Chapter 8

The National Airspace System

Introduction

The National Airspace System (NAS) is the network of United States airspace: air navigation facilities, equipment, services, airports or landing areas, aeronautical charts, information/services, rules, regulations, procedures, technical information, manpower, and material. Included are system components shared jointly with the military. The system's present configuration is a reflection of the technological advances concerning the speed and altitude capability of jet aircraft, as well as the complexity of microchip and satellite-based navigation equipment. To conform to international aviation standards, the United States adopted the primary elements of the classification system developed by the International Civil Aviation Organization (ICAO).

This chapter is a general discussion of airspace classification; en route, terminal, and approach procedures; and operations within the NAS. Detailed information on the classification of airspace, operating procedures, and restrictions is found in the Aeronautical Information Manual (AIM).

Airspace Classification

Airspace in the United States *[Figure 8-1]* is designated as follows:

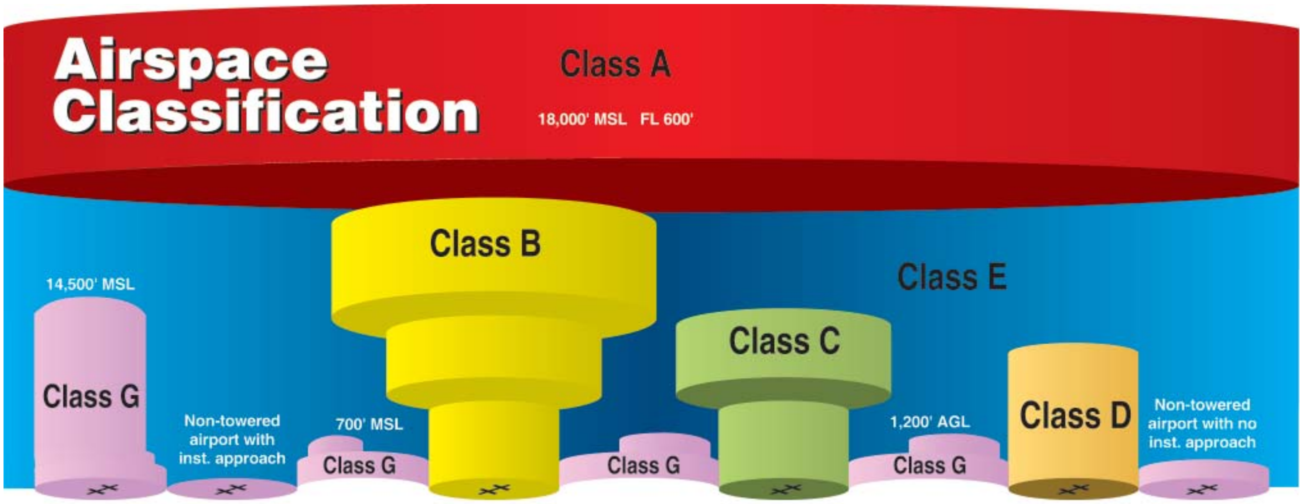
1. Class A. Generally, airspace from 18,000 feet mean sea level (MSL) up to and including flight level (FL) 600, including the airspace overlying the waters within 12 nautical miles (NM) of the coast of the 48 contiguous states and Alaska. Unless otherwise authorized, all pilots must operate their aircraft under instrument flight rules (IFR).
2. Class B. Generally, airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of airport operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored, consists of a surface area and two or more layers (some Class B airspace areas resemble upside-down wedding cakes), and is designed to contain all published instrument procedures once an aircraft enters the airspace. An air traffic control (ATC) clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace.
3. Class C. Generally, airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower, are serviced by a radar approach control, and have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C area is individually tailored, the airspace usually consists of a surface area with a 5 NM radius, an outer circle with a 10 NM radius that extends from 1,200 feet to 4,000 feet above the airport elevation and an outer area. Each aircraft must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while within the airspace.
4. Class D. Generally, that airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored and when instrument procedures are published, the airspace will normally be designed to contain the procedures. Arrival extensions for instrument approach procedures (IAPs) may be Class D or Class E airspace. Unless otherwise authorized, each aircraft must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while in the airspace.
5. Class E. Generally, if the airspace is not Class A, B, C, or D, and is controlled airspace, then it is Class E airspace. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. When designated as a surface area, the airspace will be configured to contain all instrument procedures. Also in this class are federal airways, airspace beginning at either 700 or 1,200 feet above ground level (AGL) used to transition to and from the terminal or en route environment, and en route domestic and offshore airspace areas designated below 18,000 feet MSL. Unless designated at a lower altitude, Class E airspace begins at 14,500 MSL over the United States, including that airspace overlying the waters within 12 NM of the coast of the 48 contiguous states and Alaska, up to but not including 18,000 feet MSL, and the airspace above FL 600.
6. Class G. Airspace not designated as Class A, B, C, D, or E. Class G airspace is essentially uncontrolled by ATC except when associated with a temporary control tower.

Special Use Airspace

Special use airspace is the designation for airspace in which certain activities must be confined, or where limitations may be imposed on aircraft operations that are not part of those activities. Certain special use airspace areas can create limitations on the mixed use of airspace. The special use airspace depicted on instrument charts includes the area name or number, effective altitude, time and weather conditions of operation, the controlling agency, and the chart panel location. On National Aeronautical Charting Group (NACG) en route charts, this information is available on one of the end panels.

