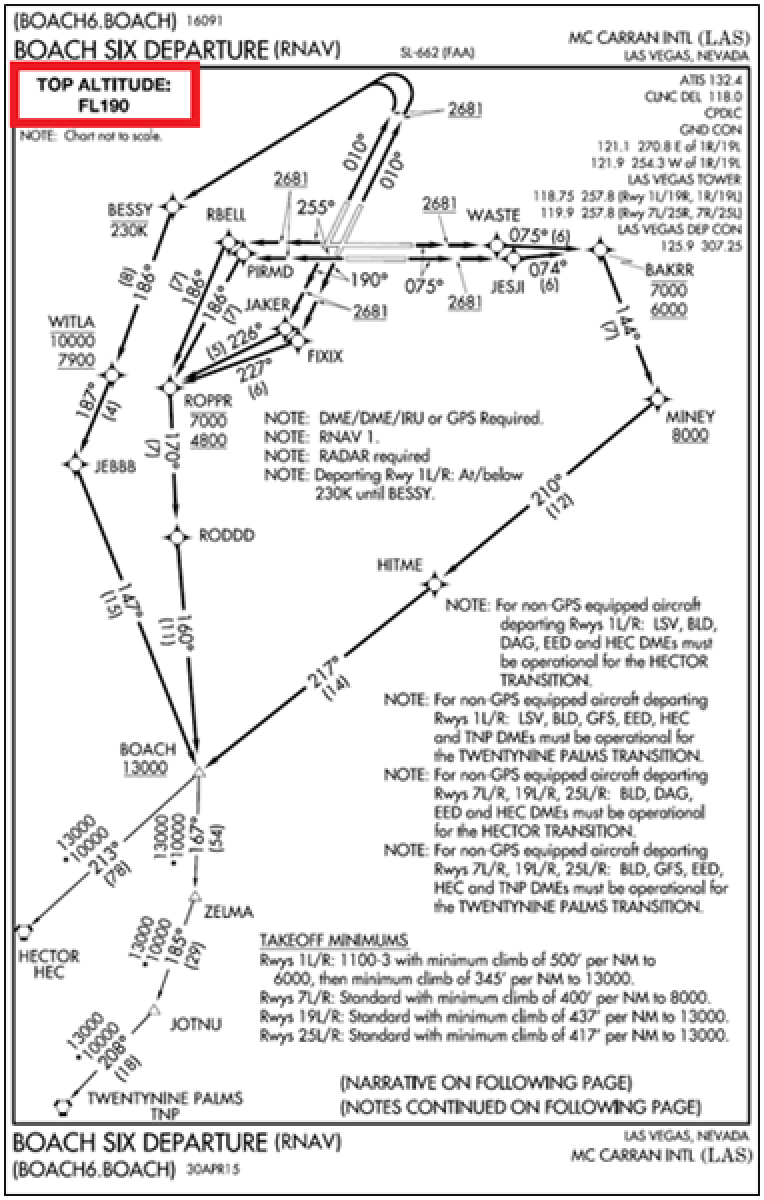
12.18.1. A heavy black line on the graphic version depicts a SID route; thin black lines on the graphic version show transition routings.

12.18.2. If a higher than standard climb gradient is required, it is published on the SID.

12.18.3. Expect an ATC clearance containing a SID at locations where one is published. If unable to fly a SID, include "NO SID" in the remarks section of the flight plan or contact ATC as soon as possible.

12.18.4. SIDs may include altitude restrictions necessary for ATC and/or obstacle clearance; the reason for the restriction may not be published. The "top altitude" is the charted "maintain" altitude contained in the procedure description or assigned by ATC (**Figure 12.17**).

Figure 12.17. Civil SID with Top Altitude.



12.18.5. ATC anticipates aircraft begin adjusting speed the minimum distance necessary prior to a published speed restriction to cross the waypoint or fix at the published speed. Once at the published speed ATC expects the aircraft to maintain published speed until additional adjustment is required to comply with further published or ATC-assigned speed restrictions.

12.19. SID Clearances. The filed or expected altitude is not relevant and has no bearing on the SID unless communications are lost between the pilot and ATC. Airspeed restrictions always remain in effect even on amended clearances unless the controller explicitly cancels or amends the speed restrictions. The pilot may consider the SID cancelled unless the controller adds “expect to resume SID” if radar vectored or cleared off an assigned SID. **Note:** ATC cannot waive the 250 knots below 10,000 feet speed restriction at any time within the NAS [14 CFR Part 91.117].

12.19.1. [AIM Section 2] In the NAS:

12.19.1.1. SID phraseology is in accordance with **Table 12.3**.

12.19.1.2. If ATC issues a new altitude restriction, all previously issued altitude restrictions are cancelled, including those published on the SID. Comply with all speed restrictions and lateral path requirements published on the SID unless cancelled by ATC.

12.19.1.3. Inform ATC upon initial contact of the altitude leaving and any assigned restrictions not published on the procedure if cleared to “climb via SID.”

12.19.1.4. ATC issues a “climb via SID” clearance if ATC reinstates the SID after issuing vectors to an aircraft. Comply with lateral navigation, vertical navigation, and speed restrictions unless otherwise directed by ATC.

12.19.1.5. Aircraft instructed to resume a SID that contains speed or altitude restrictions are issued all applicable restrictions or advised to comply with published restrictions.

Table 12.3. NAS SID Phraseology.

ATC Instruction	Explanation
"Cleared Boach Six departure"	- Follow the lateral profile of the SID
"Cleared Boach Six departure, climb and maintain eleven thousand."	- Follow the lateral profile of the SID
"Cleared Boach Six departure, climb via SID."	- Follow the lateral profile of the SID - Comply with altitude restrictions while climbing to the SID top altitude
"Cleared Boach Six departure, climb via SID except maintain eleven thousand."	- Follow the lateral profile of the SID - Comply with altitude restrictions while climbing to the assigned altitude; stop climb at the assigned altitude until issued further clearance by ATC
"Cleared Boach Six departure, climb via SID except cross WITLA at nine thousand."	- Follow the lateral profile of the SID - Comply with altitude restrictions while climbing to cross the waypoint at the assigned altitude - Fly the remainder of the SID as published
Note: Always comply with speed restrictions.	

12.19.2. [ICAO Doc 4444] (ICAO) ATC clearances issued to aircraft on a SID include if remaining speed or level restrictions are to be followed or cancelled; standard clearance phraseology is shown in **Table 12.4**.

12.19.2.1. If there are no remaining published level or speed restrictions on the SID, the phrase "climb to *[level]*" should be used.

12.19.2.2. When subsequent speed restrictions are issued, and if the cleared level is unchanged, the phrase "climb via SID to *[level]*" should be omitted.

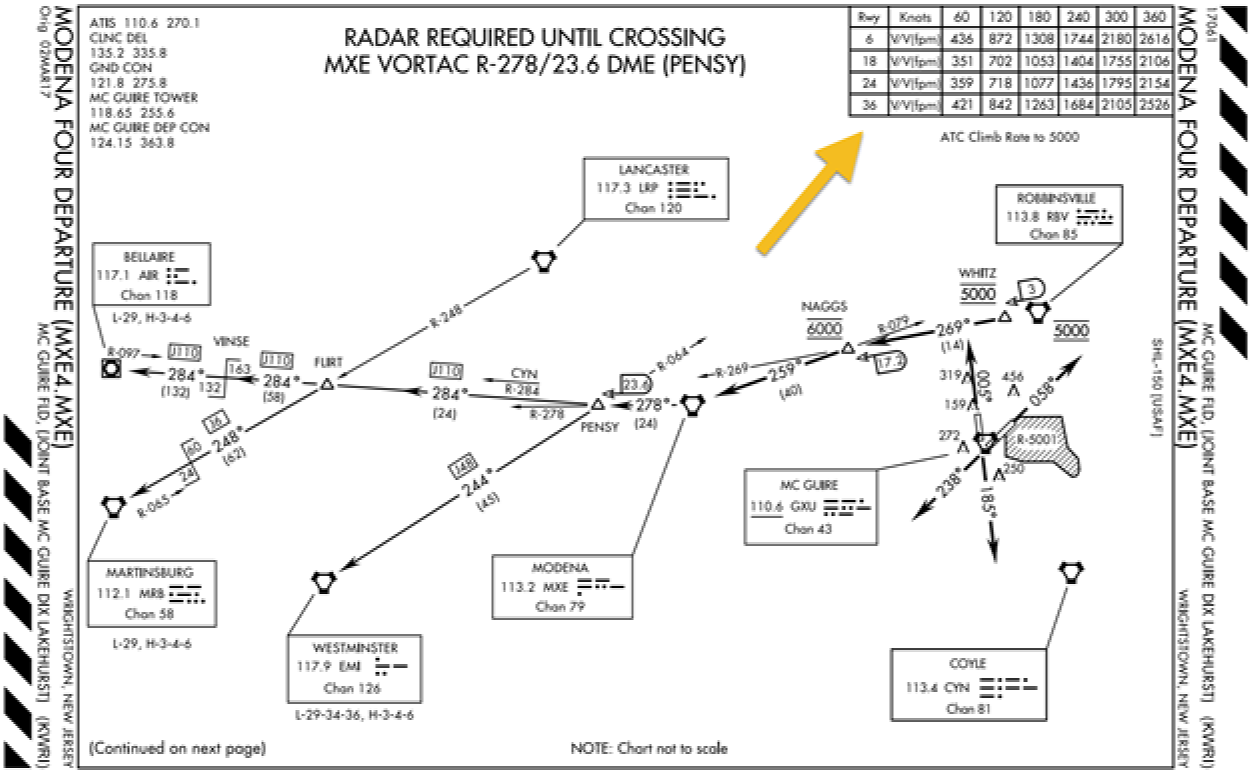
12.19.2.3. When a departing aircraft is cleared to proceed direct to a published waypoint on the SID, the speed and level restrictions associated with the bypassed waypoints are cancelled. All remaining published speed and restrictions remain applicable.

Table 12.4. ICAO SID Phraseology.

ATC Instruction	Explanation
CLIMB VIA SID TO *(level)*	- Climb to the cleared level and comply with published level restrictions - Follow the lateral profile of the SID
CLIMB VIA SID TO *(level)*, CANCEL LEVEL RESTRICTION(S)	- Climb to the cleared level, published level restrictions are cancelled - Follow lateral profile of the SID
CLIMB VIA SID TO *(level)*, CANCEL LEVEL RESTRICTION(S) AT *(point(s))*	- Climb to the cleared level, published level restriction(s) at the specified point(s) are cancelled - Follow the lateral profile of the SID
CLIMB VIA SID TO *(level)*, CANCEL SPEED RESTRICTION(S)	- Climb to the cleared level and comply with published level restrictions - Follow lateral profile of the SID - Published speed restrictions and ATC-issued speed control instructions are cancelled
CLIMB VIA SID TO *(level)*, CANCEL SPEED RESTRICTION(S) AT *point(s)*	- Climb to the cleared level and comply with published level restrictions - Follow the lateral profile of the SID - Published speed restrictions are cancelled at the specified point(s)
CLIMB UNRESTRICTED TO *(level)* or CLIMB TO *(level)*, CANCEL LEVEL AND SPEED RESTRICTION(S)	- Climb to the cleared level, published level restrictions are cancelled - Follow the lateral profile of the SID - Published speed restrictions and ATC-issued speed control instructions are cancelled
Note: Comply with published speed restrictions or ATC-issued speed control instructions.	

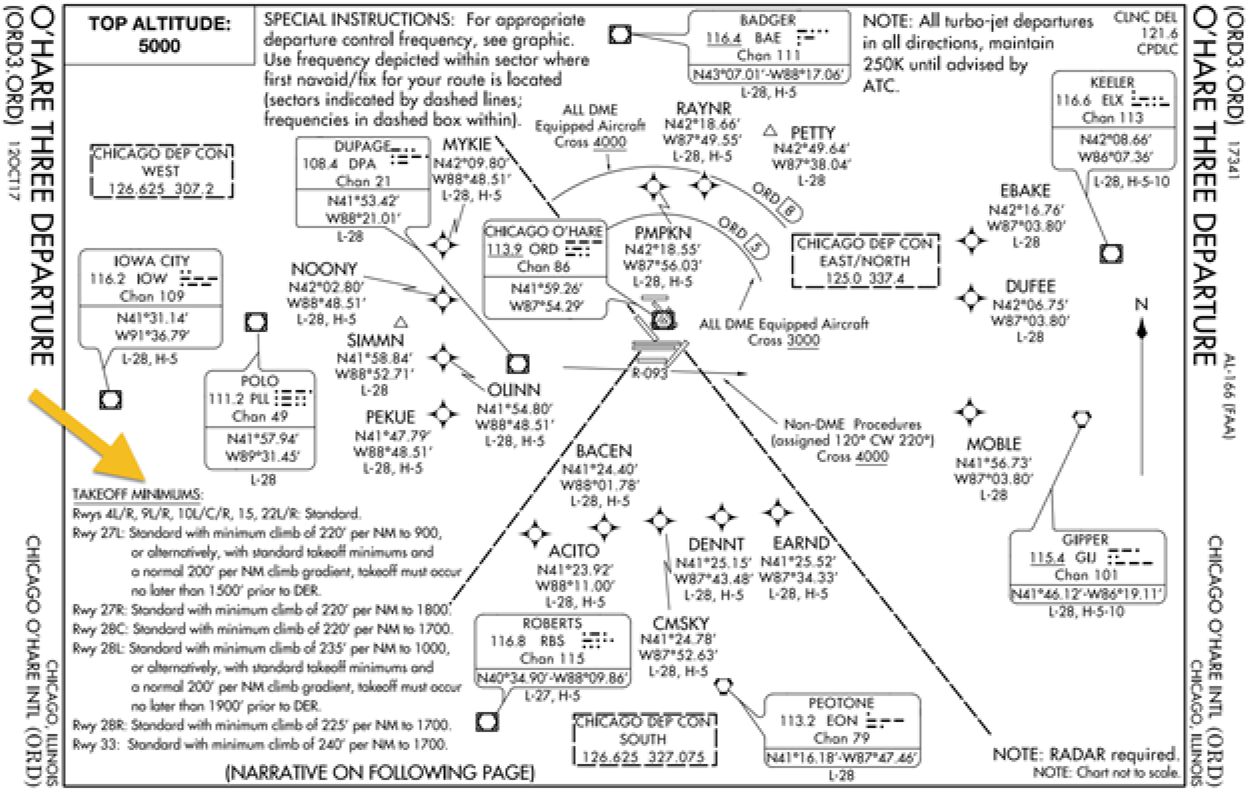
12.20. Military SID. Military SIDs within the NAS may have some obstacles charted to scale and provide a table with climb rate information (**Figure 12.18**). Obstacle clearance climb rates may be denoted with an asterisk (*) while ATC climb rates may be denoted with a dagger (†). Pilots should assume a climb rate is an obstacle clearance climb rate if only one climb rate is given. The climb rates published are given in vertical velocities for specific groundspeeds.

Figure 12.18. Military SID.



12.21. Civil SID. Obstacle climb gradients higher than the standard IFR departure climb gradient are published directly on a civil SID (**Figure 12.19**). USA SIDs are produced by the FAA within the NAS and should be treated as civil SIDs. Civil SIDs may list takeoff obstacle notes (i.e., low close-in obstacles) textually, but do not depict any obstacles graphically. **Note:** The FAA is removing takeoff obstacle notes from civil SIDs; eventually, takeoff obstacles may be found only in the "Trouble T" section of the TPP.

Figure 12.19. Civil SID.



12.22. ICAO SID.

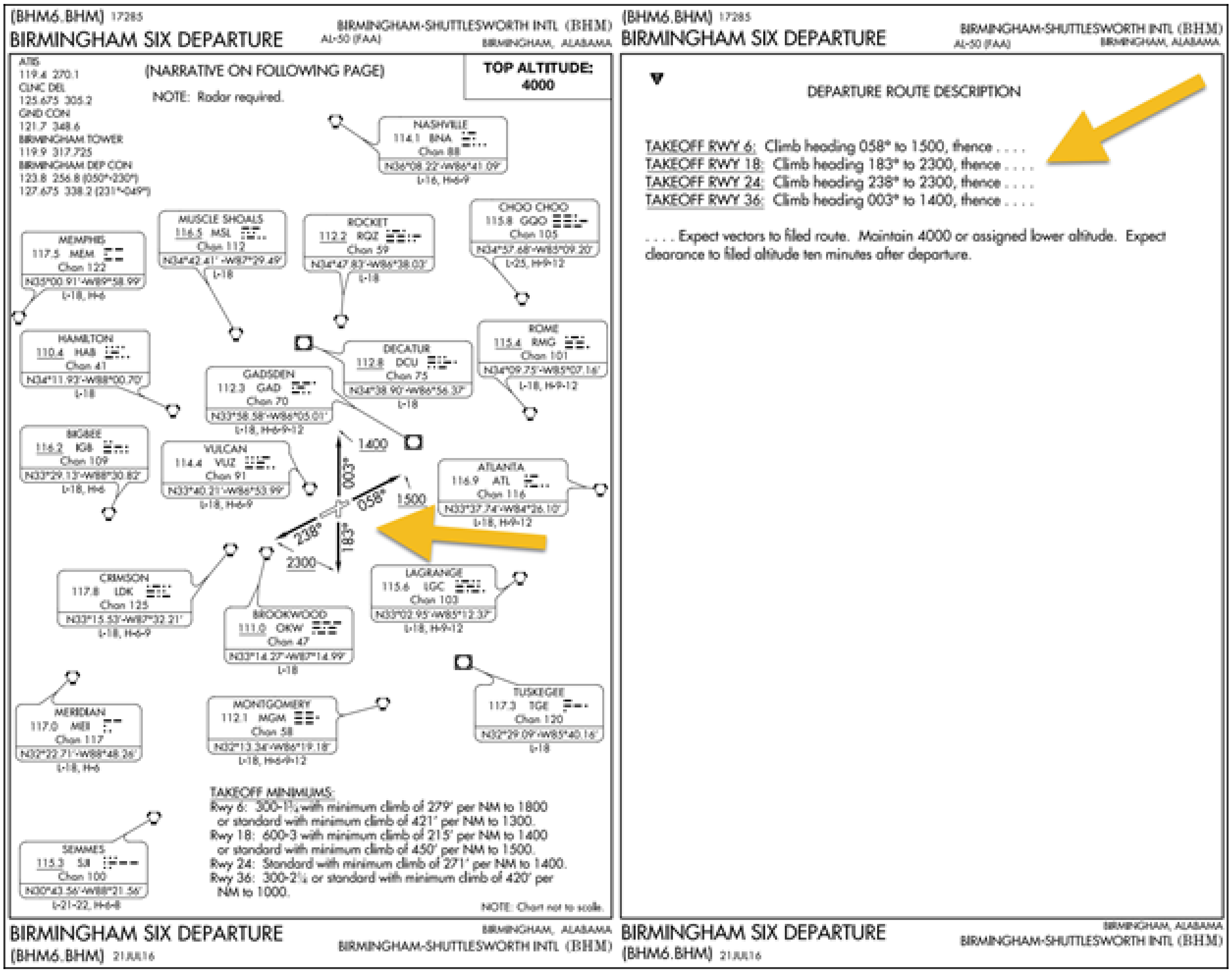
12.22. ICAO SID. [ICAO Doc 8168V2 **Chapter 3**] PANS-OPS uses the term "SID" to refer to departures using track guidance. When a departure requires a turn of more than 15 degrees of the runway heading the departure is considered a "turning departure." Turning departures are designed with standard speed limits to stay within protected airspace (**Table 7.5**). The procedure designer may restrict the SID either by aircraft category or by airspeeds if unable to provide obstacle clearance.

Figure 12.20. ICAO Maximum Speeds for "Turning Departures".

Airplane category	Maximum speed (knots)
A	120
B	165
C	265
D	290
E	300
H	90

12.23. Vector SID. Vector SIDs are established where ATC provides radar navigation guidance to a filed route, assigned route, or to a fix depicted on the SID. Typically, a vector SID depicts only area NAVAIDs or fixes with simple departure instructions (**Figure 12.20**). **Note:** The heavy black line on a vector SID depicts runway heading and not a desired ground track.

Figure 12.21. Radar Vector SID.



12.24. MAJCOM-Certified Departure. MAJCOMs may develop their own departure procedures for use by specific aircraft and MAJCOM-trained and -certified aircrews under specific conditions.

12.25. Special Departure Procedure (SDP). SDPs are aircraft-specific commercially designed and published procedures that require MAJCOM training and certification before use. SDPs can be useful for multi-engine aircraft by allowing an increased takeoff gross weight while providing escape routing in the event the aircraft loses thrust on takeoff. Notice how the SDP routing differs from the ODP routing (Figure 12.21 and Figure 12.22).

Figure 12.22. Albuquerque ODP (Runway 8).

ALBUQUERQUE INTL SUNPORT (ABQ)

TAKEOFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES

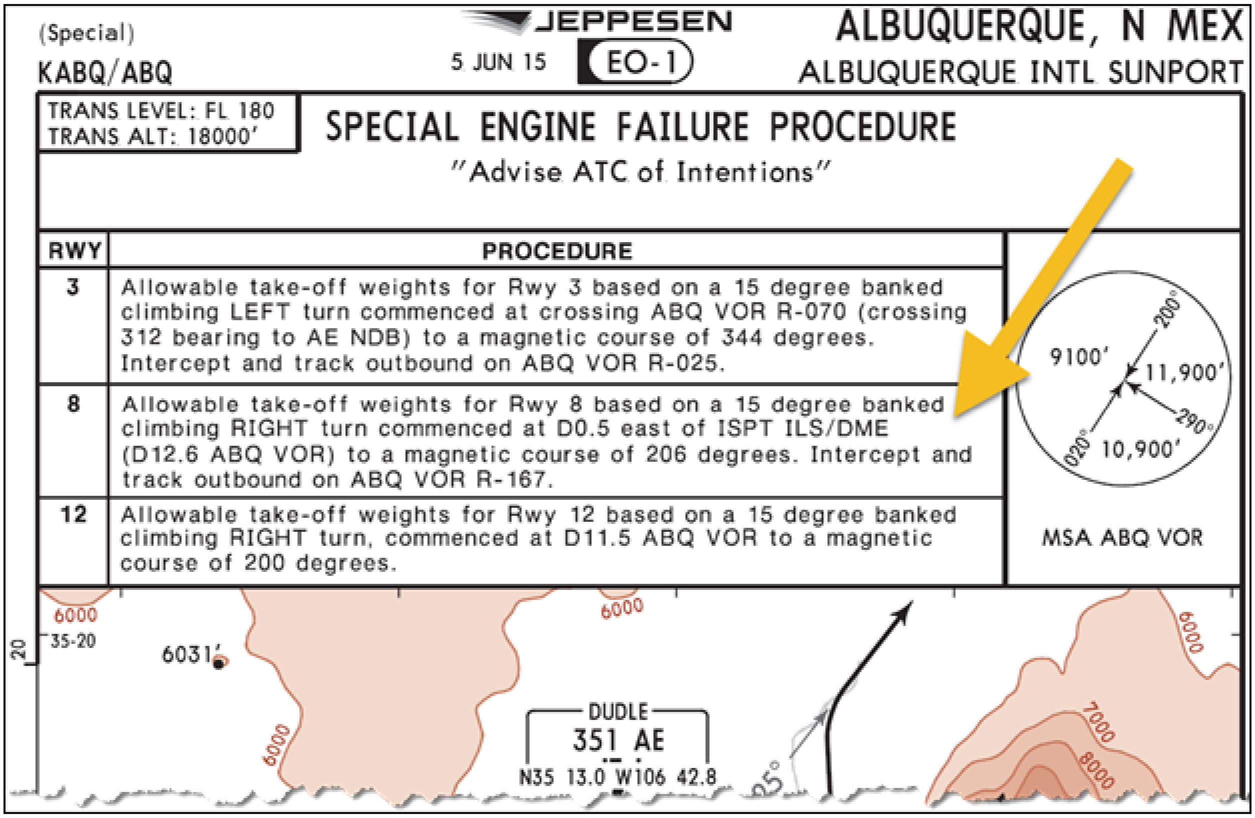
AMDT 7 14149 (FAA)

TAKEOFF MINIMUMS: **Rwy 8,** std. w/min. climb of 515' per NM to 7800.

DEPARTURE PROCEDURE: **Rwys 3, 30,** climbing left turn

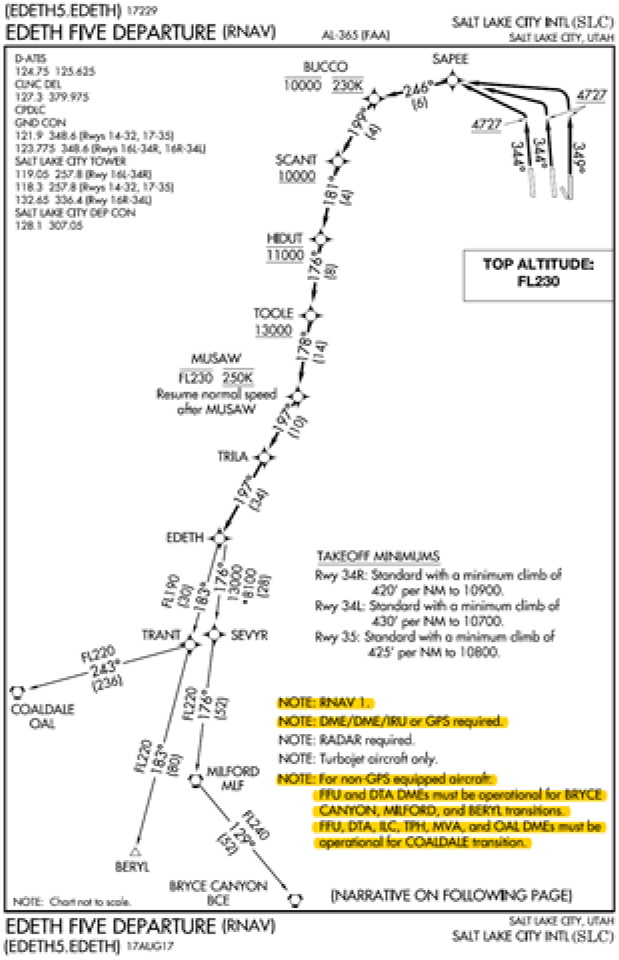
flight. **Rwy 8,** climbing right turn direct ABQ VORTAC. If required, continue climb in ABQ VORTAC holding pattern (hold W, left turns, 077° inbound) to cross ABQ VORTAC at or above MEA/MCA for route of flight. (Do not exceed 250 KTS until ABQ VORTAC). **Rwys 12, 21,** climbing right turn direct ABQ VORTAC. If required, continue climb in

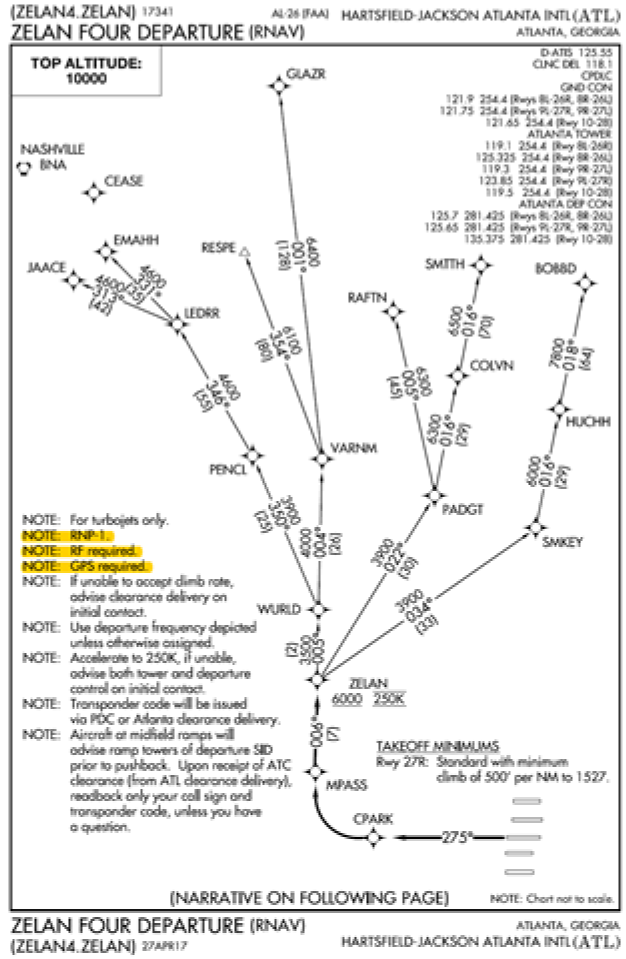
Figure 12.23. Albuquerque SDP (Runway 8).



12.26. RNAV Departures. [FAA Order 8260.46; AIM 5-1-16; AIM 5-5-16] RNAV departures may be RNAV 1 or RNP 1 (**Figure 12.23**). The default specification is RNAV 1; RNP 1 is used when a departure contains a RF leg or for DME/DME/IRU aircraft use when radar monitoring is not desired. **Note:** The required specification, equipment sensor limitations, and any critical DME facilities are annotated clearly on the procedure.

Figure 12.24. RNAV Departure Procedures.





Chapter 13

OCEANIC AND REMOTE CONTINENTAL AIRSPACE

13.1. General.

13.1.1. [AC 91-70] Procedures for operating in oceanic and remote continental airspace are constantly evolving; pilots should closely monitor these procedures for any oceanic or remote continental airspace in which they operate.

13.1.2. ICAO Doc 10037, *Global Operational Data Link (GOLD) Manual*, provides guidance and information concerning data link operations and is intended to facilitate the uniform application of SARPs contained in numerous ICAO Annexes, ICAO Doc 4444, and ICAO Doc 7030.

13.2. North Atlantic Region. NAT Doc 007, *North Atlantic Operations and Airspace Manual*, is intended to serve as guidance for operation in the North Atlantic Region. It is a single source document that references the regulatory material in numerous ICAO Annexes, ICAO Doc 4444, ICAO Doc 7030, Nation State AIPs, and current NOTAMS. The FAA's *North Atlantic Resource Guide for U.S. Operators* is updated quarterly and available via the FAA website. It discusses emphasis items, contingency procedures, weather deviation requirements, and flight planning procedures.

13.3. Pacific Region. The FAA's *Pacific Resource Guide for U.S. Operators*, is updated quarterly and available via the FAA website. It discusses emphasis items, contingency procedures, weather deviation requirements, and flight planning procedures.

13.4. West Atlantic Route System, Gulf of Mexico, and Caribbean Regions. The FAA's *WATRS, GoMex, and Caribbean Resource Guide for U.S. Operators*, is updated quarterly and available via the FAA website. It discusses emphasis items, contingency procedures, weather deviation requirements, and flight planning procedures.

13.5. Extreme Latitude Navigation. Refer to **Chapter 22** for navigation in areas of magnetic unreliability (AMU).

Chapter 14

VFR AND LOW-LEVEL NAVIGATION FUNDAMENTALS

14.1. General. The most commonly used charts for VFR operations are the Joint Operations Graphic (JOG), the Tactical Pilotage Chart (TPC), and Sectional Aeronautical Charts. Sectionals may be preferable for VFR planning because they display critical information that may not be printed on other charts (e.g., airspace boundaries, special use airspace, ATC frequencies).

14.2. Definitions.

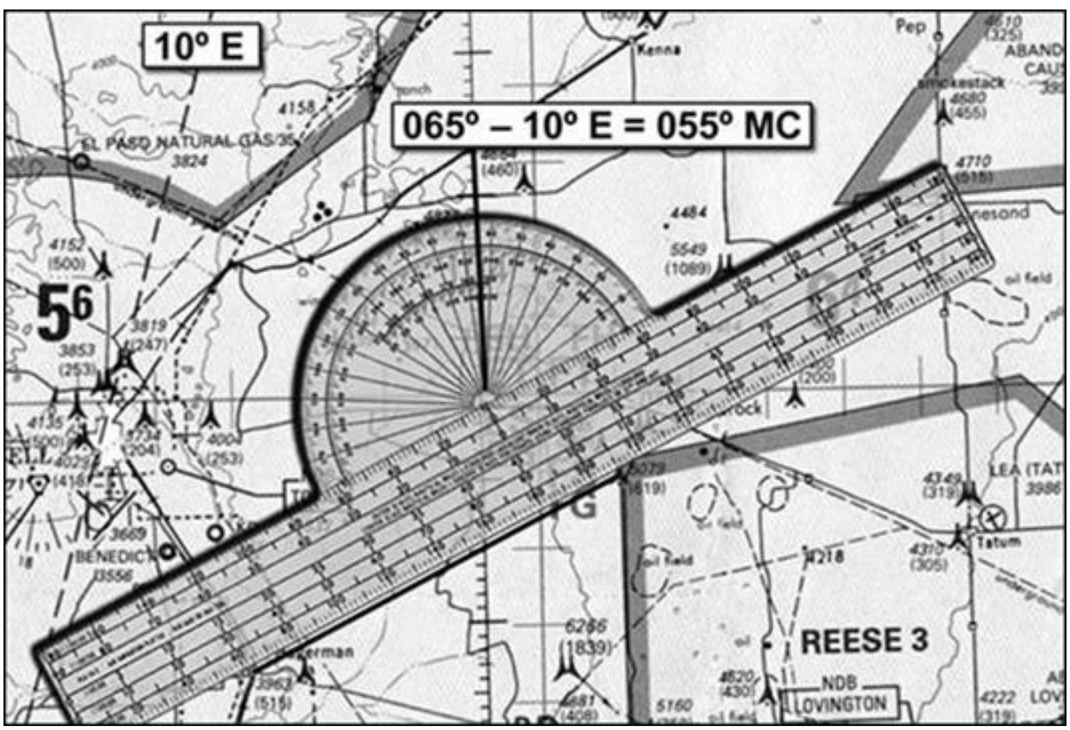
14.2.1. [FAA Pilot/Controller Glossary] Dead reckoning is the navigation of an airplane solely by means of computations based on airspeed, course, heading, wind direction, groundspeed, and elapsed time. Most VFR flights are flown in this manner.

14.2.2. True course is the intended horizontal direction of travel over the surface of the earth, expressed as an angle measured clockwise from true north (000 degrees) through 359 degrees.

14.2.3. Magnetic variation is the difference between true north and magnetic north. The magnetic variation is annotated on navigation charts, is different from one position on the earth to another and varies slightly over time.

14.2.4. Magnetic course is true course corrected for magnetic variation. As shown in **Figure 14.1**, applying 10 degrees east variation to a true course of 65 degrees results in a magnetic course of 55 degrees. **Note:** East variation is subtracted; west variation is added.

Figure 14.1. Applying Magnetic Variation.



14.2.5. A course line is a line between any two points on the route.

14.2.6. A track is the direction the aircraft moves over the ground. An aircraft's track diverges from the desired course line if the pilot does not correct for wind.

14.2.7. True heading is the horizontal direction in which an aircraft is pointed in relation to true north. The difference between track and true heading is caused by wind and is called drift.

14.2.8. Groundspeed is the speed of the aircraft over the ground. Normally expressed in nautical miles per hour (knots). (Accounts for wind effect on aircraft speed across the ground.)

14.2.9. True airspeed is the speed of an aircraft relative to the air surrounding it. True airspeed and groundspeed are rarely the same as the air mass is usually moving relative to the ground.

14.3. Chart Selection. Select charts that satisfy navigation requirements and provide the desired detail commensurate with planned altitude and speed. Charts with a scale of 1:250,000 or greater detail are desired for low-level operations. Use a larger scale (i.e., 1:50,000 or greater) to locate the objective. Use a prominent ground feature when changing between charts.

14.3.1. The FAA Aeronautical Information Service Office produces Sectional Charts, VFR Terminal Area Charts (TAC), and VFR Helicopter Charts for use during VFR navigation. The charts have effective and expiration dates; not all charts expire on the same date.

14.3.2. The Jet Navigation Chart (JNC) is a worldwide small-scale aeronautical chart series (1:2,000,000). Used for high-altitude, high-speed, long-range navigation and planning.

14.3.3. The Operational Navigation Chart (ONC) is the standard worldwide small-scale aeronautical chart series (1:1,000,000). Contains cartographic data with an aeronautical overprint depicting obstructions, airfields, special use airspace, NAVAIDs, maximum elevation figures (MEF), and related data. The ONC is designed for medium altitude high-speed visual and radar navigation.

14.3.4. The Tactical Pilotage Chart (TPC) is the standard worldwide medium-scale aeronautical chart series (1:500,000). TPCs provide essential cartographic data appropriate to scale, and are overprinted with stable aeronautical information such as obstructions, airfields, special use airspace, NAVAIDs, MEFs, and related data. Overprint depicts obstructions, airfields, special use airspace, NAVAIDs and related data. A military grid is overprinted for joint interoperability. The TPC is designed for very low-altitude through medium-altitude high speed visual and radar navigation.

14.3.5. The Joint Operations Graphic – Air (JOG-A) is the standard DoD medium scale (1:250,000) chart. The JOG-A is a standard series modified for aeronautical use. The JOG-A displays topographic data such as: relief, drainage, vegetation, populated places, cultural features, coastal hydrography, aeronautical overprint depicting obstructions, airfields, special use airspace, NAVAIDs and related data. The JOG-A supports tactical and other air activities including low altitude visual navigation.

14.3.6. The Topographic Line Map (TLM) is a lithographic map that portrays in greater detail of topographic and cultural information (1:50,000). Relief is shown by contours and spot elevations measured in meters, feet or yards. The map is a true representation of terrain detail. Features are plotted to correct orientation and true location. The map depicts the level of detail required for detailed route and objective area study as well as foot navigation in the case of a survival or evasion situation.

14.3.7. Flight planning software may be able to generate charts with even smaller scales, digital or satellite-acquired images of ground features, and are useful for selecting specific identifiable features like the western edge of a dam.

14.4. Chart Hazards. Aeronautical charts do not depict man-made obstacles less than 200 feet AGL or a change in terrain until it exceeds the chart contour interval. The worst situation would occur if a 199-foot obstacle sat on terrain with an elevation just below the next higher contour. For a TPC with a contour interval of 500 feet, this results in an uncharted obstacle existing 698 feet above charted terrain. **Note:** The Digital Vertical Obstruction File (DVOF) lists changes to all current navigation charts but does not contain man-made obstacles less than 200 feet.

14.4.1. Some charts, such as JOG and TLM in some areas of the world, may depict terrain and obstacle heights in meters instead of feet.

14.4.2. Uncharted obstacles. If an obstacle is encountered while flying a route that is not charted properly, the following list of contacts ensure future chart editions include the obstacle. For Sectionals, contact the FAA at (800) 638-8972 or email them at 9-AMC-**Aerochart@faa.gov**. For NGA products, call Aero Quality Feedback at (800) 455-0899 or email **Quality@nga.ic.gov**.

14.5. Chart Building Requirements. MAJCOMs will publish guidance on required chart information.

14.5.1. All charts will be updated with current digital aeronautical flight information file/DVOF and the date of the information will be annotated clearly on the charts. **(T-3).** Charts will be updated with the DVOF at least once a month. **(T-3).**

14.5.2. All charts used for low altitude navigation will be full color. **(T-3).** If making color copies, ensure that all colors come through, as some shades of blue and green may not transfer, causing some terrain features or obstacles to be deleted. **Exception:** Wing commanders may approve the use of black and white copies of original mission planning charts to enhance navigation capabilities on night vision missions; all mission planning and chart annotations must be done on original full color charts prior to making copies. **(T-3).**

14.5.3. VFR charts will include at a minimum: course lines, magnetic heading, leg distance, and time for segments flown below 1,000 feet AGL. **(T-3).**

14.5.3.1. Helicopters may fly in an annually surveyed low-level area with current DVOF above 200 feet AGL without the above chart requirements.

14.5.3.2. Helicopters will comply with chart requirements below 200 feet AGL on non-published routes. **(T-3).**

14.5.4. Normally, “radius of turn” procedures are used (route is drawn considering the distance an aircraft covers while it is turning after passing over a turn point) when drawing the chart, but depending on tactics, airspeed and altitude, other options like point to point may be applicable.

14.5.5. Time elapsed marks and distance remaining marks along the course line of each leg aid in dead reckoning.

14.6. Route Development. Select turn points based on a balance between their ease of identification and the tactical situation. Label each turn point with the same identifier used in the flight plan. When a landmark cannot be seen or is not available at a turn point, make the turn at the ETA. Extend the dead reckoning position to the next landmark and fix the position of the aircraft to make sure the desired course and groundspeed are maintained. The desired magnetic course on any given leg corrected for drift is the magnetic heading which parallels the course line. This minimizes departure from the intended track.

14.6.1. Course lines are normally straight segments between points but may be "spaghetti" routing to take advantage of terrain masking. Different tactical situations dictate different transitions from one course to another at turn points.

14.6.2. Checkpoints are landmarks or geographic coordinates on a VFR route used to determine the fix position of the aircraft. Checkpoints should have several related details around and stand out from the background to ensure positive identification. For example, if the checkpoint is a small town, there may be a lake to the north, a road intersection to the south, and a bridge to the east. **Note:** In open areas, any town or road intersection can be used; however, these same features in densely populated areas are difficult to distinguish.

14.6.3. When possible, find a feature on the chart that leads to the turn point. A "funneling feature" forms a visual boundary for, aids in navigating to, and helps in identifying the turn point (e.g., a stream, road, power line, railroad, terrain feature).

14.6.4. Time, distance, and fuel may be annotated in various ways on the chart and may show information for the leg being flown or for the remainder of the route. Ensure that information does not cover up important map features.

14.6.5. The objective area may be a target designated for attack, drop zone, landing zone, photo reconnaissance target, etc.

14.6.6. All charts must have VFR minimum safe altitudes (MSA) and at least one emergency route abort altitude (ERAA). **(T-2).**

14.6.6.1. A VFR MSA is an initial altitude that provides increased clearance from terrain or obstacles when dealing with minor circumstances that do not require an overall route abort. In the absence of more restrictive MAJCOM guidance, a VFR MSA will be computed for each leg of the route by adding 500 feet to the highest obstruction to flight within 5 nautical miles of route centerline to include the aircraft turn radius. **(T-3).**

14.6.6.2. The ERAA is designed to provide positive IMC terrain clearance during emergency situations that require leaving the low-level structure. Planners may compute several ERAAs for route segments transiting significant terrain differentials, or a single ERAA for the entire low-level route. Pilots will compute an ERAA by adding 1,000 feet (2,000 feet in mountainous terrain) to the elevation of the highest obstruction to flight within 22 nautical miles either side of the entire planned route. **(T-3).** Pilots will compute ERAAs for the route and conspicuously annotate them on the chart. **(T-3).**

14.6.7. Each route should include clearly highlighted emergency divert airfields that may be used if an immediate landing situation occurs on the route.

14.6.8. To enhance scanning while flying the route, pilots will annotate areas where other routes cross the planned route. **(T-3)**.

14.7. Route Navigation. Various techniques are used to control arrival time over the objective area. These techniques can be as simple as changing airspeed or more complicated applications of off-route maneuvering. Use caution when departing the planned route of flight, especially at night, to avoid encountering obstacles or flying into known areas of enemy activity when employing off-route time control techniques. If the off-course maneuvering exits the minimum safe altitude corridor, a new minimum safe altitude must be computed. This can be done quickly by adding 500 feet to the charted maximum sector elevation(s) in the off-course maneuvering area.

14.7.1. A landmark often falls right or left of course and the pilot should estimate the distance to it. While the ability to estimate distance from a landmark rests largely in skill and experience, the following methods may be of assistance:

14.7.1.1. Compare the distance to a landmark with the distance between two other points as measured on the chart.

14.7.1.2. Estimate the angle between the aircraft and the reference point on the ground. The distance in nautical miles from the landmark to the aircraft's position over the ground depends on the sighting angle:

14.7.1.2.1. (60 degrees): horizontal distance = (AGL altitude) x 1.7

14.7.1.2.2. (45 degrees): horizontal distance = AGL altitude.

14.7.1.2.3. (30 degrees): horizontal distance = (AGL altitude) x 0.6

14.7.2. Aircraft operating in the low altitude environment may elect to enhance their threat avoidance capabilities by hiding their physical, radar, and heat signatures in the available terrain features. Along the low-level route there may be vegetation or changes in elevation that can hide an aircraft from the enemy. Pilots should attempt to include terrain masking in their pre-flight route study so that off-course maneuvering does not negatively impact time on target control. In some cases however, opportunities to terrain mask are not evident until flying the route. Aggressive clearing and chart reading are essential to ensure that the benefits of terrain masking are not negated by unnecessarily increasing the overall risk factor of the mission.

14.7.3. In low-level flight, pilots should be particularly alert for obstructions. Hills and mountains are easily avoided if the visibility is good but radio and television towers, which may extend as much as 2,000 feet or more into the air, often from elevated ground, are less conspicuous. Even more dangerous, the guy-wires supporting such towers are virtually invisible. For this reason, pilots should plan to avoid all towers by a horizontal distance equal to at least the AGL height of the tower. If flying at extremely low altitudes, power lines should be crossed at poles or towers as the line a pilot sees may not be the highest one.

14.7.4. Seasonal changes can conceal landmarks or change their appearance. Small lakes and rivers may dry up during the summer. Their outlines may change considerably during the wet season. In many areas, the only indication that a river exists may be the presence of deciduous trees. Snow can cover up almost all the normally used landmarks. When flying in the winter, it is often necessary to rely on more prominent checkpoints, such as river bends, hills, or larger towns. However, due to the size of these checkpoints, course control can be somewhat degraded.

14.7.5. Many times during low-level flight, the only way to read the wind is from indicators on the surface. On water, if downwind, the leeward side of the waves appears choppy (e.g., wind speeds more than 20 knots cause whitecaps on the surface of lakes). If upwind, the windward side of the waves have a smoother appearance. In a similar fashion, the leaves on deciduous trees are lighter on the underside which show to windward. The shiny and normally darker side of the leaves are present on the leeward side of the tree. Smoke and blowing dust also provide an easy indicator of wind direction.

14.8. Chart Reading. Orient the chart so that the course line on the chart is aligned with the intended course of the aircraft and landmarks on the ground appear in the same relative position as the features on the chart.

14.8.1. To navigate accurately, check the expected time on the route segment, select a feature on the chart, and then find it on the ground rather than working from the ground to the chart.

14.8.2. Night navigation comes with certain inherent challenges including hazards due to visual illusions. Lighted reference points tend to look closer than they are at night. Large objects in the background can mask closer obstacles. Darkness adversely affects visual acuity, requiring greater use of peripheral vision. Colored lighting used for chart reading can mask features on the chart. It is critical to understand that contrast can change the way landmarks look at night. Proper use of cockpit lighting and NVDs enhances night navigation. Use special caution when operating around ridgelines utilizing high moon illumination. Shadowing can make other ridgelines and obstructions extremely difficult to see.

14.8.3. Contours are lines that connect points of equal elevation and are the most common method of showing relief features on a chart. Contour lines are closer together where the slope is steep and farther apart where the slope is gentle. Within the limits of the contour intervals, the height of points and the angle of slope can also be determined from the chart. Contour intervals are determined by the scale of the chart, the amount of relief, and the accuracy of the survey. Contours may be annotated in feet or meters in the chart legend and are frequently labeled with figures of elevation.

14.8.4. [FAA IACC 2 3.9] A maximum elevation figure is required over all land masses, including areas of unreliable relief, and open water areas containing man-made obstructions (e.g., oil rigs). The maximum elevation figure represents the highest possible elevation of both terrain and vertical obstructions (e.g., towers, trees) in an area bounded by ticked graticule lines. The maximum elevation figure is displayed in feet with large thousands digits and smaller hundreds digits.

14.8.4.1. In areas of unreliable relief, or over water where no known obstructions exceed 200 feet, a note spaced across the area is used (**Figure 14.2**)

14.8.4.2. The maximum elevation figure is useful if maneuvering off course. If the position of the aircraft is known, the MEF for the grid square the aircraft is in (or going to if transiting grid squares to a higher MEF) can be used to calculate a new minimum safe altitude or ERAA by adding an appropriate amount to the MEF.

Figure 14.2. Maximum Elevation Note – Unreliable Relief.

MAXIMUM ELEVATION FIGURES ARE
BELIEVED NOT TO EXCEED 7600 FEET.

14.9. On-Board Navigation Systems. Although not required for VFR flight in most types of airspace, it is highly recommended that pilots use their on-board navigation systems during flight under VFR when operational requirements allow. This maximizes situational awareness and enhance safety by facilitating the transition to IFR should it become necessary.

14.10. Low-Level Time-to-impact. At low altitudes, loss of situational awareness can lead to an insidious descent rate; even a minor nose-low attitude can result in terrain impact in a very short time (**Table 14.1** and **Table 14.2**). With wings level, the time differences based on pitch, altitude, and airspeed are all linear (e.g., cutting the altitude in half or doubling the nose-low pitch angle cuts the time-to-impact in half). Historical data shows that while 90% of low-level operations are straight and level, only 9% of low-level accidents occur during straight and level flight. Conversely, turning and looking accounts for only 5% of low-level flight but 52% of accidents. Clearing for terrain must be a priority while maneuvering at low altitudes.

Table 14.1. Time-to-impact (seconds) – Wings Level.

Flight Path Angle = -1 Degree				
Altitude	**480 Knots**	**360 Knots**	**240 Knots**	**120 Knots**
100’ AGL	7	10.5	14	28
300’ AGL	21	32	42	84
500’ AGL	35	53	70	140
Flight Path Angle = -2 Degrees				
Altitude	**480 Knots**	**360 Knots**	**240 Knots**	**120 Knots**
100’ AGL	3.5	5	7	14
300’ AGL	10.5	16	21	42
500’ AGL	18	25	35	70

14.10.1. Most low-level accidents occur while the aircraft is in a bank. Even the smallest distraction or inattention to the proximity of terrain while maneuvering the aircraft can result in a loss of situational awareness and a fatal accident. More back pressure is needed to maintain level flight as bank angle increases. The amount of back pressure required to maintain altitude increases dramatically at bank angles greater than 60 degrees; the descent generated by overbanking without holding the required back pressure is significant. At low altitudes this means a very short time-to-impact shows just how little time there is from 500 feet if a pilot holds the back pressure for one bank angle but flies in an overbanked condition. Considering that many aircraft fly low-levels at 300 feet AGL and normally use a 60 degrees bank angle to turn from one course to another (or even higher bank angles during simulated threat avoidance), a 20 degrees overbank error could result in less than 3 seconds time-to-impact.

14.10.2. Helicopters have additional flight characteristics to consider in banked flight. Refer to MDS specific flight manuals for cautions and warnings specific to banked flight at low altitudes.

Table 14.2. Time-to-impact (seconds) – Banked.

		Intended Degrees of Bank			
		30 degrees	45 degrees	60 degrees	
Degrees of Overbank	10 degrees	16.2	12.7	9.9	Time-to-impact from 500 feet AGL
	15 degrees	12.9	10.3	8.0	
	20 degrees	10.9	8.8	6.9	

14.10.3. If flying VFR using dead reckoning and aircraft position is unknown, continue to navigate clock to map to ground and turn on time. A slight off-course condition can be quickly corrected once on a new leg of the course with more prominent ground references. While doing this, climb to a higher altitude (weather permitting), being careful to maintain airspeed to preserve dead reckoning accuracy. This conserves fuel while improving NAVAID and radio reception. Attempt to tune and identify NAVAIDs that can provide positional information and do not delay declaring the condition to ATC.

14.11. Route Abort. Various situations may make abandoning the route necessary (e.g., low fuel, aircraft emergency, bad weather) In most emergency situations, climbing to the ERAA is the best course of action. Flying at the ERAA ensures that the aircraft is clear of obstructions and minimizes hazards to flight while abort procedures are applied. Aborting the route itself does not normally constitute an emergency; take all factors into consideration when deciding how to proceed after the abort.

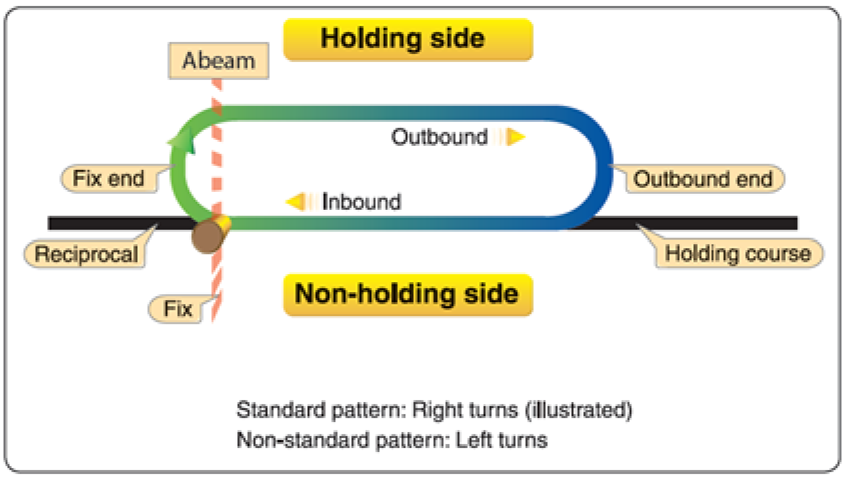
Chapter 15

HOLDING

15.1. General. Holding is a procedure that is designed in relation to a navigation fix to delay an aircraft's approach to an airfield or to delay an aircraft enroute. The purpose is to keep an aircraft within a specified airspace while providing IFR separation from other controlled traffic. The clearance to hold may be initiated by the controlling agency or may be requested by the pilot. Reference AIM 5-3-8, FAA-H-8083-16 **Chapters 2** and **3**, and ICAO Doc 8168V1 Section 6 for more detailed explanations of holding procedures.

15.2. Holding Patterns. The standard holding pattern is a racetrack design consisting of two 180-degree right turns and two straight legs (**Figure 15.1**). The holding pattern is non-standard when turns are made to the left.

Figure 15.1. Standard Holding Pattern.

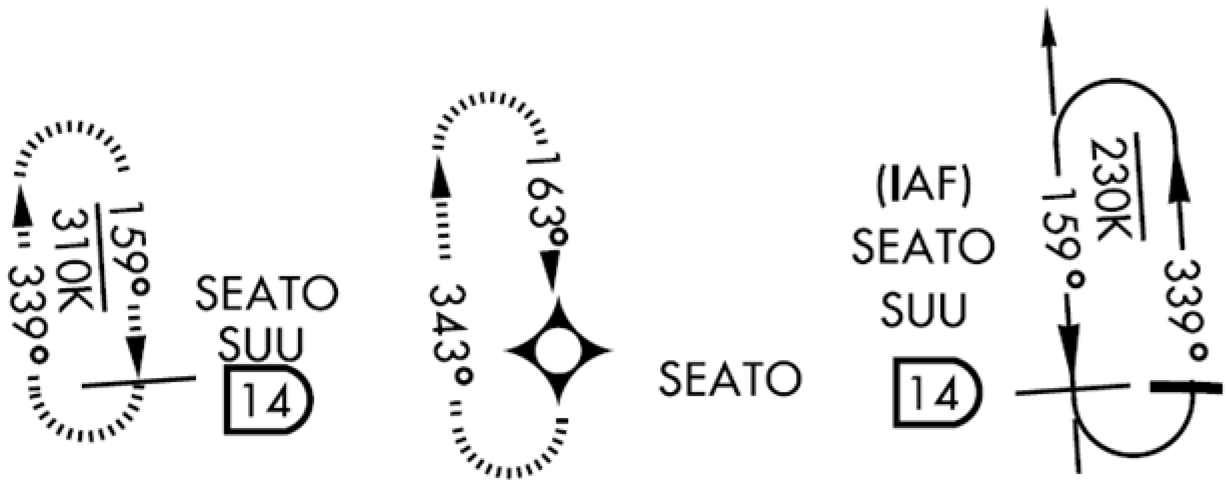


15.2.1. Holding patterns have inbound course guidance provided by a VOR, TACAN, NDB, localizer, or area navigation systems. If NAVAIDs are co-located to define the holding pattern, it is the pilot's option as to which NAVAID to use.

15.2.2. U.S. TERPS design criteria states that the use of TACAN station passage as a fix is not acceptable for holding fixes (regardless of altitude) or high altitude IAFs (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 collocated VOR/TACAN (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 approach.

15.3. Holding Instructions. ATC should issue complete holding instructions (unless the pattern is charted), an "expect further clearance" time, and best estimate of any additional delay when an aircraft is cleared to a fix other than the destination airfield and delay is expected. The pilot is expected to hold as depicted on the appropriate chart (i.e., on the assigned procedure or route) if the holding pattern is charted and the controller doesn't issue complete holding instructions. ATC may omit all holding instructions except the charted holding direction and the statement "as published" when the pattern is charted on the assigned procedure or route being flown (e.g., "Hold north as published"). Query the controller if there is any doubt about the clearance (**Figure 15.2**). **Note:** ATC must always issue complete holding instructions when pilots request them.

Figure 15.2. Multiple Holding Patterns at Same Fix.

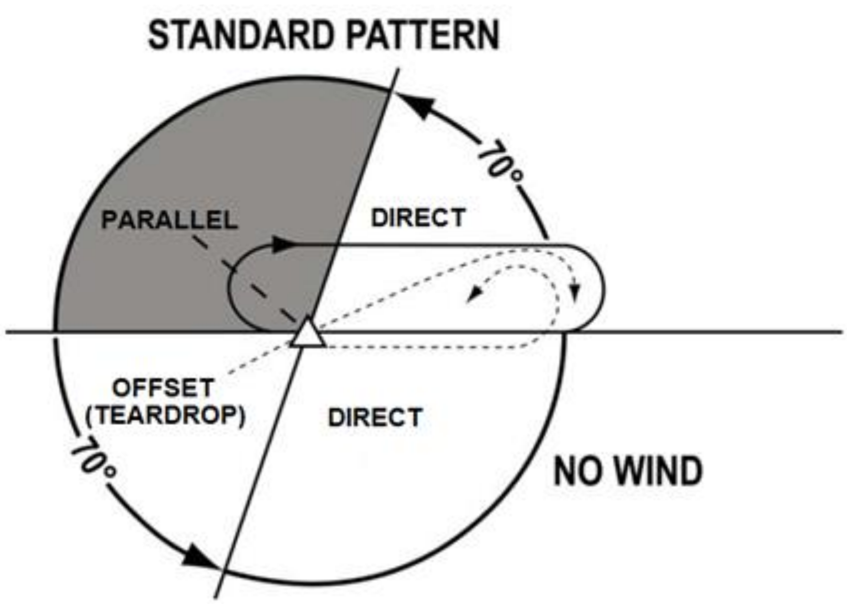


15.4. Holding Entry. Holding protected airspace is designed based in part on pilot compliance with the three holding pattern entries: parallel, direct entry, and offset or (NAS only) teardrop sectors (**Figure 15.3**).

15.4.1. Holding entry procedures are mandatory outside the NAS. **(T-0).**

15.4.2. (NAS only) Holding entry techniques using the sector method are recommended.

Figure 15.3. Holding Entry Sectors.



15.5. Holding Bank Angle. Make all turns during entry and while holding at:

15.5.1. 3 degrees per second or 25 degrees bank angle, whichever requires a lesser bank angle.

15.5.2. (NAS only) 3 degrees per second, 30 degrees bank angle, or 25 degrees bank angle when using a flight director system.

15.6. Maximum Holding Airspeed. Advise ATC immediately if unable to maintain below the maximum holding airspeed (e.g., turbulence, icing, aircraft performance) or if unable to accomplish any part of the holding procedure. When such higher speeds are no longer necessary, operate according to the appropriate published holding speed and notify ATC.

15.6.1. Maximum holding airspeeds are in accordance with **Table 15.1** and with **Table 15.2** unless depicted otherwise. Many Nation States publish their own holding airspeeds. This information should be published in the Nation State AIP and FLIP AP series. Some holding pattern airspeeds are published on instrument procedures. Maximum holding airspeeds are designed to prevent the aircraft from exceeding protected airspace and have no relation to the holding speed specified in the aircraft flight manual.

Table 15.1. ICAO Maximum Holding Airspeeds.

Altitude / Level (MSL)	Airspeed (KIAS)	Airspeed (KIAS)
	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 feet to 20,000 feet (inclusive)	240	280 or 0.8 Mach, whichever is less
Above 20,000 feet to 34,000 feet (inclusive)	265	280 or 0.8 Mach, whichever is less
Above 34,000 feet	0.83 Mach	0.83 Mach

Notes:
1. The levels shown represent altitudes or corresponding FLs depending upon the altimeter setting in use.
2. Pilots must obtain ATC approval to hold at the speeds reserved for turbulence conditions unless the relevant publications indicate that the holding area can accommodate aircraft flying at these high holding speeds. **(T-0).**
3. The maximum holding speed for helicopters is 100 knots up to 6,000 feet inclusive and 170 knots above 6000 feet.

Table 15.2. (NAS only) Maximum Holding Airspeeds.

Altitude (MSL)	Maximum Speed (KIAS)
Min Holding Altitude (MHA)-6000 feet	200
6001 feet-14000 feet	230
14001 feet and above	265
USAF Only Fields	310
USN Only Fields	230
COPTER	90

Note: A maximum airspeed of 310 knots is permitted in climb-in-holding, unless a maximum holding airspeed is published, in which case that maximum airspeed is applicable. The airspeed limitations in 14 CFR Part 91.117 still apply. Refer to **Chapter 17** for more information.

15.6.2. Holding patterns may be restricted to a maximum speed. The speed restriction is depicted in parentheses inside the holding pattern on the chart (**Figure 15.4**). The aircraft should be at or below the maximum airspeed prior to initially crossing the holding fix.

Figure 15.4. Maximum Holding Airspeed.

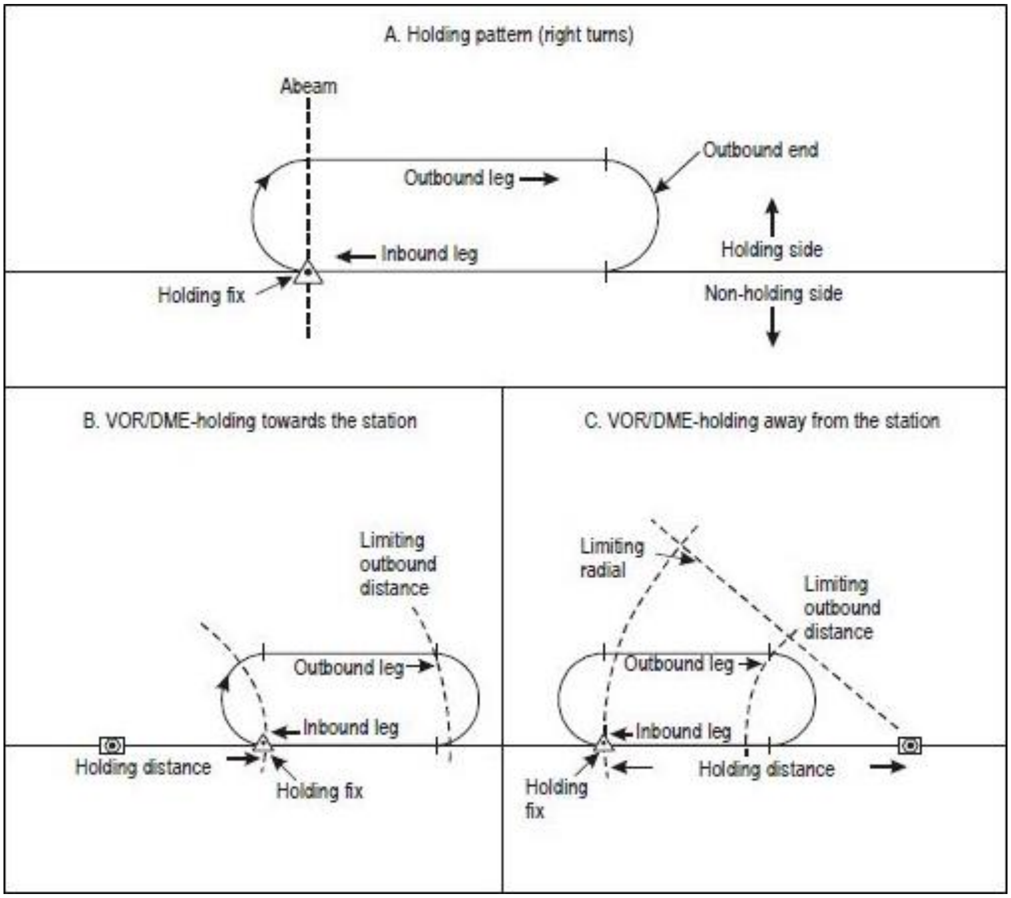
15.7. Holding Length. Holding timing is 1 minute at or below 14,000 feet MSL and 1.5 minutes above 14,000 feet MSL, unless otherwise directed by ATC.

15.7.1. Timing is based on the outbound leg. Outbound timing begins over or abeam the fix, whichever occurs later. If the abeam position cannot be determined, start timing when the turn to the outbound heading is completed.

15.7.2. (NAS only) Timing is based on the inbound leg. The initial outbound leg should be flown for 1 minute or 1.5 minutes (as appropriate). Timing for subsequent outbound legs should be adjusted, as necessary, to achieve proper inbound leg time.

15.7.3. (ICAO) A limiting radial may be published (**Figure 15.5**). In cases of holding where the distance from the holding fix to the VOR/DME station is short, a limiting radial may be specified (e.g., airspace conservation is essential). If the limiting radial is reached before the limiting outbound distance, the radial should be followed until a turn inbound is initiated at the limiting outbound distance.

Figure 15.5. ICAO Limiting Radial.



15.8. Drift Corrections. After entering the holding pattern, the pilot is expected to compensate for known winds to arrive at an outbound position from which a turn places the aircraft on the inbound holding course. Refer to **Attachment 2** for drift calculations. Compensate for wind effect primarily by drift correction on the inbound and outbound legs. When outbound, triple the inbound calculated drift correction (e.g., if correcting left by 8 degrees on the inbound leg, correct right by 24 degrees when on the outbound leg). Triple drift is the only method that allows for a constant angle of bank through inbound and outbound turns.

15.9. Fuel consideration. Once established in the holding pattern, a fuel calculation should be carried out. Determine how long it is possible to remain in the holding pattern and maintain fuel awareness throughout the holding maneuver.

15.10. Use of Area Navigation Guidance and Holding. RNAV systems, including multi-sensor flight management system (FMS) and stand-alone GNSS receivers may be used to provide lateral guidance when holding. The way holding is implemented in an RNAV system varies between aircraft and RNAV system manufacturers.

Chapter 16

ARRIVAL

16.1. General. Preparation for the arrival and approach begins long before the descent from the enroute phase of flight. The enroute descent is a transition from the enroute structure to the airfield environment. Optimum IFR arrival options include flying directly from the enroute structure to an approach gate or IAF, a visual arrival, standard terminal arrival (STAR), or radar vectors.

16.2. VFR Arrival. When arriving at a controlled airfield, contact ATC (approach or tower) and advise them of call sign, position, and intentions. ATC allows VFR aircraft to self-navigate to the landing runway when traffic permits.

16.3. Closing VFR Flight Plans. [AIM 5-1-14] VFR flight plans are not automatically closed upon landing. Pilots must ensure a VFR flight plan is closed to prevent unnecessary search and rescue operations. **(T-0)**.

16.4. Descent Planning. [FAA-H-8083-16, **Chapter 3**] Planning the descent from cruise is important because of the need to dissipate altitude and airspeed to arrive at the approach gate properly configured. To plan the descent, the pilot needs to know the cruise altitude, approach gate altitude or IAF altitude, descent groundspeed, and descent rate.

16.5. Initial Descent. Before starting descent, review instrument procedures and weather, check heading and attitude systems, and coordinate lost communication procedures if necessary. If holding is not required, reduce to maneuvering airspeed before reaching the IAF. During the descent, control descent rate and airspeed to comply with any altitude or speed restrictions imposed by ATC.

16.6. ICAO Arrival Routing. Published arrival routing to a course reversal IAF, such as a STAR, feeder route, or arrival airway, is blended into the arrival approach, either by being within the 30 degrees entry sector or a depicted holding pattern entry. Pilots need not request maneuvering airspace to perform an alignment maneuver; such requests may confuse ATC.

16.7. Standard Terminal Arrivals (STAR). [ICAO Doc 8168 Volume 1; AIM 5-4-1] A STAR is a designated IFR arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced. STARs simplify clearance delivery procedures and facilitate the transition between enroute and instrument approach procedures. 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 the less desirable method of verbally stating the same to ATC.

16.8. Arrival Clearances. Pilots navigating on arrival procedures must maintain last assigned altitude until receiving authorization to descend; comply with all restrictions published during the descent. **(T-0).**

16.9. Arrival Phraseology.

16.9.1. (NAS only) Arrival phraseology is in accordance with **Table 16.1**.

Table 16.1. NAS Phraseology.

ATC Instruction	Explanation
"Cleared Tyler One arrival."	- Follow the lateral profile of the arrival - No descent is authorized
"Cleared Tyler One arrival, descend and maintain flight level two four zero."	- Follow the lateral profile of the arrival - Descend to the cleared altitude and maintain this altitude until cleared for further descent with a newly assigned altitude or "descend via"
"Cleared Tyler One arrival, descend at pilot's discretion, maintain FL180."	- Follow the lateral profile of the arrival - Descend at pilot's discretion to the cleared altitude, maintain this altitude until cleared for further descent with a newly assigned altitude or "descend via"
"Descend via the Tyler One arrival."	- Follow the lateral profile of the arrival - Descend at pilot's discretion and comply with published altitude restrictions
"Descend via the Tyler One arrival, except after GRANT maintain nine thousand."	- Follow the lateral profile of the arrival - Descend at pilots discretion and comply with published altitude restrictions until the ATC-assigned "maintain" altitude
"Descend via the Tyler One arrival, except cross SCOTT at nine thousand then maintain six thousand."	- Follow the lateral profile of the arrival - Descend at pilot's discretion and comply with published altitude restrictions, cross the point at the ATC-assigned altitude, and then continue the descent to the ATC-assigned "maintain" altitude
"Proceed direct DILLY, cross DILLY at or above flight level two zero zero, then descend via the Tyler One arrival."	- Proceed direct to the assigned point - Follow the lateral profile of the arrival - Descend at pilot's discretion to the published or assigned altitude at the ATC-assigned point then comply with published altitude restrictions.
Note: Always comply with speed restrictions.	

16.9.2. (ICAO) [ICAO Doc 4444] ATC clearances issued to aircraft on a STAR include if remaining speed or level restrictions are to be followed or cancelled; standard clearance phraseology is shown in **Table 16.2**.

16.9.2.1. If there are no remaining published level or speed restrictions on the STAR, the phrase "DESCEND TO *(level)*" should be used.

16.9.2.2. When subsequent speed restrictions instructions are issued and if the cleared level is unchanged, the phrase "DESCEND VIA STAR TO *(level)*" should be omitted.

16.9.2.3. When an arriving aircraft is cleared to proceed direct to a published waypoint on the STAR, the speed and level restrictions associated with the bypassed waypoints are cancelled. All remaining published speed and level restrictions remain applicable.

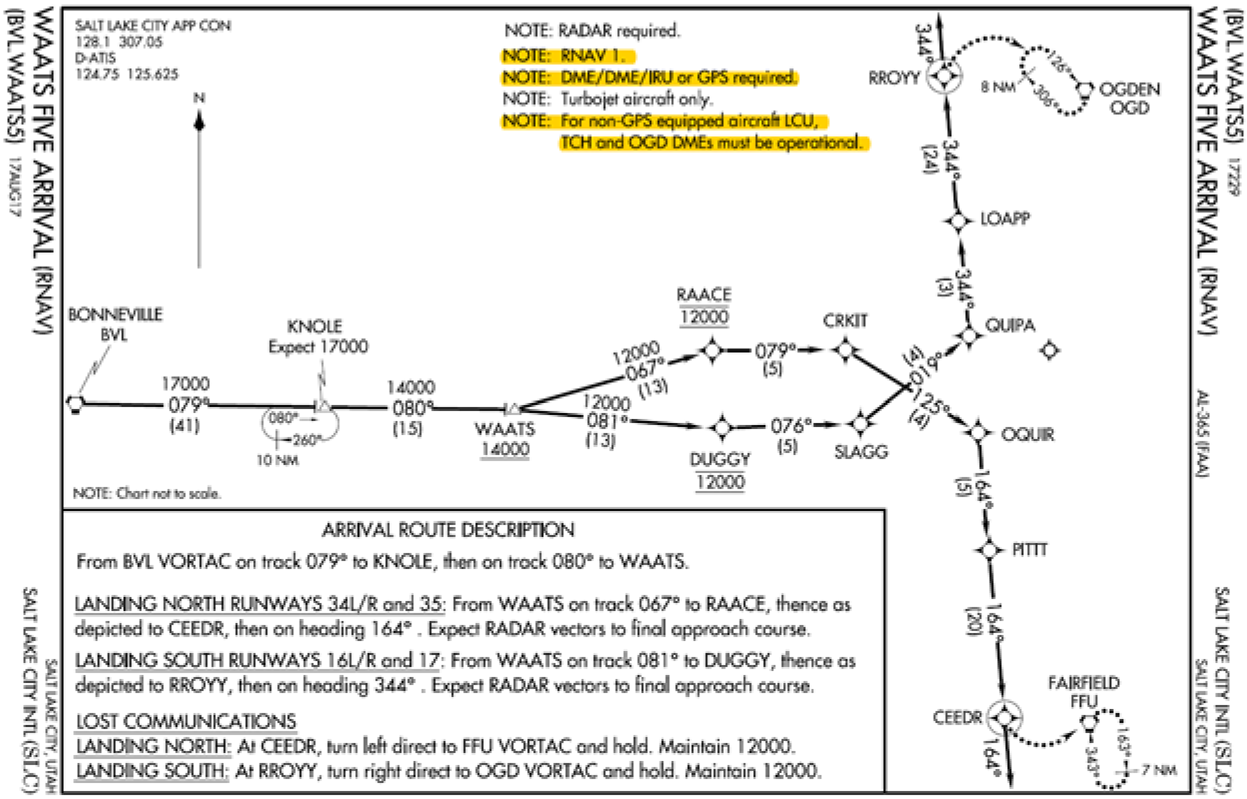
16.9.2.4. ATC instructions to rejoin a STAR after being vectored include the STAR to be rejoined, the cleared level to rejoin the STAR unless advance notification has been provided, and the position to rejoin the STAR.

Table 16.2. ICAO Phraseology.

ATC Instructions	Explanation
Descend via star to *(level)*	- Follow the lateral profile of the STAR - Descend to the cleared level and comply with published level restrictions
Descend via star to *(level)*, Cancel level restriction(s)	- Follow the lateral profile of the STAR - Descend to the cleared level and published level restrictions are cancelled
Descend via star to *(level)*, Cancel level restriction(s) at (*point(s))*	- Follow the lateral profile of the STAR - Descend to the cleared level and published level restrictions at the specified point(s) are cancelled
Descend via star to *(level)*, Cancel speed restriction(s)	- Follow the lateral profile of the STAR - Descend to the cleared level and comply with published level restrictions - Published speed restrictions and ATC-issued speed control instructions are cancelled
Descend via star to *(level)*, Cancel speed restriction(s) at *(point(s))*	- Follow the lateral profile of the STAR - Descend to the cleared level and comply with published level restrictions - Published speed restrictions are cancelled at the specified point(s)
Descend unrestricted to OR Descend to *(level)*, Cancel level and speed restrictions	- Follow the lateral profile of the STAR - Descend to the cleared level, published level restrictions are cancelled - Published speed restrictions and ATC-issued speed control instructions are cancelled
Note: Always comply with speed restrictions or ATC-issued speed control instructions, as applicable.	

16.10. RNAV Arrivals. [AIM 5-4-1; ICAO Doc 8168 Volume 1; FAA Order 8260.19] RNAV arrivals may be RNAV 1 or RNP 1 (**Figure 16.1**). The default specification is RNAV 1; RNP 1 is used when an arrival contains an RF leg or is designed for DME/DME/IRU aircraft use when ATC radar surveillance monitoring is not desired. **Note:** The required specification, equipment sensor limitations, and any critical DME facilities are annotated clearly on the procedure.

Figure 16.1. RNAV Arrival.



16.11. Anticipated Approach. ATC should provide the type of approach to expect or if vectors should be expected for a visual approach when landing at airfields with approach control services and two or more published instrument procedures. This information is broadcast either by a controller or on ATIS. It is not provided when the visibility is three miles or better and the ceiling is at or above the highest initial approach altitude established for any low altitude instrument procedures for the airfield. When making an IFR approach to an airfield not served by a tower or FSS, after ATC advises "CHANGE TO ADVISORY FREQUENCY APPROVED" the pilot should broadcast intentions, including the type of approach being executed, position, and when over the non-precision approach FAF inbound or at the precision approach glideslope intercept point. Monitor the appropriate frequency (e.g., UNICOM) for reports from other pilots.

16.12. Terminal Routings. Terminal routings from enroute or feeder facilities are considered segments of instrument procedures 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. A low altitude IAF is any fix labeled as an IAF or any procedure turn or hold-in-lieu-of procedure turn (HILPT) fix.

16.12.1. Ranges published along the terminal routing are expressed in nautical miles and not DME. The altitudes published on terminal routing are minimum altitudes and provide the same protection as an airway MEA (i.e., for navigation signal coverage and obstacle clearance).

16.12.2. If cleared for an approach while enroute to a holding fix that is not collocated with the IAF, either proceed via the holding fix or request clearance direct to the IAF. If the IAF is located along the route of flight to the holding fix, begin the approach at the IAF. If overflying a transition fix, fly the approach via the terminal routing. If in doubt as to the clearance, query the controller.

16.12.3. When cleared for the approach, maintain the last assigned altitude until established on a segment of a published route or instrument procedure. At that time, the pilot may descend to the minimum altitude associated with that segment of the published routing or instrument approach procedure.

16.13. Terminal Arrival Area (TAA). [AIM 5-4-5, ICAO Doc 8168V1, Section 1 **Chapter 2**] The TAA provides a transition from the enroute structure to the terminal environment for aircraft equipped with RNAV systems. TAAs are primarily used on RNAV approaches but may be used on instrument procedures when area navigation is the sole means for navigation to the intermediate fix (IF)/IAF.

16.14. Radar Vectors. [AIM 5-4-3] Vectors provide course guidance and expedite traffic to the final approach course of any published instrument procedure or to the traffic pattern for a visual approach.

16.14.1. (ICAO) [ICAO Doc 8168V1, Section 3, **Chapter 1**] With GNSS equipment, it may be required to manually select the next waypoint so that the GNSS is correctly using the appropriate database points and associated flight paths.

16.14.2. (ICAO) [ICAO Doc 8168V1, Section 4, **Chapter 2**] When terminal area radar is employed, the aircraft is vectored to a fix, or onto the intermediate or final approach track, at a point where the approach may be continued by the pilot referring to the instrument approach chart.

16.14.3. [AIM 5-4-5] Radar Controllers use an MVA chart to provide obstacle clearance while vectoring for an approach.

16.14.4. At all other times, unless specifically requested by the pilot, an aircraft is vectored to intercept the final approach course at least 3 miles from the FAF at a maximum intercept angle of 45 degrees (30 degrees in the NAS).

16.14.5. [FAA-H-8083-16 **Chapter 4**] Controllers are required to ensure the assigned altitude conforms to the following:

16.14.5.1. At an altitude not above the glideslope or glide path, nor below the minimum glideslope or glide path intercept altitude specified on the procedure for a precision approach.

16.14.5.2. At an altitude that allows descent in accordance with the published procedure for a non-precision approach.

16.14.6. Aircraft are normally informed when it is necessary to vector across the final approach course for spacing or other reasons. If approach course crossing is imminent and the pilot has not been informed that the aircraft is being vectored across the final approach course, the pilot should query the controller. Do not turn inbound on the final approach course unless an approach clearance has been issued. Approach clearance is normally issued with the final vector for interception of the final approach course, and the vector enables the aircraft to intercept the final approach course prior to reaching the FAF.

16.14.7. The pilot must maintain the last assigned altitude and heading until established on a segment of a published instrument procedure once approach clearance is received. **(T-0).** Comply with all course and altitude restrictions as depicted on the approach procedure; pilots must not climb above the last assigned altitude to comply with published altitude restrictions unless so instructed by the controlling agency. **(T-0).**

16.15. Operating at Non-towered Airfields. [AIM 4-1-9; AIM 4-3-3] Instrument approaches 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 airfield.

16.15.1. All CTAF and FSS calls will be in accordance with the AIM. **(T-0). Note:** Personnel providing traffic advisories at non-towered airfields are not ATC. Pilots are responsible for their own traffic avoidance, sequencing, and separation.

16.15.2. Aircraft operating on an IFR flight plan, landing at a non-towered airfield are advised to "change to advisory frequency" when ATC communications are no longer required. When directed, pilots should expeditiously change to the CTAF, as the ATC facility may not have runway in use or airfield traffic information.

16.15.3. In addition to required VFR CTAF calls, make position reports at the following locations on the approach:

16.15.3.1. Departing the FAF inbound.

16.15.3.2. Established on the final approach segment or immediately upon being released by ATC.

16.15.3.3. Completion or termination of the approach.

16.15.3.4. Executing the missed approach procedure.

16.15.4. Many VFR pilots operating near the airfield may not be familiar with fix names. Location should be referred to in the simplest terms. For example, use "5 miles south" instead of "KIRBY Intersection."

Chapter 17

APPROACH

17.1. General. Instrument procedures provide necessary navigation guidance information for alignment with the final approach courses as well as obstruction clearance. An instrument procedure can be flown in one of two ways: as a “full procedure” approach or with the assistance of ATC via radar vectors. Full procedure approaches may be requested by the pilot but are most often used in areas without radar coverage. A full procedure approach also provides the pilot with a means of completing an instrument approach in the event of a communication failure.

17.1.1. Reference AIM 5-4, FAA-H-8083-16 **Chapters 4** and **7**, and ICAO Doc 8168V1 Section 4 for more detailed explanations of arrival procedures.

17.1.2. [AIM 5-4-5] A precision approach is an instrument approach based on a navigation system that provides course and glide path deviation information meeting the precision standards of ICAO Annex 10 (i.e., PAR, ILS, and GLS).

17.1.3. [AIM 5-4-5] An approach with vertical guidance (APV) is an instrument approach based on a navigation system that is not required to meet the precision approach standards of ICAO Annex 10 but provides course and glide path deviation information (e.g., baro-VNAV, LDA with glideslope, LNAV/VNAV, LPV).

17.1.4. [AIM 5-4-5] A non-precision approach (NPA) is an instrument approach based on a navigation system which provides course deviation information, but no glide path deviation information (e.g., VOR, NDB, LNAV). Some approach procedures may provide a vertical descent angle (VDA) as an aid in flying a stabilized approach, without requiring its use to fly the procedure. This does not make the approach an APV procedure, since it must still be flown to an MDA and has not been evaluated with a glide path.

17.2. Approach Clearance. [AIM 5-4-5; AIM 5-4-6] The controller issues an approach clearance only after the aircraft is established on a segment of the instrument procedure; or the aircraft is assigned an altitude and heading to maintain until established on a segment of the instrument procedure.

17.2.1. [14 CFR Part 91.175(i)] Maintain the last assigned altitude when cleared for the approach until established on a published segment of the instrument approach procedure. **(T-0). Note:** Pilots may descend in a TAA sector to the minimum altitude depicted unless otherwise instructed by air traffic control.

17.2.2. Approach clearances cancel any previously assigned airspeed adjustments. Pilots are expected to make their own airspeed adjustments to complete the approach unless the adjustments are restated. Speed adjustments should not be assigned inside the FAF or a point 5 miles from the runway, whichever is closer to the runway. The pilots always retain the prerogative of rejecting a speed adjustment by ATC if the minimum safe airspeed for any operation is greater than the speed adjustment.

17.2.3. In ICAO, when clearance for the approach is issued, ATC expects the pilot to initiate the approach in accordance with the instrument procedure entry criteria.

17.3. Aircraft Speed. The pilot should slow the aircraft in accordance with aircraft flight manual prior to reaching the IAF. A stabilized approach inside the IAF is critical for a successful approach and landing. ICAO maximum speeds are listed in **Table 17.1**

Table 17.1. ICAO Maximum Speeds.

Aircraft Category	Range of Speeds for Initial Approach Segment (KIAS)	Range of Speeds for Final Approach Segment (KIAS)
A	90 to 150 (110*)	70 to 100
B	120 to 180 (140*)	85 to 130
C	160 to 240	115 to 160
D	185 to 250	130 to 185
E	185 to 250	155 to 230
H	70 to 120**	60 to 90**
CAT H (PinS)***	70 to 120	60 to 90

* Maximum speed for reversal and racetrack procedures.
** Maximum speed for reversal and racetrack procedures up to and including 6,000 feet is 100 knots and maximum speed for reversal and racetrack procedures above 6,000 feet is 110 knots.
*** Helicopter "Point-in-space" (PinS) procedures based on basic GNSS may be designed using maximum speeds of 120 knots for initial and intermediate segments and 90 knots on final and missed approach segments, or 90 knots for initial and intermediate segments and 70 knots on final and missed approach segments depending on the operational need.

17.4. Approach Chart Naming Convention. [FAA-H-8083-16; ICAO Doc 8168V1 Section 4 **Chapter 8**] Approach charts are identified by their procedure name (based on the NAVAIDs required for the final approach), runway served, and airfield locations.

17.5. Duplicate Procedure Identification. [ICAO Doc 8168V1 Section 4 **Chapter 8**] When two or more straight-in approaches with the same type of navigation guidance exists for the same runway a letter or numerical suffix is added to the title of the approach (e.g., VOR Z RWY 20, VOR Y RWY 20). The single letter suffix is used when:

17.5.1. Two or more NAVAIDs of the same type are used to support different approaches to the same runway;

17.5.2. Two or more missed approaches are associated with a common approach, each approach is identified by a single letter suffix;

17.5.3. Different approach procedures using the same navigation type are provided for different aircraft categories; or

17.5.4. Two or more arrivals are used to a common approach and are published on different charts.

17.6. Circling-only Approach. [FAA-H-8083-16; ICAO Doc 8168V1 Section 4 **Chapter 8**] The name of the approach is followed by a single letter starting with the letter "A" when only circling minimums are provided on an instrument approach. The suffix letter is not used again for any procedures at that airfield.

17.7. Equipment Required for an Approach. [ICAO Doc 8168 Volume 1] A slash (/) indicates that more than one type of equipment may be required to execute the final approach

(**Figure 17.1**). Additional equipment may be required to execute the other portions of the procedure (**Figure 17.2**). All navigation equipment that is required for the execution of the approach procedure and not mentioned in the procedure identification should be identified in the notes on the chart. In general, a note charted on the plan view (e.g., RADAR REQUIRED) indicates equipment that is required to transition from the enroute environment to the instrument procedure.

Figure 17.1. Equipment Required for an Approach.

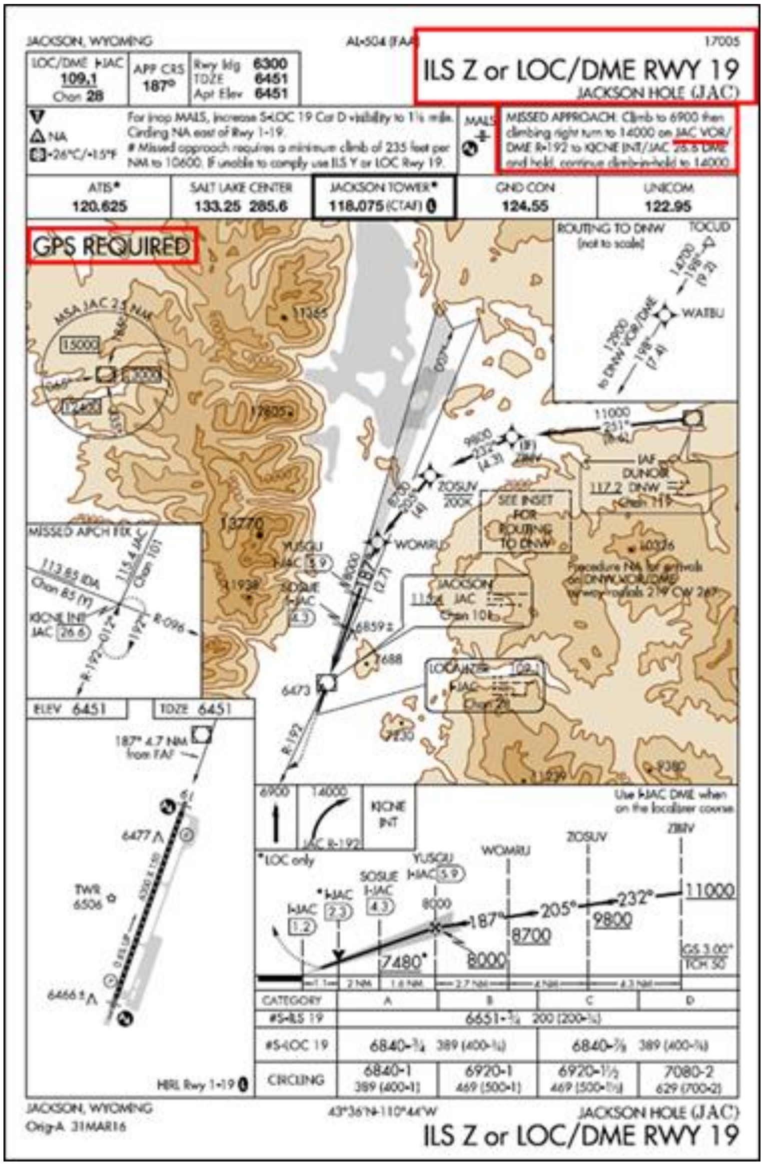
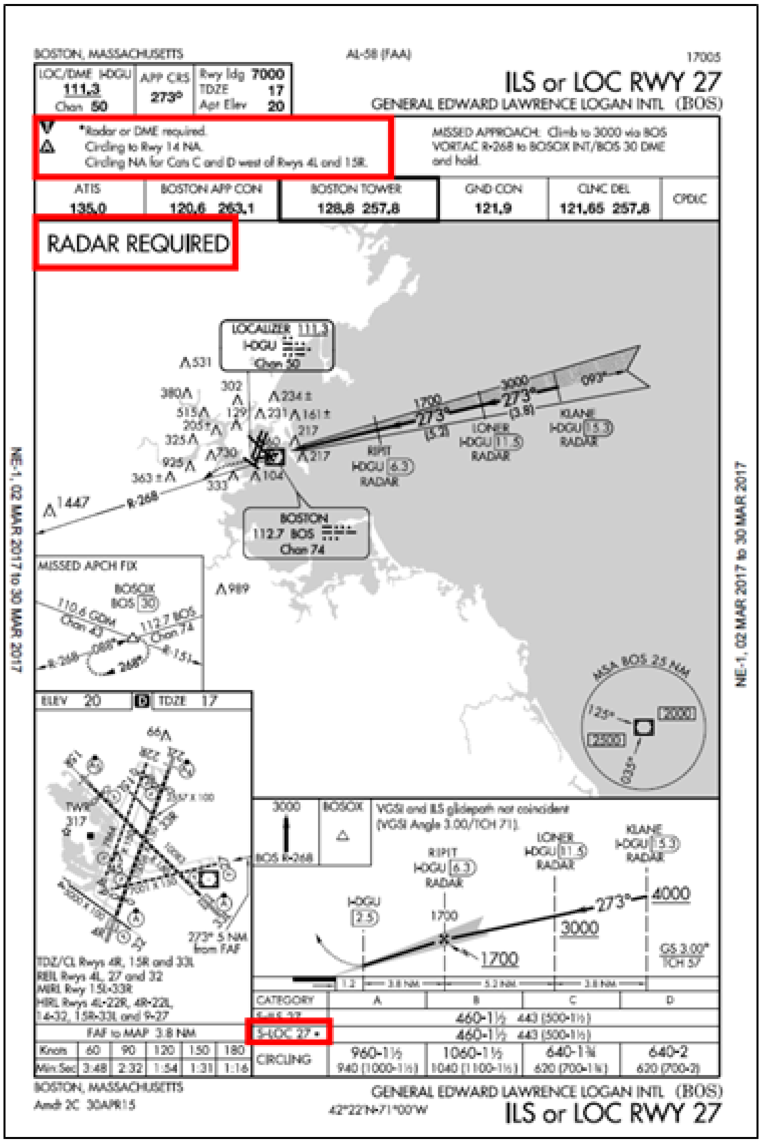


Figure 17.2. Additional Equipment Required for Approach.



17.8. Radar Approaches. Radar minima, circling MDA, and glideslope angle are in the front of the TPP (**Figure 17.3**).

Figure 17.3. Radar Approach Minimums.

PORTSMOUTH, NH Amdt 1, 05JUN08 (14261) (FAA) ELEV **100**

PORTSMOUTH INTL AT PEASE (PSM)

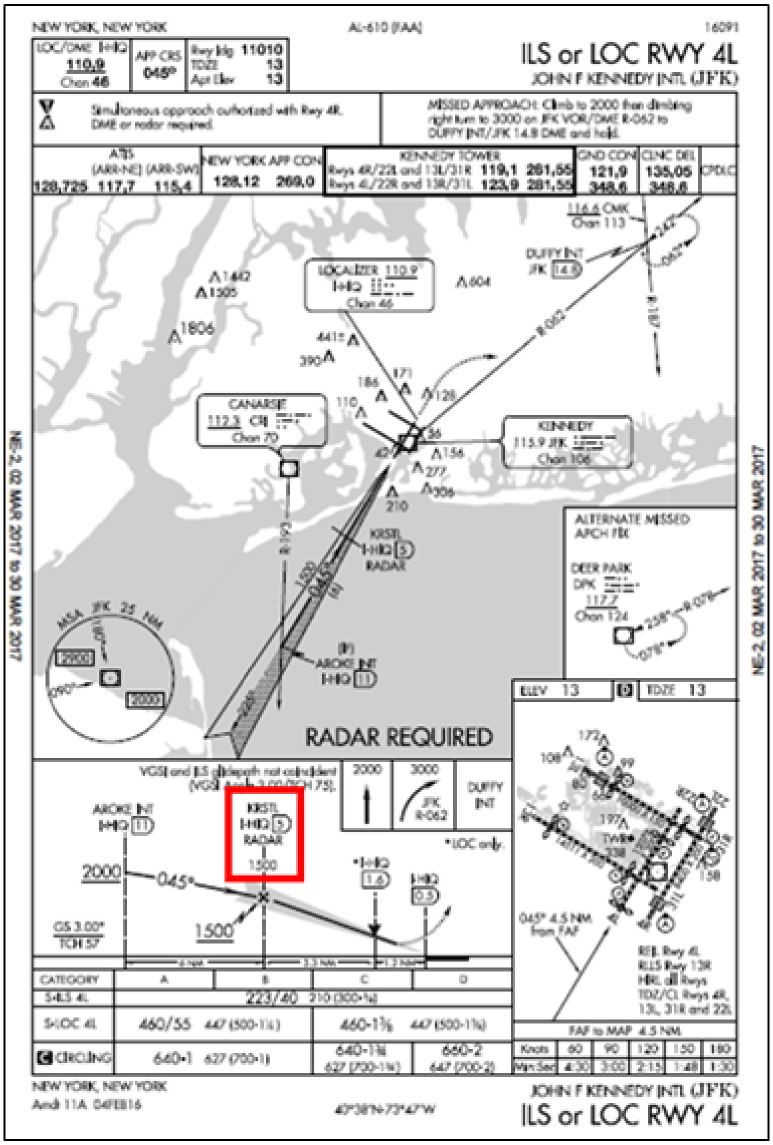
RADAR-1 125.05 269.4 NA

	RWY	GS/TCH/RPI	CAT	DA/ MDA-VIS	HAT/ HATh/ HAA	CEIL-VIS
PAR	34	3.0°/64/1221	ABCDE	**284**/24	200	(200-½)
ASR	16		ABC	**520**/40	420	(500-¾)
			DE	**520**/50	420	(500-1)
	34		ABC	**560**/40	476	(500-¾)
			D	**560**/50	476	(500-1)
			E	**560**/60	476	(500-1¼)

17.9. Non-radar Approaches. Non-radar approaches are defined as approaches that do not require radar vectoring or radar services on final approach and may or may not provide vertical glideslope or glide path guidance. Examples of non-radar approaches include ILS, LOC, VOR, TACAN, NDB, RNAV, and GLS.

17.10. Radar Fixes on Non-radar Approaches. Fixes that may utilize ATC radar for fix identification purposes are depicted with the word "RADAR" (**Figure 17.4**). Pilots are provided with navigation guidance and fix identification when transiting segments labeled with "RADAR."

Figure 17.4. Radar Fix on Non-radar Approach.



17.11. PBN Transitions to Conventional Final Approach. [ICAO Doc 8168V2; AC 90-105; AC 90-108; FAA Order 8260.58] Some published approaches may combine area navigation initial, intermediate, or missed approach segments with a conventional final approach segment (**Figure 17.5**). The PBN segments are designed under RNAV 1 or RNP 1 criteria. These approach procedures are expected to be extracted, in their entirety, from a valid and certified database without alteration.