Prohibited areas contain airspace of defined dimensions within which the flight of aircraft is prohibited. Such areas are established for security or other reasons associated with the national welfare. These areas are published in the Federal Register and are depicted on aeronautical charts. The area is charted as a "P" followed by a number (e.g., "P-123").

Restricted areas are areas where operations are hazardous to nonparticipating aircraft and contain airspace within which the flight of aircraft, while not wholly prohibited, is subject to restrictions. Activities within these areas must be confined because of their nature, or limitations may be imposed upon aircraft operations that are not a part of those activities, or both. Restricted areas denote the existence of unusual, often invisible, hazards to aircraft (e.g., artillery firing, aerial



	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*	Prior two-way communications*
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*	Yes*
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 8-1. *Airspace Classifications.*

gunnery, or guided missiles). IFR flights may be authorized to transit the airspace and are routed accordingly. Penetration of restricted areas without authorization from the using or controlling agency may be extremely hazardous to the aircraft and its occupants. ATC facilities apply the following procedures when aircraft are operating on an IFR clearance (including those cleared by ATC to maintain visual flight rules (VFR)-On-Top) via a route that lies within joint-use restricted airspace:

1. If the restricted area is not active and has been released to the Federal Aviation Administration (FAA), the ATC facility will allow the aircraft to operate in the restricted airspace without issuing specific clearance for it to do so.
2. If the restricted area is active and has not been released to the FAA, the ATC facility will issue a clearance which will ensure the aircraft avoids the restricted airspace.

Restricted areas are charted with an "R" followed by a number (e.g., "R-5701") and are depicted on the en route chart appropriate for use at the altitude or FL being flown.

Warning areas are similar in nature to restricted areas; however, the United States government does not have sole jurisdiction over the airspace. A warning area is airspace of defined dimensions, extending from 12 NM outward from the coast of the United States, containing activity that may be hazardous to nonparticipating aircraft. The purpose of such areas is to warn nonparticipating pilots of the potential danger. A warning area may be located over domestic or international waters or both. The airspace is designated with a "W" followed by a number (e.g., "W-123").

Military operations areas (MOAs) consist of airspace with defined vertical and lateral limits established for the purpose of separating certain military training activities from IFR traffic. Whenever an MOA is being used, nonparticipating IFR traffic may be cleared through an MOA if IFR separation can be provided by ATC. Otherwise, ATC will reroute or restrict nonparticipating IFR traffic. MOAs are depicted on sectional, VFR terminal area, and en route low altitude charts and are not numbered (e.g., "Boardman MOA").

Alert areas are depicted on aeronautical charts with an "A" followed by a number (e.g., "A-123") to inform nonparticipating pilots of areas that may contain a high volume of pilot training or an unusual type of aerial activity. Pilots should exercise caution in alert areas. All activity within an alert area shall be conducted in accordance with regulations, without waiver, and pilots of participating aircraft, as well as pilots transiting the area, shall be equally responsible for collision avoidance.

Military Training Routes (MTRs) are routes used by military aircraft to maintain proficiency in tactical flying. These routes are usually established below 10,000 feet MSL for operations at speeds in excess of 250 knots. Some route segments may be defined at higher altitudes for purposes of route continuity. Routes are identified as IFR (IR), and VFR (VR), followed by a number. MTRs with no segment above 1,500 feet AGL are identified by four number characters (e.g., IR1206, VR1207, etc.). MTRs that include one or more segments above 1,500 feet AGL are identified by three number characters (e.g., IR206, VR207). IFR Low Altitude En Route Charts depict all IR routes and all VR routes that accommodate operations above 1,500 feet AGL. IR routes are conducted in accordance with IFR regardless of weather conditions.

Temporary flight restrictions (TFRs) are put into effect when traffic in the airspace would endanger or hamper air or ground activities in the designated area. For example, a forest fire, chemical accident, flood, or disaster-relief effort could warrant a TFR, which would be issued as a Notice to Airmen (NOTAM).

National Security Areas (NSAs) consist of airspace with defined vertical and lateral dimensions established at locations where there is a requirement for increased security and safety of ground facilities. Flight in NSAs may be temporarily prohibited by regulation under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) part 99 and prohibitions will be disseminated via NOTAM.

Federal Airways

The primary means for routing aircraft operating under IFR is the federal airways system.

Each federal airway is based on a centerline that extends from one NAVAID/waypoint/fix/intersection to another NAVAID/waypoint/fix/intersection specified for that airway. A federal airway includes the airspace within parallel boundary lines four NM to each side of the centerline. As in all instrument flight, courses are magnetic, and distances are in NM. The airspace of a federal airway has a floor of 1,200 feet AGL, unless otherwise specified. A federal airway does not include the airspace of a prohibited area.

Victor airways include the airspace extending from 1,200 feet AGL up to, but not including 18,000 feet MSL. The airways are designated on Sectional and IFR low altitude en route charts with the letter "V" followed by a number (e.g., "V23"). Typically, Victor airways are given odd numbers when oriented north/south and even numbers when oriented east/west. If more than one airway coincides on a route segment, the numbers are listed serially (e.g., "V287-495-500"). *[Figure 8-2]*

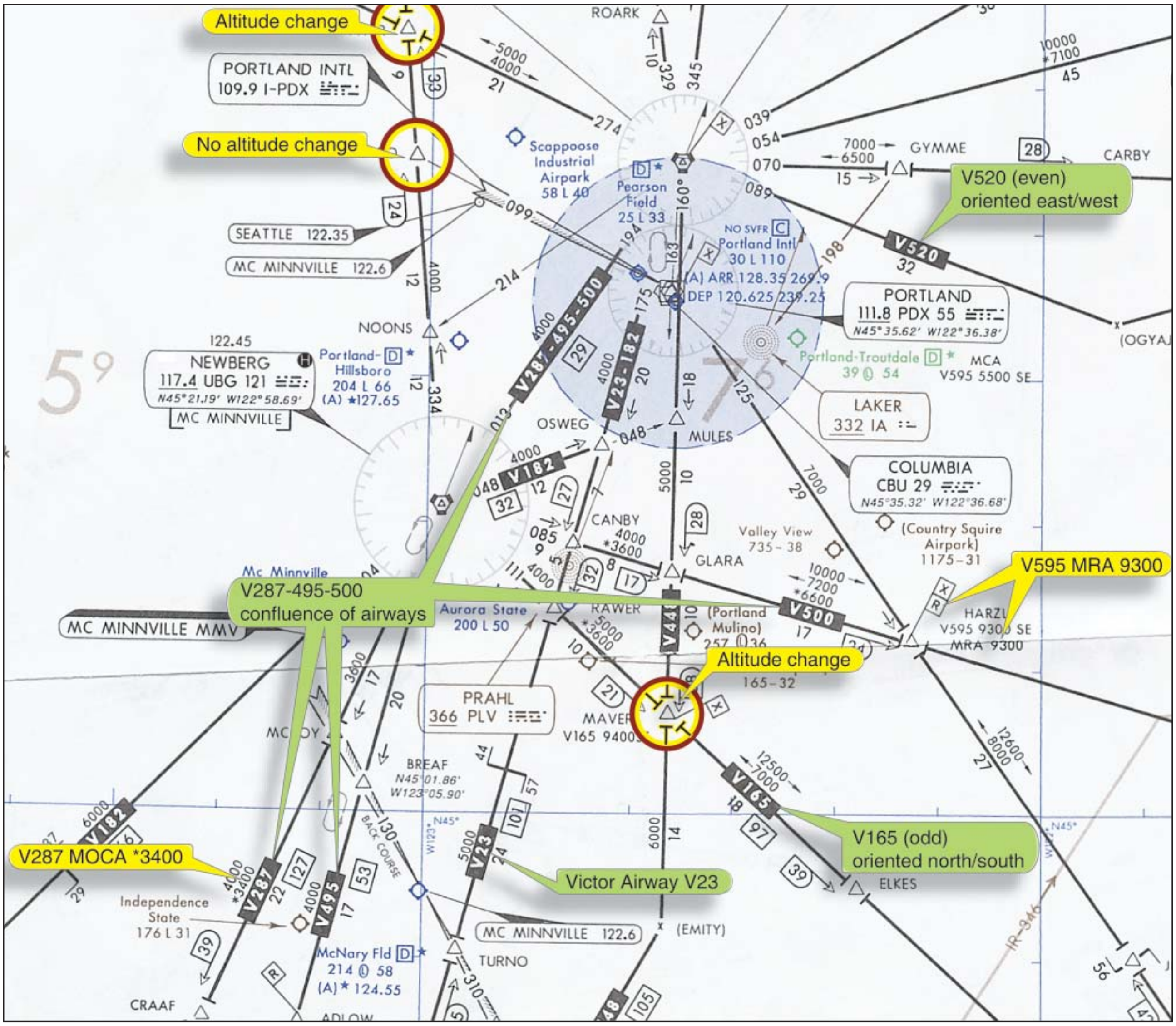


Figure 8-2. *Victor Airways and Charted IFR Altitudes.*

Jet routes exist only in Class A airspace, from 18,000 feet MSL to FL 450, and are depicted on high-altitude en route charts. The letter "J" precedes a number to label the airway (e.g., J12).

RNAV routes have been established in both the low-altitude and the high-altitude structures in recent years and are depicted on the en route low and high chart series. High altitude RNAV routes are identified with a "Q" prefix (except the Q-routes in the Gulf of Mexico) and low altitude RNAV routes are identified with a "T" prefix. RNAV routes and data are depicted in aeronautical blue.

In addition to the published routes, a random RNAV route may be flown under IFR if it is approved by ATC. Random RNAV routes are direct routes, based on area navigation capability, between waypoints defined in terms of latitude/longitude coordinates, degree-distance fixes, or offsets from established routes/airways at a specified distance and direction.

Radar monitoring by ATC is required on all random RNAV routes. These routes can only be approved in a radar environment. Factors that will be considered by ATC in approving random RNAV routes include the capability to provide radar monitoring, and compatibility with traffic volume and flow. ATC will radar monitor each flight; however, navigation on the random RNAV route is the responsibility of the pilot.

Other Routing

Preferred IFR routes have been established between major terminals to guide pilots in planning their routes of flight, minimizing route changes and aiding in the orderly management of air traffic on federal airways. Low and high altitude preferred routes are listed in the Airport/Facility Directory (A/FD). To use a preferred route, reference the departure and arrival airports; if a routing exists for your flight, then airway instructions will be listed.