17.11.1. Aircraft must be operationally certified, and aircrew must be trained and approved to fly PBN transition to conventional final approaches as applicable by their respective MAJCOMs. **(T-0).**

17.11.2. Pilots must ensure information from the correct navigation source is displayed (e.g., PBN source for PBN segments). **(T-0).**

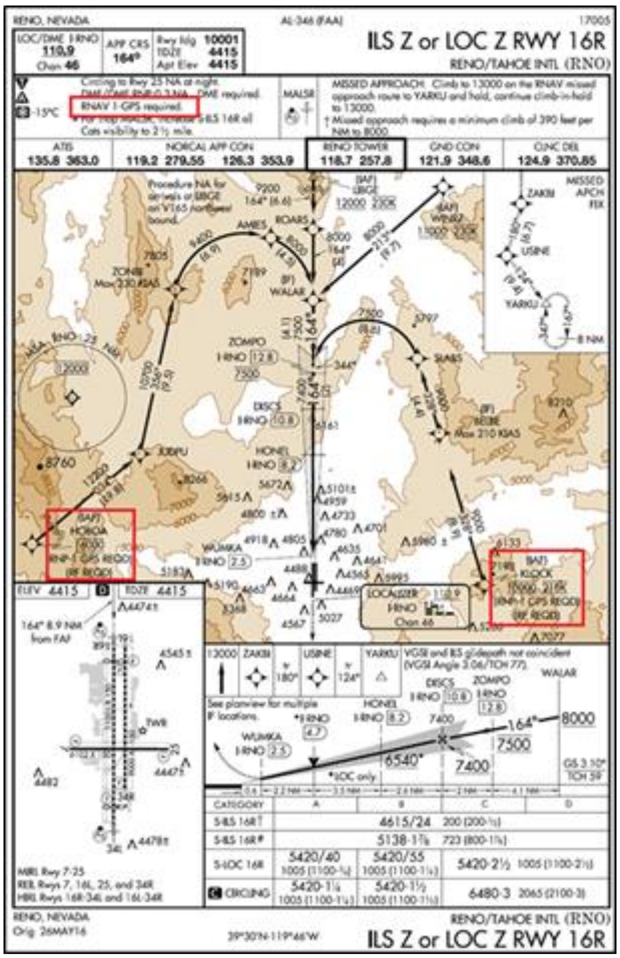
17.11.3. [AIM 1-2-3] Pilots will transition aircraft navigation from PBN to conventional course guidance prior to the FAF. **(T-0). Exception:** MAJCOMs may authorize pilots to use a suitable RNAV system or RNP system to navigate on the final approach segment of a conventional instrument approach procedure based on a VOR, TACAN, or NDB. The underlying NAVAID must be operational and the NAVAID monitored for final segment course alignment. **(T-0).**

17.11.4. Many USAF aircraft do not have conventional instrument procedures in the navigation database. Pilots may still request or accept radar vectors to the conventional final approach segment when there is no fully conventional approach to the same runway if:

17.11.4.1. The pilot coordinates for alternate missed approach instructions; or

17.11.4.2. The missed approach segment is conventional.

Figure 17.5. PBN Transitions to Conventional Final Approach.



17.12. Reading an Instrument Procedure. [FAA-H-8083-16 **Chapter 4**; DoD Publications Product Specifications paragraph 303; FAA IACC-4 **Chapter 3**] Refer to **Figure 17.6**.

17.12.1. The pilot briefing area consolidates information necessary to conduct the approach in one location. It includes final approach course, runway and airfield data, procedure restrictions, approach light data, missed approach text, and various radio frequencies.

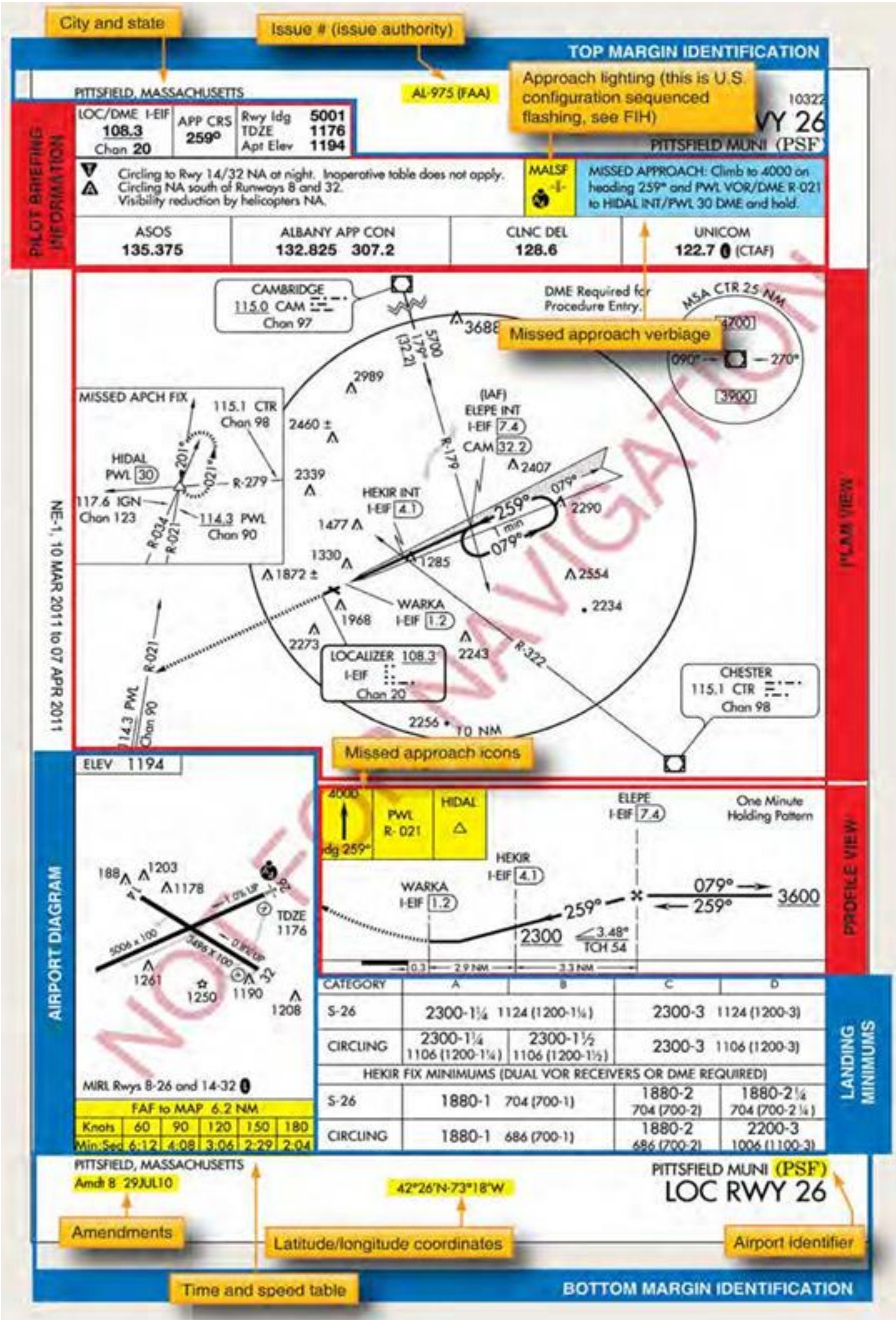
17.12.2. The plan view provides a pictorial depiction of the instrument procedure; it may be depicted with or without concentric rings.

17.12.2.1. The plan view is depicted without concentric rings when all the procedural and terminal route information can be depicted to scale.

17.12.2.2. Concentric rings are used when all procedural and terminal route information cannot be depicted to scale. A 10 nautical mile distance ring is shown when necessary; all information within the 10 nautical mile distance ring is shown to scale. **Note:** A 20 nautical mile distance ring replaces the 10 nautical mile distance ring on high procedures.

17.12.2.3. Additional rings are not depicted to scale.

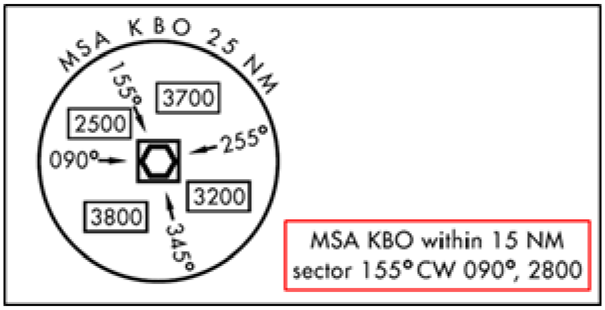
Figure 17.6. Instrument Approach Chart.



17.12.3. An emergency safe altitude (ESA) is normally published only for U.S. military procedures; it is a single altitude that provides 1,000 feet of obstacle clearance (2,000 feet in designated mountainous areas) within 100 nautical miles of the facility or fix. **Note:** Canada and other Nation States publish a "safe altitude within 100 NM" on civil or military instrument procedures; it provides the same obstacle clearance.

17.12.4. The minimum sector altitude (MSA) provides at least 1,000 feet of obstacle clearance within 25 nautical miles (on conventional navigation systems this radius may be expanded to 30 nautical miles if necessary to encompass the airfield landing surfaces) of the facility or fix. The MSA may be further divided into a maximum of four sectors when more than one MSA is required. At some airfields the MSA may have sub-sectors based on distances (**Figure 17.7**). **Note:** MSAs do not guarantee NAVAID reception.

Figure 17.7. MSA with Sub-sector Based on Distance.



17.12.5. The profile view provides a side view of prescribed altitudes, descent gradients, and a pictorial representation of the missed approach procedures.

17.12.5.1. Vertical descent angles are calculated to provide a constant descent rate in the final segment. The optimum VDA is 3.00 degrees. Where operationally feasible, straight-in non-precision approaches (all categories) have a VDA equal to the commissioned angle of an installed visual glideslope indicator (VGSI). An approach without a FAF does not have a VDA.

17.12.5.2. The threshold crossing height (TCH) refers to the point where the VDA crosses above the threshold. The typical TCH is 30 to 50 feet unless required by larger type aircraft.

17.12.6. The airfield diagram depicts field elevation, touchdown zone elevation (TDZE), runway dimensions, lighting systems, obstructions, and final approach direction. **Note:** Not all obstructions are depicted; check NOTAMs, Enroute Supplement, etc.

17.12.6.1. The field elevation is the highest point on any usable landing surface.

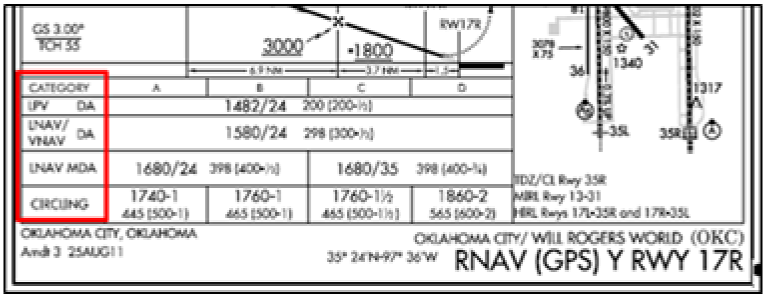
17.12.6.2. The touchdown zone elevation is the highest point in the first 3,000 feet of the landing surface.

17.12.6.3. The arrow shows the direction of the final approach in relation to the runway orientation. A final approach may be as much as 30 degrees off of the runway centerline and still be considered a straight-in approach.

17.12.7. Look carefully for notes on the instrument procedure. Notes are used to identify either nonstandard instrument procedure criteria or to emphasize areas essential for the safe completion of the approach.

17.13. RNAV Lines of Minima. [AIM 5-4-5] Each line of minima on an RNAV instrument procedure is titled to reflect the level of service required (**Figure 17.8**). The minima are dependent on the navigation equipment capability as outlined in the IFR LANDING MINIMA section at the front of the TPP. Typically, the approach chart indicates the equipment required for the approach (e.g., GPS, RNP-0.3, etc.).

Figure 17.8. RNAV Lines of Minima.



17.13.1. The LPV level of service provides lateral and VNAV guidance; it is an APV and the line of minima is published as a DA. LPV takes advantage of the improved accuracy of SBAS lateral and vertical guidance to provide an approach that is very similar to a CAT I ILS. LPV approaches are designed for angular guidance with increasing sensitivity as the aircraft gets closer to the runway; this sensitivity is nearly identical to an ILS at similar distances from the runway. **Note:** Pilots will not use the LPV line of minima unless the aircraft flight manual states installed equipment supports LPV approaches. **(T-0).**

17.13.2. The LP level of service provides LNAV guidance only; it is a non-precision approach and the line of minima is published as an MDA. LP takes advantage of the improved accuracy of SBAS to provide approaches with angular lateral guidance; therefore, lateral sensitivity increases as the aircraft gets closer to the runway, similar to localizer approaches. LP is only published when terrain, obstructions, or other reasons prevent publishing a vertically guided procedure; LP is not published with another approach that contains approved vertical guidance (i.e., LPV or LNAV/VNAV). LP is published in addition to LNAV only when it provides lower minimums. LP is not a fail-down mode for LPV. A SBAS receiver may not support LP even if it supports LPV. **Note:** Pilots will not use the LP line of minima unless the aircraft flight manual includes LP as an approved approach type. **(T-0).** Some SBAS avionics provide LP with advisory vertical guidance (LP+V); pilots will only use advisory vertical guidance for situational awareness to the LP MDA. **(T-0).**

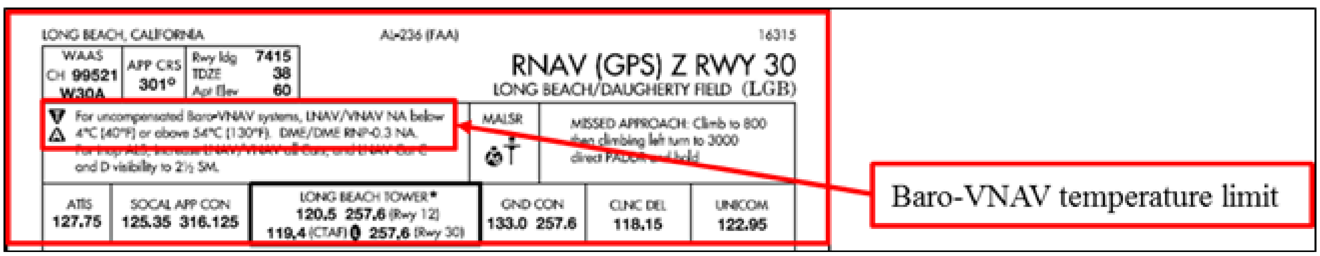
17.13.3. The LNAV/VNAV level of service provides lateral and vertical navigation guidance; it is an APV and the line of minima is published as a DA. Vertical guidance is usually provided by approach-certified Baro-VNAV but with lateral and vertical integrity limits larger than a precision approach or LPV. **Note:** Pilots will not use the LNAV/VNAV line of minima unless the aircraft flight manual states the aircraft has been demonstrated to support LNAV/VNAV approaches or the installed equipment supports GNSS approaches with approach-approved Baro-VNAV. **(T-0).**

17.13.4. The LNAV level of service provides LNAV guidance only; it is a non-precision approach and the line of minima is published as an MDA. **Note:** Some RNAV systems present LNAV with advisory vertical guidance (LNAV+V); pilots will only use advisory vertical guidance for situational awareness to the LNAV MDA. **(T-0).**

17.14. Baro-VNAV Systems. Baro-VNAV systems compute vertical guidance referenced to a specified vertical path angle (VPA). The computer resolved vertical guidance is based on aircraft barometric altimetry systems. This VPA may be greatly affected by non-standard temperatures, incorrect or rapidly changing altimeter settings, and altimeter error. Pilots must not use Baro-VNAV guidance for reference below the published DA. **(T-0).** Pilots should closely monitor compliance with step down fix altitude constraints. **Note:** 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).

17.15. Baro-VNAV Temperature Limitations. [FAA-H-8083-16 **Chapter 4**] A minimum and maximum temperature limitation is published on procedures that authorize Baro-VNAV operation (**Figure 17.9**). These temperatures represent the airfield temperature above or below which Baro-VNAV is not authorized to LNAV/VNAV minimums unless temperature compensation can be accomplished.

Figure 17.9. Baro-VNAV Temperature Limits.



17.15.1. When the temperature is above the high temperature or below the low temperature limit, Baro-VNAV may be used to provide a stabilized descent to the LNAV MDA; however, extra caution should be used in the visual segment to ensure a vertical correction is not required. If the VGSI is aligned with the published glide path, and the aircraft instruments indicate on glide path, an above or below glide path indication on the VGSI may indicate that temperature error is causing deviations to the glide path. These deviations should be considered if the approach is continued below the MDA.

17.15.2. Many systems which apply Baro-VNAV temperature compensation only correct for cold temperature. In this case, the high temperature limitation still applies. Also, temperature compensation may require activation by maintenance personnel during installation in order to be functional, even though the system has the feature. Some systems may have a temperature correction capability, but correct the barometric altimeter all the time, rather than just on the final, which would create conflicts with other aircraft if the feature were activated. Pilots should be aware of compensation capabilities of the system prior to disregarding the temperature limitations.

17.16. Approach Segments. [FAA-H-8083-16 **Chapter 4**; ICAO Doc 8168 Volume 1] There are five segments to an instrument approach procedure: arrival, initial, intermediate, final, and missed approach (**Figure 17.10**). Approach segments begin and end at designated fixes; however, there are circumstances where a segment begins at a point where no fixes are available. The intermediate segment begins at a point where the aircraft is proceeding inbound to the FAF along the final approach course within the "remain within" distance if an IF is not shown on an approach chart (**Figure 17.11**).

Figure 17.10. Approach Segments.

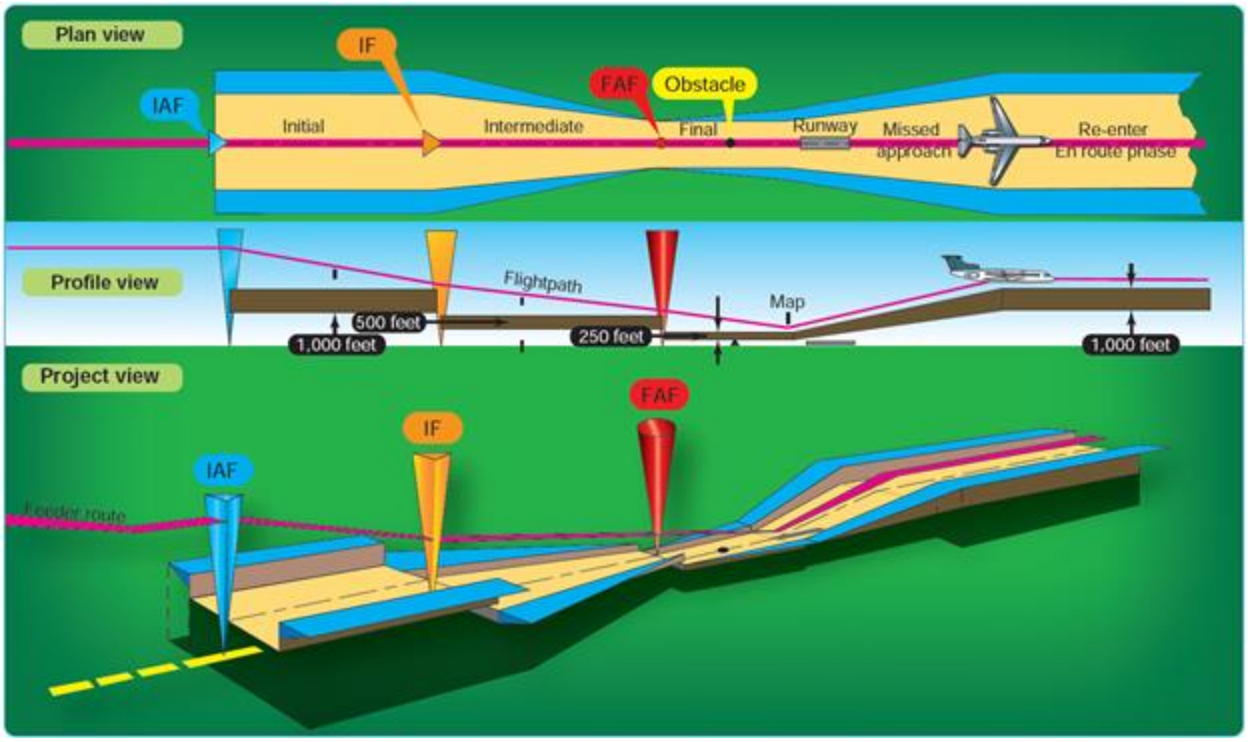
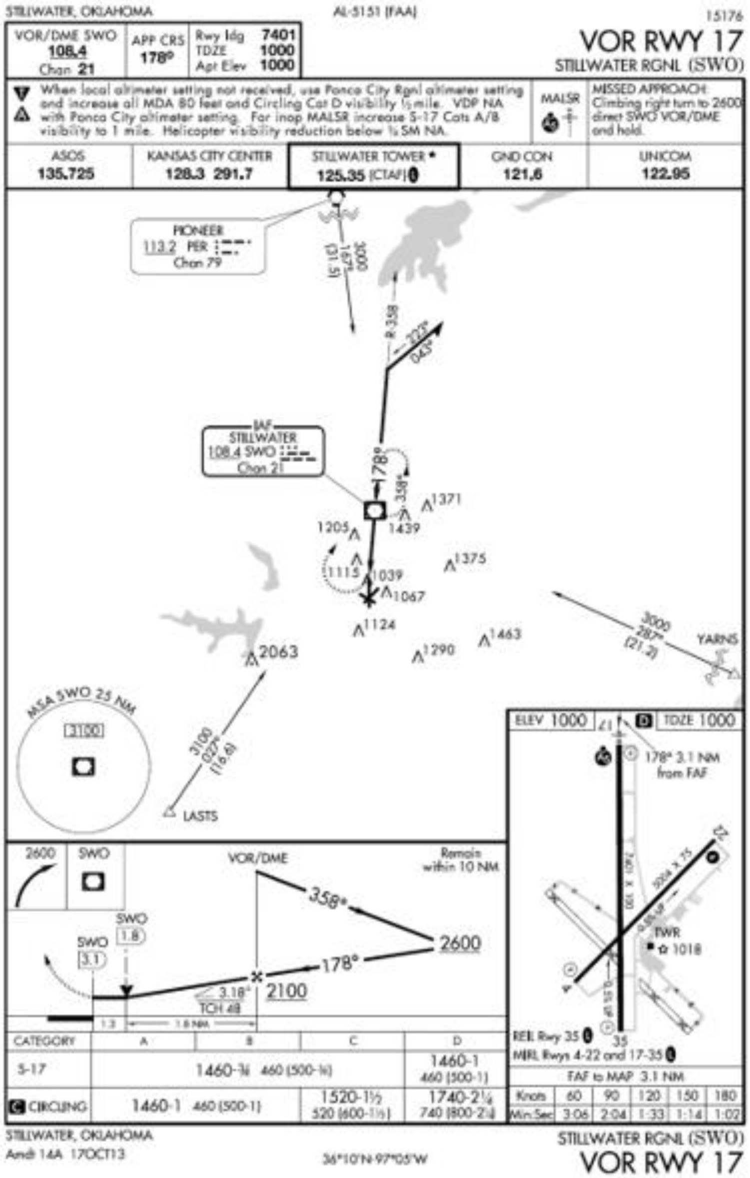


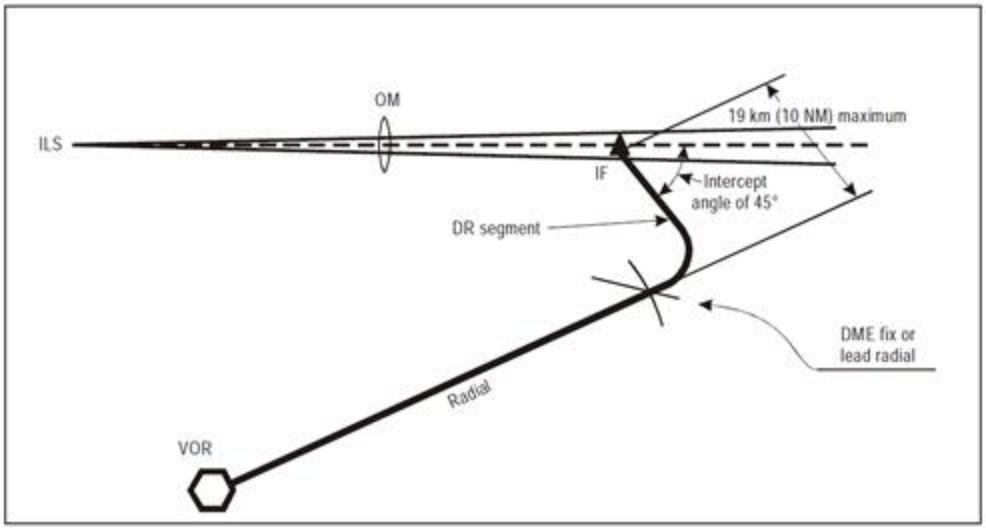
Figure 17.11. Instrument Procedure without a Charted IF.



17.17. Dead Reckoning Segment. [ICAO Doc 8168V1 Section 4 Chapter 3.3] An ILS procedure may include a dead reckoning segment from a fix to the localizer where an operational advantage can be obtained (**Figure 17.12**). The dead reckoning track intersects the localizer at 45 degrees and is not more than 10 nautical miles in length. The point of interception is the beginning of the intermediate segment and allows for proper glide path interception.

17.17.1. [FAA Order 8260.3 **Chapter 2**] (NAS only) An initial approach segment may include a dead reckoning course. The alignment of the dead reckoning course intercepts the extended intermediate course. For low altitude procedures, the intercept point is at least 1 nautical mile from the IF for each 2 nautical miles of dead reckoning flown. For high altitude procedures, the intercept point may be 1 nautical mile from the IF for each 3 nautical miles of dead reckoning flown. The intercept angle does not exceed 90 degrees and is less than 45 degrees except when DME is used or the dead reckoning distance is 3 nautical miles or less.

Figure 17.12. (ICAO) Dead Reckoning Segment.



17.18. Established on Course. [ICAO Doc 8168 Volume 1] The aircraft is not "established on course" until within the following limits:

17.18.1. Within 1X the required accuracy for RNAV or RNP segments flown [AIM 5-5-16];

17.18.2. Within half-full-scale deflection; or

17.18.3. Within +/-5 degrees of the required bearing for NDB.

17.18.4. (NAS only) Within full-scale deflection for LOC.

17.19. Shuttle, Climb-in Hold, and Descent-in Hold.

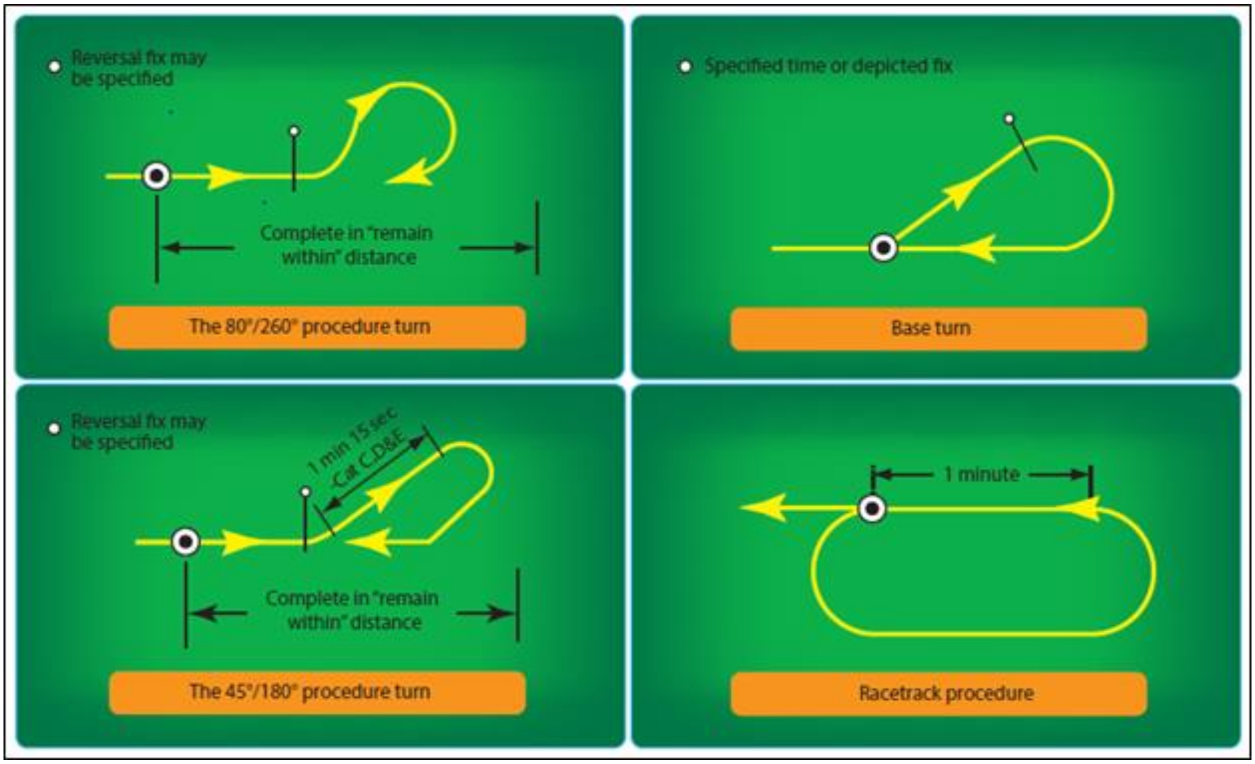
17.19.1. (ICAO) [ICAO Doc 8168V1 Chapter 3.3.8] A shuttle is a descent or climb conducted in a holding pattern. A shuttle is normally specified where the descent required between the end of the initial approach and the beginning of the final approach exceeds standard ICAO approach design limits.

17.19.2. (NAS only) When a climb-in hold is specified by a published procedure (e.g., "climb-in holding pattern to depart XYZ VORTAC at or above 10,000"), additional obstacle protection area has been provided to allow for greater airspeeds in the climb for those aircraft requiring them. A maximum airspeed of 310 KIAS is permitted in climb-in holding, unless a maximum holding airspeed is published.

17.20. Types of Course Reversals.

17.20.1. The two types of course reversal procedures are the procedure turn and the racetrack or (NAS only) HILPT. Procedure turns include the 45°/180°, 80°/260°, and base turn or (NAS only) teardrop (**Figure 17.13**).

Figure 17.13. Types of Course Reversals.



17.20.2. 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 instrument procedure before beginning a descent to the altitude associated with that segment.

17.21. ICAO-specific Course Reversal and Racetrack Procedures. [ICAO Doc 8168V1 Section 4 **Chapter 3**] Unless the procedure specifies entry restrictions, reversal procedures must be entered from a track within +/-30 degrees of the outbound track (**Figure 17.14**). **(T-0).** However, for base turns, where the +/-30 degree direct sector does not include the reciprocal of the inbound track, the entry sector is expanded to include it (**Figure 17.15**).

17.21.1. ICAO specifies a 30 degree sector entry because the course reversal protected airspace may not include any airspace except on the outbound side of the procedure turn fix. In the NAS, protected airspace includes a much larger entry zone surrounding the fix (**Figure 17.16**). If the aircraft arrival track is not within the entry sector most course reversals have a published arrival holding pattern at or near the IAF to accommodate arrivals from outside the entry sector. PANS-OPS directs pilots coming from outside the entry sector to enter holding prior to commencing the reversal procedure. In most cases the holding pattern aligns the aircraft with the entry sector for the instrument procedure.

Figure 17.14. Direct Entry Sector.

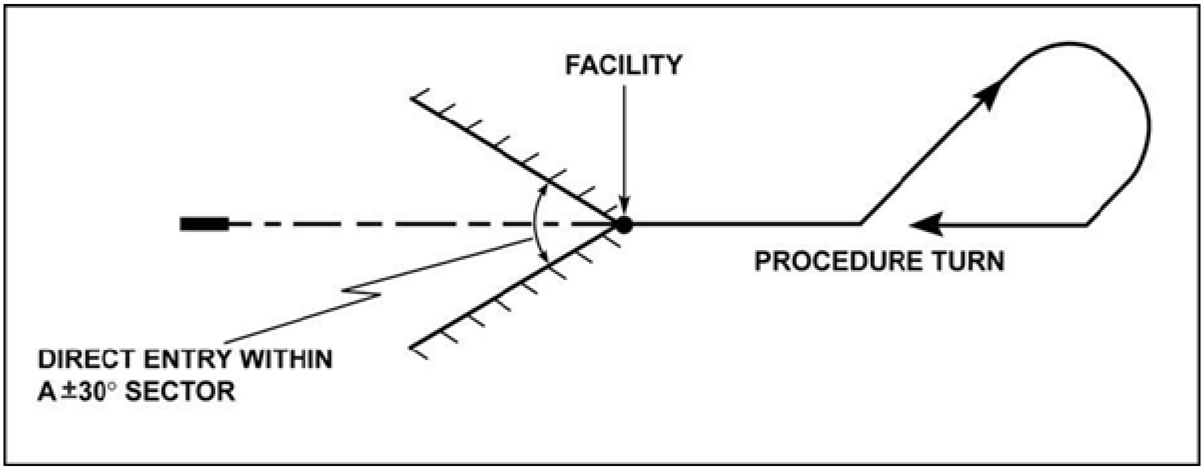
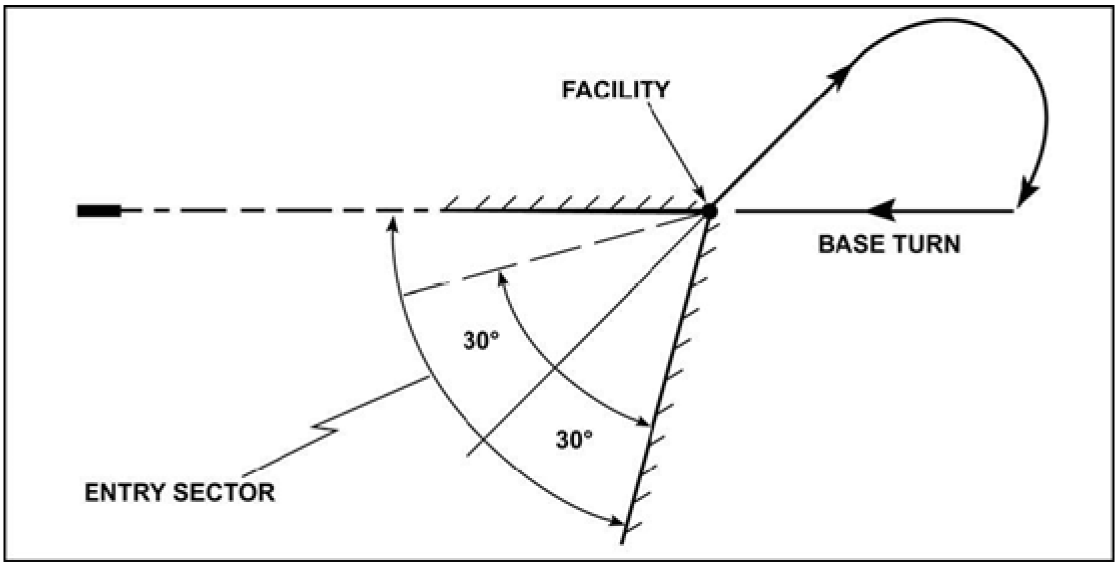
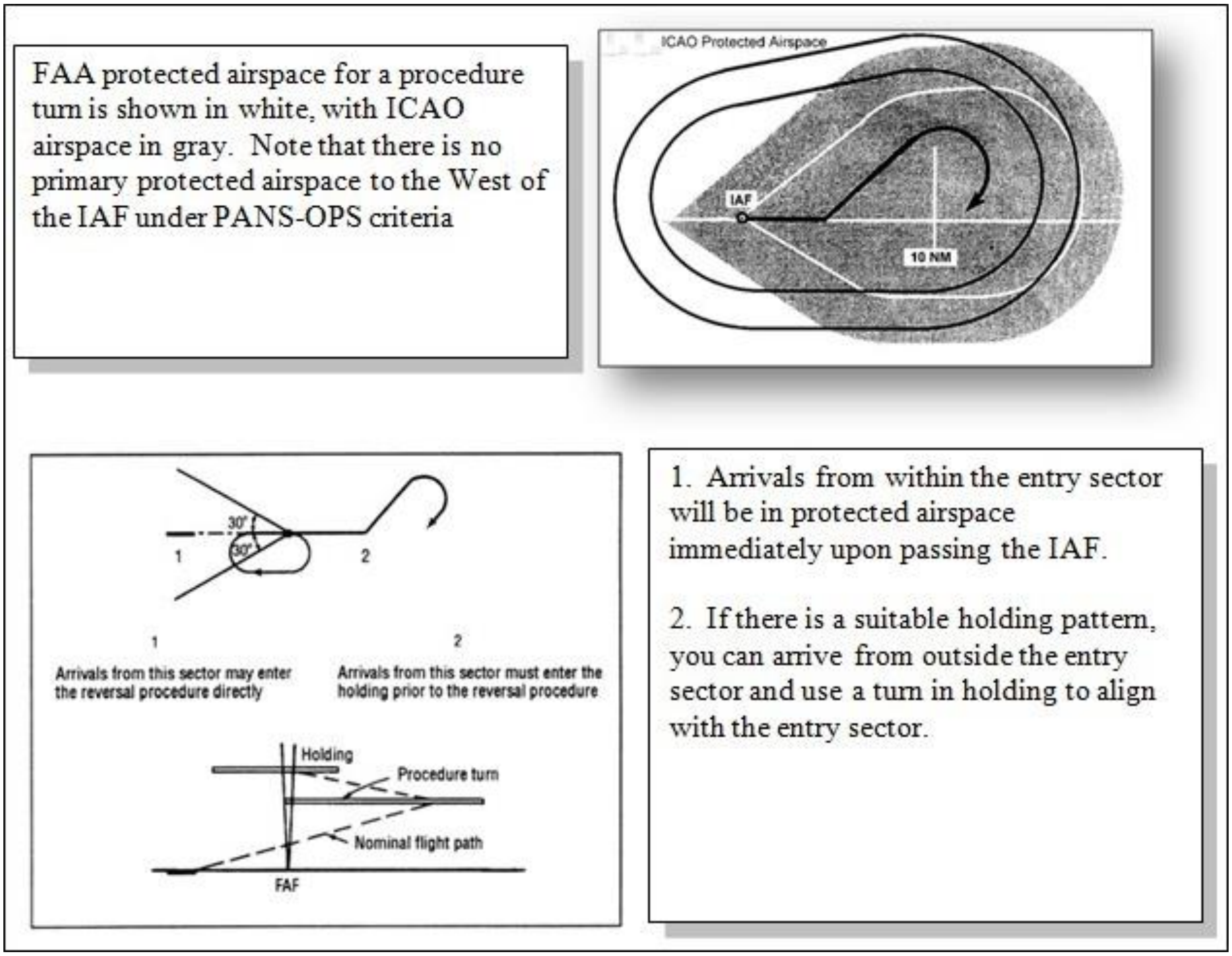


Figure 17.15. Base Turn Entry Expanded Entry Sector.



17.21.2. Bank angle is based on the average achieved bank angle of 25 degrees, or the bank angle giving a rate of 3 degrees per second (standard rate), whichever is less.

Figure 17.16. ICAO PANS-OPS versus U.S. TERPS Protected Airspace.



17.21.3. The pilot will cross the fix or facility and fly outbound on the specified track, descending, as necessary, to the procedure altitude, but no lower than the minimum crossing altitude associated with that segment. **(T-0).** If a further descent is specified after the inbound turn, the pilot will not descend until the aircraft is established on the inbound track. **(T-0).** Descent rates are in accordance with **Table 17.2**.

Table 17.2. ICAO Course Reversal and Racetrack Descent Rates

Outbound Track	Maximum Descent Rate*	Minimum Descent Rate*
Category A/B	804 feet/min	N/A
Category C/D/E/H	1197 feet/min	N/A
Inbound Track		
Category A/B	655 feet/min	394 feet/min
Category C/D/E	1000 feet/min	590 feet/min
Category H	755 feet/min	N/A
* Maximum/Minimum descent for 1 minute nominal outbound time in feet		

17.21.4. Apply drift corrections to track the published ground track. All ICAO instrument procedures must be flown as depicted. **(T-0).** The 45°/180° procedure turn is an alternative to the 80°/260° procedure turn and vice versa, unless specifically excluded on the procedure.

17.21.5. Allowances should be made in both heading and timing to compensate for the effects of wind so that the aircraft regains the inbound track as accurately and expeditiously as possible. In making these corrections, full use should be made of the indications available from the aid and from estimated and known winds. This is particularly important for slow aircraft in high wind conditions, when failure to compensate may render the procedure unflyable (i.e., the aircraft may pass the fix before establishing on the inbound track or it could depart the protected airspace).

17.21.6. Before crossing the IAF, reduce to aircraft flight manual required speeds, the maximum category speed in accordance with **Table 17.3**, or the maximum speed published on the procedure, whichever is lowest.

Table 17.3. ICAO Maximum Speeds for Course Reversals and Racetrack Procedures.

Category	Initial Approach Speed Range (KIAS)	Final Approach Speed Range (KIAS)
A	90 to 150 (110*)	70 to 100
B	120 to 180 (140*)	85 to 130
C	160 to 240	115 to 160
D	185 to 250	130 to 185
E	185 to 250	155 to 230
H	70 to 120**	60 to 90***

Note: The speeds given are converted and rounded to the nearest multiple of five for operational reasons and from the standpoint of operational safety are considered equivalent.
* Maximum speed for reversal and racetrack procedures.
** Maximum speed for reversal and racetrack procedure up to including 6,000 feet is 100 knots and 110 KIAS above 6,000 feet.
*** Helicopter point-in-space procedures based on basic GNSS may be designed using maximum speeds of 120 knots for initial and intermediate segments and 90 knots on final, or 90 knots for initial and intermediate segments and 70 knots on final depending on the operational need. Refer to PANS-OPS, Vol II, Part IV, Chapter 2, PinS RNP APCH approach procedures for helicopter down to LNAV minima.

17.22. Procedure Turn. [AIM 5-4-9] Procedure turns are depicted in the plan view on U.S. Government instrument procedure charts with a "barb" arrow indicating the maneuvering side of the outbound course on which the procedure turn is to be accomplished (**Figure 17.17**). A procedure turn is NA when there is no barb depicted (**Figure 17.18**).

Figure 17.17. Procedure Turn.

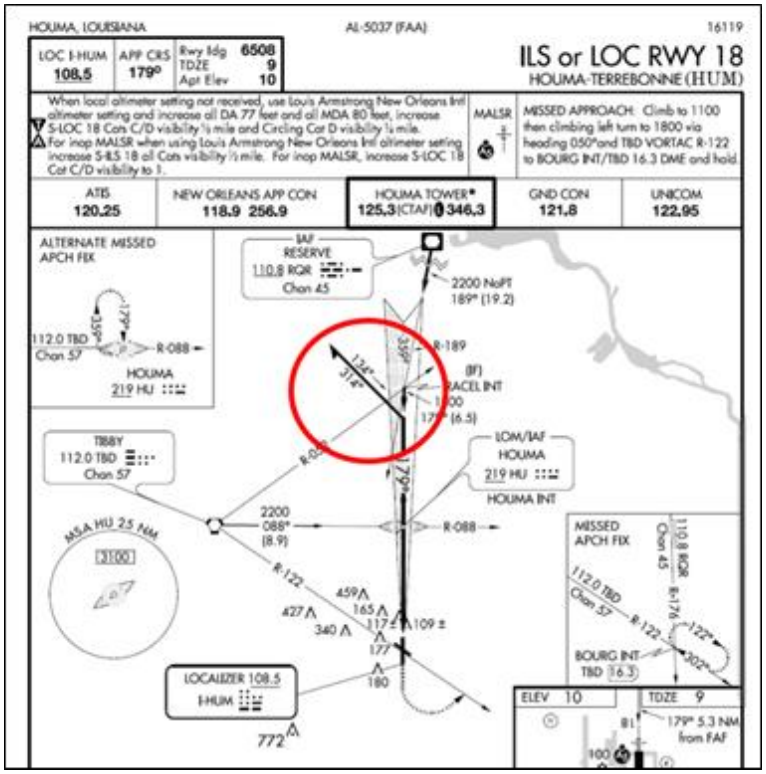
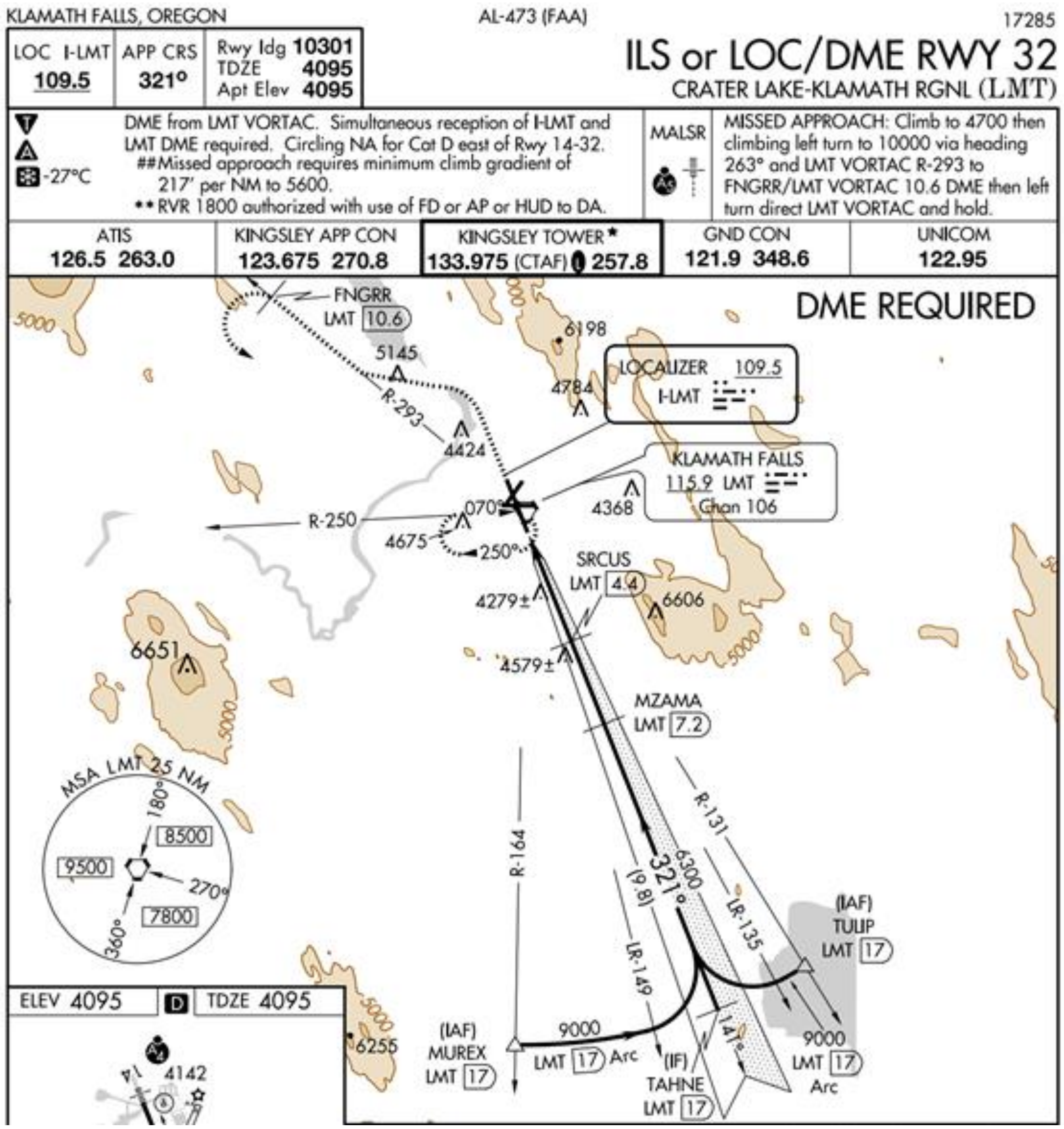


Figure 17.18. Procedure Turn Not Authorized.



17.22.1. (NAS only) Headings are provided for course reversals using the 45°/180° procedure turn; however, the point at which the turn may be commenced, the type (i.e., 45°/180°, 80°/260°, or teardrop) and the rate of turn is at the pilot's discretion limited by the charted "remain within distance."

17.22.2. Procedure turns should be flown at airspeeds of 200 KIAS or less to ensure containment within the obstruction clearance area provided by the design criteria.