Tower En Route Control (TEC) is an ATC program that uses overlapping approach control radar services to provide IFR clearances. By using TEC, a pilot is routed by airport control towers. Some advantages include abbreviated filing procedures and reduced traffic separation requirements. TEC is dependent upon the ATC's workload, and the procedure varies among locales.

The latest version of Advisory Circular (AC) 90-91, North American Route Program (NRP), provides guidance to users of the NAS for participation in the NRP. All flights operating at or above FL 290 within the conterminous United States and Canada are eligible to participate in the NRP, the primary purpose of which is to allow operators to plan minimum time/cost routes that may be off the prescribed route structure. NRP aircraft are not subject to route-limiting restrictions (e.g., published preferred IFR routes) beyond a 200 NM radius of their point of departure or destination.

IFR En Route Charts

The objective of IFR en route flight is to navigate within the lateral limits of a designated airway at an altitude consistent with the ATC clearance. Your ability to fly instruments safely and competently in the system is greatly enhanced by understanding the vast array of data available to the pilot on instrument charts. The NACG maintains and produces the charts for the United States government.

En route high-altitude charts provide aeronautical information for en route instrument navigation (IFR) at or above 18,000 feet MSL. Information includes the portrayal of Jet and RNAV routes, identification and frequencies of radio aids, selected airports, distances, time zones, special use airspace, and related information. Established Jet routes from 18,000 feet MSL to FL 450 use NAVAIDs not more than 260 NM apart. The charts are revised every 56 days.

To effectively depart from one airport and navigate en route under instrument conditions a pilot needs the appropriate IFR en route low-altitude chart(s). The IFR low altitude en route chart is the instrument equivalent of the Sectional chart. When folded, the cover of the NACG en route chart displays an index map of the United States showing the coverage areas. Cities near congested airspace are shown in black type and their associated area chart is listed in the box in the lower left-hand corner of the map coverage box. Also noted is an explanation of the off-route obstruction clearance altitude (OROCA). The effective date of the chart is printed on the other side of the folded chart. Information concerning MTRs is also included on the chart cover. The en route charts are revised every 56 days.

When the NACG en route chart is unfolded, the legend is displayed and provides information concerning airports, NAVAIDs, communications, air traffic services, and airspace.

Airport Information

Airport information is provided in the legend, and the symbols used for the airport name, elevation, and runway length are similar to the sectional chart presentation. Associated city names are shown for public airports only. FAA identifiers are shown for all airports. ICAO identifiers are also shown for airports outside of the contiguous United States. Instrument approaches can be found at airports with blue or green symbols, while the brown airport symbol denotes airports that do not have instrument approaches. Stars are used to indicate the part-time nature of tower operations, ATIS frequencies, part-time or on request lighting facilities, and part-time airspace classifications. A box after an airport name with a "C" or "D" inside indicates Class C and D airspace, respectively, per *Figure 8-3*. D

Charted IFR Altitudes

The minimum en route altitude (MEA) ensures a navigation signal strong enough for adequate reception by the aircraft navigation (NAV) receiver and obstacle clearance along the airway. Communication is not necessarily guaranteed with MEA compliance. The obstacle clearance, within the limits of the airway, is typically 1,000 feet in non-mountainous areas and 2,000 feet in designated mountainous areas. MEAs can be authorized with breaks in the signal coverage; if this is the case, the NACG en route chart notes "MEA GAP" parallel to the affected airway. MEAs are usually bidirectional; however, they can be single-directional. Arrows are used to indicate the direction to which the MEA applies.

The minimum obstruction clearance altitude (MOCA), as the name suggests, provides the same obstruction clearance as an MEA; however, the NAV signal reception is ensured only within 22 NM of the closest NAVAID defining the route. The MOCA is listed below the MEA and indicated on NACG charts by a leading asterisk (e.g., "*3400"—see *Figure 8-2*, V287 at bottom left).

The minimum reception altitude (MRA) identifies the lowest altitude at which an intersection can be determined from an off-course NAVAID. If the reception is line-of-sight based, signal coverage will only extend to the MRA or above. However, if the aircraft is equipped with distance measuring equipment (DME) and the chart indicates the intersection can