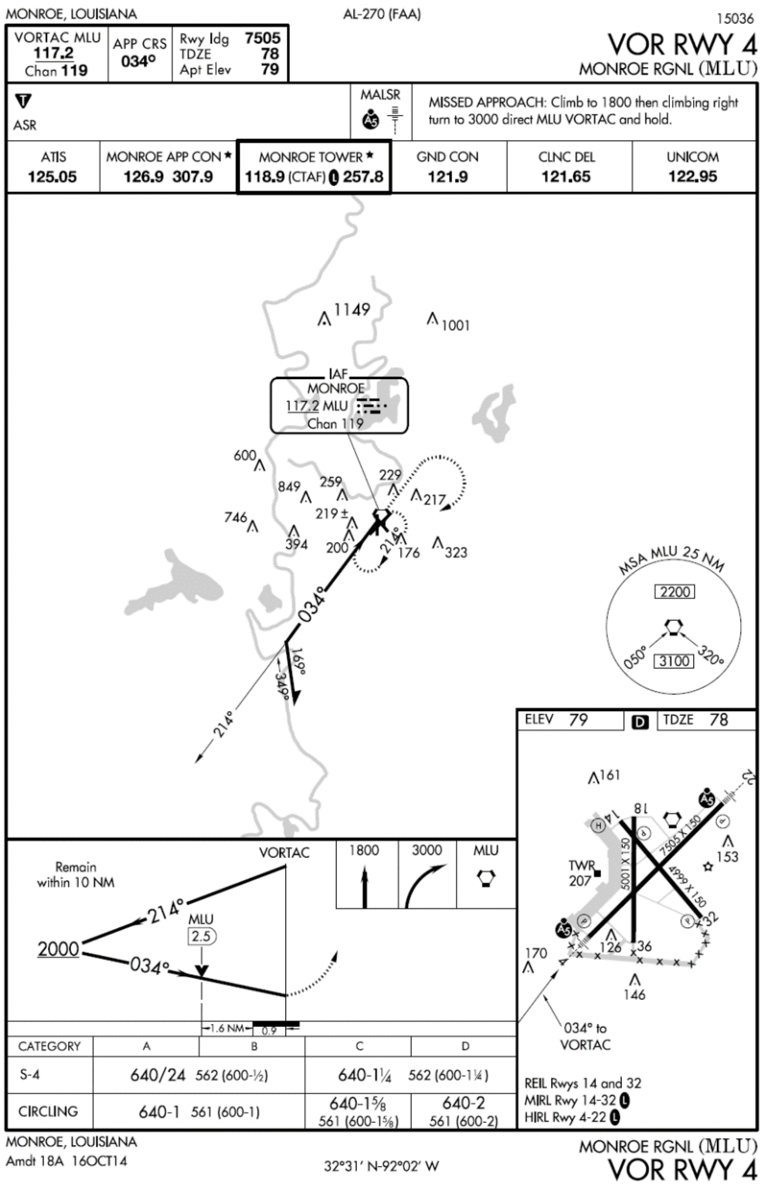
17.22.3. Plan the outbound leg to allow enough time for configuration and any descent required prior to the FAF. Adjust the outbound leg length to ensure the aircraft will stay inside the "remain within distance" noted on the profile view of the instrument procedure. **(T-0).** The "remain within distance" is measured from the procedure turn fix unless the instrument procedure specifies otherwise. Turn to intercept the inbound course at the completion of the outbound leg. The normal remain within distance is 10 miles; it may be reduced to 5 miles where only CAT A and helicopters operate or increased to 15 miles to accommodate high performance aircraft.

17.22.3.1. When the NAVAID is on the field and no FAF is depicted, 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 (**Figure 17.19**).

17.22.3.2. When flying this type of approach, the FAF is the point when the pilot begins descending from the procedure turn completion altitude. Since this point is considered the FAF, the pilot should establish approach configuration and airspeed prior to departing procedure turn completion altitude unless aircraft flight manual procedures require otherwise.

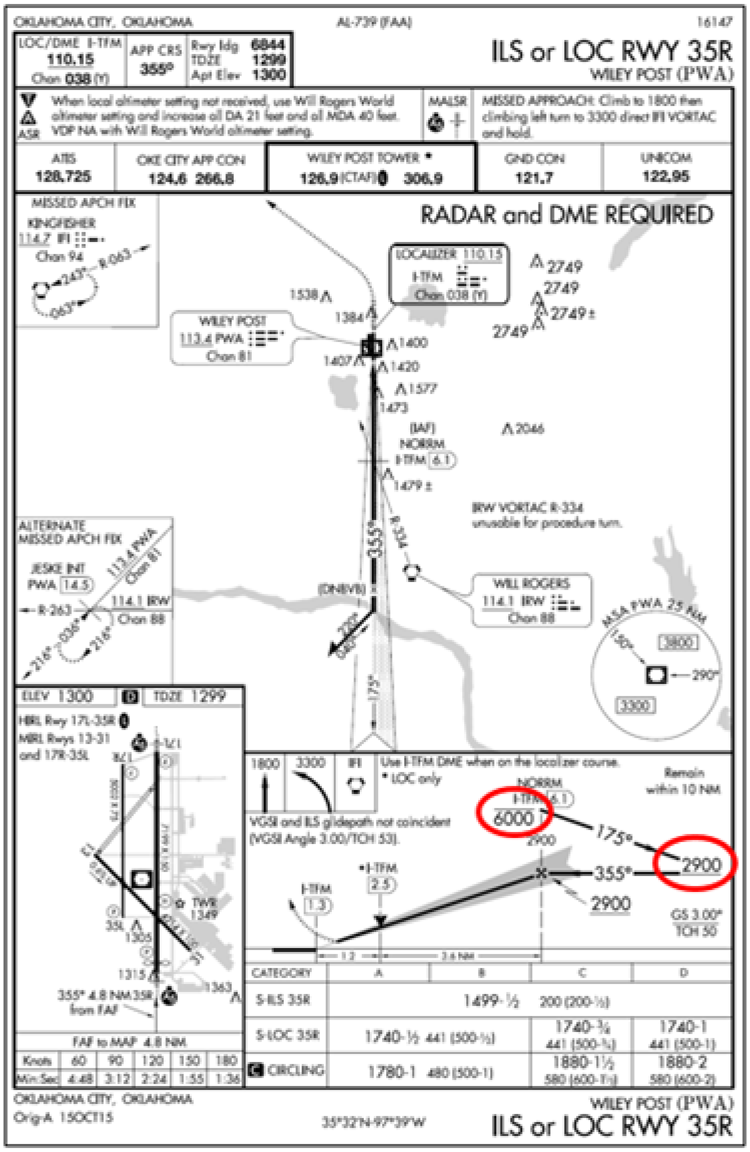
17.22.4. Do not descend from the procedure turn fix altitude (published or assigned) until crossing over or outbound abeam the procedure turn fix. Do not descend from the procedure turn completion altitude until established on the inbound segment of the approach. Procedures may contain a note on the chart profile or depict an “at or above” altitude at the procedure turn fix without a note (**Figure 17.20**). Absence of a chart note or a specified minimum altitude adjacent to the procedure turn fix is an indication that descent to the procedure turn altitude can commence immediately upon crossing over the procedure turn fix, regardless of the direction of flight.

Figure 17.19. Procedure Turn with No FAF Depicted.



CATEGORY	A	B	C	D
S-4	640/24 562 (600-½)		640-1¼ 562 (600-1¼)	
CIRCLING	640-1 561 (600-1)		640-1⅝ 561 (600-1⅝)	640-2 561 (600-2)

Figure 17.20. Procedure Turn Fix Altitude.



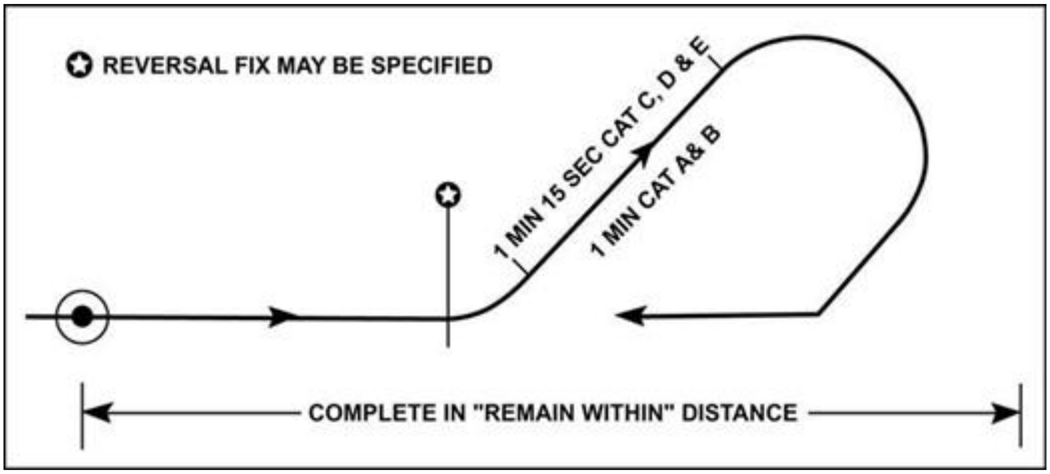
17.23. Procedure Turn - 45°/180°. The 45°/180° starts at a facility or fix IAF and consists of the following (**Figure 17.21**):

17.23.1. A straight outbound leg with course guidance limited by time, radial or distance;

17.23.2. A 45-degree turn commenced at the designated radial or DME fix, or at the completion of the published timing requirement.

17.23.3. A timed straight leg without track guidance. Begin timing upon initiating the 45-degree turn. Time for 1 minute (Categories A and B) or 1 minute and 15 seconds (Categories C, D, and E); timing is mandatory under ICAO. **(T-0).** Adjust the time or distance on the outbound track to ensure the reversal is initiated at a point specified on the instrument procedure if so depicted, or the maneuver is completed within the specified "remain within" distance.

Figure 17.21. 45°/180° Procedure Turn.



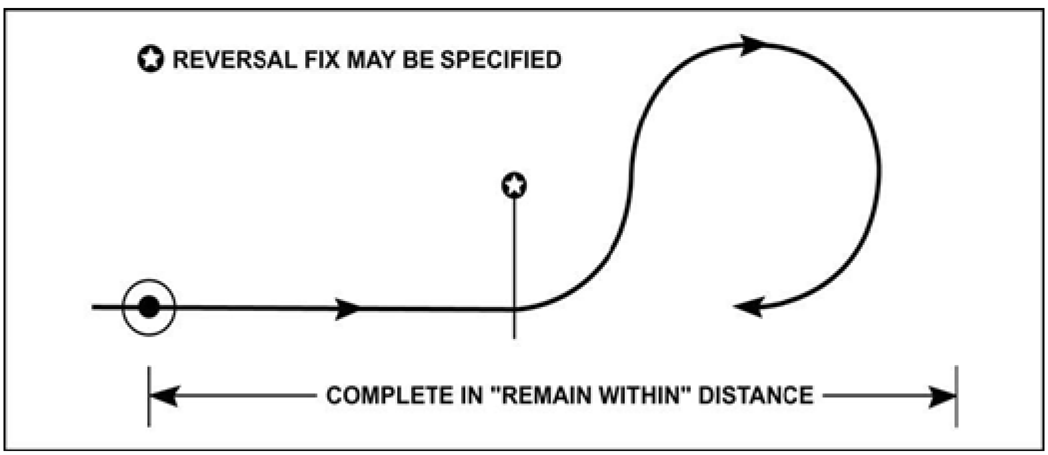
17.24. Procedure Turn – 80°/260°. The 80°/260° starts at a facility, fix, or IAF and consists of the following (**Figure 17.22**):

17.24.1. A straight outbound leg with course guidance limited by time, radial or distance; **Note:** Adjust the time or distance on the outbound course to ensure the reversal is initiated at a point specified on the instrument procedure if depicted, or the maneuver is completed within the specified "remain within" distance.

17.24.2. An 80-degree turn commenced at the designated radial or DME fix, or at the completion of the published timing requirement, followed immediately by;

17.24.3. A 260-degree turn in the opposite direction to intercept the inbound track.

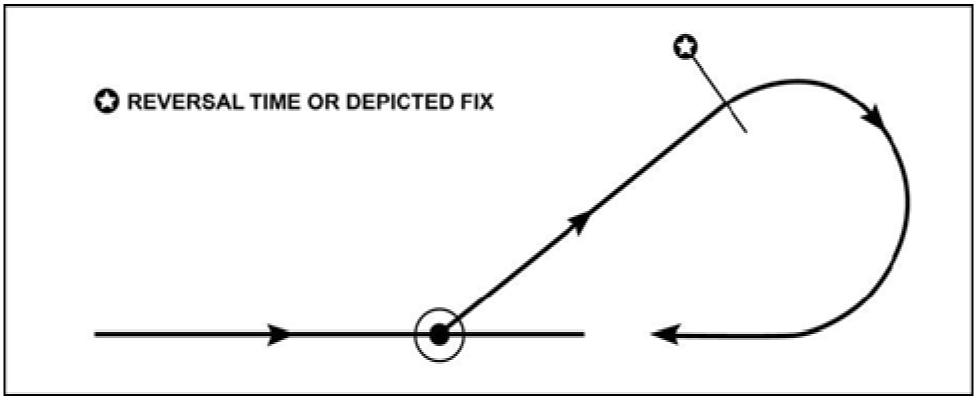
Figure 17.22. 80°/260° Procedure Turn.



17.25. Base Turn or (NAS only) Teardrop.

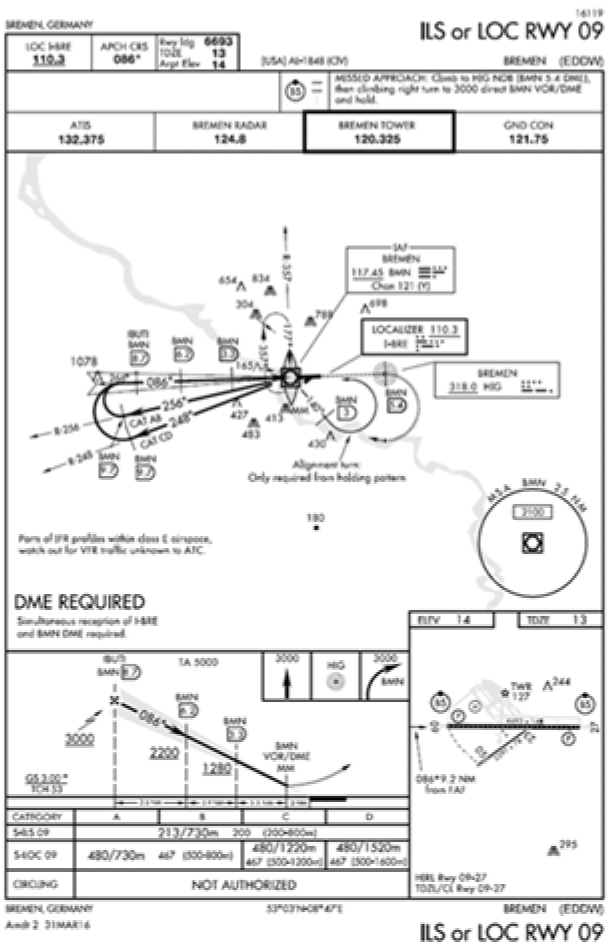
17.25.1. [ICAO Doc 8161V1 Section 4 **Chapter 3**; AIM 5-4-9] This procedure consists of intercepting and maintaining a specified outbound track, timing or DME distance from a facility or fix followed by a turn to intercept the inbound track (**Figure 17.23**).

Figure 17.23. Base Turn or (NAS only) Teardrop.



17.25.2. The base turn must be flown as depicted. **(T-0).** More than one track may be depicted depending on aircraft category (**Figure 17.24**).

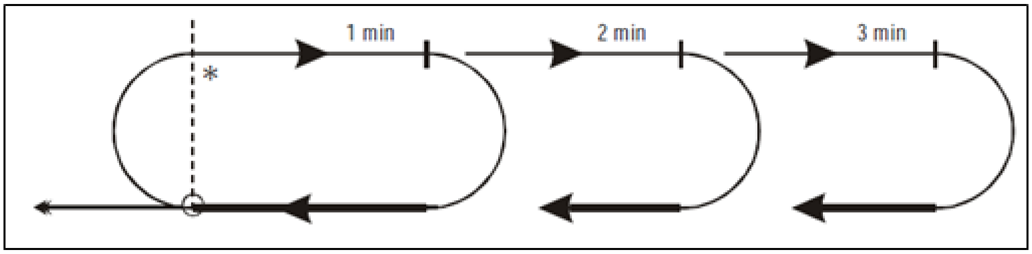
Figure 17.24. Base Turn with More Than One Track.



17.26. Racetrack or (NAS only) HILPT [ICAO Doc 8168V1 I-4-3; AIM 5-4-9] This procedure consists of a turn from the inbound track through 180-degree from overhead the facility or fix on to the outbound track, for 1, 2 or 3 minutes specified in 30-second increments, followed by a 180 degree turn in the same direction to return to the inbound track (**Figure 17.25** and **Figure 17.26**). As an alternative to timing, a DME distance or an intersecting radial or bearing may limit the outbound leg. Racetrack procedures are used when sufficient distance is not available in a straight segment to accommodate the required loss of altitude and when entry into a reversal procedure is not practical. They may also be specified as alternatives to reversal procedures to increase operational flexibility (in this case, they are not necessarily published separately).

17.26.1. (NAS only) The HILPT is depicted as a holding pattern printed with a heavy black line in the plan view and established over an IF or FAF.

Figure 17.25. Racetrack or (NAS only) HILPT.



17.26.2. Entry procedures are in accordance with the holding entry procedures from **Chapter 15** with the following considerations:

17.26.2.1. Pilots will limit time on a 30 degrees teardrop track to 1 minute and 30 seconds, then turn to a heading parallel to the outbound track for the remainder of the outbound time for an offset entry; pilots will limit time on a 30 degrees teardrop track to 1 minute if the outbound time is only 1 minute. **(T-0).**

17.26.2.2. Pilots will not turn direct to the facility without first intercepting the inbound track for a parallel entry. **(T-0).**

17.26.2.3. Pilots will maneuver on the maneuvering side of the inbound track. **(T-0).**

17.26.3. Timing:

17.26.3.1. When the procedure is based on a facility, the outbound timing starts from abeam the facility or on attaining the outbound heading, whichever occurs last.

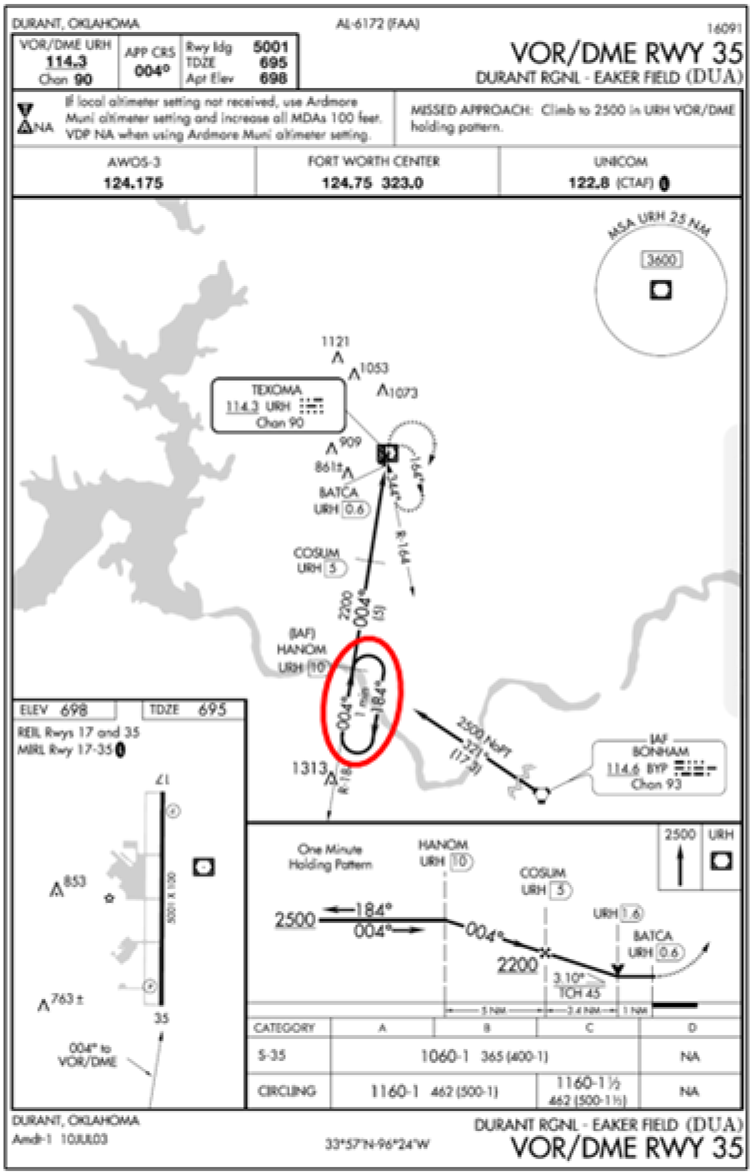
17.26.3.2. When the procedure is based on a fix, the outbound timing starts from attaining the outbound heading.

17.26.3.3. The turn onto the inbound track should be started within the specified time (adjusted for winds), when encountering the published DME distance, or when the limiting radial or bearing has been reached, whichever occurs first.

17.26.3.4. Descent from the minimum holding altitude may be depicted in two ways: descent at the holding fix or descent on the inbound leg. The pilot must be established on the inbound segment of the approach before beginning descent when a descent is depicted on the inbound leg. **(T-0).**

17.26.3.5. [AIM 5-4-9] If cleared for the approach prior to returning to the holding fix and the aircraft is at the prescribed altitude, additional circuits of the holding pattern are not necessary nor expected by ATC. If pilots elect to make additional circuits to lose excessive altitude or to become better established on course, it is their responsibility to advise ATC upon receipt of their approach clearance.

Figure 17.26. HILPT Approach.



17.27. Limitations on Procedure Turns (NAS Only).

[14 CFR Part 91.175(j)] Pilots will not execute a course reversal when:

17.27.1. Cleared for a straight-in approach; **(T-0).**

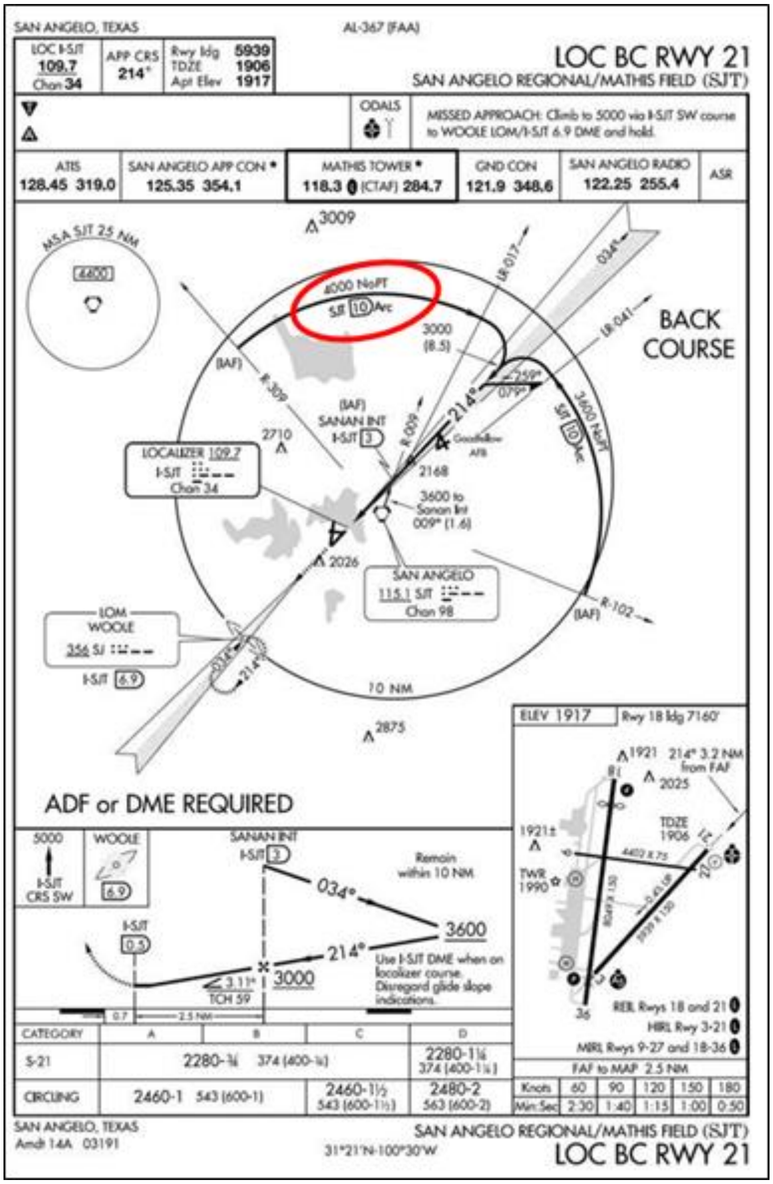
17.27.2. The symbol "NoPT" is depicted on the initial approach segment of the approach (**Figure 17.27**); **(T-0).**

17.27.3. Established on the inbound course after executing the appropriate entry and subsequently cleared for the approach; **(T-0).**

17.27.4. A radar vector to the final approach course is provided; or **(T-0).**

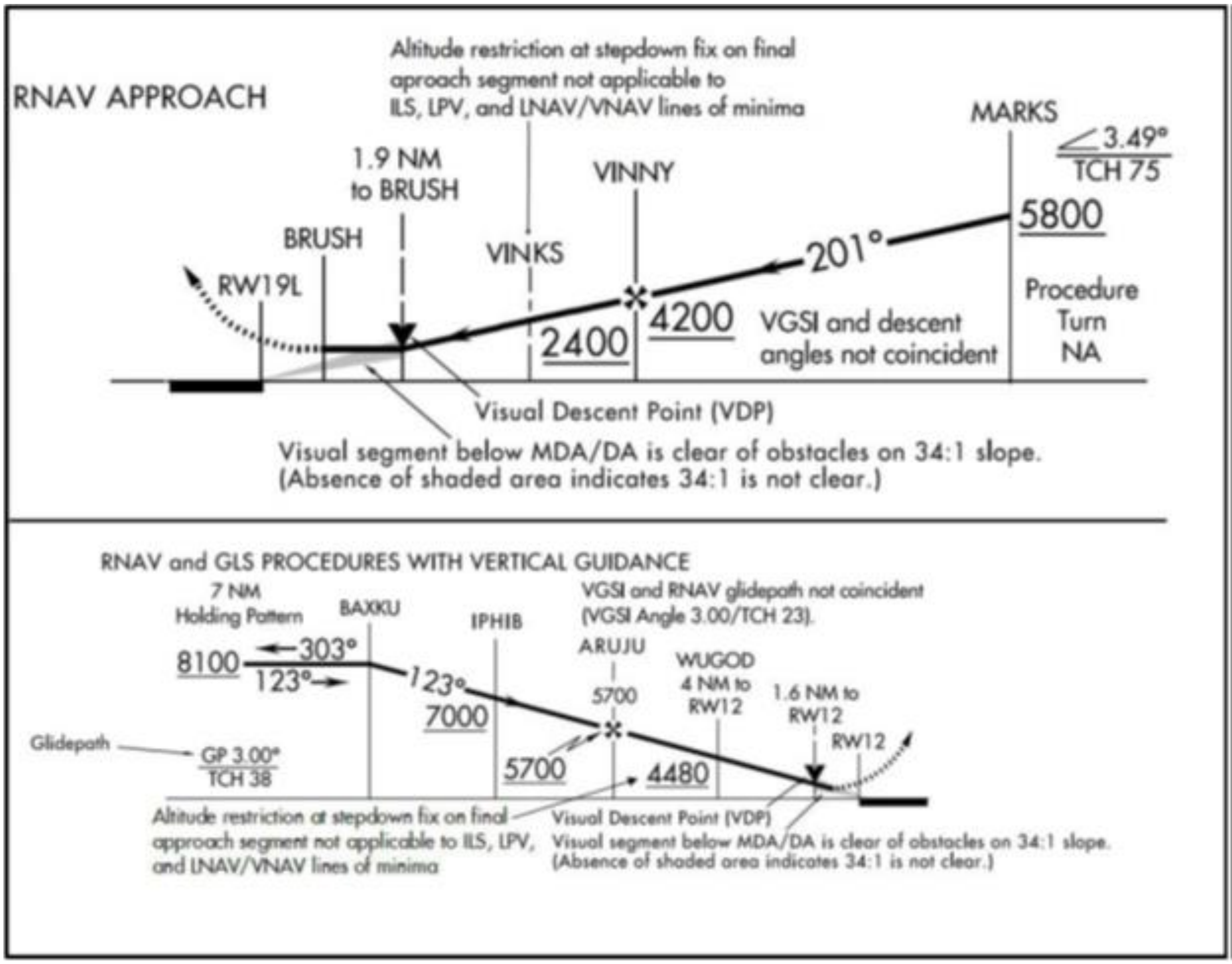
17.27.5. Conducting a timed approach from a holding fix [AIM 5-4-10]. **(T-0).**

Figure 17.27. (NAS only) NoPT Routing.



17.28. Stepdown Fixes. [AIM 5-4-5] Altitude restrictions depicted at stepdown fixes within the final approach segment are applicable only when flying a non-precision approach to a straight-in or circling line of minima identified as a MDA (**Figure 17.28**). Stepdown fix altitude restrictions within the final approach segment do not apply to pilots using precision approach or approach with vertical guidance lines of minima identified as a DA or decision height (DH), since obstacle clearance on these approaches are based on the aircraft following the applicable vertical guidance. Pilots are responsible for adherence to stepdown fix altitude restrictions when outside the final approach segment regardless of which type of procedure the pilot is flying. **(T-0).**

Figure 17.28. Instrument Procedure Stepdown Fixes.



17.29. High Altitude Approaches. Establish approach configuration and airspeed prior to the FAF unless aircraft flight manual procedures require otherwise. For high altitude approaches only, once a lead point is reached and a turn to the next segment has begun, the aircraft is considered established on the next segment and descent to the next applicable altitude may be commenced.

17.30. Non-DME Teardrop High Altitude Approach. Non-DME teardrop high altitude approaches are normally associated with VOR or NDB facilities (**Figure 17.29**).

17.30.1. 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 established on a parallel or intercept heading to the approach course and outbound from IAF. Use a descent gradient of 800-1,000 feet per nautical mile (8 degrees to 10 degrees) to ensure the aircraft remains in protected airspace.

17.30.1.1. If arriving at the IAF below the published altitude, the pilot should maintain altitude and proceed outbound 15 seconds for each 1,000 feet the aircraft is below the published altitude before starting descent.

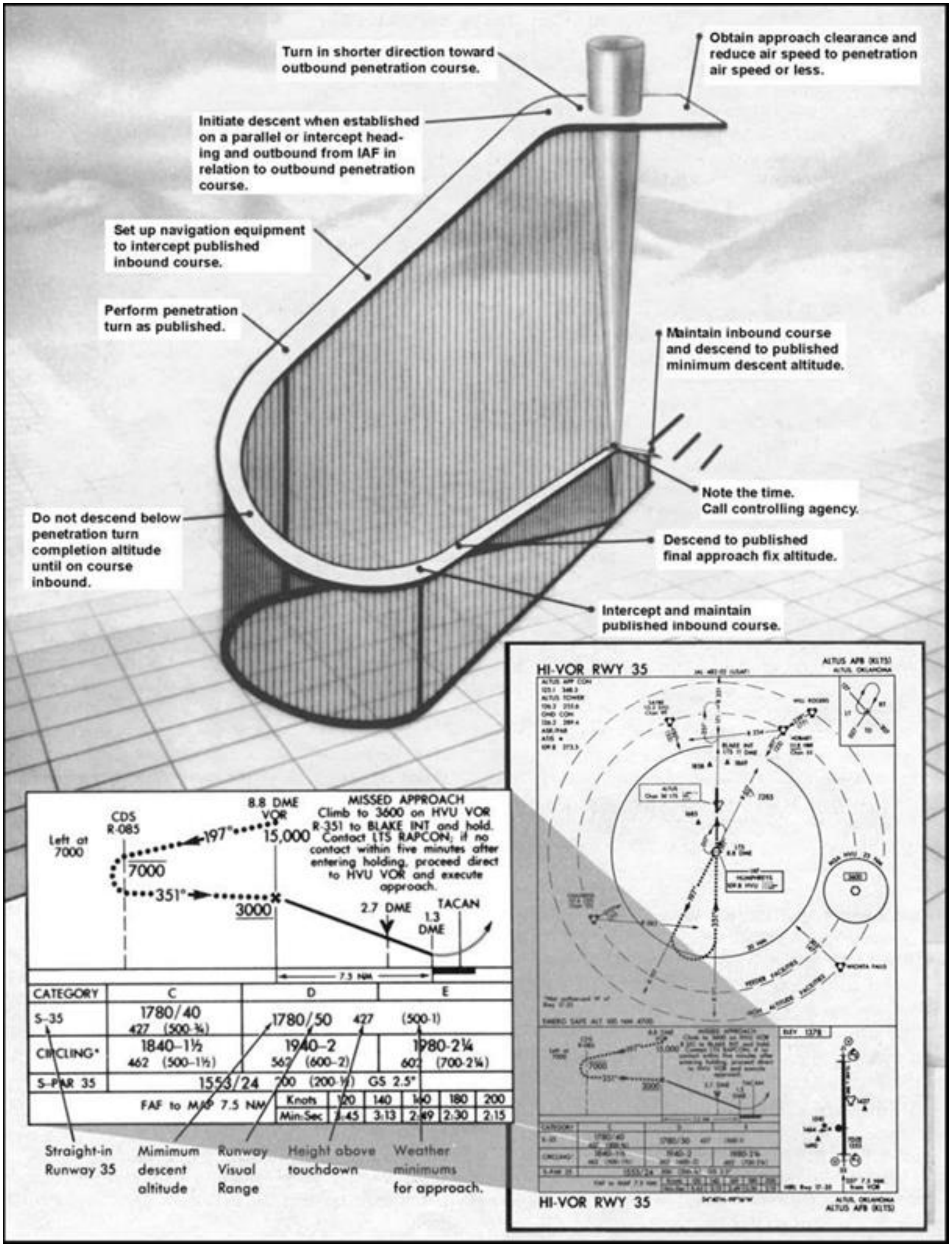
17.30.1.2. If arriving at the IAF above the published altitude, the pilot should descend to the published IAF altitude prior to starting the approach. Request maneuvering airspace from ATC if descent is required at the IAF.

17.30.2. A 30-degree angle of bank is normally used during the penetration turn; however, bank may be shallowed if undershooting course.

17.30.2.1. When a penetration turn altitude is not published, start the turn after descending one-half the total altitude between the IAF and FAF altitudes.

17.30.2.2. If a penetration turn completion altitude is published, do not descend below this altitude until established on the inbound course.

Figure 17.29. Non-DME Teardrop High Altitude Approach.

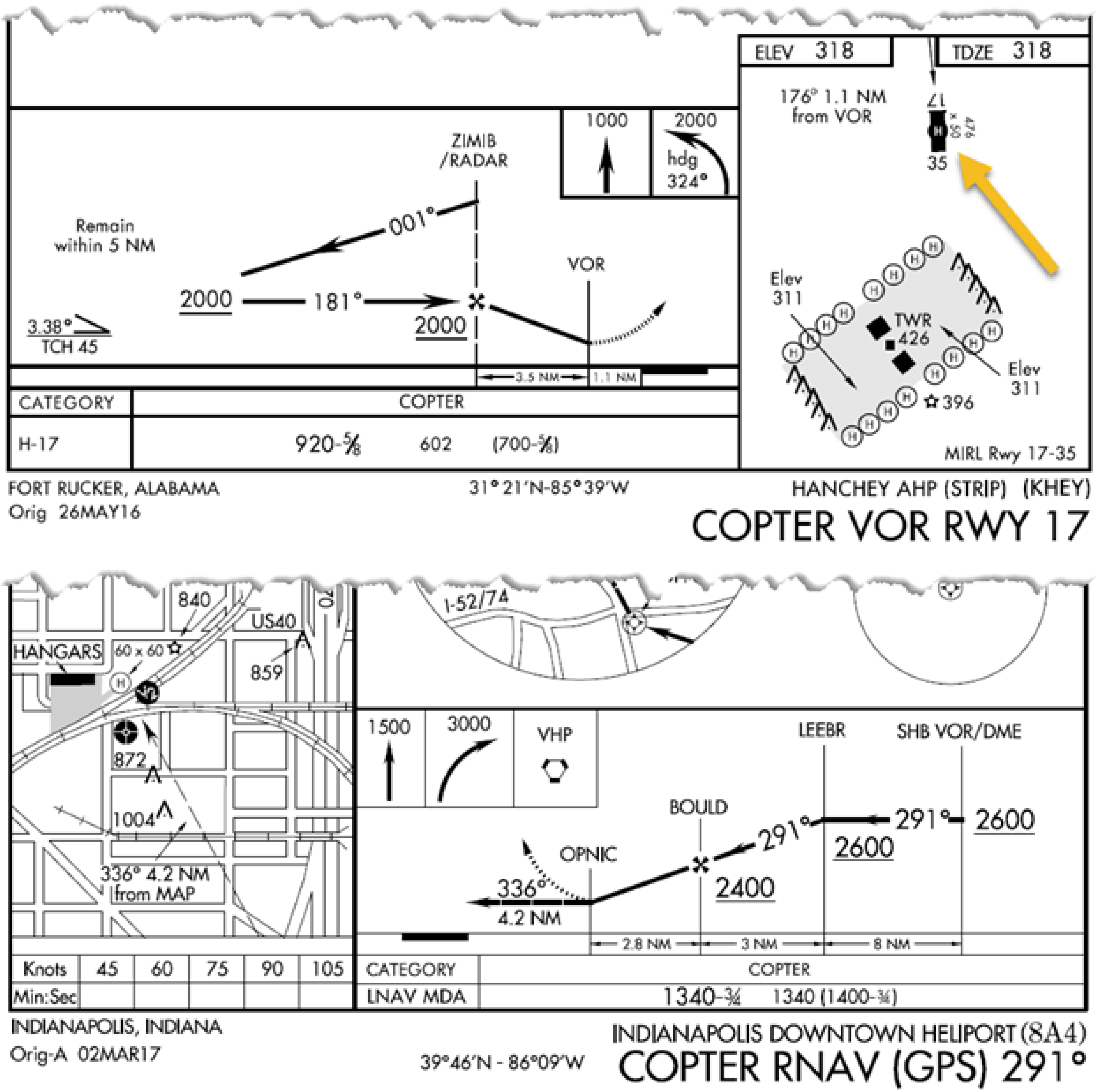


17.31. Helicopter-only Approaches. Helicopter-only approaches are identified by the term "COPTER", the type of facility producing final approach course guidance, and a numerical identification of the final approach course; for example, "COPTER VOR RWY 17" or "COPTER RNAV (GPS) 291°" (**Figure 17.30**).

17.31.1. These approaches are considered "straight-in" approaches. The pilot should plan to touch down on the threshold of the procedure runway or helipad. The designated instrument helipad is shown with inverse symbology if there are multiple helipads (**Figure 17.30**).

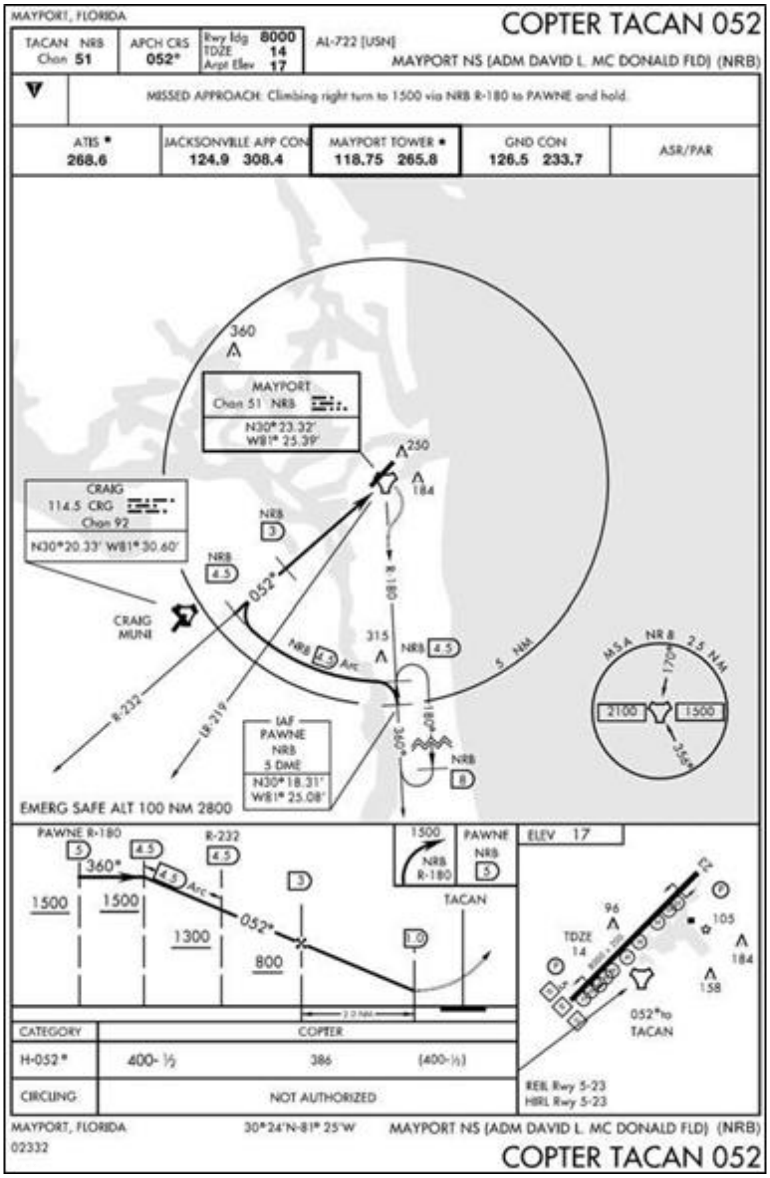
17.31.2. A maximum descent of 400 feet per nautical mile is normally planned for low altitude approaches; it may be as high as 800 feet per nautical mile for helicopter only approaches.

Figure 17.30. Helicopter-only Approach.



17.31.3. Figure 17.31 is an example of a short final approach. The IAF is only 0.5 miles from the DME arc procedural track. The FAF to the missed approach point (MAP) is 2.3 miles. While this approach should not be difficult to accomplish, careful review could prevent the pilot from becoming rushed during the maneuver.

Figure 17.31. Short Final Approach.



17.31.4. At locations where the MAP is located more than 2 statute miles from the landing site, the turn from the final approach to the visual segment is greater than 30 degrees, or the VFR segment from the MAP to the landing site has obstructions that require pilot actions to avoid them a Point-In-Space (PinS) procedure may be developed (**Figure 17.32** and **Figure 17.33**). These approaches are annotated "Proceed VFR from (MAP) or conduct the specified missed approach." Some PinS approaches allow the pilot to fly to multiple heliports after reaching the MAP. If planning to use this type of approach, pay careful attention to weather conditions upon arrival, as VMC conditions are required to maneuver.

Figure 17.32. Point-in-Space (PinS) Approach.

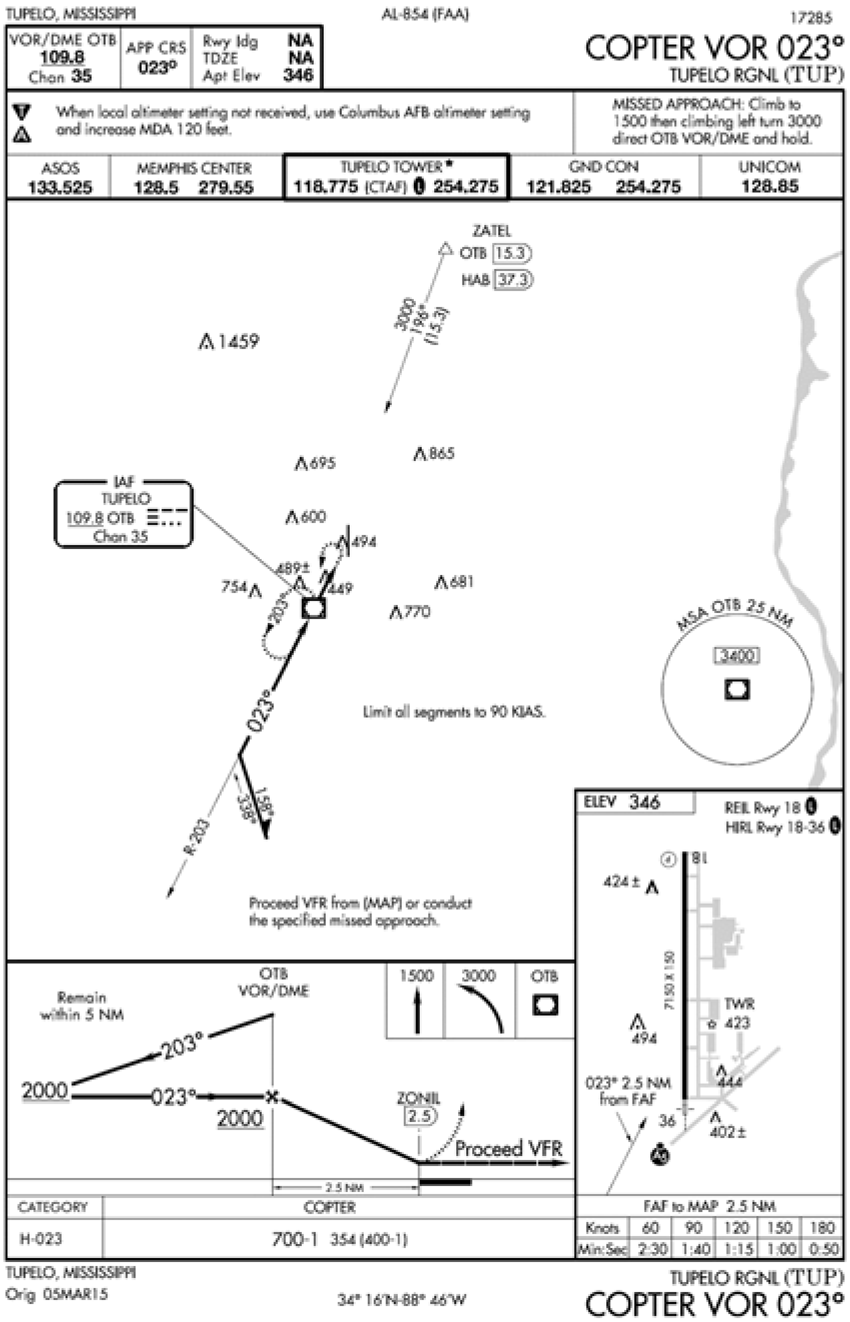
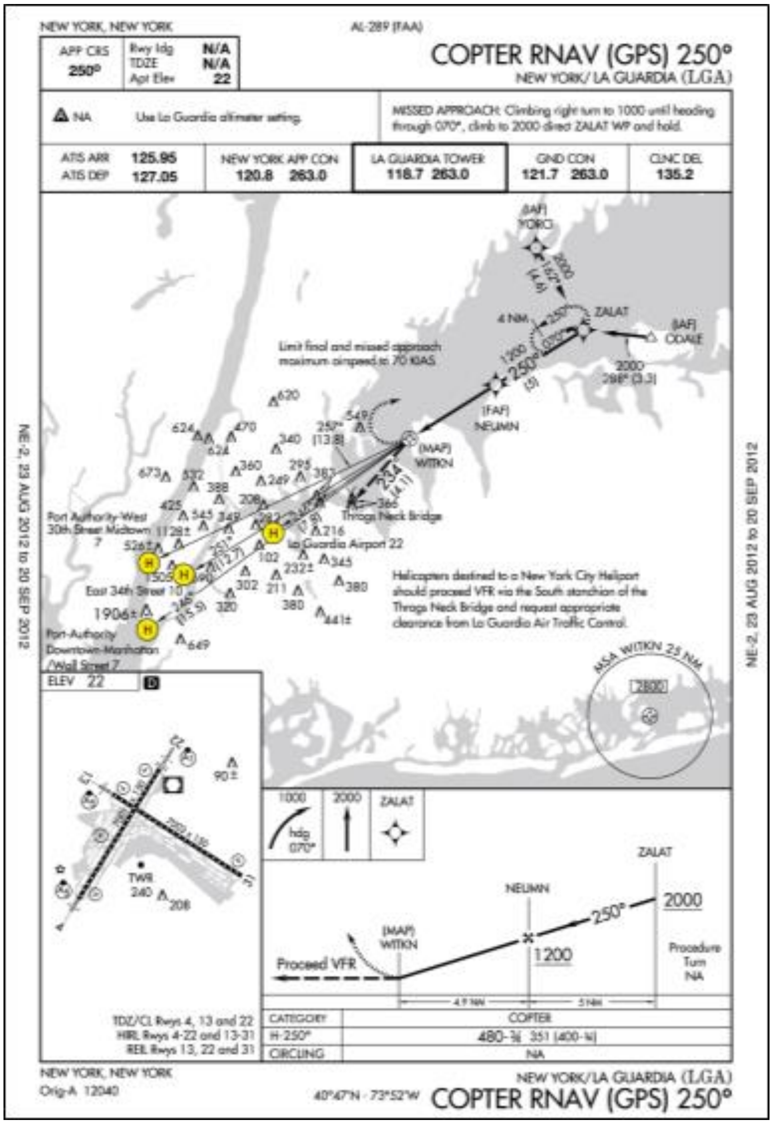


Figure 17.33. PinS Approach to Multiple Heliports.