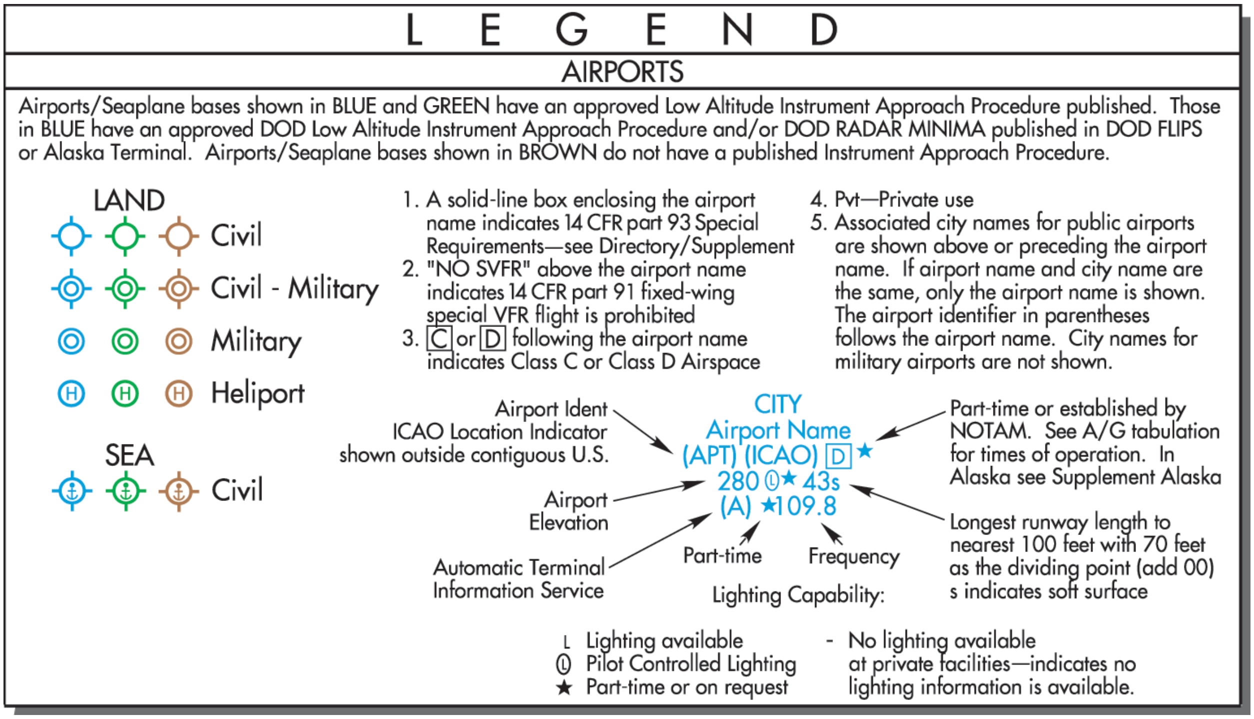


Figure 8-3. *En Route Airport Legend.*

be identified with such equipment, the pilot could define the fix without attaining the MRA. On NACG charts, the MRA is indicated by the symbol and the altitude preceded by "MRA" (e.g., "MRA 9300"). *[Figure 8-2]*

The minimum crossing altitude (MCA) will be charted when a higher MEA route segment is approached. The MCA is usually indicated when a pilot is approaching steeply rising terrain, and obstacle clearance and/or signal reception is compromised. In this case, the pilot is required to initiate a climb so the MCA is reached by the time the intersection is crossed. On NACG charts, the MCA is indicated by the symbol , and the Victor airway number, altitude, and the direction to which it applies (e.g. "V24 8000 SE").

The maximum authorized altitude (MAA) is the highest altitude at which the airway can be flown with assurance of receiving adequate navigation signals. Chart depictions appear as "MAA-15000."

When an MEA, MOCA, and/or MAA change on a segment other than at a NAVAID, a sideways "T" is depicted on the chart. If there is an airway break without the symbol, one can assume the altitudes have not changed (see the upper left area of *Figure 8-2*). When a change of MEA to a higher MEA is required, the climb may commence at the break, ensuring obstacle clearance. *[Figure 8-4]*

Navigation Features

Types of NAVAIDs

Very high frequency omnidirectional ranges (VORs) are the principal NAVAIDs that support the Victor and Jet airways. Many other navigation tools are also available to the pilot. For example, nondirectional beacons (NDBs) can broadcast signals accurate enough to provide stand-alone approaches, and DME allows the pilot to pinpoint a reporting point on the airway. Though primarily navigation tools, these NAVAIDs can also transmit voice broadcasts.

Tactical air navigation (TACAN) channels are represented as the two- or three-digit numbers following the three-letter identifier in the NAVAID boxes. The NACG terminal procedures provide a frequency-pairing table for the TACAN-only sites. On NACG charts, very-high frequencies and ultra-high frequencies (VHF/UHF) NAVAIDs (e.g., VORs) are depicted in black, while low frequencies and medium frequencies (LF/MF) are depicted as brown. *[Figure 8-5]*

Identifying Intersections

Intersections along the airway route are established by a variety of NAVAIDs. An open triangle △ indicates the location of an ATC reporting point at an intersection. If the triangle is solid, ▲ a report is compulsory. *[Figure 8-4]*