17.32. MAJCOM-Certified Approach. At specific airfields, MAJCOMs may develop their own approach procedures for use by specific aircraft and MAJCOM-trained and -certified aircrews under specific conditions. MAJCOM-certified procedures are in accordance with AFI 11-202V3.

17.33. Visual Approach. [AIM 5-4-23] Visual approaches reduce pilot/controller workload and expedite traffic by shortening flight paths to the airfield. A visual approach is an instrument maneuver conducted under VMC. Comply with controller's instructions for vectors toward the airfield of intended landing or to a visual position behind a preceding aircraft. **(T-0).**

17.33.1. A visual approach does not alter IFR flight plan cancellation responsibility. Radar service is automatically terminated without advising the pilot when instructed to change to advisory frequency.

17.33.2. If instructed by ATC to follow another aircraft, notify the controller if the aircraft to be followed is not in sight, unable to maintain visual contact with the aircraft to be followed, or for any other reason responsibility for visual separation cannot be assured. 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.

17.33.3. After being cleared for a visual approach, proceed visually and clear of clouds to the airfield 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 the pilot to do an overhead or VFR traffic pattern.

17.33.4. 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 airfields are issued an appropriate advisory, clearance, or instruction by the tower. At non-towered airfields, 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 (i.e., separation from other IFR aircraft is maintained under these circumstances).

17.33.5. [ICAO Doc 4444] The pilot must maintain visual reference to the terrain. **(T-0).** The reported ceiling at the airfield must be at or above the initial approach altitude, or the pilot must report that meteorological conditions are such that a visual approach and landing can be completed. **(T-0).** Visual approaches may be requested by the pilot or initiated by the controller. If initiated by the controller, in ICAO, concurrence by the pilot is required. Pilots will not fly visual approaches without ATC authorization. **(T-0).**

17.33.6. (NAS only) The pilot must have either the airfield or the preceding identified aircraft in sight, and the approach must be authorized and controlled by the appropriate ATC facility. **(T-0).** The reported weather at the airfield must have a ceiling at or above 1000 feet and visibility of 3 miles or greater. **(T-0). Note:** Helicopters making a PinS Approach may be requested to report when able to proceed to the landing area by visual reference to the prescribed surface route.

17.34. Contact Approach (NAS Only). A contact approach is a procedure that may be used by a pilot in lieu of conducting an instrument procedure to an airfield. It is not intended to be used to operate to an airfield without a published and functioning instrument procedure. Nor is it intended for an aircraft to conduct an approach to one airfield, and then when “in the clear”, discontinue that approach and proceed to another airfield.

17.34.1. 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 airfield in those conditions, may request ATC authorization for a contact approach.

17.34.2. ATC may authorize a contact approach provided:

17.34.2.1. The contact approach is specifically requested by the pilot. ATC cannot initiate this approach.

17.34.2.2. The reported ground visibility at the destination is at least 1 statute mile.

17.34.2.3. Contact approaches are made to an airfield having an instrument approach procedure.

17.34.3. Advise ATC immediately if unable to continue the contact approach or if visibility is reduced to less than 1 mile.

17.34.4. When executing a contact approach, the pilot assumes responsibility for obstruction clearance. If radar service is being received, it automatically terminates when the pilot is instructed to change to advisory frequency.

17.34.5. Being cleared for a visual or contact approach does not authorize the pilot to fly a 360 degrees overhead traffic pattern. An aircraft conducting an overhead maneuver is VFR and the IFR flight plan is canceled when the aircraft reaches the initial point. Aircraft operating at an airfield without a functioning control tower must initiate cancellation of the IFR flight plan prior to executing the overhead maneuver. **(T-0).**

17.35. Charted Visual Flight Procedures. Charted visual flight procedures may be established at airfields with control towers for environmental or noise abatement considerations as well as when necessary for safety and efficiency of air traffic operations (**Figure 17.34**). Designed primarily for turbojet aircraft, charted visual flight procedures depict prominent landmarks, courses, and recommended altitudes to a specific runway equipped with a visual or electronic vertical guidance. Most charted visual flight procedures also depict NAVAID information for supplemental navigation guidance only.

17.35.1. When informed charted visual flight procedures are in use, the pilot must advise the arrival controller on initial contact if unable to accept the charted visual flight procedure. **(T-0).**

17.35.2. Pilots must have a charted visual landmark or a preceding aircraft in sight, and weather must be at or above the published minimums before ATC issues a charted visual flight procedure clearance. **(T-0).**

17.35.3. 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 charted visual flight procedures provide VFR cloud clearance at minimum vectoring altitudes. Therefore, clearance for a charted visual flight procedure is possible at MVA, which may be below the depicted altitudes.

17.35.4. When landmarks used for navigation are not visible at night, the approach is annotated “procedure not authorized at night.”

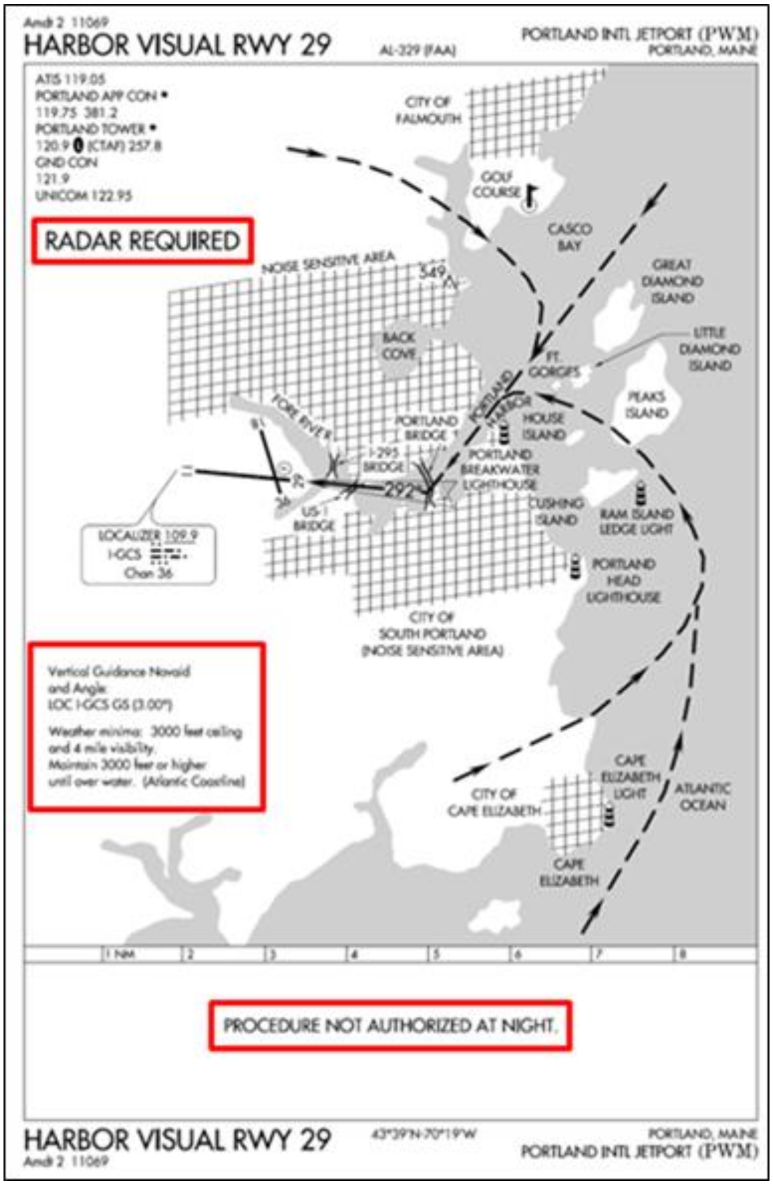
17.35.5. Charted visual flight procedures usually begin within 20 miles from the airfield.

17.35.6. Published weather minimums for charted visual flight procedures are based on minimum vectoring altitudes rather than recommended altitudes depicted on the charts.

17.35.7. ATC does not issue clearances for charted visual flight procedures when the weather is below the published minimum. When accepting a clearance 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.

17.35.8. Charted visual flight procedures are not instrument approaches and do not have missed approach segments. The pilot should have preplanned climb-out options based on aircraft performance and terrain features.

Figure 17.34. Charted Visual Flight Procedure.



17.36. Simultaneous Approaches to Parallel Runways. [AIM 5-4-13] ATC procedures permit ILS, RNAV, or GLS instrument approach operations to dual or triple parallel runway configurations. Approaches to parallel runways are grouped into three classes: Simultaneous Dependent Approaches; Simultaneous Independent Approaches; and Simultaneous Close Parallel Precision Runway Monitor (PRM) Approaches (**Figure 17.35**).

17.36.1. RNAV approach procedures that are approved for simultaneous operations require GNSS as the sensor for position updating; VOR/DME, DME/DME and IRU position updating are NA.

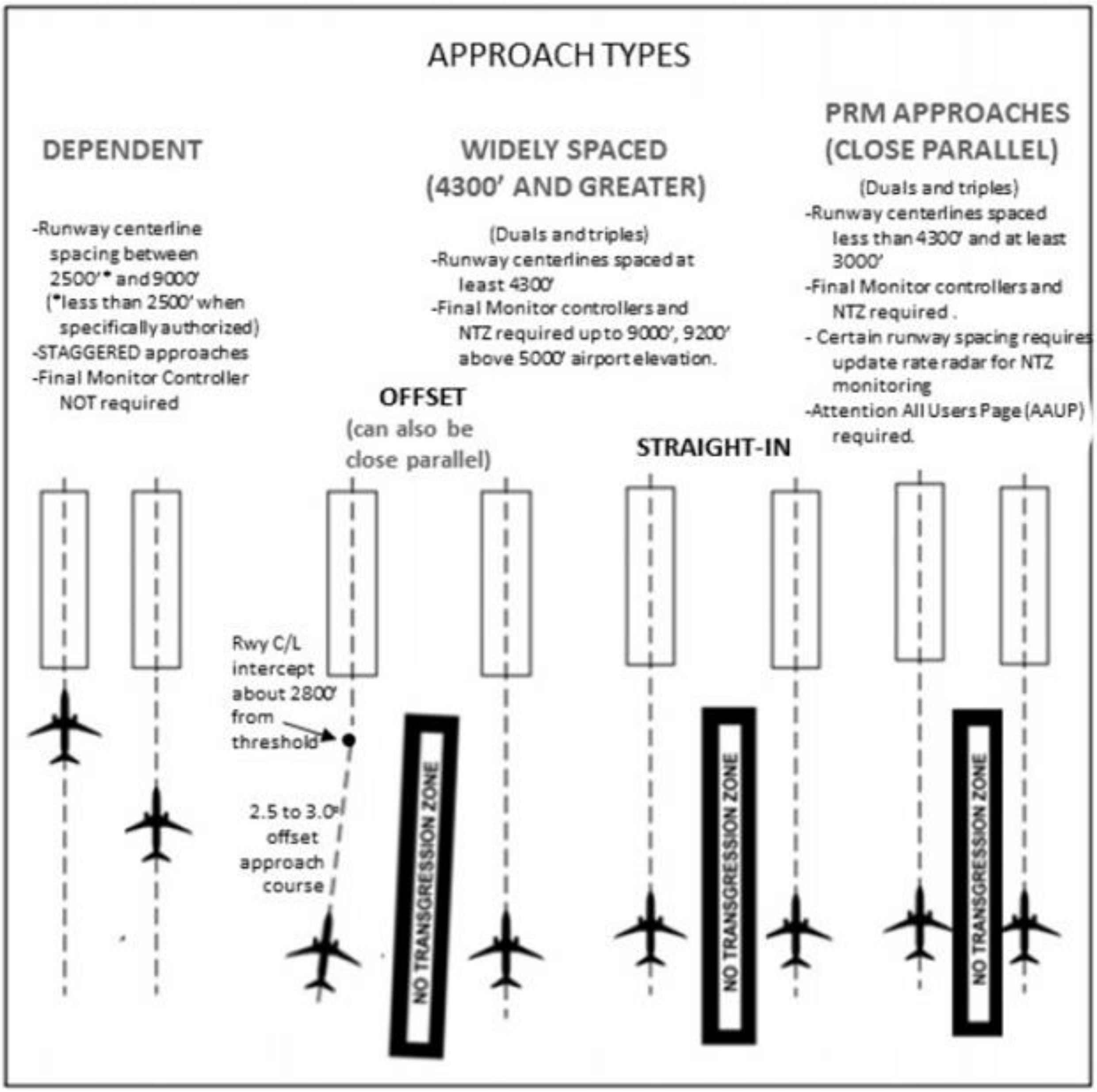
17.36.2. The classification of a parallel runway approach procedure is dependent on adjacent parallel runway centerline separation, ATC procedures, and airfield ATC final approach radar monitoring and communications capabilities.

17.36.3. At some airfields, one or more approach courses may be offset up to 3 degrees. ILS approaches with offset localizer configurations result in loss of CAT II/III capabilities and an increase in the DH (50 feet).

17.36.4. Depending on weather conditions, traffic volume, and the specific combination of runways being utilized for arrival operations, a runway may be used for different types of simultaneous operations, including closely spaced dependent or independent approaches. Pilots should ensure that they understand the type of operation that is being conducted, and ask ATC for clarification if necessary.

17.36.5. Refer to **Chapter 19** for simultaneous close parallel PRM approaches.

Figure 17.35. Simultaneous Approaches to Parallel Runways.

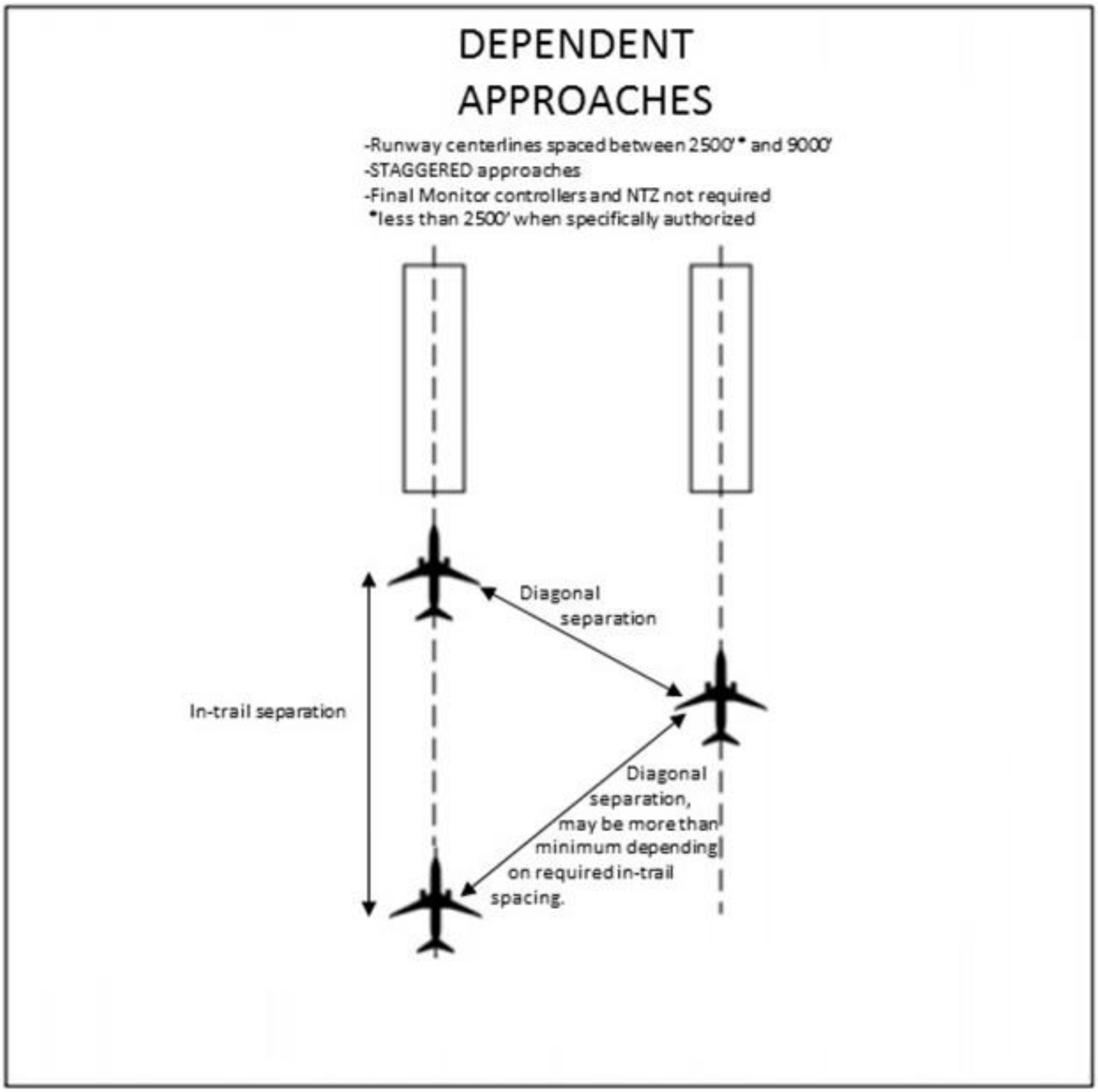


17.37. Simultaneous Dependent Approaches. [AIM 5-4-14] Simultaneous dependent approaches are an ATC procedure permitting approaches to airfields having parallel runway centerlines separated by at least 2,500 feet up to 9,000 feet (**Figure 17.36**).

17.37.1. Although non-precision minimums may be published, pilots must only use those procedures specifically authorized by chart note. **(T-0).**

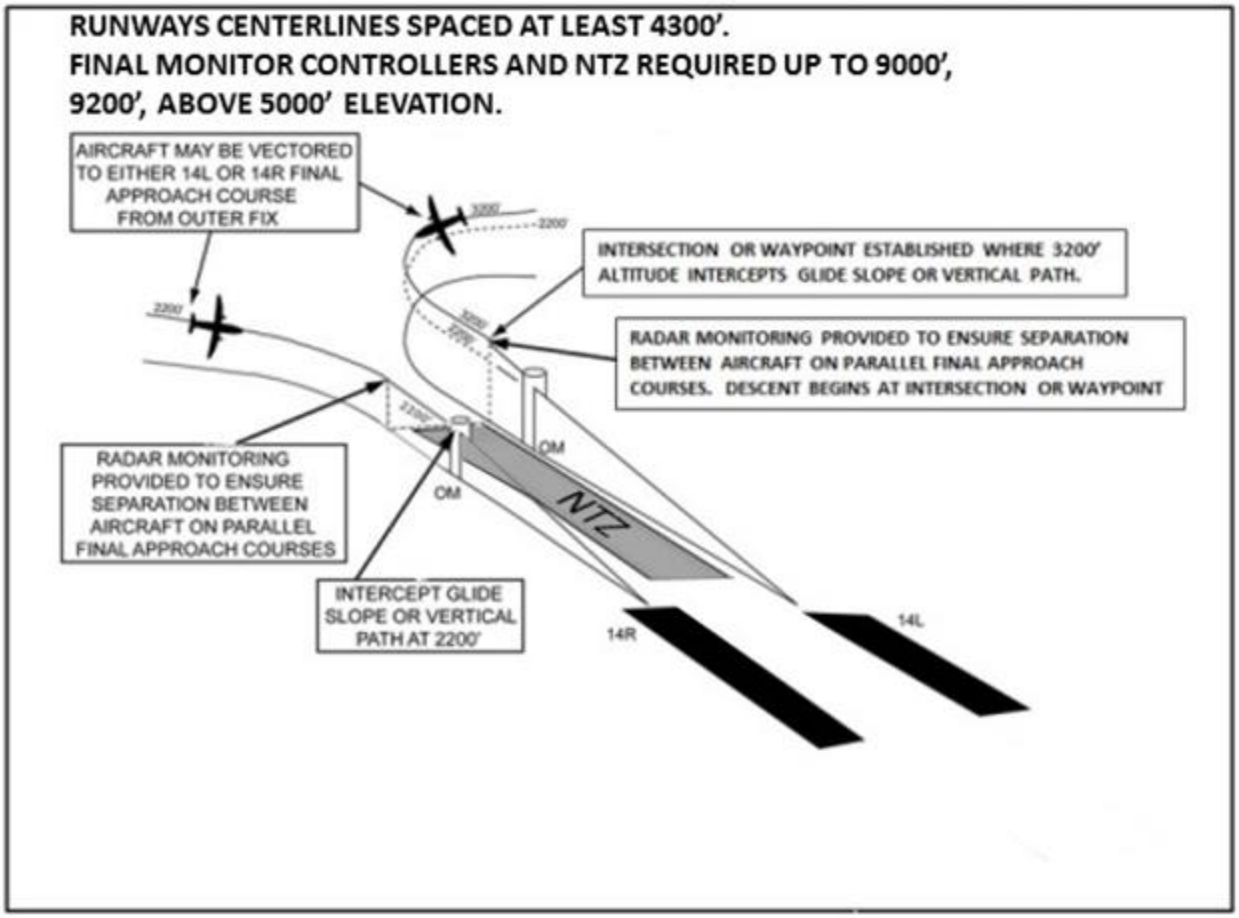
17.37.2. A simultaneous dependent approach differs from a simultaneous independent approach in that, the minimum distance between parallel runway centerlines may be reduced; there is no requirement for radar monitoring or advisories; and a staggered separation of aircraft on the adjacent final course is required.

Figure 17.36. Simultaneous Dependent Approaches.



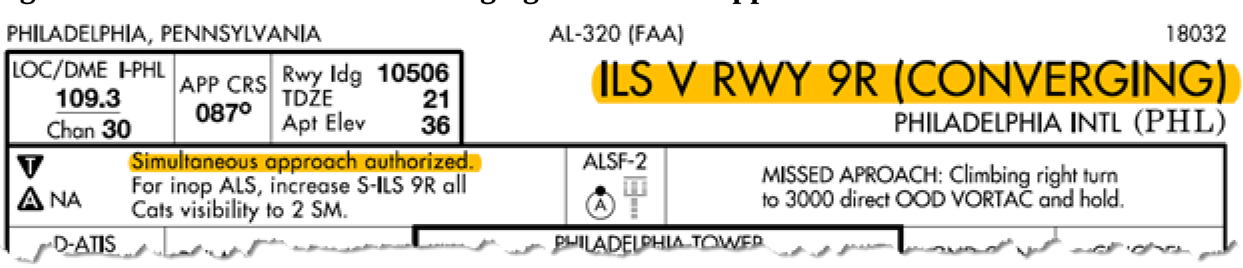
17.38. Simultaneous Independent Approaches. [AIM 5-4-15] An approach system permitting simultaneous ILS, RNAV, or GLS approaches to parallel runways with centerlines separated by 4,300 to 9,000 feet (9,200 feet for airfields above 5,000 feet elevation) utilizing no-transgression zone (NTZ) final monitor controllers (**Figure 17.37**).

Figure 17.37. Simultaneous (Parallel) Independent Approaches.



17.39. Simultaneous Converging Instrument Approaches. [AIM 5-4-17] ATC may conduct instrument approaches simultaneously to converging runways (i.e., runways having an included angle from 15 to 100 degrees) at airfields where a program has been specifically approved to do so. The basic concept requires that dedicated, separate standard instrument approach procedures be developed for each converging runway included. These approaches can be identified by the letter "V" in the title; for example, "ILS V RWY 17 (CONVERGING)" (**Figure 17.38**).

Figure 17.38. Simultaneous Converging Instrument Approach.



Chapter 18

FINAL APPROACH

18.1. General. Final approach guidance is categorized as non-radar, radar, procedures with a visual component (visual approach, contact approach, approaches with a visual segment and charted visual chart procedures), MAJCOM-certified approaches, or specialized procedures (converging approaches, simultaneous dependent and independent parallel approaches). Once inside the FAF, one navigation receiver available to the pilot flying must remain tuned to and display the facility that provides final approach course guidance. **(T-0).** Refer to AIM Chapter 5-4-5 for detailed final approach information.

18.2. Final Approach Components. In general, the final approach segment consists of glideslope or glide path angles, intercept altitudes, FAF, stepdown fixes, visual descent point (VDP), VDA, MAP, MDA and DA. The FAF, stepdown fixes, VDP and the MAP can be defined by a NAVAID, a waypoint, crossing radials of two NAVAIDs, or a radial and DME. The optimum final approach course length is 5 miles but may be up to 10 miles.

18.2.1. For a precision approach or approach with vertical guidance, the final approach segment begins where the glide path intercepts the minimum glide path intercept altitude indicated on the approach chart by the lightning bolt symbol. If ATC authorizes a lower intercept altitude, the final approach segment begins upon glideslope or glide path interception at that altitude.

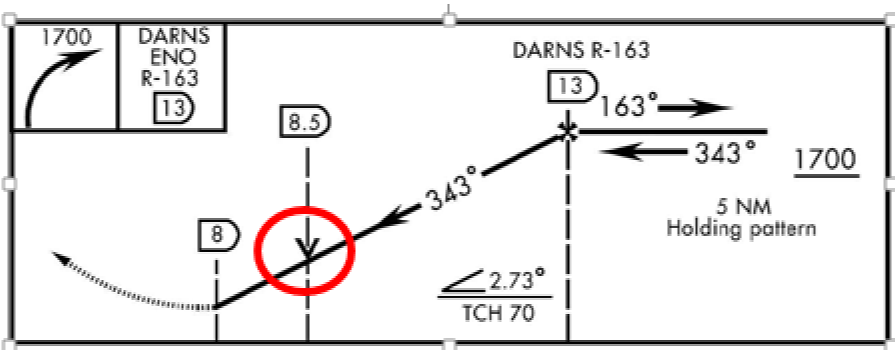
18.2.2. For a non-precision approach, the final approach segment begins either at the FAF depicted by a “Maltese cross” in the profile view of the approach along with a recommended, minimum, or mandatory crossing altitude; or at the point where the aircraft is established inbound on the final approach course where no FAF is depicted. Normally, aircraft cross the FAF at approach speed in the landing configuration.

18.3. Visual Descent Point (VDP). The VDP is a defined point on the final approach course of a non-precision approach straight-in procedure from which a stabilized descent from the MDA to the runway touchdown point may be commenced (**Figure 18.1**). Pilots should not descend below MDA prior to reaching the VDP. The VDP is identified by DME or area navigation along-track distance (i.e., LNAV only approaches) to the MAP. The VDP is based on the lowest MDA published on the instrument procedure and is harmonized with the angle of the VGSI if installed or the procedure VDA when not installed. If flying a higher MDA (e.g., higher category, higher minimums required, etc.) calculate a new VDP. VDPs are not a mandatory part of the procedure.

18.3.1. While pilots should calculate a VDP if one is not published, use extreme caution when departing the MDA, as there may be an obstacle penetrating the 20:1 surface. Unless familiar with the airfield, if visibility is limited, consider remaining at the MDA even if the runway environment is in sight if terrain and obstacles along the final approach cannot be discerned.

18.3.2. Divide the HAT by the desired descent angle in degrees times 100. For example, a HAT of 450 feet and a desired descent angle to the runway of 3 degrees: 450 ÷ (3 x 100) = 1.5 miles to descend from the MDA to TDZE.

Figure 18.1. VDP.



18.4. Vertical Descent Angle (VDA). VDAs are published to the maximum extent possible on non-precision approaches except those published in conjunction with vertically guided minimums (e.g., ILS, LNAV/VNAV, LPV, etc.), no-FAF procedures without stepdown fixes, or circling-only approaches. The published angle is for information only as it does not guarantee obstacle clearance below the MDA in the visual segment. Use the published angle and groundspeed to find a target rate of descent that can be flown with the VVI. When there are obstacles in the visual area between the MDA and touchdown, the instrument procedure does not show a VDA in the profile view and one of two statements is charted in the profile view: "Visual Segment-Obstacles" (**Figure 18.2**) or "Descent Angle NA" (**Figure 18.3**). A chart note indicates if the VGSI is not coincident with the VDA.

Figure 18.2. Visual Segment – Obstacles.

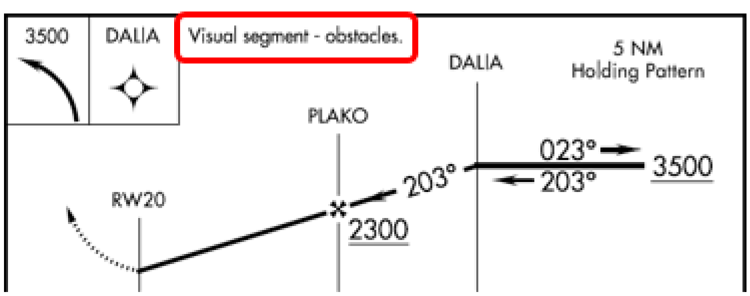
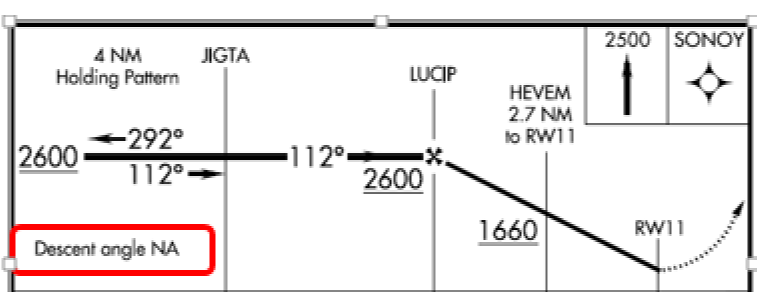


Figure 18.3. Descent Angle NA.



18.5. Constant Descent Final Approach (CDFA). [ICAO Doc 8168 Volume 1; AC 120-108] Many ICAO Nation States require the use of the CDFA technique and apply increased visibility or runway visual range (RVR) requirements when the technique is not used. Pilots should use the CDFA technique when practicable.

18.5.1. [EU-OPS 1] Civil operators in the EU must fly all non-precision approaches using the CDFA technique unless otherwise approved by the authority for a specific approach to a particular runway. An increase to the approach minima is required if the CDFA technique is not used. Refer to the Nation State AIP or the FLIP AP series for exceptions.

18.5.2. CDFA is the preferred method that allows for flying the final approach segment of a non-precision approach as a continuous descent. It is consistent with stabilized approach procedures and has no level-off. A CDFA starts from an altitude/height at or above the FAF and proceeds to an altitude/height approximately 50 feet above the landing runway threshold or to a point where the flare maneuver should begin for the type of aircraft being flown. This method harmonizes USAF flight operations with FAA, European Aviation Safety Agency and ICAO standards.

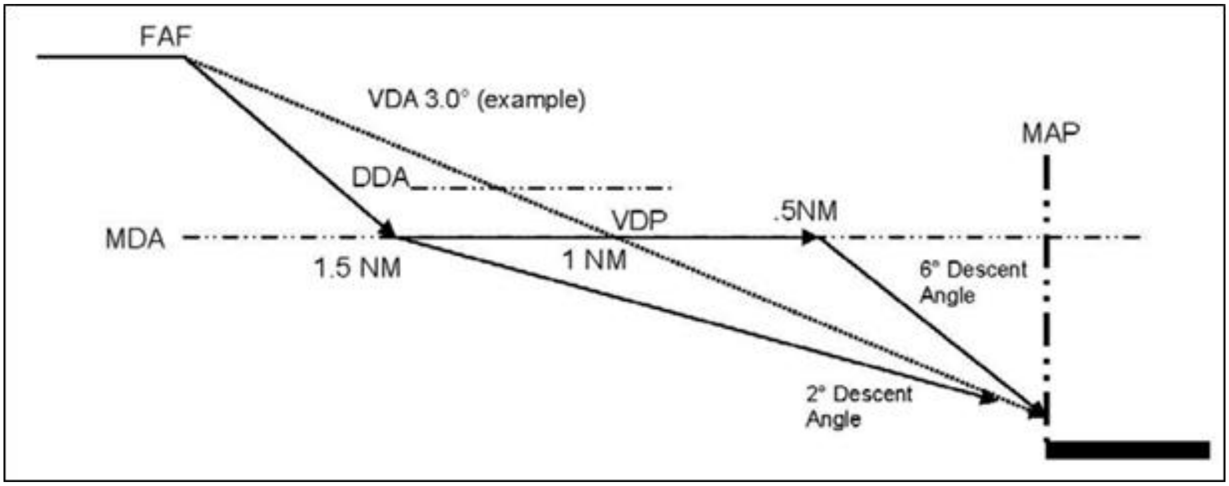
18.5.3. Controlled flight into terrain (CFIT) is a primary cause of worldwide commercial aviation fatal accidents. Unstable approaches are a key contributor to CFIT events. Non-precision approaches are designed with and without stepdown fixes in the final segment. Stepdowns flown without a constant descent require multiple thrust, pitch, and altitude adjustments inside the FAF. These adjustments increase pilot workload and potential errors during a critical phase of flight. Non-precision approaches designed without stepdown fixes in the final segment allow pilots to immediately descend to the MDA after crossing the FAF. In both cases, the aircraft remains at the MDA until descending for the runway or reaching the MAP. This practice is commonly referred to as "dive and drive," can result in extended level flight as low as 250 feet AGL in IMC and shallow or steep final approaches.

18.5.3.1. **Figure 18.4** is an example of an aircraft leveled at the MDA ("dive and drive") and is proceeding to the MAP to acquire the visual references to continue the approach below the MDA. The 3.0-degree VDA would be used in this example to fly a CDFA.

18.5.3.2. As the aircraft approaches the published MAP, the required descent angle to the runway threshold steepens. At approximately 0.5 nautical miles from the MAP, the required angle increases to 6 degrees. At a groundspeed of 120 knots, a 1,270 foot per minute rate of descent would be required to cross the threshold at the planned TCH of 50 feet. The steep final angle, low-power setting and high descent rate may result in an unstable approach and unsafe condition in the transition to landing.

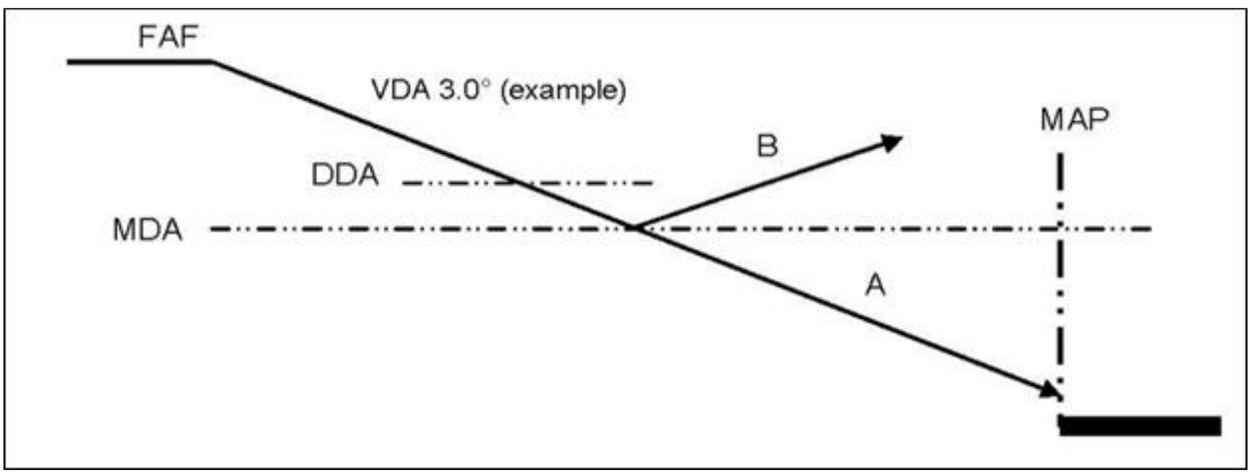
18.5.3.3. If the pilot descends 0.5 nautical miles early, a 2-degree descent angle is required. At a groundspeed of 120 knots, this corresponds to a 425 foot per minute rate of descent. Higher power settings and increased deck angles are required.

Figure 18.4. Dive and Drive.



18.5.4. **Figure 18.5** is an example of using a CDFA. In this example, flying the VDA or CDFA from the FAF results in reaching the DDA and MDA prior to the published MAP. The pilot has two courses of action: continue visually to the landing runway if the required visual cues are acquired or execute a missed approach.

Figure 18.5. CDFA.



18.5.5. A stabilized approach is a key feature to a safe approach and landing. Operators are encouraged by the FAA and ICAO to use the stabilized approach concept to help eliminate CFIT. The stabilized approach concept is characterized by maintaining a stable approach speed, descent rate, vertical flightpath, and configuration to the landing touchdown point. Depart the FAF configured for landing and on the proper approach speed, power setting, and flightpath before descending below the minimum stabilized approach height.

18.5.6. Precision instrument procedures and approach procedures with vertical guidance have a continuous descent approach profile in their design. Non-precision approaches were not originally designed with this vertical path but may easily be flown using the CDFA technique. Flying non-precision approaches with a continuous descent profile provides a safety advantage over flying approaches using the “dive and drive” technique. CDFA has several advantages:

18.5.6.1. Increased safety by employing the concepts of stabilized approach criteria and procedure standardization;

18.5.6.2. Improved situational awareness and reduced pilot workload;

18.5.6.3. Improved fuel efficiency by minimizing the low-altitude level flight time;

18.5.6.4. Reduced noise level (noise abatement) by minimizing the level flight time at high thrust settings;

18.5.6.5. Procedural similarities to precision approach operations; and

18.5.6.6. Reduced probability of infringement on required obstacle clearance during the final approach segment

18.5.7. CDFA requires the use of a published VDA or barometric vertical guidance on the instrument procedure. RNAV approaches with LNAV/VNAV minima are published with a glide path. Non-precision approach or RNAV approaches with LNAV only minima are published with a VDA. Aircraft with FMS, Baro-VNAV, or WAAS typically provide the published glide path or VDA when the instrument procedure is selected from the database. Aircraft equipped with flight path angle allow the pilot to enter an electronic descent angle based on the published glide path or VDA.

18.5.8. Pilots should use the "Instrument Takeoff or Approach Procedure Charts Rate of Climb/Descent Table" on the inside back cover of the TPP to convert the published VDA or glideslope into the required rate of descent (**Figure 18.6**).

Figure 18.6. Find Descent Gradient.

INSTRUMENT TAKEOFF OR APPROACH PROCEDURE CHARTS
RATE OF CLIMB/DESCENT TABLE
(ft. per min)

A rate of climb/descent table is provided for use in planning and executing climbs or descents under known or approximate ground speed conditions. It will be especially useful for approaches when the localizer only is used for course guidance. A best speed, power, altitude combination can be programmed which will result in a stable glide rate and altitude favorable for executing a landing if minimums exist upon breakout. Care should always be exercised so that minimum descent altitude and missed approach point are not exceeded.

ft/NM	%	GROUND SPEED (knots)											ANGLE
		60	90	120	150	180	210	240	270	300	330	360	
1[illegible]2	2.50	150	230	300	380	460	530	610	680	760	840	910	1.43
2[illegible]0	3.29	200	300	400	500	600	700	800	900	1000	1100	1200	1.89
2[illegible]0	3.46	210	320	420	530	630	740	840	950	1050	1160	1260	1.98
2[illegible]0	3.62	220	330	440	550	660	770	880	990	1100	1210	1320	2.07
2[illegible]0	3.79	230	350	460	580	690	810	920	1040	1150	1270	1380	2.17
2[illegible]0	3.95	240	360	480	600	720	840	960	1080	1200	1320	1440	2.26
2[illegible]0	4.11	250	380	500	630	750	880	1000	1130	1250	1380	1500	2.36
2[illegible]0	4.28	260	390	520	650	780	910	1040	1170	1300	1430	1560	2.45
2[illegible]0	4.44	270	410	540	680	810	950	1080	1220	1350	1490	1620	2.54
2[illegible]0	4.61	280	420	560	700	840	980	1120	1260	1400	1540	1680	2.64
2[illegible]0	4.77	290	440	580	730	870	1020	1160	1310	1450	1600	1740	2.73
3[illegible]0	4.94	300	450	600	750	900	1050	1200	1350	1500	1650	1800	2.83
3[illegible]0	5.10	310	470	620	780	930	1090	1240	1400	1550	1710	1860	2.92
3[illegible]0	5.27	320	480	640	800	960	1120	1280	1440	1600	1760	1920	3.01
[illegible]	5.43	330	500	660	830	990	1160	1320	1490	1650	1820	1980	3.11
340	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.20
350	5.76	350	530	700	880	1050	1230	1400	1580	1750	1930	2100	3.30
360	5.92	360	540	720	900	1080	1260	1440	1620	1800	1980	2160	3.39

18.5.9. Find the descent rate based on groundspeed. In **Figure 18.7**, with a 3.2-degree VDA and a groundspeed of 150 KIAS, the descent rate is 850 feet per minute.

Figure 18.7. Find Descent Rate.

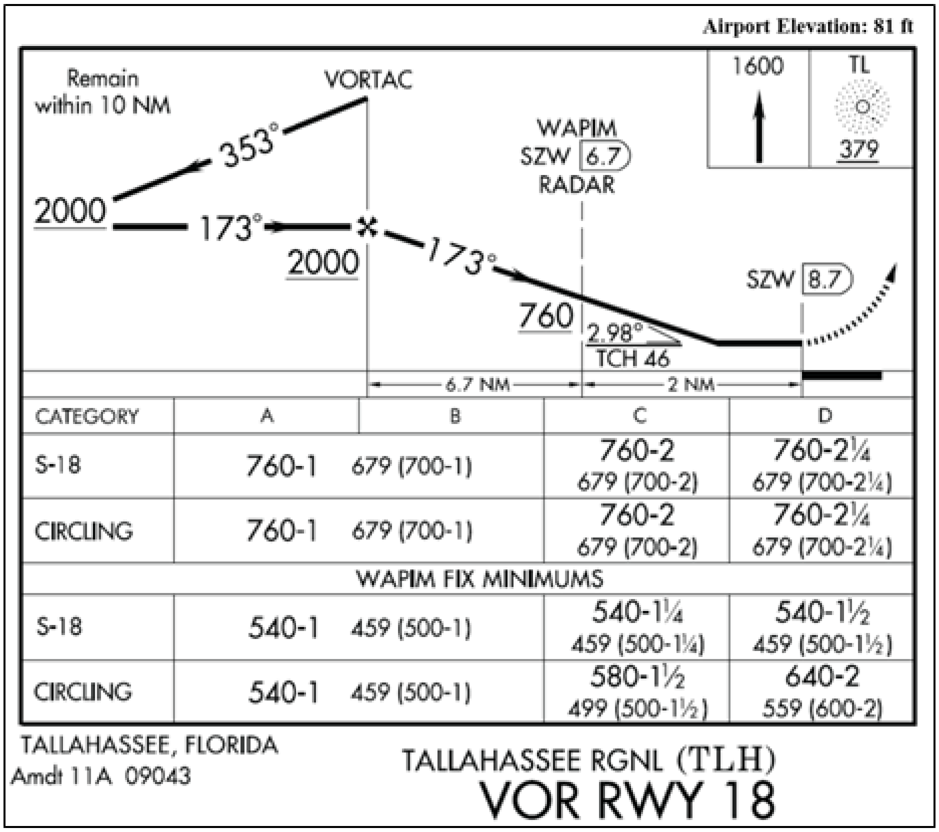
INSTRUMENT TAKEOFF OR APPROACH PROCEDURE CHARTS
RATE OF CLIMB/DESCENT TABLE
(ft. per min)

A rate of climb/descent table is provided for use in planning and executing climbs or descents under known or approximate ground speed conditions. It will be especially useful for approaches when the localizer only is used for course guidance. A best speed, power, altitude combination can be programmed which will result in a stable glide rate and altitude favorable for executing a landing if minimums exist upon breakout. Care should always be exercised so that minimum descent altitude and missed approach point are not exceeded.

ft/NM	%	GROUND SPEED (knots)											ANGLE
		60	90	120	150	180	210	240	270	300	330	360	
152	2.50	150	230	300	[illegible]	460	530	610	680	760	840	910	1.43
200	3.29	200	300	400	[illegible]	600	700	800	900	1000	1100	1200	1.89
210	3.46	210	320	420	[illegible]	630	740	840	950	1050	1160	1260	1.98
220	3.62	220	330	440	[illegible]	660	770	880	990	1100	1210	1320	2.07
230	3.79	230	350	460	[illegible]	690	810	920	1040	1150	1270	1380	2.17
240	3.95	240	360	480	[illegible]	720	840	960	1080	1200	1320	1440	2.26
250	4.11	250	380	500	[illegible]	750	880	1000	1130	1250	1380	1500	2.36
260	4.28	260	390	520	[illegible]	780	910	1040	1170	1300	1430	1560	2.45
270	4.44	270	410	540	[illegible]	810	950	1080	1220	1350	1490	1620	2.54
280	4.61	280	420	560	[illegible]	840	980	1120	1260	1400	1540	1680	2.64
290	4.77	290	440	580	[illegible]	870	1020	1160	1310	1450	1600	1740	2.73
300	4.94	300	450	600	[illegible]	900	1050	1200	1350	1500	1650	1800	2.83
310	5.10	310	470	620	[illegible]	930	1090	1240	1400	1550	1710	1860	2.92
320	5.27	320	480	640	[illegible]	960	1120	1280	1440	1600	1760	1920	3.01
330	5.43	330	500	660	[illegible]	990	1160	1320	1490	1650	1820	1980	3.11
340	5.60	340	510	680	850	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.20
350	5.76	350	530	700	880	1050	1230	1400	1580	1750	1930	2100	3.30
360	5.92	360	540	720	900	1080	1260	1440	1620	1800	1980	2160	3.39

18.5.10. The VDA is calculated from the FAF altitude to the TCH. On approaches with stepdown fixes, the goal is to publish a VDA that clears the stepdown fix altitude. The VDA may be calculated from the stepdown fix altitude to the TCH. In this situation, the VDA is published on the instrument procedure following the associated stepdown fix. The descent angle between the FAF altitude and the stepdown fix altitude is often shallower than the published VDA (**Figure 18.8**). Pilots should plan to descend beyond the FAF at the published VDA and clear the stepdown fix altitude.

Figure 18.8. KTLH VOR 18.



18.5.11. To calculate the descent point beyond the FAF, first determine the desired altitude to lose: FAF (2,000 feet) – [airfield elevation (81 feet) + TCH (46 feet)] = 1,873 feet. Divide the desired altitude to lose (1,873 feet) by the descent gradient (316 feet per nautical mile). This produces a distance of 5.9 nautical miles from the runway threshold, which is a point approximately 2.8 DME beyond the FAF (**Figure 18.9**).

Figure 18.9. Calculating a CDFA Descent Point beyond the FAF.

$$= \frac{FAF \; - (Airport\ Elevation + TCH)}{Descent\ Gradient}$$

$$= \frac{2000ft - (81ft + 46ft)}{316ft/NM} = \frac{1873ft}{316ft/NM} = 5.9NM$$

18.5.12. Do not descend below the MDA when executing a missed approach from a CDFA. **(T-0).** A DDA is an altitude above the MDA where a missed approach should be initiated to ensure the aircraft does not descend below the published MDA. Follow aircraft flight manual guidance for DDA; MAJCOMs will establish acceptable methods for calculating DDA if aircraft flight manual guidance does not adequately address DDA (e.g., use of demonstrated altitude lost in a go-around, use of industry practice 50 feet above the MDA as the DDA, etc.).

18.6. Flying the Approach. Avoid rapid descents on final by crossing the FAF at the published altitude. When a turn is required over the FAF, turn immediately and intercept the final approach course to remain within the protected airspace. Do not descend to the MDA or stepdown fix altitude until past the FAF. When the FAF is identified by the NAVAID for the approach, a straight-in approach course change of up to 30 degrees may be published. To determine the approximate initial descent rate required on final, refer to the VVI chart in the instrument procedure or use one of the formulas provided in **Attachment 2**. Timing is required when the final approach does not terminate at a published fix. When timing is used to identify the MAP, begin timing when passing the FAF or the starting point designated in the timing block on the instrument procedure. This point is usually the FAF but it may be a fix not co-located with the FAF such as an outer marker (OM), NDB, crossing radial, or DME fix. Time and distance tables on the approach chart are based on groundspeed.