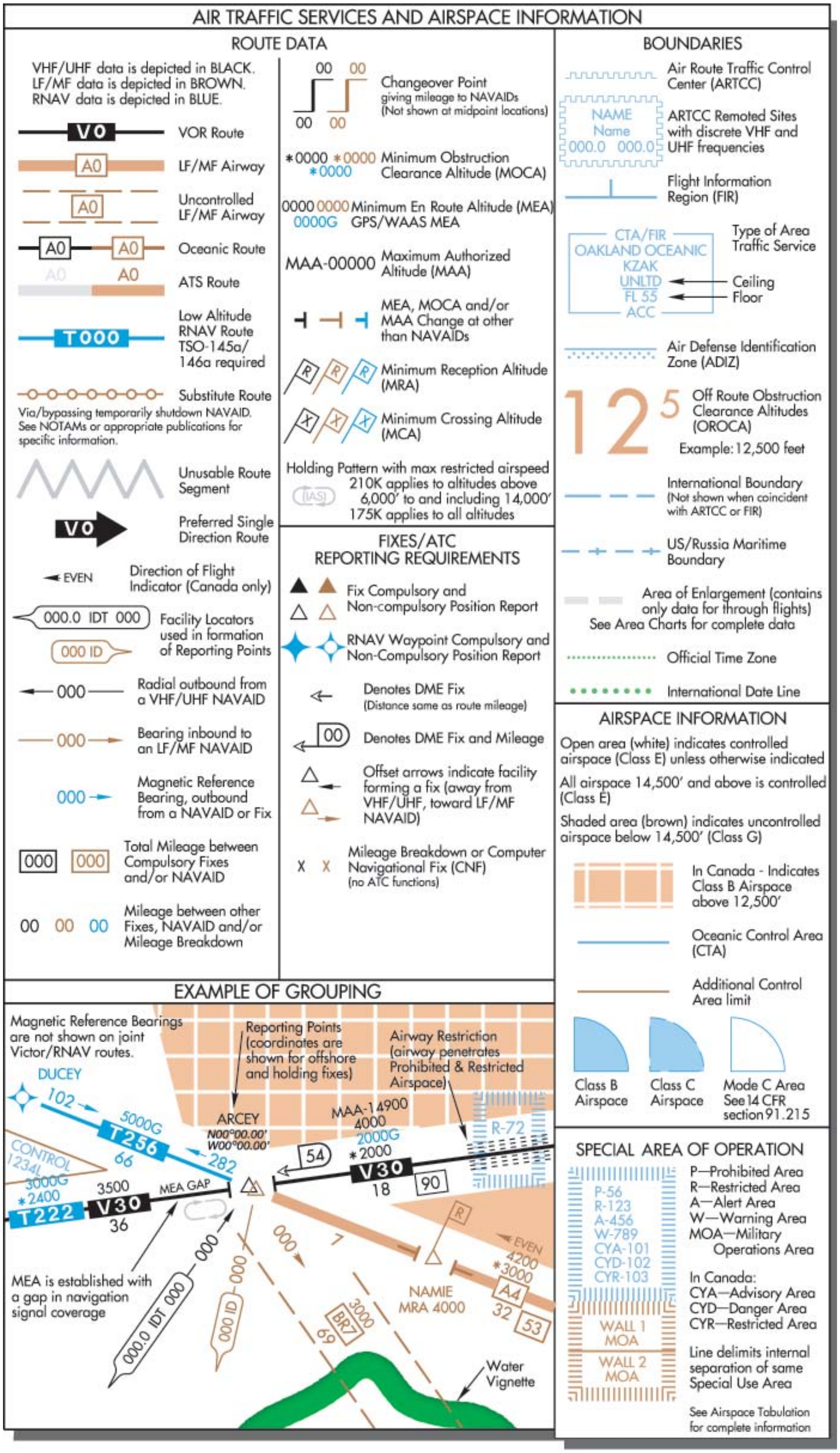


Figure 8-4. *Legend From En Route Low Attitude Chart, Air Traffic Services and Airspace Information Section.*

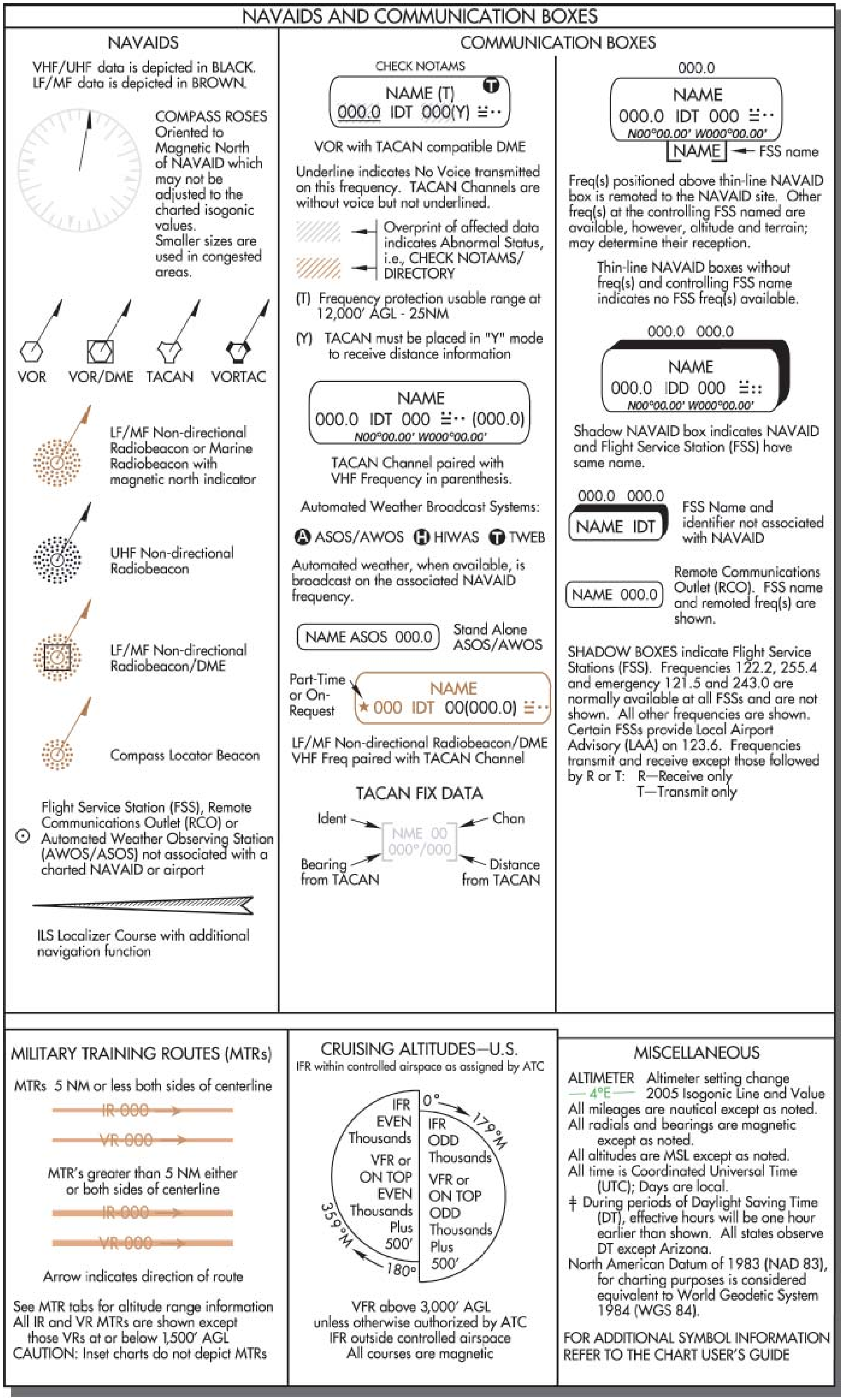


Figure 8-5. *Legend From En Route Low Attitude Chart.*

NDBs, localizers, and off-route VORs are used to establish intersections. NDBs are sometimes collocated with intersections, in which case passage of the NDB would mark the intersection. A bearing to an off-route NDB also can provide intersection identification. A localizer course used to identify an intersection is depicted by a feathered arrowhead symbol on the en route chart. If feathered markings appear on the left-hand side of the arrowhead, a back course (BC) signal is transmitted. On NACG en route charts, the localizer symbol is only depicted to identify an intersection.

Off-route VORs remain the most common means of identifying intersections when traveling on an airway. Arrows depicted next to the intersection indicate the NAVAID to be used for identification. Another means of identifying an intersection is with the use of DME. A hollow arrowhead indicates DME is authorized for intersection identification. If the DME mileage at the intersection is a cumulative distance of route segments, the mileage is totaled and indicated by a D-shaped symbol with a mileage number inside. 00 *[Figure 8-4]* Approved IFR GPS units can also be used to report intersections.

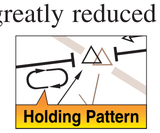
Other Route Information

DME and GPS provide valuable route information concerning such factors as mileage, position, and groundspeed. Even without this equipment, information is provided on the charts for making the necessary calculations using time and distance. The en route chart depicts point-to-point distances on the airway system. Distances from VOR to VOR are charted with a number inside of a box. 000 To differentiate distances when two airways coincide, the word "TO" with the three-letter VOR identifier appear to the left of the distance boxes. TO PDX 97

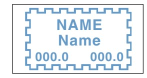
VOR changeover points (COPs) are depicted on the charts by this symbol: 45 53 The numbers indicate the distance at which to change the VOR frequency. The frequency change might be required due to signal reception or conflicting frequencies. If a COP does not appear on an airway, the frequency should be changed midway between the facilities. A COP at an intersection may indicate a course change.

Occasionally an "x" will appear at a separated segment of an airway that is not an intersection. The "x" is a mileage breakdown or computer navigation fix and may indicate a course change.

Today's computerized system of ATC has greatly reduced the need for holding en route. However, published holding patterns are still found on charts at junctures where ATC has deemed it necessary to enable traffic flow. When a holding pattern is charted, the controller may provide the holding direction and the statement "as published." *[Figure 8-4]*



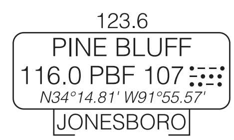
Boundaries separating the jurisdiction of Air Route Traffic Control Centers (ARTCC) are depicted on charts with blue serrations. The name of the controlling facility is printed on the corresponding side of the division line. ARTCC remote sites are depicted as blue serrated boxes and contain the center name, sector name, and the sector frequency. *[Figure 8-4]*



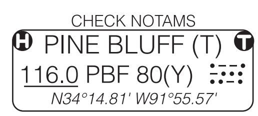
Weather Information and Communication Features

En route NAVAIDs also provide weather information and serve communication functions. When a NAVAID is shown as a shadowed box, an automated flight service station (AFSS) of the same name is directly associated with the facility. If an AFSS is located without an associated NAVAID, the shadowed box is smaller and contains only the name and identifier. The AFSS frequencies are provided above the box. (Frequencies 122.2 and 255.4, and emergency frequencies 121.5 and 243.0 are not listed.)

A Remote Communications Outlet (RCO) associated with a NAVAID is designated by a thin-lined box with the controlling AFSS frequency above the box, and the name under the box. Without an associated facility, the thin-lined RCO box contains the AFSS name and remote frequency.



Automated Surface Observing Station (ASOS), Automated Weather Observing Station (AWOS), Hazardous Inflight Weather Advisory Service (HIWAS) and Transcribed Weather Broadcast (TWEB) are continuously transmitted over selected NAVAIDs and depicted in the NAVAID box. ASOS/AWOS are depicted by a white "A", HIWAS by a "H" and TWEB broadcasts by a "T" in a solid black circle in the upper right or left corner.