18.6.1. If timing is not specifically depicted on the instrument approach procedure, timing is NA as a means of identifying the MAP.

18.6.2. If both timing and another means of identifying the MAP are published (e.g., DME), timing is normally only used as a backup unless the other means of MAP identification is not operational.

18.7. Runway Environment. Descent below MDA, DA, or DH is not authorized until sufficient visual reference with the runway environment has been established and the aircraft is in position to execute a safe landing in accordance with AFI 11-202V3.

18.7.1. The runway environment consists of one or more of the following elements:

18.7.1.1. The approach light system.

18.7.1.2. The runway end identifier lights (REIL).

18.7.1.3. The runway lights.

18.7.1.4. The visual approach slope indicator (VASI).

18.7.1.5. The threshold, threshold markings, or threshold lights.

18.7.1.6. The touchdown zone, touchdown zone markings, or touchdown zone lights.

18.7.1.7. The runway or runway markings.

18.7.2. The pilot will not descend below 100 feet above the TDZE using the approach lights as a reference unless the red terminating bars or the red side row bars are also distinctly visible and identifiable. **(T-0).**

18.8. ILS or LOC. Required components of the ILS are the glideslope, localizer, and outer marker.

18.8.1. If the OM is inoperative or not installed, it may be replaced by DME. (NAS Only) The OM may be replaced by another NAVAID, a crossing radial, a waypoint, or a radar fix, provided these substitutes are depicted on the approach plate or identified by NOTAM [FAA Order 6750.24].

18.8.2. If the glideslope fails or is unavailable, the approach reverts to an approach without glide path guidance.

18.8.3. The ILS or LOC approach must be discontinued if the localizer course becomes unreliable, or any time full-scale deflection of the CDI occurs on final approach. **(T-0).**

18.8.4. [FAA Order 6750.24] An OM or suitable substitute is only required to indicate the FAF for NPA operations (i.e., LOC only). The FAF for ILS approach operations is the published glideslope intercept altitude, not the OM. Therefore, an OM or suitable substitute is not required for ILS approach operations.

18.8.5. Airborne marker beacon receivers that have a selective sensitivity feature should always be operated in the "low" sensitivity position.

18.8.6. If making an autopilot coupled approach or auto land operations, use the aircraft flight manual procedures for the category of ILS approach being conducted. When the ceiling is less than 800 feet or the visibility of less than 2 miles, 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 airfield (except for aircraft that land, exit a runway, depart or execute a missed approach). When executing either an autopilot coupled approach or auto land operations and the ceiling is above 800 feet and the visibility is more than 2 miles, the pilot should advise ATC as soon as practical but not later than the FAF. This allows time for the appropriate ILS critical area to be cleared or an advisory issued. If controllers advise "Localizer/glideslope signal not protected," 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 glideslope 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.

18.8.7. Set the published localizer front course in the course selector window prior to attempting localizer interception for ILS, LOC, and LOC Back Course (LOC BC) approaches. On a LOC BC, the term "front course" refers to the inbound course depicted on the ILS or LOC approach for the opposite runway. Follow aircraft flight manual guidance for aircraft specific procedures.

18.8.7.1. Unless the aircraft's ILS equipment includes reverse sensing capability, when flying inbound on the back course it is necessary to steer the aircraft in the direction opposite the needle deflection when making corrections from off-course to on-course. This "fly away from the needle" is also required when flying outbound on the front course of the localizer. Do not use back course signals for approach unless a LOC BC instrument procedure is published for that particular runway and the approach is authorized by ATC.

18.8.7.2. [AIM 1-1-9] False glideslope signals may exist around the localizer back course approach which can cause the glideslope flag alarm to disappear and present unreliable glideslope indications. Disregard all glideslope signal indications when making a localizer back course approach unless a glideslope is specified on the approach and landing chart.

18.8.8. [AIM 1-1-9] Be alert when approaching the glideslope intercept. False courses and reverse sensing occur at angles considerably greater than the published glide path. Where available, use other NAVAIDs to help identify the localizer course and glideslope intercept point.

18.8.9. [AIM 1-1-9] Do not descend below localizer minimums if the aircraft is more than half-scale below or full scale above the glideslope. If the glideslope is recaptured to within the above tolerance, descent may be continued to the DA.

18.8.10. The middle marker (MM) may not be used as the sole means of identifying the MAP. If the MM is the only way to identify the MAP (e.g., no timing published or DME out of service), then the approach is not authorized. Although the MM cannot be the sole means, it may assist the pilot in identifying the MAP on certain localizer approaches. 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 the primary indications (e.g., DME or timing) agree, consider the aircraft to be at the MAP and take appropriate action.

18.9. RNAV (GPS) and GPS Approach Procedures.

18.9.1. Unless circling from the approach, VNAV guidance should be followed if provided by aircraft avionics and certified for use in accordance with AFI 11-202V3.

18.9.1.1. VNAV guidance may be used to LNAV minimums; however, the aircraft must level off at the MDA or utilize a DDA if the runway environment is not in sight. **(T-0).** Due to the temperature and pressure altitude effects, USAF crews will not use VNAV guidance below any published MDA or DA. **(T-0).**

18.9.1.2. VNAV guidance should provide appropriate vertical clearance for all step-down fix altitudes. Aircrew must monitor aircraft altitude at all step-down fixes to ensure compliance with published altitude restrictions. **(T-0).**

18.9.2. Do not activate the missed approach lateral navigation or turn away from the final approach course prior to the missed approach waypoint. **(T-2).**

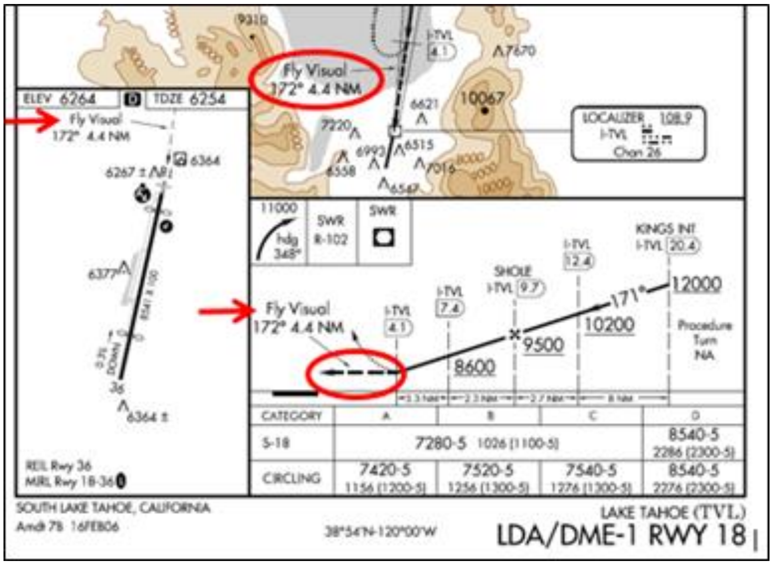
18.10. Visual Segment. Some instrument procedures contain a published visual segment (**Figure 18.10**). The visual segment of an instrument procedure begins at the DA or MDA and continues to the runway. The words "Fly Visual" or "Fly Visual to Airport" appear in the profile view of the instrument procedure. A dashed line in the profile view with an approximate heading and distance to the end of the runway.

18.10.1. The depicted ground track associated with the visual segment should be flown as dead reckoning course. When executing the visual segment, remain clear of clouds and proceed to the airfield maintaining visual contact with the ground.

18.10.2. Altitude on the visual segment is at the discretion of the pilot, and it is the pilot's responsibility for obstacle clearance.

18.10.3. Missed approach obstacle clearance is assured only if the missed approach is commenced at the published MAP. Before initiating an instrument procedure that contains a visual segment, the pilot should have preplanned climb out options based on aircraft performance and surrounding terrain. Obstacle clearance is the responsibility of the pilot when the approach is continued beyond the MAP.

Figure 18.10. Visual Segment.



Chapter 19

SPECIAL AIRCREW AND AIRCRAFT CERTIFICATION REQUIRED APPROACHES

19.1. General. Certain instrument procedures require specific aircraft certification and additional aircrew training and certification. MAJCOMs must provide training and operational approval in accordance with AFI 11-202V3 for each individual procedure type listed in this chapter; training and approval for one procedure type does not extend to other procedure types (e.g., operational approval for CAT II procedures does not also authorize Special Authorization CAT I procedures). Aircrews may identify these instrument procedures by a chart note:

19.1.1. "SPECIAL AIRCREW & AIRCRAFT CERTIFICATION REQUIRED", or

19.1.2. "AUTHORIZATION REQUIRED".

19.2. Special Authorization Category I (SA CAT I). [FAA Order 8400.13] Special Authorization CAT I allows a DH of 150 feet and RVR 1400 at runways with reduced lighting; a HUD must be used to DH (**Figure 19.1**). **(T-0).**

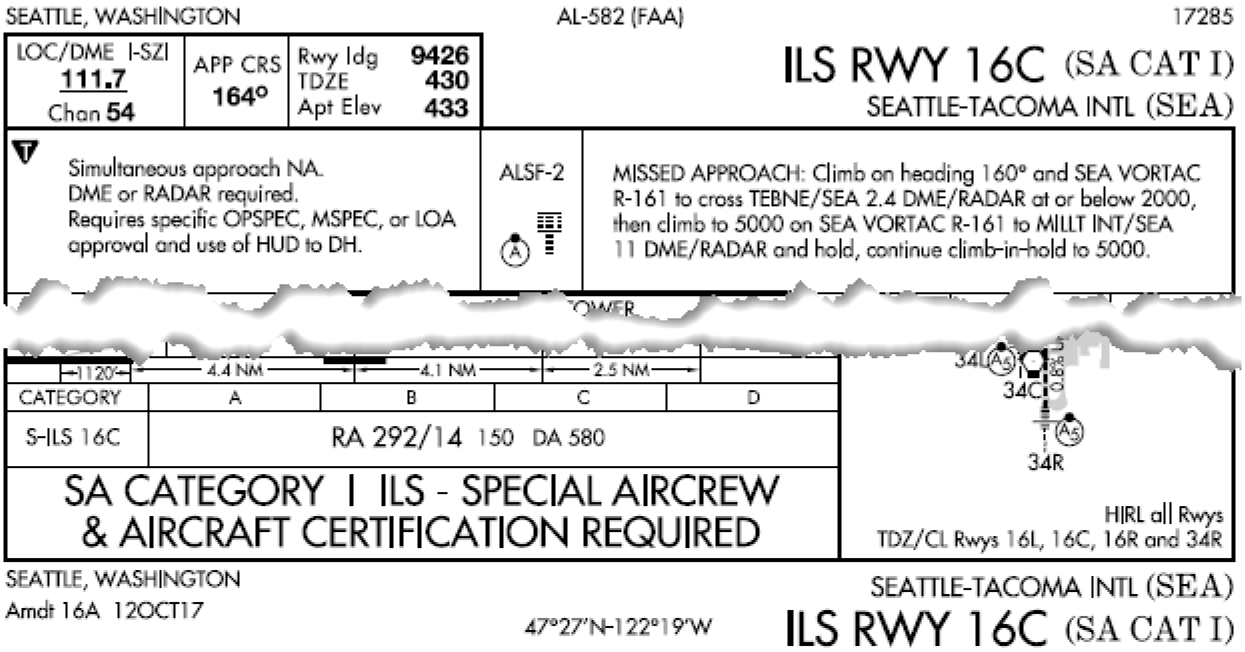
19.2.1. Single pilot operators are prohibited from using SA CAT I landing minimums.

19.2.2. The runway has a landing distance of at least 5000 feet.

19.2.3. Required lighting and equipment: simplified short approach lighting system with runway alignment indicator lights (SSALR), medium intensity approach lighting system with runway alignment indicator lights (MALSR), approach lighting system with sequenced flashing lights (ALSF) -1, or ALSF-2; high intensity runway lighting (HIRL); and touchdown RVR sensor.

19.2.4. Only aircrew authorized for CAT II operations flying operationally certified CAT II aircraft equipped with an operable CAT II or better HUD may fly SA CAT I approaches.

Figure 19.1. SA CAT I ILS Approach.



19.3. Category II (CAT II). [FAA Order 8400.13] CAT II allows a DH of 100 feet and an RVR of 1200 feet; RVR may be reduced to 1000 feet with autoland or HUD to touchdown when noted on the procedure (**Figure 19.2**).

19.3.1. Required lighting: ALSF-2; HIRL; touchdown zone (TDZ) lighting; and runway centerline light system (RCLS).

19.3.2. CAT II ILS operations require a touchdown RVR sensor. A rollout sensor is also required for CAT II operations below RVR 1600. When the runway is in excess of 8000 feet in length, a midpoint RVR sensor is required in addition to the touchdown and rollout sensors for CAT II operations below RVR 1600.

19.3.3. The crosswind component on the landing runway must be 15 knots or less, unless the aircraft flight manual crosswind limitations are more restrictive [FAA Notice 8900.443 Appendix I]. **(T-0).**

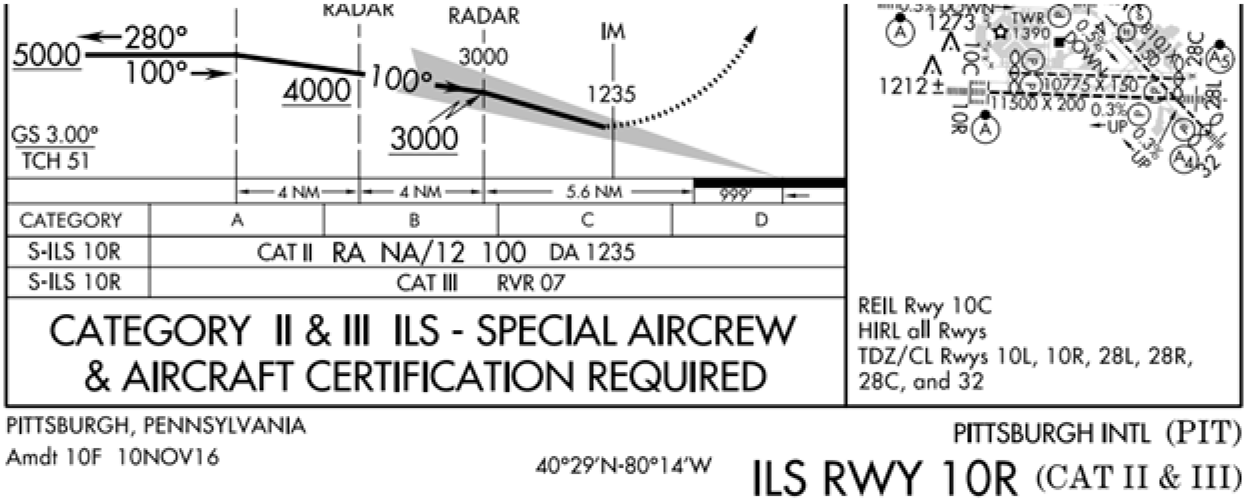
19.3.4. CAT II operations require an operational air traffic control tower; if the tower does not provide continuous service, operations are not authorized when the tower is closed.

19.3.5. "RA NA" is annotated in the CAT II line of minima when radio altimeter minimums are not authorized for a CAT II approach. Only the inner marker (IM) may be used to identify the DH due to terrain, obstacles, or other local requirements that preclude the use of radio altimeter minimums.

19.3.6. Only aircrew authorized for CAT II operations flying operationally certified CAT II aircraft may fly CAT II approaches.

19.3.7. Only aircrew authorized for CAT II operations flying aircraft operationally certified CAT III aircraft equipped with an operable autoland or HUD approved to touchdown capability may fly CAT II approaches to RVR 1000 minimums [FAA Order 8400.13D Chapter 6].

Figure 19.2. CAT II ILS Approach.



19.4. "Copter" Category II. [FAA Order 8900.1 Volume 4] Copter ILS CAT II allows a DH of 100 feet and an RVR of 1200 feet (**Figure 19.3**).

19.4.1. Unpublished DH reductions are not authorized.

19.4.2. The required visibility may not be reduced [14 CFR Part 97.3].

19.4.3. A marker beacon receiver with aural and visual indications of the IM or a functioning radio altimeter is required for Copter CAT II ILS operations with DH below 150 feet.

Figure 19.3. COPTER CAT II ILS Approach.

19.5. Special Authorization Category II with Reduced Lighting (SA CAT II). [FAA Order 8400.13] Special Authorization CAT II allows a DH of 100 feet and an RVR of 1200 feet; autoland or HUD must be used to touchdown (**Figure 19.4**). **(T-0).**

19.5.1. The runway has a landing distance of at least 6000 feet.

19.5.2. Required lighting: SSALR, MALSR (with threshold bar that is separate from runway end lights), ALSF-1, or ALSF-2; and HIRL.

19.5.2.1. CAT II and III operations (including SA CAT II) may continue if an installed ALSF-2 is operating as a SSALR or SALS, or MALSR is operating as a MALS [FAA Order 6750.24].

19.5.2.2. MAJCOMs may authorize SA CAT II authorized aircrew to continue CAT II operations if the installed TDZ and/or RCLS fail [FAA Order 6750.24].

19.5.3. SA CAT II operations at RVR 1600 require a touchdown RVR sensor. SA CAT II operations at RVR 1200 require a minimum of two RVR sensors; one RVR sensor must be for the touchdown zone. **(T-0).**

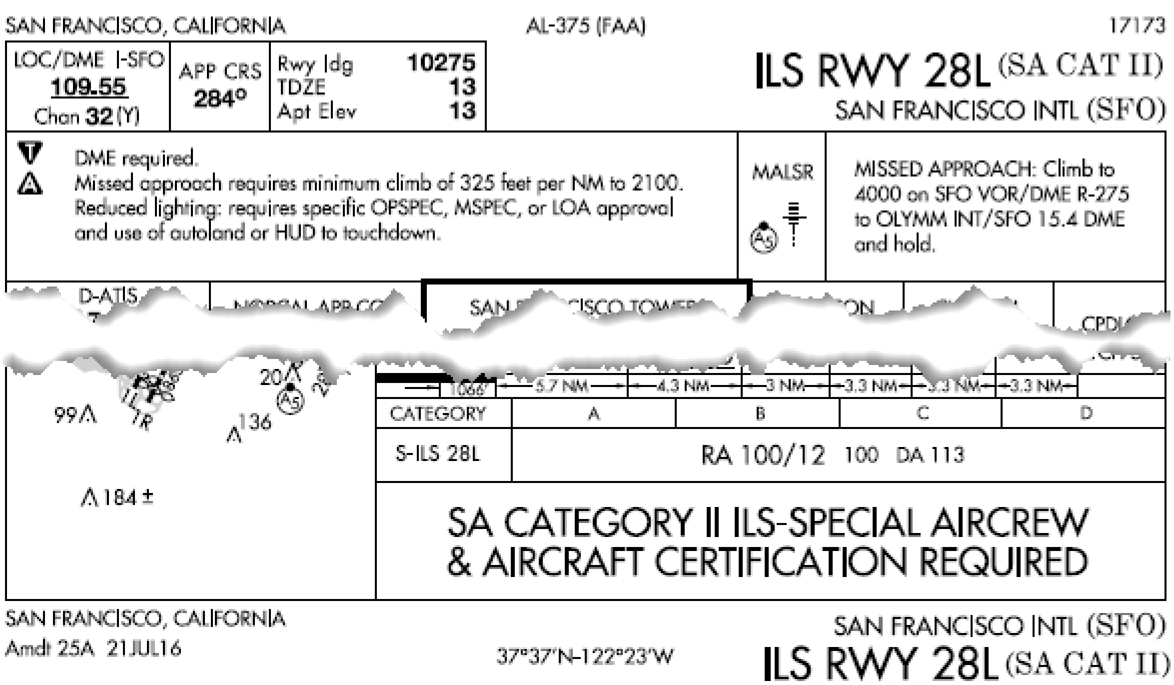
19.5.4. The crosswind component on the landing runway must be 15 knots or less, unless the aircraft flight manual crosswind limitations are more restrictive [FAA Notice 8900.443 Appendix I]. **(T-0).**

19.5.5. SA CAT II operations require an operational air traffic control tower; if the tower does not provide continuous service, operations are not authorized when the tower is closed.

19.5.6. "RA NA" is annotated in the SA CAT II line of minima when radio altimeter minimums are not authorized for a SA CAT II approach. Only the IM may be used to identify the DH due to terrain, obstacles, or other local requirements that preclude the use of radio altimeter minimums.

19.5.7. Only aircrew authorized for CAT II operations flying operationally certified CAT III aircraft equipped with an operable autoland or HUD approved to touchdown capability may fly SA CAT II approaches.

Figure 19.4. SA CAT II ILS Approach.



19.6. Category III (CAT III). [FAA Order 8400.13] CAT III operations allow a DH below 100 feet or no DH and a visibility of RVR 300 (**Figure 19.5**).

19.6.1. CAT III operations are separated into three subcategories [AIM 1-1-9]:

19.6.1.1. CAT IIIa has no DH or DH below 100 feet; RVR not less than 700 feet.

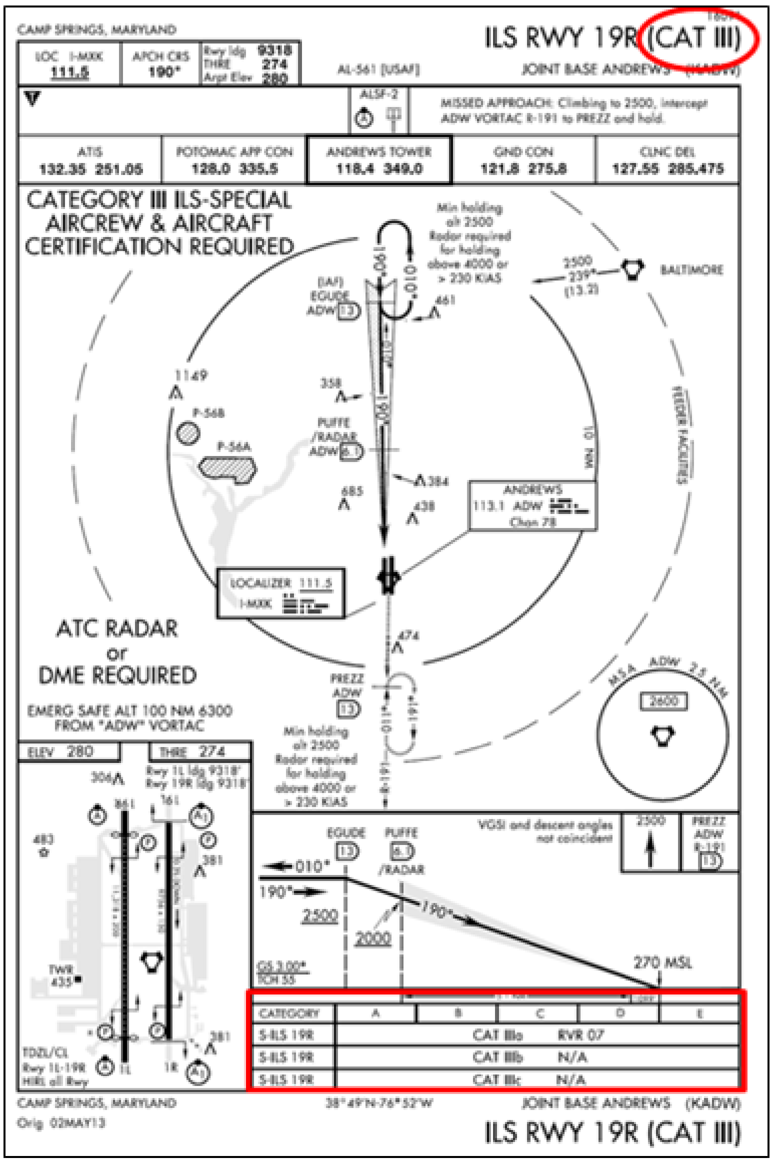
19.6.1.2. CAT IIIb has no DH or DH below 50 feet; RVR less than 700 feet but not less than 150 feet or (NAS only) 300 feet.

19.6.1.3. CAT IIIc has no DH and no RVR limitation. CAT IIIc operations are currently not authorized [FAA Order 8900.1 Volume 4 **Chapter 2**].

19.6.1.4. Alert Height is 100 feet above the highest elevation in the touchdown zone, above which a CAT 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 CAT III systems.

19.6.2. DH and Alert Height are referenced by AGL measured on the radar altimeter.

Figure 19.5. CAT III ILS Approach.

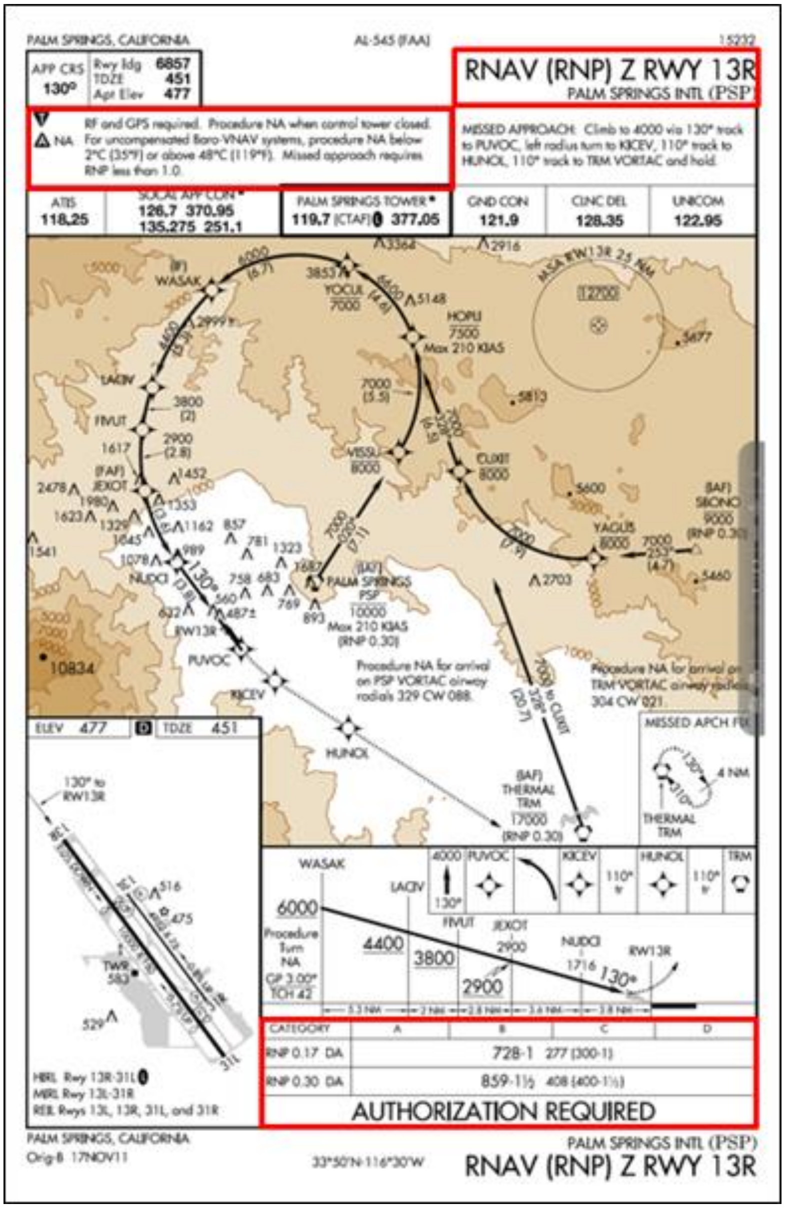


19.7. Simultaneous Close Parallel ILS Precision Runway Monitor (PRM) / RNAV PRM / GLS PRM Approaches. [AIM 5-4-16] The term "PRM" alerts pilots that specific airborne equipment, training, and procedures are required for the approach. MAJCOM training and certification is required prior to participation in ILS PRM, RNAV PRM, or GLS PRM approaches.

19.8. Simultaneous Offset Instrument Approaches (SOIA). [AIM 5-4-16] The SOIA procedure utilizes an ILS PRM approach to one runway and an offset LDA PRM approach with glideslope to the adjacent runway. MAJCOM training and certification is required prior to participation in SOIA.

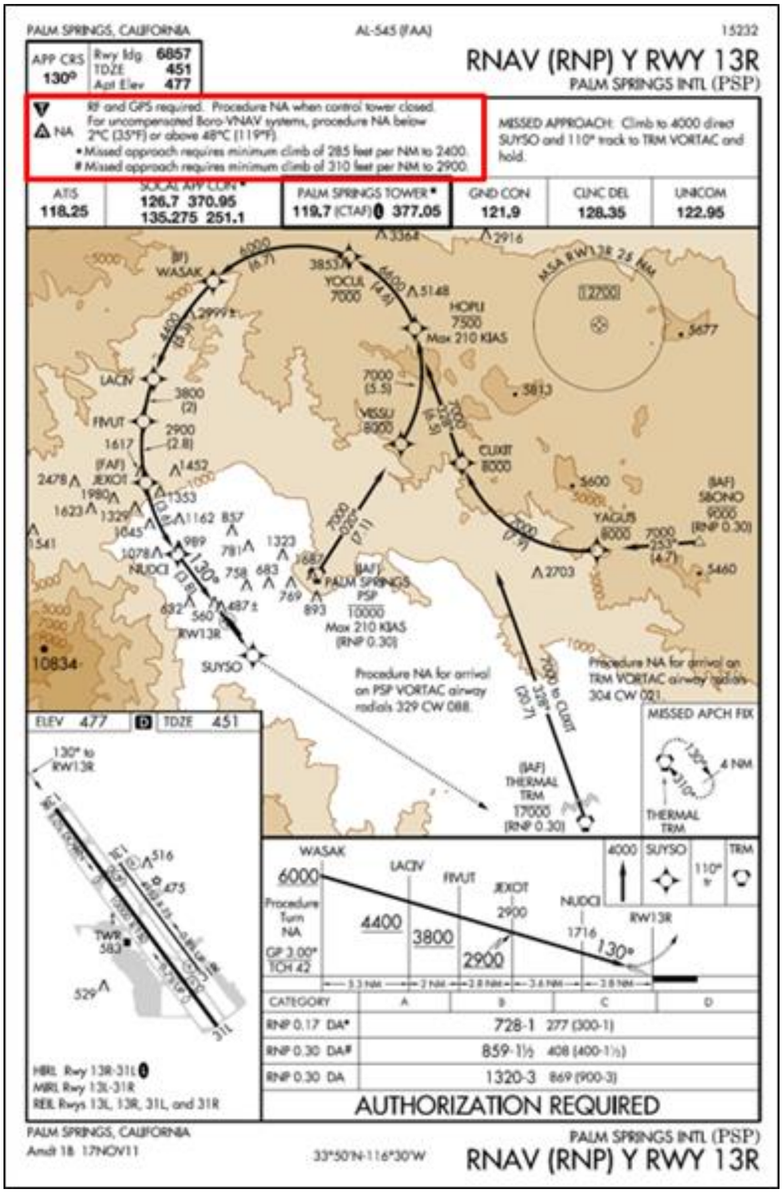
19.9. RNP Authorization Required (AR) Approach Procedures. [AC 90-101; AIM 5-4-18] Each published line of minima has an associated RNP value defining the lateral and vertical performance requirements. A minimum RNP type is documented as part of the RNP AR authorization and may vary depending on aircraft configuration or operational procedures (e.g., GPS inoperative, use of flight director vice autopilot, etc.). Procedures may require RF capability or missed approach instructions with RNP values less than 1.0. (**Figure 19.6**)

Figure 19.6. RNP Values.



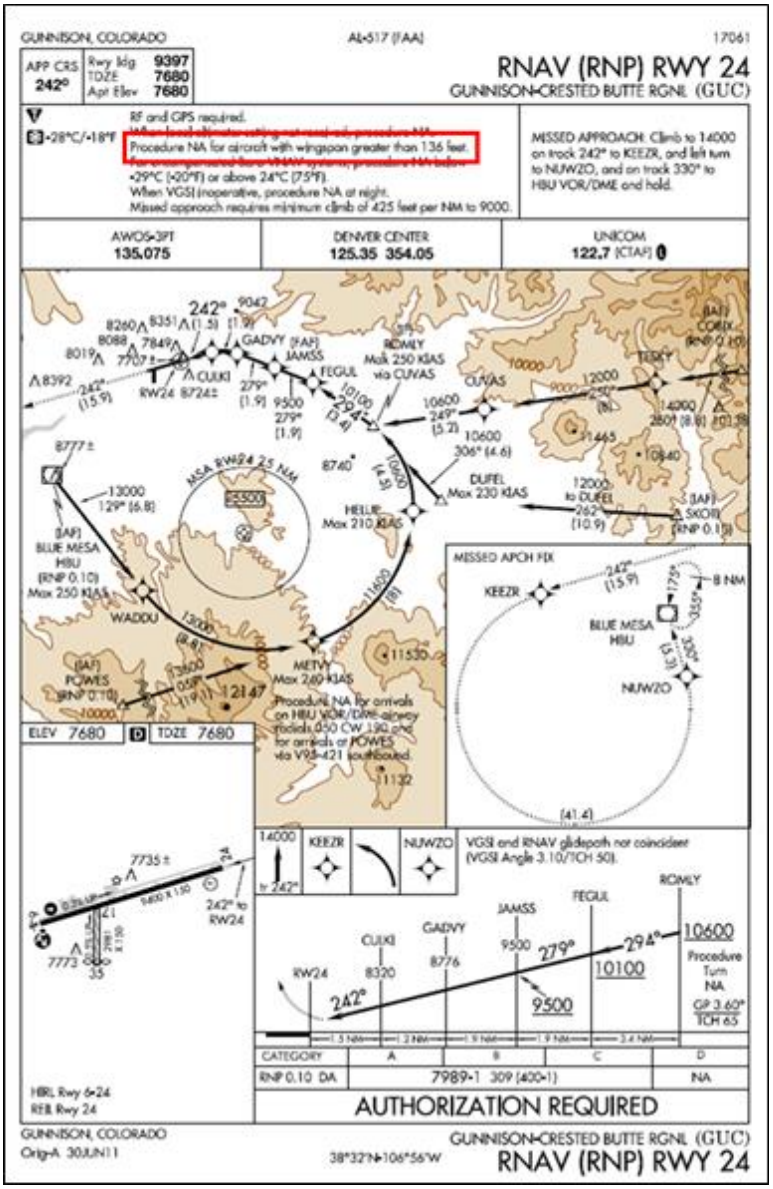
19.9.1. RNP AR approaches are developed based on standard approach speeds and a 200 foot per nautical mile climb gradient in the missed approach. Any exceptions to these standards are indicated on the approach procedure (**Figure 19.7**).

Figure 19.7. Nonstandard Missed Approach Climb Gradient.



19.9.2. RNP AR approach minimums may be dependent on aircraft size (**Figure 19.8**). Large aircraft may require higher minimums due to gear height or wingspan. Approach procedure charts are annotated with applicable aircraft size restrictions.

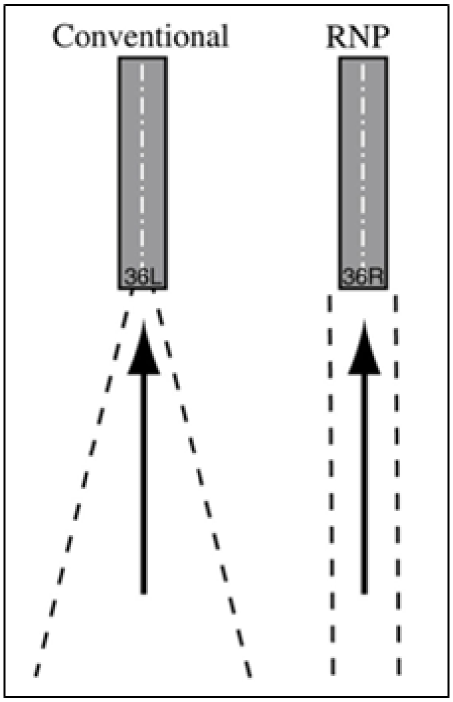
Figure 19.8. Aircraft Size Restrictions.



19.9.3. RNP stand-alone approach operations provide access to runways regardless of the ground-based NAVAID infrastructure and designed to avoid obstacles, terrain, airspace, or resolve environmental constraints.

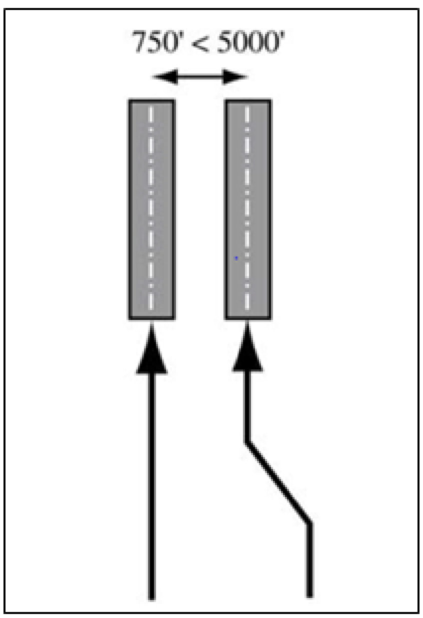
19.9.4. RNP parallel approach operations may be used for parallel approaches where the runway separation is adequate (**Figure 19.9**). Parallel approach procedures may be used either simultaneously or as stand-alone operations. They may be part of either independent or dependent operations based on ATC's ability to provide radar monitoring.

Figure 19.9. RNP Parallel Approach Operations.



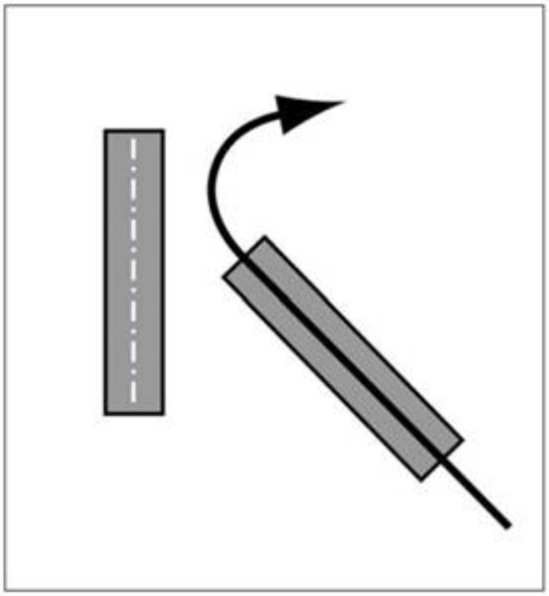
19.9.5. RNP parallel approach runway transition approaches begin as a parallel IFR approach operation using simultaneous runway procedures (**Figure 19.10**). Visual separation standards are used after the FAF to permit aircraft to transition in visual conditions along a predefined lateral and vertical path to align with the runway centerline.

Figure 19.10. RNP Parallel Approach Runway Transition Operations.



19.9.6. RNP converging runway operations provide a precise curved missed approach path that conforms to aircraft separation minimums for simultaneous operations at airfields where runways converge (**Figure 19.11**). Dual runway operations may continue to lower ceiling and visibility values than currently available by flying the curved RNP missed approach path.

Figure 19.11. RNP Converging Runway Operations.



Chapter 20

LANDING

20.1. General. 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.

20.2. Illusions and Vision in Flight. [AIM 8-1-5; AIM 8-1-6] There are many phenomena, such as rain, smoke, snow, and haze, which may restrict visibility. Knowledge of these various factors aids in making a safe, smooth transition from instrument to visual flight. Refer to AFH 11-203 Volume 1, *Weather for Aircrews*, for a detailed description of weather conditions.

20.2.1. Approach lights, runway markings, runway lights, and contrasts are the primary sources of visual cues. Become familiar with the lighting and marking patterns at the destination and correlate them with the weather to prepare for the 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 visible until considerably below published minimums.

20.2.2. 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 challenges in a landing situation in which the approach lights and runway lights are the only visual cues available.

20.2.3. Instrument approach lights do not provide adequate vertical guidance to the pilot during low visibility instrument approaches. Available visual cues may not allow the pilot 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 flight instruments, and instead rely on the poor visual cues. When flying into ground fog from above, if the pilot initially sees the runway or approach lights, these cues tend to disappear entering the fog bank. The loss of these visual cues can induce the illusion or sensation of climbing. Limited visual cues can cause the illusion that the aircraft is above normal glide path and potentially result in a pushover reaction (i.e., "duck-under"), an increased rate of descent, and a short or hard landing.

20.2.4. In limited visibility, approach lights may not be seen until the aircraft is close to the ground which may delay the normal transition to landing. The delay in reducing the descent rate 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 the aircraft is going to land short.

20.2.4.1. A method to prevent a high rate of descent and a short or hard landing is to maintain composite cross-check using external visual cues, the glideslope indicator or flight director, VVI, and AI indications.

20.2.4.2. Another potential duck-under situation occurs when the pilot attempts to land within the first 500 to 1,000 feet of the runway after breaking out of an overcast condition. In this case, the pilot may attempt to establish a visual profile similar to the one used 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. High sink rates and poor thrust/lift relationships can develop quickly which may cause undershoots or hard landings. Landing decisions should be based upon the normal touchdown point from the instrument approach. If stopping distances are in doubt, proceed to an alternate.

20.2.4.3. At 100-foot elevation and a 3 degrees glideslope, an aircraft is approximately 1,900 feet from the runway point of intercept. If the aircraft's final approach speed is 130 knots (215 feet per second), the pilot has about 9 seconds to bring visual cues into the cross-check, ascertain lateral and vertical position, determine a visual flight path, and establish appropriate corrections. More than likely, 3 to 4 seconds is spent integrating visual cues before making a necessary control input. By this time, the aircraft is 600 to 800 feet closer to the runway point of intercept, 40 to 60 feet lower, and possibly well into the flare. Therefore, it is 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.

20.3. Approach Lighting Systems. [FLIP FIH] 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) or medium intensity. 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. The approach lighting systems currently in use appear in the FIH.

20.4. Runway Lighting Systems. [AFI 11-218] Basic runway lighting systems are used to aid the pilot in defining the usable landing area of the runway. These are runway edge lighting system, runway centerline lighting system and touchdown zone lights.

20.5. Runway Markings. [AFI 11-218] Runway markings are designed to make the landing area more conspicuous and to add a third dimension for night and low visibility operations.

20.6. Circling Approaches. [AIM 5-4-20; ICAO Doc 8168V1 4-7] Visual maneuvering (i.e., "circling") is the term used to describe the phase of flight after an instrument approach has been completed. It brings the aircraft into position for landing on a runway which is not suitably located for straight-in approach (i.e., one where the criteria for alignment or descent gradient cannot be met). A circling approach is a visual flight maneuver conducted under IFR. Each circling situation is different due to variables such as runway layout, final approach track, wind velocity, and meteorological conditions.

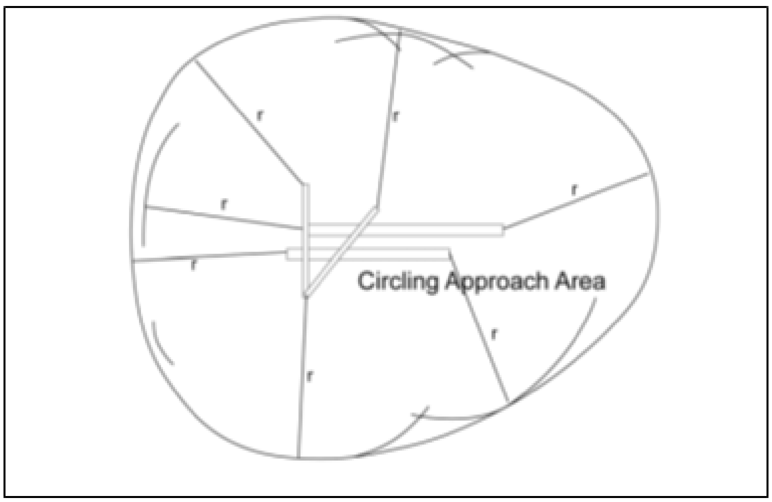
20.6.1. Pilots will not circle from a GLS, an ILS without a localizer line of minima, or an RNAV (GPS) approach without an LNAV line of minima. **(T-0).** Pilots will not circle from an approach without a published circling line of minima. **(T-0).**

20.6.2. State the aircraft category when requesting circling MDA from the controller prior to circling from an airport surveillance radar (ASR) approach.

20.6.3. The circling minima listed on instrument procedures apply to all approach types on the instrument procedure (e.g., ILS or LOC, VOR or TACAN, etc.). If planning to circle from an approach with vertical guidance, pilots must ensure the aircraft is within the appropriate circling radius for the aircraft category and above the circling MDA before abandoning the precision glideslope. **(T-0).**

20.7. Circling Protected Area. [AIM 5-4-20; ICAO Doc 8168V1 4-7] Circling approach protected areas are defined by the tangential connection of arcs drawn from each runway end as shown in **Figure 20.1**. Obstruction clearance areas (i.e., "protected airspace") are determined by aircraft category. If it is necessary to maneuver at speeds in excess of the upper limit of the speed range authorized, use the landing minima for the category appropriate to the maneuvering speed. Pilots must ensure they remain within the required obstacle clearance radius and maintain situational awareness. **(T-0).** If there is any doubt accomplish the missed approach.

Figure 20.1. Circling Approach Area.



20.7.1. (NAS only) Prior to late 2012, circling approach protected areas used fixed-radius distances, dependent on aircraft category, as shown in **Table 20.1**. These approaches can be identified by the absence of the "negative C" symbol on the circling line of minima.

Table 20.1. U.S. TERPS Standard Circling Criteria.

Circling MDA (feet MSL)	CAT A	CAT B	CAT C	CAT D	CAT E
All Altitudes	1.3	1.5	1.7	2.3	4.5
Note: Distances are in nautical miles					

20.7.2. After 2012, circling approach protected areas used a radius distance dependent on the aircraft category and the altitude of the circling MDA, which accounts for true airspeed increase with altitude. The approaches utilizing the expanded circling approach areas can be identified by the presence of the “negative C” symbol on the circling line of minima (**Figure 20.2** and **Table 20.2**).

Figure 20.2. Expanded Circling Area Annotation.

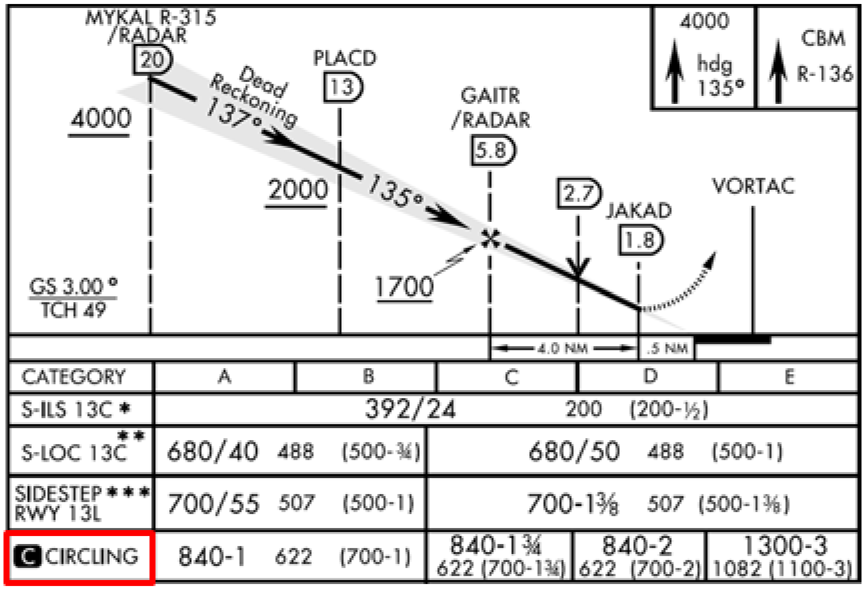


Table 20.2. U.S. TERPS Expanded Circling Approach Maneuvering Airspace.

Circling MDA (feet MSL)	CAT A	CAT B	CAT C	CAT D	CAT E
1000 or less	1.3	1.7	2.7	3.6	4.5
1001 – 3000	1.3	1.8	2.8	3.7	4.6
3001 – 5000	1.3	1.8	2.9	3.8	4.8
5001 – 7000	1.3	1.9	3.0	4.0	5.3
7001 – 9000	1.4	2.0	3.2	4.2	5.3
9001 and above	1.4	2.1	3.3	4.4	5.5
Note: Distances are in nautical miles					

20.7.3. (ICAO) Circling area radii are in accordance with **Table 20.3**. ICAO circling bank angle is 20 degrees average achieved or 3 degrees per second, whichever requires less bank.

Table 20.3. PANS-OPS Circling Area Radii.

	CAT A	CAT B	CAT C	CAT D	CAT E
Maximum Speed (KIAS)	100	135	180	205	240
Obstruction Clearance	90 meters (295 feet)		120 meters (394 feet)		150 meters (492 feet)
Circling MDA (feet MSL)	**Circling Area Radii in Nautical Miles**				
1000 or less	1.6	2.5	4.1	5.1	6.7
1001 – 3000	1.6	2.6	4.2	5.2	6.9
3001 – 5000	1.7	2.7	4.3	5.4	7.0
5001 – 7000	1.7	2.8	4.5	5.6	7.4
7001 – 9000	1.8	2.9	4.7	5.9	7.8
9001 and above	1.9	3.1	4.9	6.2	8.2

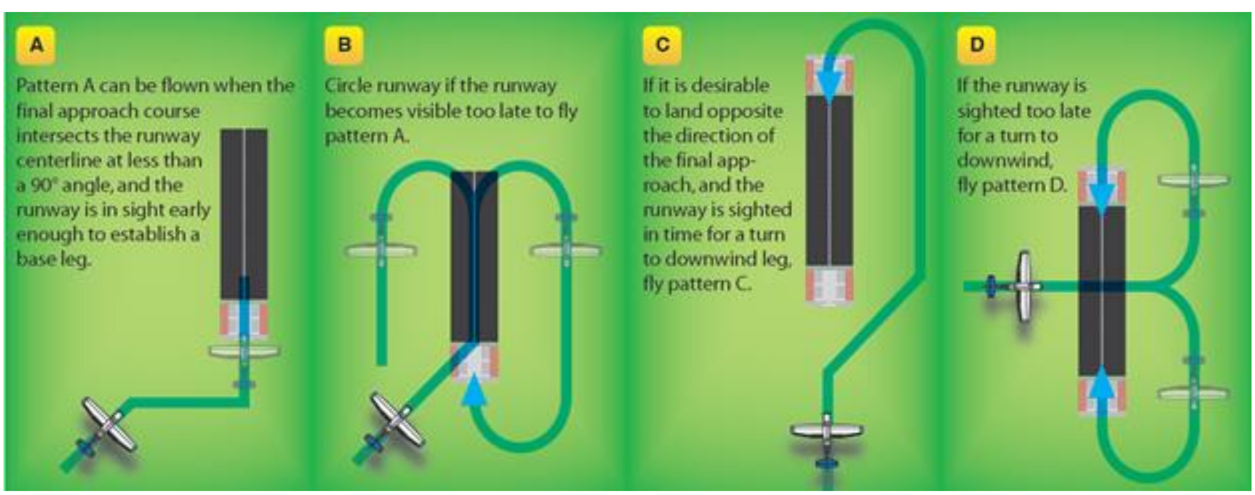
20.7.4. There is no secondary obstacle clearance area for circling maneuvers. Certain sectors may be excluded from consideration where prominent obstacles exist. In this case, a note is provided excluding this sector from use during the circling maneuver.

20.7.5. The maximum speed for circling is in accordance with **Table 20.3**. (NAS only) The maximum speed for circling is the aircraft category speed for the instrument procedure flown.

20.7.6. If the controller has a requirement to specify the direction of the circling maneuver in relation to the airfield or runway, the controller issues instructions in the following manner: "Circle west of the airport for a right base to runway one eight." ATC should not issue clearances such as "extend downwind leg" that take the aircraft out of the protected area.

20.7.7. There may be situations when a circling approach is required but no ceiling is published. In this case, the required ceiling is the HAA plus 100 feet and rounded up to the next 100-foot value. For example, if the HAA is 757 feet, add 100 feet to get 857 feet and then round up to the nearest 100-foot value, which would be 900 feet.

Figure 20.3. Circling Maneuver Examples.



20.8. Accomplishing the Circling Maneuver. Maneuver the shortest path to the base or downwind leg, as appropriate, considering existing weather conditions (**Figure 20.3**). There is no restriction from passing over the airfield or other runways.

20.8.1. Make either left or right turns to final unless directed by the controlling agency to turn in a specific direction or limited by published restrictions. Circling maneuvers may be made while VFR or other flying operations are in progress at the airfield.

20.8.2. At non-towered airfields consider over flying the airfield to observe current wind and other traffic which may be on the runway or flying near the airfield.

20.8.3. Do not descend below circling MDA until the pilot is able to place the aircraft on a normal glide path to the landing runway and execute a safe landing. The common tendency is to maneuver too close to the runway at altitudes lower than normal VFR pattern altitude due to using the same visual cues as normal VFR pattern altitudes. Select a pattern that displaces the aircraft far enough from the runway for a turn to final without overbanking or overshooting.

20.9. (ICAO) Visual Maneuver Using a Prescribed Track. [ICAO Doc 8168V1 4-7] A Nation State may prescribe a specific track for visual maneuvering in addition to the circling area in those locations where clearly defined visual features permit and if it is operationally desirable. Flight crews need to be familiar with the terrain and visual cues to be used for this procedure. **Note:** Navigation is primarily by visual reference and any radio navigation information presented is advisory only and the missed approach for the normal instrument procedures applies.

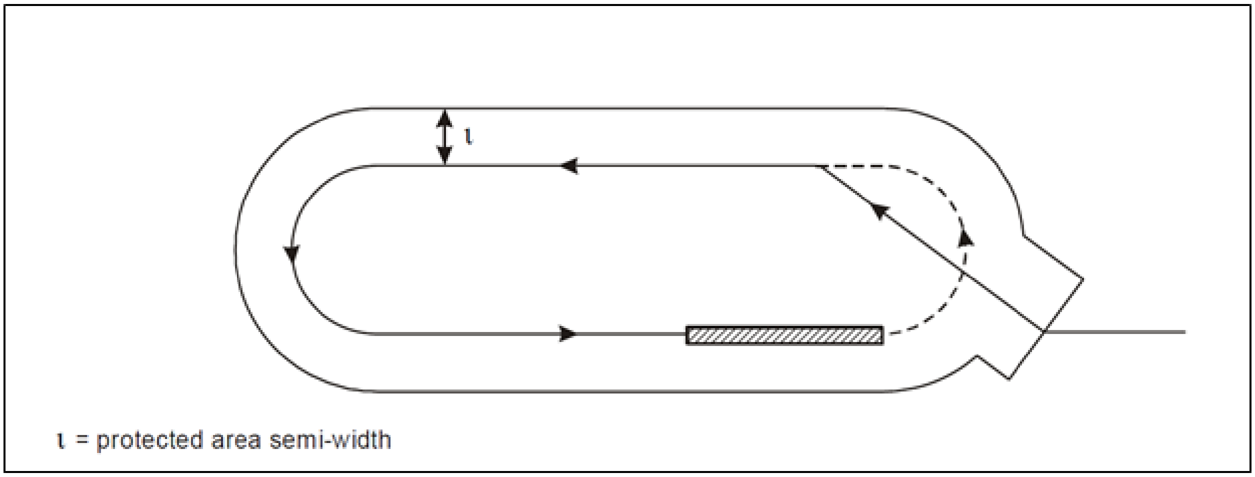
20.9.1. The direction and length of each segment are defined, if a speed restriction is prescribed, it is published on the chart. The length of the final segment is based on an allowance of 30 seconds of flight before the threshold. When a minimum altitude/height is specified at the beginning of a segment, the length of the final segment is adjusted, if necessary considering the descent gradient or angle.

20.9.2. The protected area is based on a corridor with a constant width, centered on the nominal track. The corridor starts at the "divergence" point and follows the track, including a go-around for a second visual maneuvering with prescribed track (**Table 20.4** and **Figure 20.4**).

Table 20.4. Semi-Width of the Corridor.

Semi-Width of the Corridor	Aircraft Category				
	A	B	C	D	E
Meters	1,400	1,500	1,800	2,100	2,600
Feet	4,593	4,921	5,905	6,890	8,530

Figure 20.4. Visual Maneuver Using a Prescribed Track Protected Area.



20.10. Side-Step Maneuver. [AIM 5-4-19] ATC may authorize an instrument procedure which serves either one of parallel runways that are separated by 1,200 feet or less, followed by a straight-in landing on the adjacent runway where side-step minimums are published (**Figure 20.5**). Aircraft executing a side-step maneuver are cleared for a specified non-precision approach and landing on the adjacent parallel runway. For example: "Cleared ILS runway seven left approach, side-step to runway seven right."

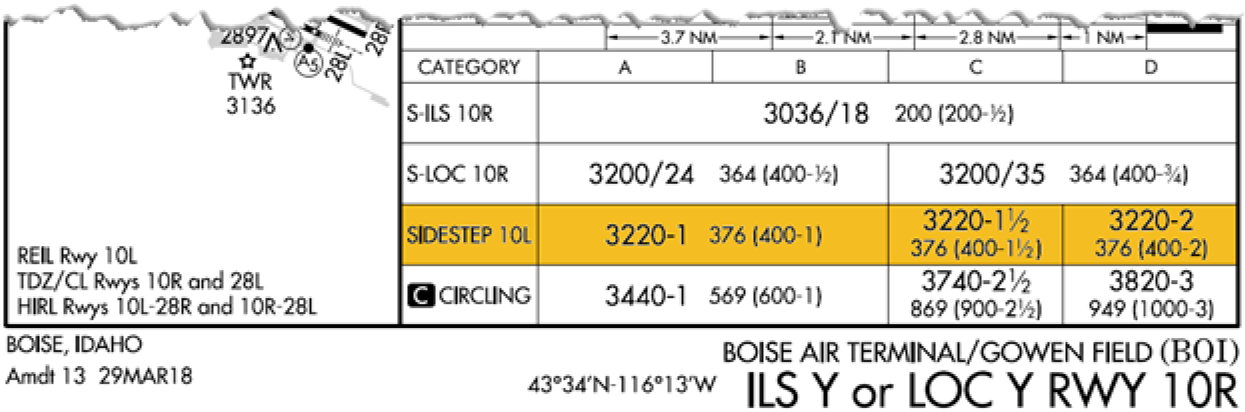
20.10.1. Pilots will not side-step without a published sidestep line of minima. **(T-0).**

20.10.2. Pilots are 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.

20.10.3. Side-step minimums are flown to a MDA regardless of the approach authorized.

20.10.4. Follow the missed approach specified for the approach procedure just flown unless otherwise directed by ATC if visual reference is lost during the maneuver. An initial climbing turn toward the landing runway ensures that the aircraft remains within the obstruction clearance area.

Figure 20.5. Published Side-Step Minimums.



2897 TWR 3136 28L 28R

REIL Rwy 10L
TDZ/CL Rwys 10R and 28L
HIRL Rwys 10L-28R and 10R-28L

	3.7 NM	2.1 NM	2.8 NM	1 NM
CATEGORY	A	B	C	D
S-ILS 10R	3036/18 200 (200-½)			
S-LOC 10R	3200/24 364 (400-½)		3200/35 364 (400-¾)	
SIDESTEP 10L	3220-1 376 (400-1)		3220-1½ 376 (400-1½)	3220-2 376 (400-2)
CIRCLING	3440-1 569 (600-1)		3740-2½ 869 (900-2½)	3820-3 949 (1000-3)

BOISE, IDAHO
Amdt 13 29MAR18

BOISE AIR TERMINAL/GOWEN FIELD (BOI)
43°34′N-116°13′W ILS Y or LOC Y RWY 10R

Chapter 21

MISSED APPROACH

21.1. General. When a landing cannot be accomplished, advise ATC and, upon reaching the missed approach point defined on the approach procedure chart, the pilot must comply with the missed approach instructions for the procedure being used or with an alternate missed approach procedure specified by ATC. References for this chapter are AIM 5-4-21 and 5-5-5, FAA-H-8083-16 **Chapter 4**, and ICAO Doc 8168V1 Part 1 Section 4 **Chapter 6**, unless otherwise noted.

21.2. ICAO Bank Angle. [ICAO Doc 8168V1 Table I-2-3-1] ICAO missed approach bank angle is 15 degrees average achieved or 3 degrees per second, whichever requires lesser bank.

21.3. Missed Approach Instructions. A clearance for an approach includes a clearance to fly the published missed approach on the instrument procedure, unless otherwise instructed by ATC.

21.3.1. Pilots must comply with the missed approach instructions for the procedure being flown or ATC-issued alternate missed approach instructions. **(T-0).**

21.3.2. ATC may vector an aircraft in accordance with **paragraph 5.22.1**.

21.3.3. Pilots must ensure that they have climbed to a safe altitude prior to proceeding off the published missed approach. **(T-0).**

21.3.4. Abandoning the missed approach procedure prior to reaching the published altitude may not provide adequate terrain clearance. An additional climb may be required after reaching the holding pattern before proceeding back to the IAF or to an alternate.

21.4. ATC Notification. [AIM 5-4-7] When executing a missed approach (i.e., when cleared to land and subsequently execute a missed approach or upon reaching the MAP and unable to continue) the pilot will notify ATC as soon as possible. **(T-0).** Request follow-on action clearance as time permits (e.g., clearance to an alternate airfield, another approach, or holding).

21.5. Missed Approach Airspeed. Comply with any published speed restrictions on the instrument procedure. The maximum ICAO missed approach speeds are shown in **Table 21.1** [ICAO Doc 8168V1].

21.5.1. The initial phase begins at the MAP and ends at the start of climb. This phase requires concentrated attention of the pilot on establishing the climb and the changes in airplane configuration. It is assumed that guidance equipment is not extensively utilized and no turns are specified in this phase.

21.5.2. The intermediate phase begins at the start of climb. The climb is continued, normally straight ahead. It extends to where 50 meters (164 feet) obstacle clearance is obtained and can be maintained. The intermediate missed approach track may be changed by a maximum of 15 degrees from that of the initial missed approach phase. During this phase it is assumed that the aircraft begins track corrections.

21.5.3. The final phase begins at the point where 50 meters (164 feet) obstacle clearance is first obtained and can be maintained; the final phase begins at the point where 40 meters (131 feet) obstacle clearance is first obtained and can be maintained for CAT H procedures. It extends to the point where a new approach, holding, or a return to enroute flight is initiated. Turns may be prescribed in this phase.

Table 21.1. ICAO Maximum Missed Approach Speed.

Aircraft Category	Maximum Speed for MAP (knots) Intermediate	Maximum Speed for MAP (knots) Final
A	100	110
B	130	150
C	160	240
D	185	265
E	230	275
H	90	90
CAT H (PinS)	70 or 90	70 or 90
CAT H (PinS) procedures based on basic GNSS may be designed using maximum speeds of 90 KIAS or 70 KIAS depending on operational need.		
Notes: 1) The minimum final approach speed considered for a CAT A aircraft is 70 knots. This is only critical when the missed approach point is specified by a distance from the FAF. In these cases, a slower speed when combined with a tailwind may cause the helicopter to reach the start of climb after the point calculated for CAT A aircraft. This reduces the obstacle clearance in the missed approach phase. 2) Conversely, a slower speed combined with a headwind could cause the helicopter to reach the missed approach point and any subsequent turn altitude before the point calculated for CAT A aircraft, and hence depart outside the protected area. 3) Therefore, for helicopters, speed should be reduced below 70 knots only after the visual references necessary for landing have been acquired and the decision has been made that an instrument missed approach procedure will not be departed.		

21.6. Turning Missed Approach. [ICAO Doc 8168 Volume 1 1-4-6] Turns in a missed approach procedure are only prescribed where terrain or other factors make a turn necessary.

21.7. RNAV Missed Approach. The missed approach waypoint for RNAV approaches without vertical guidance (i.e., LP and LNAV), is normally the runway threshold but may be located prior to the threshold, on or off runway centerline. RNAV approaches with vertical guidance (i.e., LPV and LNAV/VNAV) and GLS approaches utilize a DA.

21.7.1. RNAV missed approach procedures are RNAV 1 or RNP 1.

21.7.2. There are no RNP requirements for the missed approach if it is based on conventional means (e.g., VOR, DME, NDB, or dead reckoning, etc.).

21.7.3. RNAV missed approach holding waypoints are fly-over waypoints. If these waypoints are dual-use (i.e., the named waypoint has a different attribute on another procedure or enroute chart), then the waypoint may be depicted on the instrument procedure as a fly-by waypoint. This charting depiction (fly-by) versus aircraft display (fly-over) is an acceptable difference. Obstacle protection is still provided at the missed approach holding waypoint.

21.7.3.1. [ICAO Doc 9613; AC 90-105] The flight guidance mode should remain in LNAV when initiating a go-around or missed approach to enable display of deviation and positive course guidance during a missed approach RF leg. If the aircraft does not provide this capability, crew procedures must be used that assure the aircraft will adhere to the specified flightpath during the RF leg. **(T-0).** Pilots must be able to couple the autopilot or FD to the navigation system (i.e., engage LNAV) by 500 feet AGL during missed approach procedures that include an RF leg. **(T-0).**

21.7.4. [AIM 1-1-17] To execute a missed approach, activate the missed approach after crossing the missed approach waypoint. GPS missed approach procedures require pilot action to sequence from the missed approach waypoint to the missed approach procedure. If the missed approach is not activated, the GPS receiver displays an extension of the inbound final approach course and displayed distance increases from the missed approach waypoint. Once the missed approach is activated, CDI sensitivity is set to 1 nautical mile. 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 in accordance with aircraft flight manual procedures.

21.8. Radar Approaches. [AIM 5-4-11] Precision approach radar (PAR) approaches utilize a radar glide path to a DA to determine the MAP. ASR approaches utilize an MDA to the MAP. The pilot is advised of the location of the MAP procedure and is advised of the aircraft's position each mile from the runway, airfield, heliport or MAP, as appropriate. At locations where ATC radar service is provided, conform to radar vectors when provided by ATC in lieu of the published missed approach procedure.

21.9. CDFA Missed Approach Procedures. [ICAO Doc 8168v1 Ch 1.7.2.3]

21.9.1. If the visual references required to land have not been acquired when the aircraft is approaching the MDA, the climbing portion of the missed approach is initiated at an altitude above the MDA sufficient to prevent the aircraft from descending below the MDA. At no time is the aircraft flown in level flight at or near the MDA.

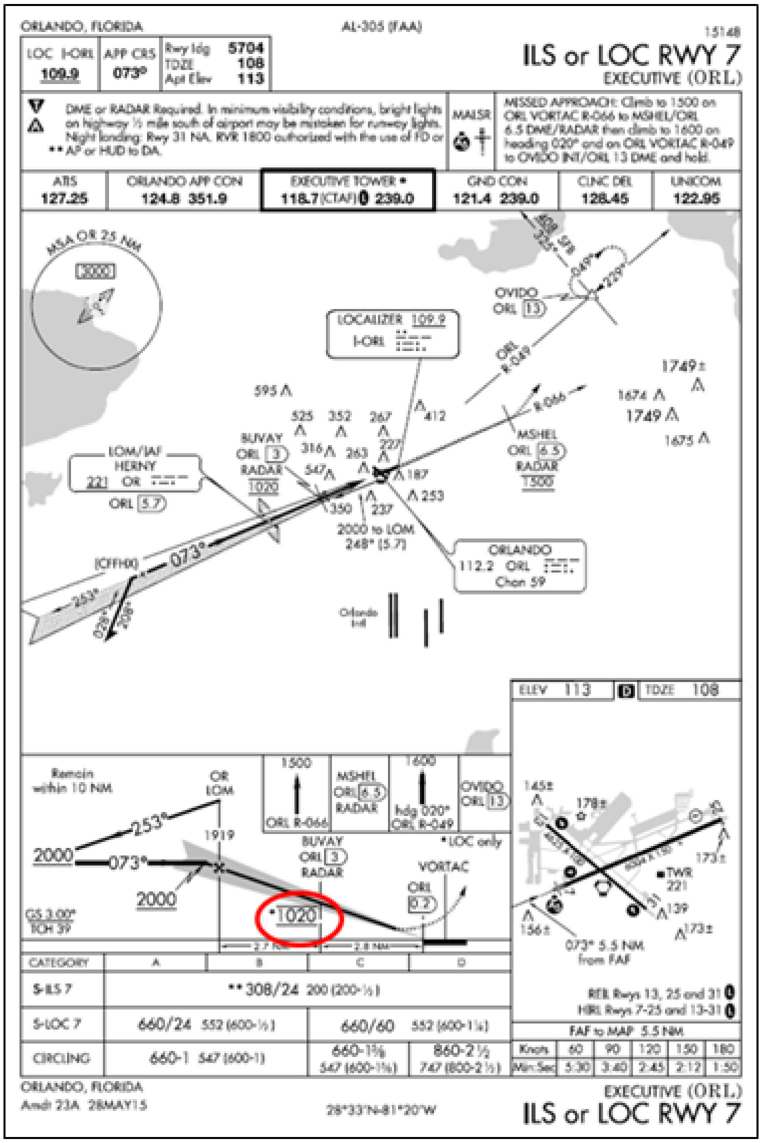
21.9.2. Depending upon the location of the MAP, the descent from the MDA, once the runway environment is in sight, often needs to be initiated prior to reaching the MAP to execute a normal (i.e., 3 degrees) descent to landing.

21.10. Early Missed Approach Initiation. When the missed approach is initiated prior to the MAP, the pilot will, unless otherwise cleared by ATC, fly the instrument procedure as specified on the approach plate, including altitude restrictions, to the MAP at or above the MDA, DA, or DH before executing the missed approach instructions. **(T-0).**

21.10.1. Any turns on the missed approach will not begin until the aircraft reaches the MAP; likewise, if the aircraft reaches the MAP before descending to the MDA, the missed approach will be initiated at the MAP. **(T-0).**

21.10.2. **Figure 21.1** is an example of an approach altitude restriction that would not permit an early climb should the pilot choose to initiate a missed approach prior to BUVAY. In this example, unless authorized by ATC, a missed approach initiated prior to BUVAY would still require the pilot to descend to the 1,020 feet altitude restriction at BUVAY prior to climbing due to overlying protected airspace for approach routes into Orlando International.

Figure 21.1. Early Missed Approach Restriction.



21.11. Delayed Missed Approach Decision. Obstacle clearance is the pilot's responsibility if the decision to execute a missed approach occurs beyond the MAP or below the MDA, DA, or DH. Contact ATC as soon as possible to obtain an amended clearance.

21.11.1. If unable to contact ATC for any reason, the pilot should attempt to re-intercept a published segment of the missed approach and comply with route and altitude instructions.

21.11.2. If unable to contact ATC, and in the pilot's judgment it is no longer appropriate to fly the published missed approach procedure, then consider either maintaining visual conditions if practicable and reattempt a landing, or a circle-climb over airfield. Executing a missed approach past the MAP at a location with high terrain may necessitate an excessive climb gradient and make intercepting the published MAP procedure impractical.

21.11.3. Continuous contact with an air traffic facility may not be possible when a missed approach becomes necessary while operating at an airfield that is not served by an operating control tower. The pilot should execute the appropriate missed approach procedure without delay and contact ATC when able to do so.

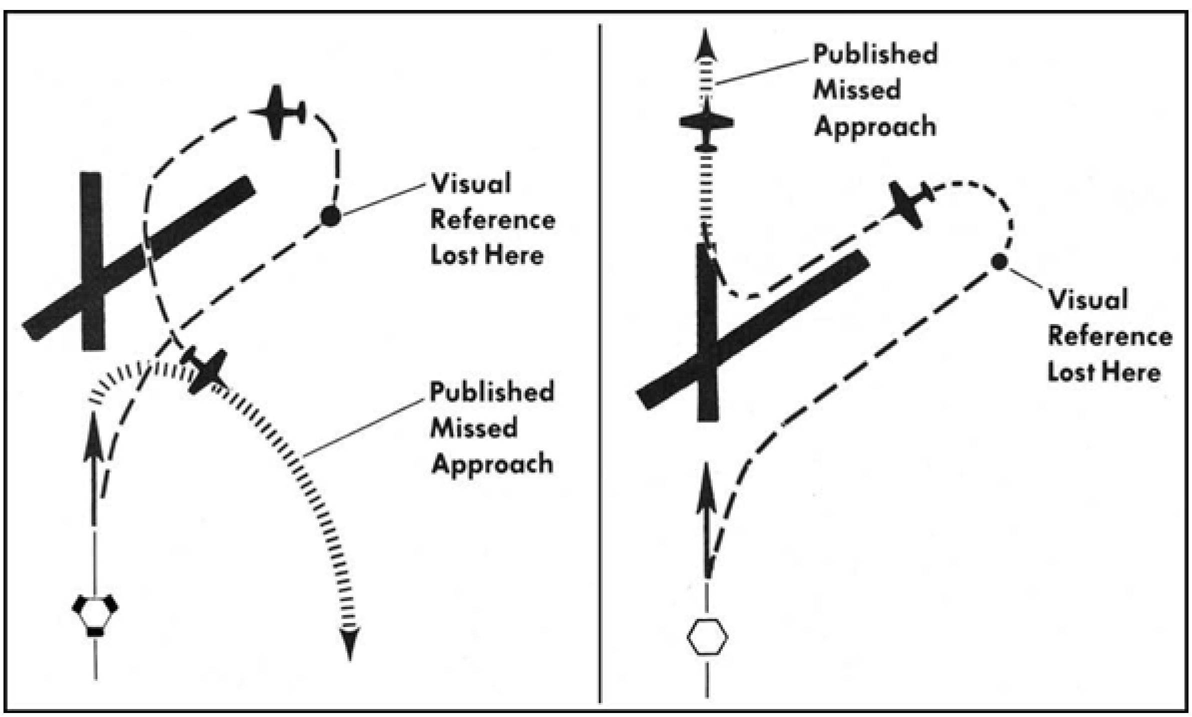
21.11.4. In all cases, prudent mission planning should be performed to consider geographical features, obstacles, restrictions, aircraft performance capabilities. The "Trouble T" section and departure procedures in the TPP are a good supplemental source of information for obstacle, takeoff visual climb requirements, and standard climb rate data not specifically expressed on the approach chart.

21.12. Loss of Visual Reference While Circling. [AIM 5-4-21 & ICAO Doc 8168v1 Part 1 Section 4 **Chapter 7**] If unable to maintain required visual references while circling or unable to make a safe landing, execute the missed approach specified for the instrument procedure just flown, unless otherwise directed. Transition from the circling maneuver to the missed approach by executing a climbing turn, within the protected circling area, towards the landing runway, returning to circling altitude or higher. Continue to turn until established on the missed approach course (**Figure 21.2**) or alternate missed approach instructions. An immediate climb must be initiated to ensure climb gradient requirements are met. **(T-0).**

21.12.1. (ICAO) A missed approach will be executed whenever the runway environment is not in sight during the circling maneuver. **(T-0).** The runway environment includes features such as the runway threshold, approach lighting aids, or other markings identifiable with the runway.

21.12.2. (NAS only) A missed approach will be executed whenever an identifiable part of the airfield is not distinctly visible to the pilot during a circling maneuver at or above MDA, unless the inability to see an identifiable part of the airfield results only from a normal bank of the aircraft during the circling maneuver. **(T-0).**

Figure 21.2. Missed Approach from the Circling Approach.



21.13. Training – Multiple Approaches. [FAA Order 7110.65] 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 terminates prior to beginning the approach. ATC climb-out instructions include a specific heading or a route of flight and altitude. The controller should state, "After completing low approach/touch-and-go, climb and maintain (altitude). Turn (left/right) heading (degrees)." Climb-out instructions may be omitted after the first approach if instructions remain the same.

Chapter 22

EXTREME LATITUDE NAVIGATION

22.1. General. Areas of Magnetic Unreliability (AMU) consist of two large areas of operation, centered around the earth's poles where unique features significantly complicate air navigation. The two major factors affecting navigation in the polar regions are magnetic variation and the convergence of true meridians at the poles.

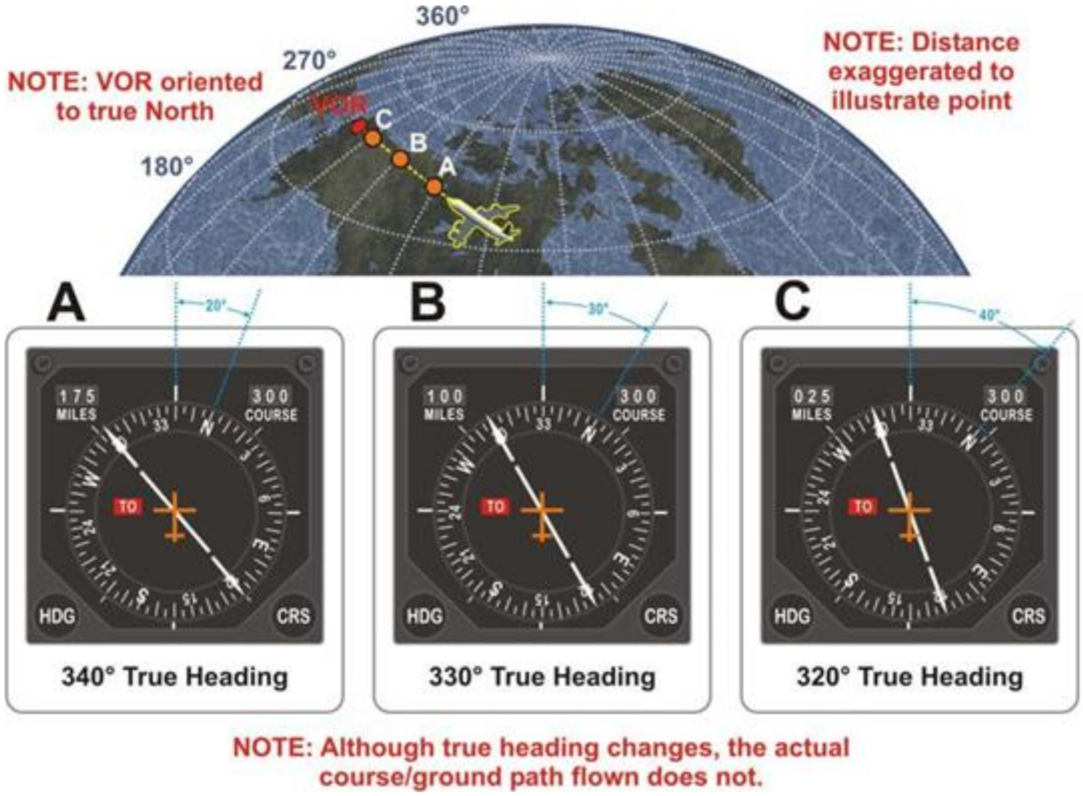
22.1.1. MAJCOMs will provide aircraft-specific operational approval and training prior to authorizing operations using NAVAIDs oriented to true or grid north. As a minimum, procedures and training should address: identification of areas where reference to true or grid north is required, procedures for 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.

22.1.2. Since the horizontal component of the Earth's magnetic field vanishes near the magnetic poles, magnetic compasses are highly unreliable and unusable in an area approximately 1,000 nautical miles from each magnetic pole. Within these areas, air navigation is further complicated by very rapid changes in magnetic variation over short distances as isogonic lines converge. For example, when flying between the magnetic north pole and the geographic North Pole, a heading of true north results in a magnetic heading of south (magnetic variation of 180).

22.1.3. Since the two major AMUs also occur near the geographic poles, the convergence of meridians also presents an additional navigation problem. When flying courses at the extreme latitudes (polar operations), convergence of the meridians can create rapid changes in true headings and true courses with small changes in aircraft position. While maintaining a course without turning, the true heading changes strictly based on the aircraft's relative position to the true pole as it crosses meridians. **Figure 22.1** provides a graphical depiction of how heading information changes in relation to the angular difference from true north as meridians are crossed. As a result, relatively small errors introduced can make determining the aircraft's actual position very difficult when trying to determine the proper heading to fly to maintain or correct back to the desired flight path. When even small errors occur, very large navigation errors can develop over extremely short distances.

22.1.4. Due to the combined effects of magnetic unreliability and the geographic convergence of meridians at acute angles, when flying in the polar regions, to navigate more precisely, a "grid" system was developed. Navigating in the AMU was also enhanced by the development of gyro driven heading indicators.

Figure 22.1. Heading Indications While Crossing Meridians.



22.2. Boundaries of the AMU.

22.2.1. The Canadian AIP establishes the basic boundaries for the Northern Hemisphere AMU. In general, this corresponds to Canadian Northern Domestic Airspace, and the entire Canadian Northern and Arctic Control Areas. AMUs are also depicted on Canadian enroute charts. The FAA refers to the Northern Hemisphere AMU as the "north polar area" and defines this region as all geographical areas and airspace located above 78 degrees north.

22.2.2. The FAA refers to the Southern Hemisphere AMU as the "south polar area" and defines this region as any area south of the 60 degrees south latitude.

22.3. Grid Operations. Grid navigation is a reorientation of the standard heading references and is used to offset the difficulties of trying to navigate in an AMU (north or south polar area) using conventional techniques and procedures. Grid navigation uses a set of parallel and perpendicular "green" lines depicted on most GNC and JNC charts and enables the aircrew to fly a constant grid heading while crossing rapidly changing longitudinal lines and contend with the erratic magnetic variations present in the AMU. The use of a grid heading, whether provided automatically by on board systems or manually calculated, provides a method upon which an aircrew can safely navigate in an AMU region. Most modern USAF aircraft incorporate a heading reference switch that allows the pilot to select between true, magnetic, or grid. With the heading reference selected to grid mode, the on board navigation systems should automatically switch to grid operations and update the navigation displays to reflect aircraft grid heading/position. In grid mode, the onboard navigation magnetic variation is automatically set to "0" (zero) and therefore magnetic heading is equal to true heading. The on-board system then applies a known correction (added or subtracted), based on the current longitudinal line to provide a grid heading for the pilot to fly.

22.3.1. There are several ways grid lines may be depicted on charts depending on the type of projection. For example, the polar grid chart is designed using the prime meridian as the base reference line of longitude. A grid heading is then calculated based on this standard reference.

22.3.2. To manually calculate a grid heading, the pilot needs to multiply the appropriate longitude with the chart's convergence factor (normally stated in the margin) and then add or subtract the aircraft true heading. The convergence factor is particular to the chart being used and is determined by the angle at which the "longitudinal line" cuts across the "grid" line. This angle is known as the convergence angle. In the Southern Hemisphere, the pilot adds "east longitudinal" lines and subtracts "west longitudinal" lines to calculate a grid heading. It is the opposite in the Northern Hemisphere (add "west longitude" and subtract "east longitude"). Since the convergence factor on the polar grid chart is equal to 1 (one), to obtain grid heading, the pilot adds or subtracts the longitudinal line to true heading. As an example, at McMurdo Station, the longitudinal line of the Pegasus Field (NZPG) runway is 167 "east;" therefore for any given true heading, adding 167 gives grid heading. Refer to AFPAM 11-216 for more details on grid navigation.

22.4. Definition of an Emergency in the AMU.

22.4.1. Many situations are considered an emergency regardless of geographic location. For example, engine failure is considered an emergency by most aircrews whether in or out of the AMU. When operating in the AMU, USAF directives require aircraft to be equipped with a heading source other than magnetic. However, there are situations (e.g., electrical power loss, gyro failure) where the heading source may become inoperative after entering the AMU. A simple gyro failure typically would not be considered an emergency outside the AMU, especially if an alternative means of navigation is available. This situation is dramatically different in the AMU where navigation options may be extremely limited, diversion airfields widely spaced, radar vectors are generally unavailable, weather conditions are less than optimal, and communications often unreliable. Any equipment failure in the AMU that leaves an aircrew with magnetic information as the sole source of heading information is typically considered an emergency.

22.4.2. The techniques outlined below are useful for emergency navigation should the true/grid heading source become inoperative or unreliable while operating in the AMU. Use of these techniques should be limited to emergency navigation to an alternate, the planned destination, or out of the AMU. They should not be used as normal navigation procedures for aircraft not equipped with a heading source other than magnetic.

22.4.2.1. In the unlikely event that all navigation systems become unavailable, reversion to manual navigation (i.e., dead reckoning) is required. Radar, NAVAIDs, or visual fixes may be available. Application of basic navigation principles ensures that the aircraft proceeds in a direction that at least approximates the desired track until more accurate navigation or a safe landing is possible. A thorough review of basic dead reckoning techniques and procedures is recommended prior to flight in the AMU, particularly without a navigator on board. The pilot should always have a backup dead reckoning plan ready for every flight in the AMU. **Note:** Accurately plotting the cleared flight path track on a suitable chart, along with frequent position checks, helps ensure the flight remains on course. This not only increases and maintains positional awareness but enables the pilot to make the transition to dead reckoning should one or more navigation systems fail.

22.4.2.2. If the aircraft has an additional heading reference system, the pilot may be able to operate the system in directional gyro mode and manually set the heading to coincide with the FMS, true, or inertial heading from the primary navigation source in accordance with flight manual instructions. This provides a backup true heading reference in case the primary navigation system fails. Update the heading periodically in accordance with the flight manual to correct for drift. **Note:** This technique is not acceptable for use as the primary means of navigation but is very useful as an emergency backup source of true heading information.

22.5. Using the VOR in the AMU.

22.5.1. Flight instrument indications and interpretation:

22.5.1.1. Because of problems associated with magnetic referenced navigation in the AMU, VOR navigation stations are aligned to true north in this area.

22.5.1.2. Flight instrument indications and interpretation for VORs in the AMU are different than for conventional VORs outside the AMU. This is due to convergence of the meridians and the fact that VOR radials are defined at the station, not at the aircraft. The VOR display does not provide a "relative bearing" to the VOR, it uses the received radial and displays it against that azimuth value on the horizontal situation indicator. At lower latitudes, the received radial matches the relative bearing to the station, so there appears to be no difference between them. In the AMU, it is quite likely that the VOR bearing pointer does not point at the station or even at the correct true bearing to the station. This is because the radial being sent out from the station is specific to true north from the station which is slightly different from true north seen at the aircraft.

22.5.1.3. True VOR radials, which are based on phase relationships formed at the VOR transmitter are decoded in the aircraft. The radial leaving the VOR station is based on the meridian (true north) location of the station, while at the aircraft, the VOR radial information is decoded and portrayed using a heading which is based on the meridian at the location of the aircraft, not the VOR station. The difference or apparent error seen on the instruments depends on the aircraft distance from the VOR and the convergence angle of the meridians involved. The difference seen become zero as the VOR station is crossed, where the station and aircraft meridians are the same.

22.5.1.4. Aligning the VORs to true north eliminates the magnetic variation problem and compass unreliability factors but does not eliminate the convergence angle problem.

22.5.2. Navigating TO the station:

22.5.2.1. To proceed direct to the station, center the CDI with an inbound bearing and make heading corrections as necessary to keep the CDI centered. Make heading corrections similar to wind corrections to maintain a desired track. Approaching the station, the true heading changes progressively until passing the station when it is the same as the CDI course (+/- wind drift). Reference the VOR indications versus the heading indications represented in **Figure 22.1**. Do not select magnetic heading references, stay in true heading. Do not turn to a true heading that places the bearing pointer at the top of the case and keep it there until the aircraft arrives over the station. Doing this would eventually get the aircraft to the station, but it would take the aircraft off the direct course.

22.5.3. Navigating FROM the station:

22.5.3.1. Making use of VOR bearing information in this case is the reverse of the paragraph above. Set the desired outbound radial and keep the CDI centered. The heading required to keep the CDI centered progressively diverges from the CDI course. If the outbound radial is not printed on the chart and outbound information is desired, draw a true north line from the station symbol, then plot a course line from the station and measure the course. Set that radial and keep it centered. This should not be relied upon as the primary means of navigation.

22.5.4. Using off-route true VORs to perform coast-in/out, and enroute accuracy checks:

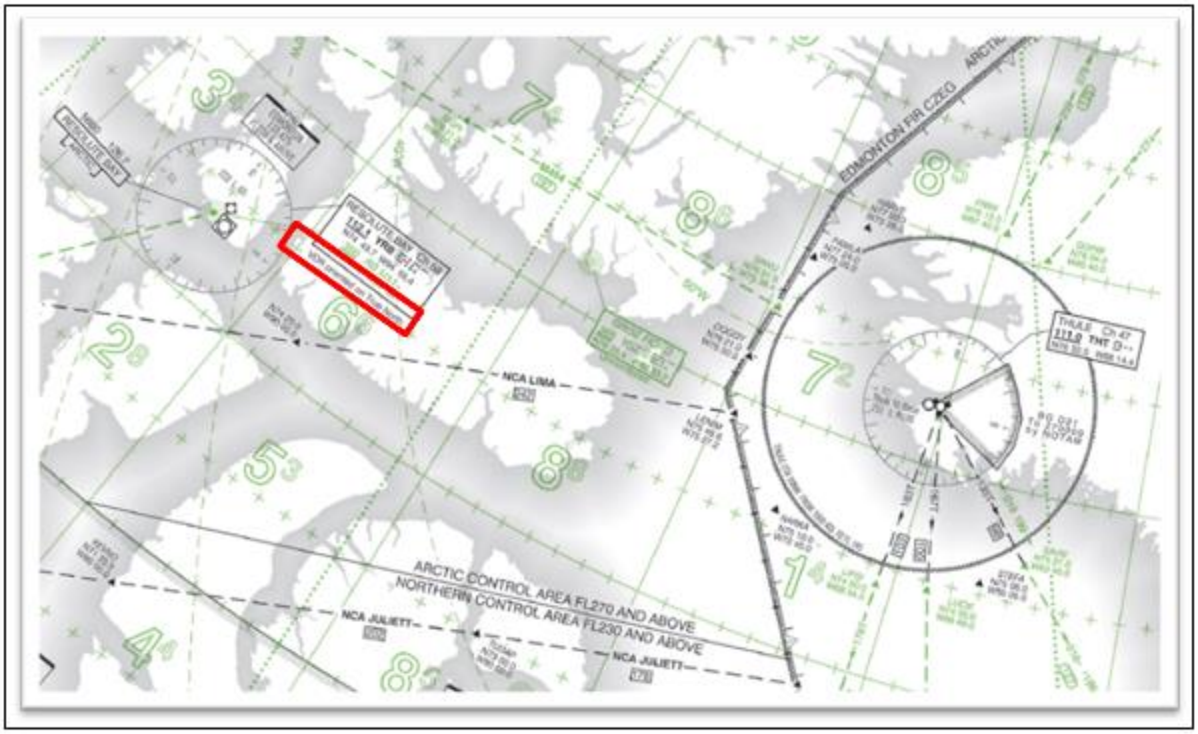
22.5.4.1. Interpreting bearing information from an off-route VOR station is somewhat involved. Plot a true north line from the station as a reference to draw the true radial or bearing that represents the centered CDI radial. Locate the aircraft’s position on this line using the DME indicated distance.

22.5.4.2. To check the FMS indicated true track to the station, plot a true north line from the plotted aircraft position and measure the true track back to the VOR station using the true north line at the aircraft location. This should match the indicated FMS true track. The FMS distance to the VOR station should match the DME indication.

22.6. Using an NDB in the AMU. Despite some inherent errors that may cause minor inaccuracies, the NDB offers an excellent source upon which to navigate from in the AMU since the basic operating principle remains unaffected. The automatic direction finder (ADF) needle simply points directly towards the NDB station. Even if the compass card and other navigation anomalies are occurring from operating in the AMU, the ADF needle points to a properly tuned and identified NDB station. This attribute of the NDB can greatly reduce some of the concerns experienced when dealing with the navigation complexities caused by the rapidly changing magnetic variation or meridian convergence at higher latitudes.

22.7. Enroute Navigation at 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 is essential to accurate navigation at higher latitudes. Refer to enroute charts for proper heading source and NAVAID orientation (**Figure 22.2**).

Figure 22.2. Enroute Charts for Navigation at Higher Latitudes.



22.7.1. Normally, navigation north of 70 degrees north latitude or south of 60 degrees 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.

22.7.1.1. There are areas officially designated AMU at extreme high and low latitudes. For areas north of 70 degrees north and south of 60 degrees south that are not officially designated as AMUs, MAJCOMs will determine the highest allowable latitude for aircraft capable of displaying only magnetic heading.

22.7.1.2. Although partly south of 70 degrees north, the entire Canadian Northern and Artic Control Areas and areas of Northern Domestic Airspace are designated as Areas of Magnetic Unreliability (**Figure 22.3**).

22.7.2. Aircraft navigation displays must be set to display true north prior to flying true headings or courses. **(T-2).** Suitably equipped aircraft may also use grid reference.

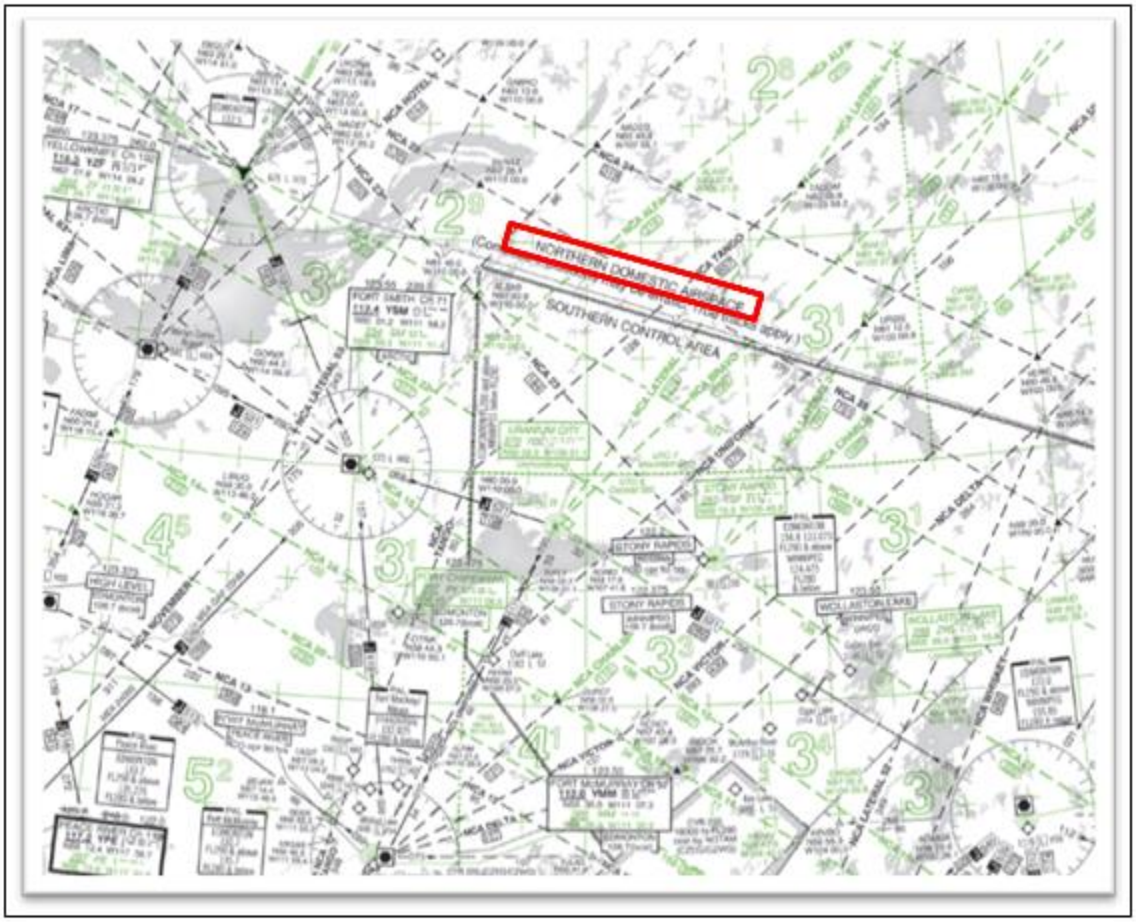
22.7.3. Outside of designated AMUs, aircraft unable to display true or grid heading may use NAVAIDs oriented to true north for enroute navigation provided procedures listed below are followed.

22.7.3.1. Aircraft navigation computers may automatically provide magnetic variation information. Accuracy of this magnetic variation depends on the period since the last magnetic variation update and aircraft system.

22.7.3.2. When true or grid heading information cannot be displayed, aircraft magnetic variation information must be verified with current aeronautical charts prior to use of area navigation equipment to fly true or grid courses. **(T-2).**

22.7.3.3. Consult the aircraft flight manual and MAJCOM guidance for specific procedures for navigation with reference to true or grid north.

Figure 22.3. Canadian Northern Control Area Boundaries.



22.8. True North Enroute Procedures.

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

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

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

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

22.8.1.2.2. Set the desired true course in the CDI. The aircraft CDI indicates deviations left and right of the desired true course. With magnetic heading displayed, the bearing pointer does not point to the station, but instead indicates true bearing to the station. Therefore, when established on course, the CDI is centered on the desired true course, but the bearing pointer indicates true bearing to the station and is displaced from aircraft no-wind heading by the amount of station magnetic variation. For example, the Thule magnetic variation was approximately 45 degrees west in 2015 (-0.86 degrees/year rate of change). When proceeding inbound on the Thule 180T radial (360T course), the aircraft no-wind heading is 060, while the bearing pointer points to 360T. This discrepancy between aircraft heading and desired course may make flight director guidance unreliable.

22.8.1.2.3. All headings require corrections for magnetic variation.

22.8.2. Unlike a VOR or TACAN, an NDB cannot be oriented to true north. ADF needles always display relative bearing to the station. Use the following procedures:

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

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

22.8.2.2.1. Aircrew should compute and fly the appropriate magnetic course by correcting the desired true course for the magnetic variation at the current aircraft location.

22.8.2.2.2. This correction should be updated at least every 5 degrees of magnetic variation or every 30 nautical miles, whichever occurs first.

22.9. Chart Reading in High Latitudes. Chart reading in high latitudes presents unique challenges. The nature of the terrain is significantly different, charts are less detailed and less precise, seasonal changes may alter the terrain appearance or hide it completely from view, and there are fewer cultural features.

22.9.1. In high latitudes, there are few distinguishable features from which to determine a position. Built-up features are practically nonexistent and the few that do exist are usually closely grouped, offering little help when flying long navigation legs. Natural features may be limited in variety and are difficult to distinguish from each other. Lakes can seem endless in number and identical in appearance. The countless coastal inlets are extremely difficult to identify. Recognizable, reliable checkpoints are few and far between.

22.9.2. Map reading in high latitudes is further complicated by inadequate charting. Some polar areas are yet to be thoroughly surveyed. The charts portray the appearance of general locales, but many individual terrain features are merely approximated or omitted entirely. In place of detailed outlines of lakes, for example, charts often carry the brief annotation, “Many lakes”.

22.9.3. When snow blankets the terrain from horizon to horizon, pilotage becomes acutely difficult. Coastal ice becomes indistinguishable from the land, coastal contours can change dramatically, and many inlets, streams, and lakes disappear. Blowing snow may extend to heights of 200 to 300 feet and may continue for several days, but visibility is usually excellent. However, when snow obliterates surface features and the sky is covered with a uniform layer of clouds so that no shadows are cast, the horizon disappears, causing earth and sky to blend together. This forms an unbroken expanse of white called whiteout. In this complete lack of contrast, distance and height above ground are virtually impossible to estimate. Whiteout is particularly prevalent in northern Alaska during late winter and spring. The continuous darkness of night presents another hazard; nevertheless, surface features are often visible because the snow is an excellent reflector of light from the moon, the stars, and the aurora.

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Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

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Adopted Forms

AF Form 679, *Air Force Publication Compliance Item Waiver Request/Approval*

AF Form 847, *Recommendation for Change of Publication*

Abbreviations and Acronyms

ABAS—Aircraft-Based Augmentation System

AC—Advisory Circular

ACES—Aeronautical Content Exploitation System

ACP—Actual Communication Performance

ADF—Automatic Direction Finder

ADIZ—Air Defense Identification Zone

ADS-B—Automatic Dependent Surveillance - Broadcast

AFFSA—Air Force Flight Standards Agency

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFPD—Air Force Policy Directive

AGL—Above Ground Level

AI—Attitude Indicator

AIM—Aeronautical Information Manual

AIP—Aeronautical Information Publication

ALSF—Approach Lighting System with Sequenced Flashing Lights

AMU—Area of Magnetic Unreliability

AP—Area Planning

APV—Approach with Vertical Guidance

AR—Authorization Required

ASDA—Accelerate-Stop Distance Available

ASR—Airport Surveillance Radar

ATC—Air Traffic Control

ATM—Air Traffic Management

ATS—Air Traffic Services

ATIS—Automatic Terminal Information Service

Baro-VNAV—Barometric Vertical Navigation

BC—Back Course

BDS—BeiDou Navigation Satellite System

CAT—Category

CDFA—Constant Descent Final Approach

CDI—Course Deviation Indicator

CFIT—Controlled Flight Into Terrain

CFR—Code of Federal Regulations

CTAF—Common Traffic Advisory Frequency

DA—Decision Altitude

DAIP—DoD Aeronautical Information Portal

DDA—Derived Decision Altitude

DER—Departure End of Runway

DH—Decision Height

DME—Distance Measuring Equipment

DP—Departure Procedure

DVA—Diverse Vector Area

DVFR—Defense Visual Flight Rules

DVOF—Digital Vertical Obstruction File

EGNOS—European Geostationary Navigation Overlay System

ERAA—Emergency Route Abort Altitude

ESA—Emergency Safe Altitude

ETA—Estimated Time of Arrival

EU—European Union

FAA—Federal Aviation Administration

FAF—Final Approach Fix

FCG—Foreign Clearance Guide

FD—Fault Detection

FDE—Fault Detection and Exclusion

FIH—Flight Information Handbook

FL—Flight Level

FLIP—Flight Information Publication

FMS—Flight Management System

FSS—Flight Service Station

FTE—Flight Technical Error

GAGAN – GPS and Geo—Augmented Navigation System

GBAS—Ground Based Augmentation System

GEO—Geostationary Earth Orbit

GLONASS—*Globalnaya Navigazionnaya Sputnikovaya Sistema*

GLS—GBAS Landing System

GNSS—Global Navigation Satellite System

GPS—Global Positioning System

FTIP—Foreign Terminal Instrument Procedure

HAA—Height Above Airfield

HAT—Height Above Touchdown

HMD—Helmet Mounted Display

Hg—Mercury

HILPT—Hold-In-Lieu-of Procedure Turn

HIRL—High Intensity Runway Lighting

HIWAS—Hazardous Inflight Weather Advisory Service

HPMA—High Performance Military Aircraft

hPa—Hectopascals

HUD—Head-Up-Display

IAF—Initial Approach Fix

ICAO—International Civil Aviation Organization

IF—Intermediate Fix

IFR—Instrument Flight Rules

IGS—Instrument Guidance System

ILS—Instrument Landing System

IM—Inner Marker

IMC—Instrument Meteorological Conditions

IR—IFR Military Training Routes

IRU—Inertial Reference Unit

ISA—International Standard Atmospheric

JNC—Jet Navigation Chart

JOG-A—Joint Operations Graphics-Air

KIAS—Knots Indicated Airspeed

LAAS—Local Area Augmentation System

LDA—Landing Distance Available

LDA—Localizer Type Directional Aid

LLZ—Localizer

LNAV—Lateral Navigation

LOC—Localizer

LP—Localizer Performance

LPV—Localizer Performance with Vertical Guidance

MAJCOM—Major Command

MALSR—Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights

MAP—Missed Approach Point

mbar—Millibars

MDA—Minimum Descent Altitude

MDS—Mission Design Series

MEA—Minimum Enroute Altitude

MEF—Maximum Elevation Figure

MHz—Megahertz

MIPS—Military Instrument Procedure Standardization

MM—Middle Marker

MOCA—Minimum Obstruction Clearance Altitude

MON—Minimum Operational Network

MSA—Minimum Sector Altitude

MSAS—Multi-function Satellite Augmentation System

MSL—Mean Sea Level

MTR—Military Training Route

MVA—Minimum Vectoring Altitude

N/A—Not Applicable

NA—Not Authorized

NAS—National Airspace System

NATO—North Atlantic Treaty Organization

NAVAID—Navigation Aid

NDB—Non-Directional Beacon

NGA—National Geospatial-Intelligence Agency

NM—Nautical Mile

NOTAM—Notice to Airmen

NPA—Non-precision Approach

NSA—National Security Area

NSE—Navigation System Error

NTAP—Notices to Airmen Publication

NTZ—No Transgression Zone

NVD—Night Vision Device

ODP—Obstacle Departure Procedure

OIS—Obstacle Identification Surface

OM—Outer Marker

ONC—Operational Navigation Chart

OPR—Office of Primary Responsibility

PANS-OPS—Procedures for Air Navigation Services-Aircraft Operations

PAR—Precision Approach Radar

PBCS—Performance-Based Communication and Surveillance

PBN—Performance-Based Navigation

PDE—Path Definition Error

PinS—Point-in-Space

PRM—Precision Runway Monitor

RA—Resolution Advisory

RAIM—Receiver Autonomous Integrity Monitoring

RCLS—Runway Centerline Light System

RCP—Required Communication Performance

REIL—Runway End Identifier Light

RF—Radius-To-Fix

RNAV—Area Navigation

RNP—Required Navigation Performance

RSP—Required Surveillance Performance

RTRL—Reduced Takeoff Runway Length

RVR—Runway Visual Range

RVSM—Reduced Vertical Separation Minimum

RWY—Runway

SARP—Standards and Recommended Practices

SBAS—Satellite-Based Augmentation System

SDCM—System for Differential Corrections and Monitoring

SDP—Special Departure Procedure

SID—Standard Instrument Departure

SOIA—Simultaneous Offset Instrument Approach

SR—Slow Speed Low Altitude Training Route

SSALR—Simplified Short Approach Lighting System with Runway Alignment Indicator Lights

STAR—Standard Terminal Arrival

SVFR—Special Visual Flight Rules

TA—Transition Altitude

TAA—Terminal Arrival Area

TAC—Terminal Area Chart

TACAN—Tactical Air Navigation

TCAS—Traffic Collision Avoidance System

TCH—Threshold Crossing Height

TCN—Terminal Change Notice

TDZ—Touchdown Zone

TDZE—Touchdown Zone Elevation

TERPS—Terminal Instrument Procedures

TFR—Temporary Flight Restriction

TLM—Topographic Line Map

TLv—Transition Level

TODA—Takeoff Distance Available

TORA—Takeoff Run Available

TPC—Tactical Pilotage Chart

TSE—Total System Error

TSO—Technical Standard Order

UNICOM—Universal Communications

USA—United States Army

USAF—United States Air Force

USN—United States Navy

VASI—Visual Approach Slope Indicator

VCOA—Visual Climb Over the Airport

VDA—Vertical Descent Angle

VDB—VHF Data Broadcast

VDP—Visual Descent Point

VFR—Visual Flight Rules

VGSI—Visual Glideslope Indicator

VHF—Very High Frequency

VMC—Visual Meteorological Conditions

VNAV—Vertical Navigation

VOR – VHF Omni—Directional Radio Range

VORTAC – VHF Omni—directional Range/Tactical Air Navigation

VPA—Vertical Path Angle

VR—VFR Military Training Route

VVI—Vertical Velocity Indicator

WAAS—Wide Area Augmentation System

WGS—World Geodetic Survey

Terms

Note—Refer to FLIP *General Planning* for a comprehensive list of industry standard terms.

Abeam—An aircraft is "abeam" a fix, point, or object when that fix, point, or object is approximately 90 degrees to the right or left of the aircraft track. Abeam indicates a general position rather than a precise point.

Airfield—An area on land or water that is used or intended to be used for the landing and takeoff of aircraft; includes its buildings and facilities, if any. The FAA term "airport" and the ICAO term "aerodrome" may be used interchangeably with airfield for the purposes of this instruction.

Airspace Concept—An airspace concept describes the intended operations within a defined airspace. Airspace concepts are developed to satisfy explicit strategic objectives such as improved safety, increased air traffic capacity, and mitigation of environmental impact. Airspace concepts can include details of the practical organization of the airspace and its users based on specific assumptions (e.g., route structure, separation minima) *[ICAO Doc 9613]*.

Air Traffic Control (ATC)—A service operated by appropriate authority to promote the safe, orderly and expeditious flow of air traffic *[AIM Pilot/Controller Glossary]*.

Aircraft Approach Category—Aircraft approach category is equal to the stall speed (V^{so}) multiplied by 1.3 or stall speed (V^{s1g}) multiplied by 1.23 in the landing configuration at the maximum certificated landing mass. If both V^{so} and V^{s1g} are available, the higher resulting speed is used *[ICAO Doc 8168 Volume 1]*.

Alternate Airfield—An airfield at which an aircraft may land if a landing at the intended airfield becomes inadvisable *[AIM Pilot/Controller Glossary]*.

Altimeter Setting—The barometric pressure reading used to adjust a pressure altimeter for variations in existing atmospheric pressure or to the standard altimeter setting (29.92) *[AIM Pilot/Controller Glossary]*.

Altitude—The height of a level, point, or object measured in feet AGL or MSL *[AIM Pilot/Controller Glossary]*.

Approach with Vertical Guidance (APV)—A term used to describe RNAV approach procedures that provide lateral and vertical guidance but do not meet the requirements to be considered a precision approach *[AIM Pilot/Controller Glossary]*.

Arc—The track over the ground of an aircraft flying at a constant distance from a NAVAID by reference to DME *[AIM Pilot/Controller Glossary]*.

Area Navigation (RNAV)—a method of navigation which permits aircraft operation on any desired flight path within the coverage of ground-based or space-based NAVAIDs or within the limits of the capability of self-contained aids, or a combination of these.

Bearing—The horizontal direction to or from any point, usually measured clockwise from true north, magnetic north, or some other reference point through 360 degrees *[AIM Pilot/Controller Glossary]*.

Civil Twilight—Defined to begin in the morning, and end in the evening when the center of the Sun is geographically 6 degrees below the horizon *[U.S. Naval Observatory]*.

Controlled Flights—ICAO definition for any flight which is subject to an air traffic control clearance.

Decision Altitude (DA)—A specified barometric altitude (MSL) on an instrument approach procedure (ILS, GLS, vertically guided RNAV) at which the pilot decides whether to continue the approach or initiate an immediate missed approach if the pilot does not see the required visual references *[AIM Pilot/Controller Glossary]*.

Decision Height (DH)—With respect to the operation of aircraft, means the height at which a decision is made during an ILS or PAR instrument approach to either continue the approach or to execute a missed approach. Decision height is referenced to the threshold elevation (e.g., radar altimeter) *[AIM Pilot/Controller Glossary]*.

Departure Procedure (DP)—A preplanned IFR departure procedure published for pilot use, in graphic or textual format, that provides obstruction clearance from the terminal area to the appropriate enroute structure. There are two types of departure procedures: ODP which are printed textually or graphically, and SID which are printed graphically *[AIM Pilot/Controller Glossary]*.

Diverse Departure—If the airfield has at least one published approach, the absence of any non-standard takeoff minimums or IFR departure procedures for a specific runway normally indicates that runway meets diverse departure criteria.

Diverse Vector Area—In a radar environment, that area in which a prescribed departure route is not required as the only suitable route to avoid obstacles. The area in which random radar vectors below the MVA or minimum IFR altitude, established in accordance with the criteria for diverse departures, obstacles and terrain avoidance, may be issued to departing aircraft *[AIM Pilot/Controller Glossary]*.

Fault Detection and Exclusion (FDE)—A function performed by some GNSS receivers, which can detect the presence of a faulty satellite signal and exclude it from the position calculation *[ICAO Doc 9613]*.

Final Approach Course—A bearing, radial, or track of an instrument approach leading to a runway or an extended runway centerline all without regard to distance *[AIM Pilot/Controller Glossary]*.

Final Approach Fix (FAF)—The fix from which the final approach to an airfield is executed and which identifies the beginning of the final approach segment. It is designated on U.S. Government charts by the "Maltese Cross" symbol for non-precision approaches and the "lightning bolt" symbol for precision approaches; or when ATC directs a lower-than-published glide path or vertical path intercept altitude, it is the resultant actual point of the glide path or vertical path intercept *[AIM Pilot/Controller Glossary]*.

Fix—A geographical position determined by visual reference to the surface, by reference to one or more radio NAVAIDs, by celestial plotting, or by another navigation device *[AIM Pilot/Controller Glossary]*.

Flight Management System (FMS)—A computer system that uses a large data base to allow routes to be preprogrammed and fed into the system by means of a data loader. The system is constantly updated with respect to position accuracy by reference to conventional NAVAIDs. The sophisticated program and its associated data base ensures that the most appropriate aids are automatically selected during the information update cycle *[AIM Pilot/Controller Glossary]*.

Global Navigation Satellite System (GNSS)—GNSS refers collectively to the worldwide positioning, navigation, and timing determination capability available from one or more satellite constellations in conjunction with a network of ground stations *[AIM Pilot/Controller Glossary]*.

Ground Based Augmentation System (GBAS)—A ground based GNSS station which provides local differential corrections, integrity parameters and approach data via VHF data broadcast to GNSS users to meet real-time performance requirements for precision approaches. The aircraft applies the broadcast data to improve the accuracy and integrity of its GNSS signals and computes the deviations to the selected approach. A single ground station can serve multiple runway ends up to an approximate radius of 23 nautical miles *[AIM Pilot/Controller Glossary]*.

Height Above Touchdown (HAT)—The height of the Decision Height or Minimum Descent Altitude above the highest runway elevation in the touchdown zone (first 3,000 feet of the runway). HAT is published on instrument approach charts in conjunction with all straight-in minimums *[AIM Pilot/Controller Glossary]*.

Inner Marker (IM)—A marker beacon used with a CAT II ILS precision approach located between the middle marker and the end of the ILS runway, transmitting a radiation pattern keyed at six dots per second and indicating aurally and visually that the pilot is at the designated DH, normally 100 feet above the touchdown zone elevation, on the ILS CAT II approach. It also marks progress during a CAT III approach *[AIM Pilot/Controller Glossary]*.

Instrument Approach—A series of predetermined maneuvers for the orderly transfer of an aircraft under instrument flight conditions from the beginning of the initial approach to a landing or to a point from which a landing may be made visually *[AIM Pilot/Controller Glossary]*.

Instrument Flight Rules (IFR)—Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate type of flight plan *[AIM Pilot/Controller Glossary]*.

Instrument Meteorological Conditions (IMC)—Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling less than the minima specified for visual meteorological conditions *[AIM Pilot/Controller Glossary]*.

Intermediate Fix (IF)—The fix that identifies the beginning of the intermediate approach segment of an instrument approach procedure *[AIM Pilot/Controller Glossary]*.

International Civil Aviation Organization (ICAO)—A United Nations Specialized Agency, established by Nation States in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention). ICAO works with the Convention's 192 Member Nation States and industry groups to reach consensus on international civil aviation SARPs and policies in support of safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector.

Kollsman Window—A barometric scale window of a sensitive altimeter used to adjust the altitude for the altimeter setting *[FAA-H-8083-25]*.

Lateral Navigation (LNAV)—A function of area navigation equipment which calculates, displays, and provides lateral guidance to a profile or path *[AIM Pilot/Controller Glossary]*.

Low Close-in Obstacles—Obstacles that require a climb gradient greater than 200 feet per nautical mile to an altitude of 200 feet or less above the DER *[FAA Order 8260.46]*.

Marker Beacon—An electronic navigation facility transmitting a 75 MHz vertical fan or boneshaped radiation pattern. Marker beacons are identified by their modulation frequency and keying code, and when received by compatible airborne equipment, indicate aurally and visually that the pilot is passing over the facility *[AIM Pilot/Controller Glossary]*.

Minimum Descent Altitude (MDA)—The lowest altitude, expressed in feet above mean sea level, to which descent is authorized on final approach or during circle-to-land maneuvering in execution of a standard instrument approach procedure where no electronic glideslope is provided *[AIM Pilot/Controller Glossary]*.

Mode S—A secondary surveillance radar process that allows selective interrogation of aircraft according to the unique 24-bit address assigned to each aircraft *[ICAO Annex 10]*.

Mountainous Terrain—ICAO PANS-OPS defines mountainous terrain as an area over which the changes of surface elevation exceed 900 meters (3,000 feet) within a distance of 18.5 kilometers (10.0 nautical miles). Defined in 14 CFR §95.11 for the NAS.

National Airspace System (NAS)—The common network of U.S. airspace; air navigation facilities, equipment and services, airfields or landing areas; aeronautical charts, information and serviced; rules regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military *[AIM Pilot/Controller Glossary]*.

NAVAID Infrastructure—Refers to the ground-based and space-based NAVAIDs available to meet requirements in the navigation specification *[ICAO Doc 9613]*.

Navigation Aid (NAVAID)—Any visual or electronic device airborne or on the surface which provides point-to-point guidance information or position data to aircraft in flight *[AIM Pilot/Controller Glossary]*.

Navigation Application—The application of a navigation specification and the supporting NAVAID infrastructure, to routes, procedures, and defined airspace volume in accordance with the intended airspace concept *[ICAO Doc 9613]*.

Navigation Specification—A set of aircraft and aircrew requirements needed to support PBN operations within a defined airspace. There are two kinds of navigation specification: RNAV specifications and RNP specifications *[ICAO Doc 9613]*.

Night—The time between the end of evening civil twilight and the beginning of morning civil twilight, as published in the *Air Almanac*, converted to local time *[AIM Pilot/Controller Glossary]*.

Non-precision Approach—An instrument approach based of a navigation system which provides course deviation but no glide path deviation information (e.g., VOR, NDB, LNAV) *[AIM Pilot/Controller Glossary]*.

Notice to Airmen (NOTAM)—A notice containing information (not known sufficiently in advance to publicize by other means) concerning the establishment, condition, or change in any component (facility, service, or procedure of, or hazard in the NAS) the timely knowledge of which is essential to personnel concerned with flight operations *[AIM Pilot/Controller Glossary]*.

Obstacle—An existing object, object of natural growth, or terrain at a fixed geographical location or which may be expected at a fixed location within a prescribed area with reference to which vertical clearance is provided during flight operation *[AIM Pilot/Controller Glossary]*.

Obstacle Clearance—The margin of altitude between the obstacle and the procedure design criteria path.

Obstacle Departure Procedure (ODP)—A preplanned IFR departure procedure printed for pilot use in textual or graphic form to provide obstruction clearance via the least onerous route from the terminal area to the appropriate enroute structure *[AIM Pilot/Controller Glossary]*.

Obstacle Identification Surface (OIS)—An inclined or level surface associated with a defined area for obstruction evaluation *[FAA Order 8260.3]*.

Oceanic Airspace—Airspace over the oceans of the world, considered international airspace, where oceanic separation and ICAO procedures are applied. Responsibility for the provisions of air traffic control service in this airspace is delegated to various Nation States based generally upon geographic proximity and availability of required resources *[AIM Pilot/Controller Glossary]*.

Outer Marker (OM)—A marker beacon at or near the glideslope intercept altitude of an ILS approach *[AIM Pilot/Controller Glossary]*.

Performance-based Navigation (PBN)—Area navigation based on performance requirements for operating along an air traffic route, on an instrument procedure, or in a designated airspace *[ICAO Doc 9613]*.

Precision Approach—An instrument approach based on a navigation system that provides course and glide path deviation information meeting the precision standards of ICAO Annex 10 (i.e., PAR, ILS, and GLS) *[AIM Pilot/Controller Glossary]*.

Precision Runway Monitor (PRM) Approach—An approach conducted to parallel runways separated by less than 4,300 feet and the parallel runways have a precision radar monitoring system that permits simultaneous independent instrument approaches.

Procedure Turn—The maneuver prescribed when it is necessary to reverse direction to establish an aircraft on the intermediate approach segment or final approach course. The outbound course, direction of turn, distance within which the turn is to be completed, and minimum altitude are specified in the procedure. However, unless otherwise restricted, the point at which the turn may be commenced and the type and rate of turn are left to the discretion of the pilot *[AIM Pilot/Controller Glossary]*.

QFE—Atmospheric pressure at airfield elevation (or at runway threshold) *[ICAO Doc 8168V1]*.

QNE—The barometric pressure used for the standard altimeter setting (29.92 inches Hg) *[AIM Pilot/Controller Glossary]*.

QNH—The barometric pressure as reported by a particular station *[AIM Pilot/Controller Glossary]*.

Radar—A device which, by measuring the time interval between transmission and reception of radio pulses and correlating the angular orientation of the radiated antenna beam or beams in azimuth or elevation, provides information on range, azimuth, or elevation of objects in the path of the transmitted pulses *[AIM Pilot/Controller Glossary]*.

Radar Required—A term displayed on charts and approach plates and included in FDC NOTAMs to alert pilots that segments of either an instrument approach or a route are not navigable because of either the absence or unusability of a NAVAID.

Receiver Autonomous Integrity Monitoring (RAIM)—A technique whereby a civil GNSS receiver determines the integrity of the GNSS navigation signals without reference to sensors or non-DoD integrity systems other than the receiver itself. This determination is achieved by a consistency check among redundant pseudorange measurements *[AIM Pilot/Controller Glossary]*.

Reduced Vertical Separation Minimum (RVSM)—RVSM airspace is where air traffic control separates aircraft by a minimum of 1,000 feet vertically between FL290 and FL410 inclusive *[FAA-H-8083-16]*.

Relief—A means of graphically portraying important topographic features ranging from ridge lines, canyons and peaks in rugged terrain to isolated sharply rising hills in areas of flat terrain.

Reporting Point—A geographical location in relation to which the position of an aircraft is reported *[AIM Pilot/Controller Glossary]*.

Required Navigation Performance (RNP)—A statement of the navigation performance necessary for operation within a defined airspace *[AIM Pilot/Controller Glossary]*.

RNAV Approach—An instrument approach procedure which relies on aircraft area navigation equipment for navigation guidance *[AIM Pilot/Controller Glossary]*.

RNAV Operations—Operations using area navigation for RNAV applications *[ICAO Doc 9613]*.

RNAV System—Navigation system which permits aircraft operation on any desired flight path within the coverage of station-referenced NAVAIDs or within the limits of the capability of self-contained aids, or a combination of these. An RNAV system may be included as part of an FMS *[ICAO Doc 9613]*.

RNP APCH—RNP APCH has a lateral approach accuracy of 1 nautical mile in the terminal and missed approach segments and scales to 0.3 nautical miles in the final approach. "RNAV (GPS)" is equivalent to "RNP APCH" *[AIM 1-2-2; ICAO Doc 9613]*.

RNP AR APCH—RNP AR APCH capability requires specific aircraft performance, design, operational processes, and specific procedure design criteria to achieve the required target level of safety. RNP AR APCH has lateral accuracy values that can range below 1 nautical mile in the terminal and missed approach segments and scale to RNP 0.3 or lower in the final approach. "RNAV (RNP)" is equivalent to "RNP AR APCH" *[AIM 1-2-2; ICAO Doc 9613]*.

RNP Operations—Operations using an RNP system for RNP navigation applications *[ICAO Doc 9613]*.

RNP System—Area navigation system which supports on-board performance monitoring and alerting *[ICAO Doc 9613]*.

Runway Visual Range (RVR)—The range over which the pilot of an aircraft on the centerline of a runway can see the runway surface markings or the lights delineating the runway or identifying its centerline *[AIM Pilot/Controller Glossary]*.

Smooth Flight—An academic concept taught throughout a pilot's career and is found throughout industry technical handbooks. Used in this AFMAN only to highlight that maneuvering an aircraft with reference to the onboard instruments is a skill to be mastered.

Special Departure Procedure (SDP)—Aircraft-specific commercially designed and published procedures that require MAJCOM training and certification before use.

Standard Instrument Departure (SID)—A preplanned IFR departure procedure printed in graphic form to provide obstacle clearance and a transition from the terminal area to the appropriate enroute structure *[AIM Pilot/Controller Glossary]*.

Standard Rate Turn—A turn of three degrees per second *[AIM Pilot/Controller Glossary]*.

Standard Terminal Arrival (STAR)—A preplanned IFR arrival procedure published graphic *[AIM Pilot/Controller Glossary]*.

Stepdown Fix—A fix permitting additional descent within a segment of an instrument approach procedure by identifying a point at which a controlling obstacle has been safely overflown *[AIM Pilot/Controller Glossary]*.

Stopway—An area beyond the takeoff runway no less wide than the runway and centered upon the extended centerline of the runway, able to support the airplane during an aborted takeoff, without causing structural damage to the airplane, and designated by the airfield authorities for use in decelerating the airplane during an aborted takeoff *[AIM Pilot/Controller Glossary]*.

Tactical Air Navigation (TACAN)—An ultra-high frequency electronic rho-theta air navigation aid which provides suitably equipped aircraft a continuous indication of bearing and distance to the TACAN station *[AIM Pilot/Controller Glossary]*.

Terminal Area—A general term used to describe airspace in which approach control service or airfield traffic control service is provided *[AIM Pilot/Controller Glossary]*.

Threshold Crossing Height (TCH)—The theoretical height above the runway threshold at which the aircraft's glideslope antenna would be if the aircraft maintains the trajectory established by the mean ILS glideslope or the altitude at which the calculated glide path of an RNAV or GPS approaches *[AIM Pilot/Controller Glossary]*.

Touchdown Zone Elevation (TDZE)—The highest elevation in the first 3,000 feet of the landing surface *[AIM Pilot/Controller Glossary]*.

Traffic Collision Avoidance System (TCAS)—An airborne collision avoidance system based on radar beacon signals which operates independent of ground-based equipment.

Transponder—The airborne radar beacon receiver/transmitter portion of the Air Traffic Control Radar Beacon System (ATCRBS) which automatically receives radio signals from interrogators on the ground, and selectively replies with a specific reply pulse or pulse group only to those interrogations being received on the mode to which it is set to respond *[AIM Pilot/Controller Glossary]*.

Unreliable Relief—Source materials are insufficient to show a complete illustration of relief.

Vertical Navigation (VNAV)—A function of area navigation equipment which calculates, displays, and provides vertical guidance to a profile or path *[AIM Pilot/Controller Glossary]*.

Very High Frequency (VHF)—The frequency band between 30 and 300 MHz. Portions of this band, 108 to 118 MHz, are used for certain NAVAIDs; 118 to 136 MHz are used for civil air/ground voice communications *[AIM Pilot/Controller Glossary]*.

Visual Descent Point (VDP)—A defined point on the final approach course of a non-precision straight-in approach procedure from which normal descent from the MDA to the runway touchdown point may be commenced, provided the approach threshold of that runway, or approach lights, or other markings identifiable with the approach end of that runway are clearly visible to the pilot *[AIM Pilot/Controller Glossary]*.

Visual Flight Rules (VFR)—Rules that govern the procedures for conducting flight under visual conditions. The term "VFR" is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, it is used by pilots and controllers to indicate type of flight plan *[AIM Pilot/Controller Glossary]*.

Visual Meteorological Conditions (VMC)—Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than specified minima *[AIM Pilot/Controller Glossary]*.

Vortices—Circular patterns of air created by the movement of an airfoil through the air when generating lift. As an airfoil moves through the atmosphere in sustained flight, an area of low pressure is created above it. The air flowing from the high pressure area to the low pressure area around and about the tips of the airfoil tends to roll up into two rapidly rotating vortices, cylindrical in shape. These vortices are the most predominant parts of aircraft wake turbulence and their rotational force is dependent upon the wing loading, gross weight, and speed of the generating aircraft. The vortices from medium to super aircraft can be of extremely high velocity and hazardous to smaller aircraft *[AIM Pilot/Controller Glossary]*.

Wake Turbulence—Phenomena resulting from the passage of an aircraft through the atmosphere. The term includes vortices, thrust stream turbulence, jet blast, jet wash, propeller wash, and rotor wash both on the ground and in the air *[AIM Pilot/Controller Glossary]*.

World Geodetic Survey-1984 (WGS-84)—Developed by the U.S. for world mapping, WGS 84 is the ICAO standard for an earth fixed global reference frame.

Attachment 2

THE "60-TO-1 RULE"

What is the "60-to-1 rule"?

The 60-to-1 Rule is a technique for determining the pitch attitude or pitch change required to satisfy a climb/descent gradient. It is also a technique used to determine lateral displacement in "degrees" for course interceptions and offset computations.

1. It allows the pilot to compute the pitch attitude when ESTABLISHING an attitude during the CONTROL AND PERFORMANCE procedure.
2. It reduces the pilot's workload and increases efficiency by requiring fewer changes and less guess work.
3. It gives an alternative to the "TLAR" (that looks about right) method of instrument flying.
4. You can teach the "60-to-1 RULE" as opposed to trying to teach experience, as in the "TLAR" method.

Simply stated the "60-to-1" rule is:

1° = 1 NM at 60 NM
or
1° = 100 Ft at 1 NM

Let's look at relationship. First look at a circle with a 60 NM radius.

We know that the circumference of a circle is $2\pi r$, therefore the mathematical data supporting this:

Circumference = 2 x 3.1416 x 60
= <u>376.99 NM</u>

Since there are 360° in a circle, we can determine the length of a 1° arc:
376.99 NM / 360° = 1.05 NM per Degree or, approximately 1 NM per degree at 60 NM

Since 1 NM = 6076 Ft or about 6000 Ft,
1° = 6000 Ft at 60 NM

This relationship is true not only in the horizontal plane, but also in the vertical plane. If this 1° = 6000 Ft at 60 NM relationship is drawn in the form of a vertically inclined plane and the height of the plane is measured at different points, you can see that there is a definite relationship between the height of the 1° plane and the distance from the apex of the 1° angle. The height of the plane at 1 NM is 100 Ft, therefore,

This relationship is constant. If the distance (NM) or the angle is changed, the altitude (Ft) is changed by the same factor.

That is,

1° = 100 Ft at 1 NM
or
1° = 100 Ft/NM

At 1 NM, 3° = 300 Ft

At 10 NM, 3° = 3000 Ft etc.

In this relationship, 1° = 100 Ft/NM, if the distance is changed, multiply the altitude by the same factor. If the angle is changed, multiply the altitude by the same factor. If both the distance and the angle are changed, multiply the altitude by both factors.
Notice that in the discussion of the mathematical data, there has been no mention of aircraft type or speed.
Speed has no effect on the 1° = 100 Ft/NM relationship! Look at the following Example.

An O-1 at 60 KTAS and an F-15 at 180 KTAS over a 10 NM distance on a 300 Ft/NM descent gradient (3° pitch change from level flight

[a] How many Ft/NM will the O-1 travel?
Answer: 300
[b] How many Ft/NM will the F-15 travel?
Answer: 300

Both aircraft fly the same descent gradient since their pitch changes are the same. Speed has no effect!

Before we discuss how a rate of descent, Ft/Min, can be derived from a pitch change or descent gradient, aircraft speed must be expressed in Nautical Miles per Minute (NM/Min)

From TAS: **NM/Min = $\frac{TAS}{60}$**

If TAS is 420, NM/Min = $\frac{420}{60}$ = 7 NM/Min

From MACH number: **NM/Min = MACH x 10**
If MACH is .7, NM/Min = .7 x 10 = 7 NM/Min

This relationship is true when 600 NM/Hr is the speed of sound. Since it's always close, MACH can be used to approximate NM/Min. NM/Min can be determined from IAS by converting IAS to TAS. There are two methods available:

a. **TAS = IAS + IAS x (2% per) 1000'**
If IAS is 250 and altitude is FL 200
TAS = 250 + 250 x (.02 x 20)
= 250 + 250 x .4
= 250 + 100 KIAS = 350

b. **TAS = IAS + $\frac{\text{Flight Level}}{2}$**
= 250 + 100 KIAS = 350

Now from the example above:
NM/Min = $\frac{350}{60}$ = 5.8 or 6 NM/Min

Now back to the O-1 and the F-15:

The O-1 at 60 KTAS is traveling at 1 NM/Min
The F-15 at 180 KTAS is traveling at 3 NM/Min
How long will it take each aircraft to travel the 10 NM in the example? O-1 at 1 NM/Min takes 10 Min, F-15 at 3 NM/Min takes 3.3 Min.

What will each aircraft's VVI be indicating during the 3000 Ft descent?

O-1's VVI = $\frac{3000\text{ Ft}}{10\text{ Min}}$ = 300 Ft/Min
F-15's VVI = $\frac{3000\text{ Ft}}{3.3\text{ Min}}$ = 900 ft/Min

By restating some previous facts, a relationship between Pitch, Gradient and VVI is clear.

(1) The O-1 is traveling at 1 NM/Min and its VVI is indicating 300 Ft/Min for a 300 Ft/NM gradient or 3° pitch change. (Remember 1° = 100 Ft/NM)
(2) The F-15 is traveling at 3NM/Min and its VVI is indicating 900 Ft/Min for a 300 Ft/NM gradient or 3° pitch change.

VVI = NM/Min x Ft/NM
or
The VVI for each 1° of pitch change is equal to speed in NM/Min x 100 Ft/NM.

Example: An aircraft makes a 6° pitch change from level flight (it establishes a 600 Ft/NM climb/descent gradient). What does the VVI indicate if the speed is .8 MACH?

NM/Min = .8 x 10 = 8 NM/Min
VVI = 8 NM/Min x 600 Ft/NM
VVI = 4800 Ft/Min

Practical Applications

1. You're climbing at 285 KIAS (.6 MACH) and 3000 Ft/Min. What pitch change do you make to level off?

$$\frac{3000 \text{ Ft/Min}}{6 \text{ NM/Min}} = 500 \text{ Ft/NM} = 5°$$

2. ARTCC tells you to climb to FL 250 and be at FL 250 in 10 NM. You're currently at FL 200 and are indicating .6 MACH. What minimum pitch change is necessary, what should your VVI indicate, and can you make it?

$$\frac{5000 \text{ Ft}}{10 \text{ NM}} = 500 \text{ Ft/NM} = 5°$$

6 NM/Min x 500 Ft/NM = 3000 Ft/Min

Whether you make it or not depends upon your aircraft's performance capability, but at least you know what you need to establish to make it.

3. You're at FL 330 proceeding direct to the BFD TACAN. ARTCC clears you to descend to 3000 Ft and cross the TACAN at 3000 Ft. You are now 50 DME from the TACAN, what do you do? Lower your pitch 6° and verify this by checking that your VVI reads 600 Ft/NM x NM/Min.

$$\frac{33{,}000 \text{ Ft} - 3000 \text{ Ft}}{50 \text{ NM}} = 600 \text{ Ft/NM} = 6°$$

If you are indicating .7 MACH, your VVI should read:

600 Ft/NM x 7 NM/Min = 4200 Ft/Min

During the descent, you slow to .5 MACH. What should your VVI read if you are still maintaining the 600 Ft/NM descent gradient?
600 Ft/NM x 5 NM/Min = 3000 Ft/Min

So far, all of our calculations have been "no wind." How does wind affect the relationship between pitch, VVI and the descent gradient?

Let's add a 60 kt tailwind to the last problem. You still need to descend at 600 Ft/NM (fly a 600 Ft/NM descent gradient), but you must figure your VVI using NM/Min in groundspeed.

The no-wind speed was .7 MACH or 7 NM/Min

The groundspeed in NM/Min is 7 NM/Min + 60 kts
or
7 NM/Min + 1 NM/Min = 8 NM/Min

Now, the required VVI to fly the 600 Ft/NM is:
VVI = 8 NM/Min x 600 Ft/NM = 4800 Ft/Min

To find the pitch change necessary to get this VVI, the "in the air" NM/Min formula must be used.

$$\frac{4800 \text{ Ft/Min}}{7 \text{ NM/Min}} = 690 \text{ Ft/NM} = \text{Approx. } 7°$$

(since 1° = 100 Ft/NM)
The no wind answer was 6° with a VVI of 4200 Ft/Min.

This 1° pitch correction for the 60 kt wind is a good figure to remember. It is not an exact relationship, but it is within ½° in most cases.

For example, if you have a 120 kt tailwind, you must increase your pitch change by about 2° to realize the computed gradient. If you have a 60 kt headwind, you can decrease your pitch change by about 1° to fly the computed gradient.

Horizontal Plane

Turn radius of your aircraft

Distance to turn 90° using 30° of bank.

a. NM/Min - 2 or (Mach x 10) - 2

b. $\frac{(NM/Min)^2}{10}$ or $(Mach)^2$ x 10

The more accurate method is b., but a. is easier and will give a small "pad" in determining a lead point.

For turns other than 90° use the following:

Degrees To Turn	Fraction Of 90° Turn
180°	2
150°	1 5/6
135°	1 2/3
120°	1 1/2
90°	1
60°	1/2
45°	1/3
30°	1/6

Determining the lead point for intercepting a radial.

First determine the turn radius of the aircraft. Now convert that turn radius to a number of degrees. For a 90° turn, as in turning from an arc to a radial, the formula is simple:

$$\text{Lead Degrees} = \frac{\text{Turn Radius(NM)} \times 60}{\text{DME}}$$

By the 60-to-1 rule, on the 60 DME arc 1° = 1 NM and on the 10 DME arc, 1° = 1/6 NM or 1 NM = 6°. From this, the number of degrees per NM on any arc can be determined by 60/DME. To find the lead point in degrees, just multiply this factor by the lead point in NM.

For example, how many degrees lead should an aircraft use to turn onto a radial from the 15 DME arc at 180 KTAS?

The turn radius is: $\frac{180}{60} - 2 = 1\text{nm}$

The lead point in degrees is: $\frac{1\text{ NM} \times 60}{15} = 4°$

Bank angle required to maintain an arc.

On close-in arcs, constant bank angle may be necessary to stay on the arc. There are two methods to compute the required bank angle.

$$\text{Required bank angle} = \frac{\text{Turn Radius} \times 30}{\text{Arc}}$$

Required bank angle = ½ the lead for an arc to radial intercept

Example: If the required lead point for an arc to radial intercept is 16°, then 8° of bank is required to maintain the arc.

Teardrop penetrations.

The only guidance usually available to fly this type of approach is just a recommended turn altitude and a "remain within" distance. It would be helpful to be able to compute a distance to go outbound so that a 30° bank turn will leave you on course inbound or, if a turn point is depicted or you choose to go further outbound to lessen the descent gradient, what bank angle is needed to roll out on course inbound. Examples 1 and 2 illustrate these two problems.

(a) Outbound distance for a 30° turn:

$$\frac{\text{Turn Radius} \times 120}{\#\text{ of } \textit{degrees} \text{ between radials}}$$

(b) Bank angle required for the teardrop turn (when 30° will not work):

$$\frac{\text{TR x 60}}{\textit{distance}\text{ between radials}}$$

Teardrop entry for holding.

This is the same formula as above but "distance outbound" and "degrees between radials" have been switched. Leg length (distance outbound) is the known value and you have to solve for offset (degrees between radials).

$$\frac{\text{Turn Radius x 120}}{\text{Leg Length}} = \text{Offset Heading}$$

Example: Holding pattern with 10 NM legs. TAS is 240 knots.

$$\text{Turn Radius} = \frac{(240)}{60} - 2 = 2$$

$$\frac{2 \times 120}{10} = 24° \text{ offset}$$

VDP calculations

On non-USAF designed approach plates a VDP is not always published. Compute it for your desired glide slope, usually 3° (300 Ft/NM) or 2½° (250 Ft/NM).

$$\frac{\text{HAT}}{\text{Desired gradient}} = \text{VDP in NM from end of runway}$$

SUMMARY OF 60:1 RULES AND FORMULAS

CLIMBS AND DESCENTS

The 60:1 Rule:

1° = 1 NM at 60 NM   1° = 100 FT at 1 NM

Climb and Descent Gradients:

Required gradient (FT/NM) = $\frac{\text{altitude to lose (or gain)}}{\text{distance to travel}}$ Pitch change = $\frac{\text{gradient}}{100}$ (1° pitch change = 100 FT/NM)

VVI:

VVI = Gradient (or pitch X 100) X TAS in minutes

VVI for a 3° glideslope = $\frac{\text{GS X 10}}{2}$ VVI for a 2.5° glideslope = $\frac{\text{GS X 10 - 100}}{2}$

Determine TAS and NM/MIN:

TAS = IMN X 600   TAS = IAS + (FL / 2)

NM/MIN = IMN X 10   NM/MIN = TAS / 60

Steps to Determine Required Pitch and VVI (Winded Application). Mathematical steps:

Required gradient: Gradient = $\frac{\text{alt to lose}}{\text{dist to travel}}$

Required VVI with wind: VVI = gradient X groundspeed (NM/MIN)

Required pitch change: Pitch change = $\frac{\text{required VVI}}{\text{TAS (in NM/MIN)}}$

NOTE: *For practical applications, each 60 KTS of wind will change pitch 1°.*

TURNS

Turn Radius (TR)   Turn Diameter (TD) = 2 X TR

Distance to turn 90° using 30° of bank:

TR = NM/MIN - 2 or TR = (IMN X 10) - 2

or   or

TR = $\frac{\text{(NM/MIN) squared}}{10}$ or TR = IMN squared X 10

Distance to turn 90° using SRTs and 1/2 SRTs:

SRT = 1% of TAS (or groundspeed)   1/2 SRT = 1/2% of TAS (or groundspeed)

Bank for Rate Turns:

Bank for SRT = $\frac{\text{TAS}}{10}$ + 7   Bank for 1/2 SRT = $\frac{\text{TAS}}{20}$ + 7

Lead Point for Radial to an Arc or 90° Intercept of an Arc:

Lead point in DME = Desired Arc ± TR

Lead Point for Arc to Radial or 90° Intercept of a Radial:

Lead point (in degrees) = $\frac{60}{\text{Arc}}$ X TR (in NM) or $\frac{60}{\text{DME}}$ X TR (in NM)

For Turns Less or More Than 90°, Use The Following: (These cover most situations):

Degrees to Turn	Fraction of 90° Turn	Degrees to Turn	Fraction of 90° Turn
180°	2	90°	1
150°	1 5/6	60°	1/2
135°	1 2/3	45°	1/3
120°	1 1/2	30°	1/6

Bank Angle Required to Maintain an Arc:

Required bank angle = $\frac{30}{\text{Arc}}$ X TR (Use IMN squared for TR to obtain best results)

or Required Bank angle = Radial Lead Point / 2

HOLDING

Teardrop Holding Calculations:

$$\text{Offset in degrees} = \frac{TD \times 60}{\text{outbound distance}} \quad \text{or} \quad \frac{TR \times 120}{\text{outbound distance}}$$

Timing:

$\leq 14{,}000 = 1{+}00$ $> 14{,}000 = 1{+}30$

Outbound Correction for Inbound:

1+00 Correction = 3600 / inbound time = outbound time
1+30 Correction = 8100 / inbound time = outbound time

Drift calculation:

$$\text{Drift} = \frac{\text{Crosswind Component}}{\text{NM/MIN of TAS}} \qquad 180^\circ \text{ turn} = \frac{1\%\ \text{TAS}}{2}$$

Ex. 240 TAS = 2.4 / 2 = 1.2 Min = 1+12

Double Drift:

Into wind turn = 30° bank - 1° for every deg of drift
Inbound to fix = course heading ± drift

Other Turn = 30° bank
Outbound leg = outbound heading ± (drift X 2)

Hold double drift for same amount
of time as the time in 180° turn

Triple drift:

Into Wind Turn = 30° bank
Inbound to fix = Course heading ± drift

Other Turn = 30° bank
Outbound leg = outbound heading ± (drift X 3)

Hold triple drift for same amount
of time as the time in 180° turn

APPROACH

Teardrop Penetration Calculation:

Determine outbound distance for 30° bank turn:

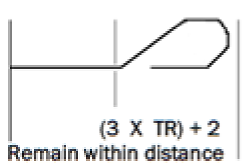
$$\text{Outbound distance} = \frac{TD \times 60}{\text{Degrees Between Radials}} \quad \text{or} \quad \frac{TR \times 120}{\text{Degrees Between Radials}}$$

Determine bank angle required for teardrop penetration (When 30° bank will not work):

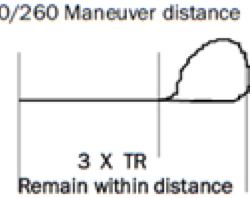
$$\text{Bank Angle} = \frac{TR \times 60}{\text{Distance Between Radials in NM}}$$

Procedure Turn Calculations:

45/180 Maneuver distance = (3 X TR) + 2



80/260 Maneuver distance = 3 X TR



VDP Calculation:

$$\text{VDP (in NM) From the } \textit{end of the runway} = \frac{HAT}{\text{Gradient (normally 300)}}$$

$$\text{VDP (in timing) From the } \textit{FAF} = \text{(FAF to End of runway Distance)} - \frac{HAT}{\text{Gradient (normally 300)}} = \text{FAF to VDP Dist (NM)}$$

$$\frac{\text{Timing to MAP (From timing box)}}{\text{NM from FAF to MAP}} = \text{Seconds per Mile} \quad \text{or} \quad \frac{60}{(TAS / 60)} = \text{Seconds per Mile}$$

(Seconds per Mile) X FAF to VDP Dist (NM) = Time (in Seconds)

CIRCLE

Perpendicular to Runway
Timing passing runway =
10% TAS (corrected for winds)
(TAS + headwind - tailwind component)
(Yes, subtract tailwind to counteract
it "pushing you across the ground")

Displacement using 45° rule
Turn 45° off RWY HDG
(Kill Drift)
Displace using Runway

Displacement using 30° rule
Turn 30° off RWY HDG
(Kill Drift)
Time for 10% TAS X 4