New Technologies

Technological advances have made multifunction displays and moving maps more common in newer aircraft. Even older aircraft are being retrofitted to include "glass" in the flight deck. *[Figure 8-6]* Moving maps improve pilot situational awareness by providing a picture of aircraft location in

Figure 8-6. *Moving Map Display.*

relation to NAVAIDS, waypoints, airspace, terrain, and hazardous weather. GPS systems can be certified for terminal area and en route use as well as approach guidance.

Additional breakthroughs in display technology are the new electronic chart systems or electronic flight bags that facilitate the use of electronic documents in the general aviation flight deck. *[Figure 8-7]* An electronic chart or flight bag is a self-powered electronic library that stores and displays en route charts and other essential documents on a screen. These electronic devices can store the digitized United States terminal procedures, en route charts, the complete airport facility directory, in addition to Title 14 of the Code of Federal Regulations (14 CFR) and the AIM. Full touch-screen based computers allow pilots to view airport approach and area charts electronically while flying. It replaces paper charts as well as other paper materials including minimum equipment lists (MELs), standard operating procedures (SOPs), standard instrument departures (SIDs), standard terminal arrival routes (STARs), checklists, and flight deck manuals. As with paper flight publications, the electronic database needs to be current to provide accurate information regarding NAVAIDS, waypoints, and terminal procedures. Databases are updated every 28 days and are available from various commercial vendors. Pilots should be familiar with equipment operation, capabilities, and limitations prior to use.

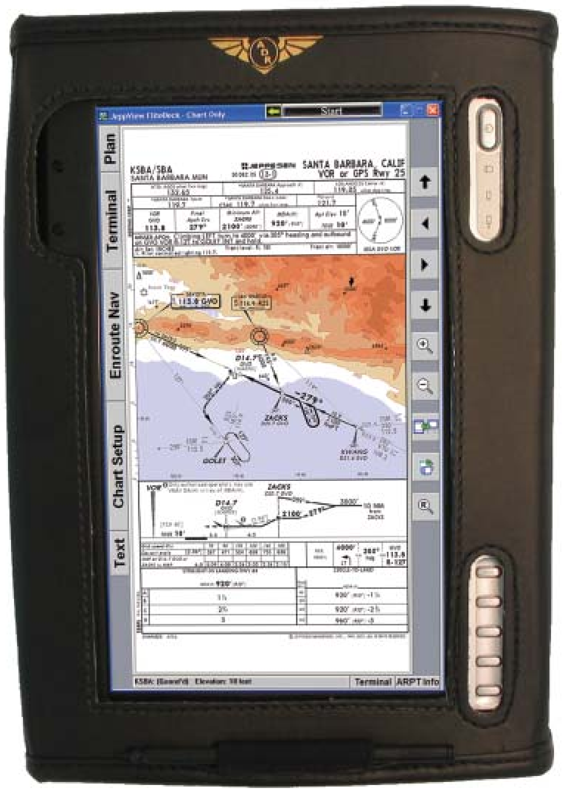


Figure 8-7. *Example of an Electronic Flight Bag.*

Terminal Procedures Publications

While the en route charts provide the information necessary to safely transit broad regions of airspace, the United States Terminal Procedures Publication (TPP) enables pilots to guide their aircraft in the airport area. Whether departing or arriving, these procedures exist to make the controllers' and pilots' jobs safer and more efficient. Available in booklets by region (published by NACG), the TPP includes approach procedures, STARs, Departure Procedures (DPs), and airport diagrams.

Departure Procedures (DPs)

There are two types of DPs, Obstacle Departure Procedures (ODP) and SIDs. *[Figure 8-8]* Both types of DPs provide obstacle clearance protection to aircraft in instrument meteorological conditions (IMC), while reducing communications and departure delays. DPs are published in text and/or charted graphic form. Regardless of the format, all DPs provide a way to depart the airport and transition to the en route structure safely. When possible, pilots are strongly encouraged to file and fly a DP at night, during marginal visual meteorological conditions (VMC) and IMC.

All DPs provide obstacle clearance provided the aircraft crosses the end of the runway at least 35 feet AGL; climbs to 400 feet above airport elevation before turning; and climbs at least 200 feet per nautical mile (FPNM), unless a higher climb gradient is specified to the assigned altitude. ATC may vector an aircraft off a previously assigned DP; however, the 200 FPNM or the FPNM specified in the DP is required.

Textual ODPs are listed by city and airport in the IFR Take-Off Minimums and DPs Section of the TPP. SIDs are depicted in the TPP following the approach procedures for the airport.

Standard Terminal Arrival Routes (STARs)

STARs depict prescribed routes to transition the instrument pilot from the en route structure to a fix in the terminal area from which an instrument approach can be conducted. If a pilot does not have the appropriate STAR, write "No STAR" in the flight plan. However, if the controller is busy, the pilot might be cleared along the same route and, if necessary, the controller will have the pilot copy the entire text of the procedure.

STARs are listed alphabetically at the beginning of the NACG booklet. *Figure 8-9* shows an example of a STAR, and the legend for STARs and DPs printed in NACG booklets.

Instrument Approach Procedure (IAP) Charts

The IAP chart provides the method to descend and land safely in low visibility conditions. The FAA establishes an IAP after thorough analyses of obstructions, terrain features, and navigational facilities. Maneuvers, including altitude changes, course corrections, and other limitations, are prescribed in the IAP. The approach charts reflect the criteria associated with the United States Standard for Terminal Instrument Approach Procedures (TERPs), which prescribes standardized methods for use in designing instrument flight procedures.

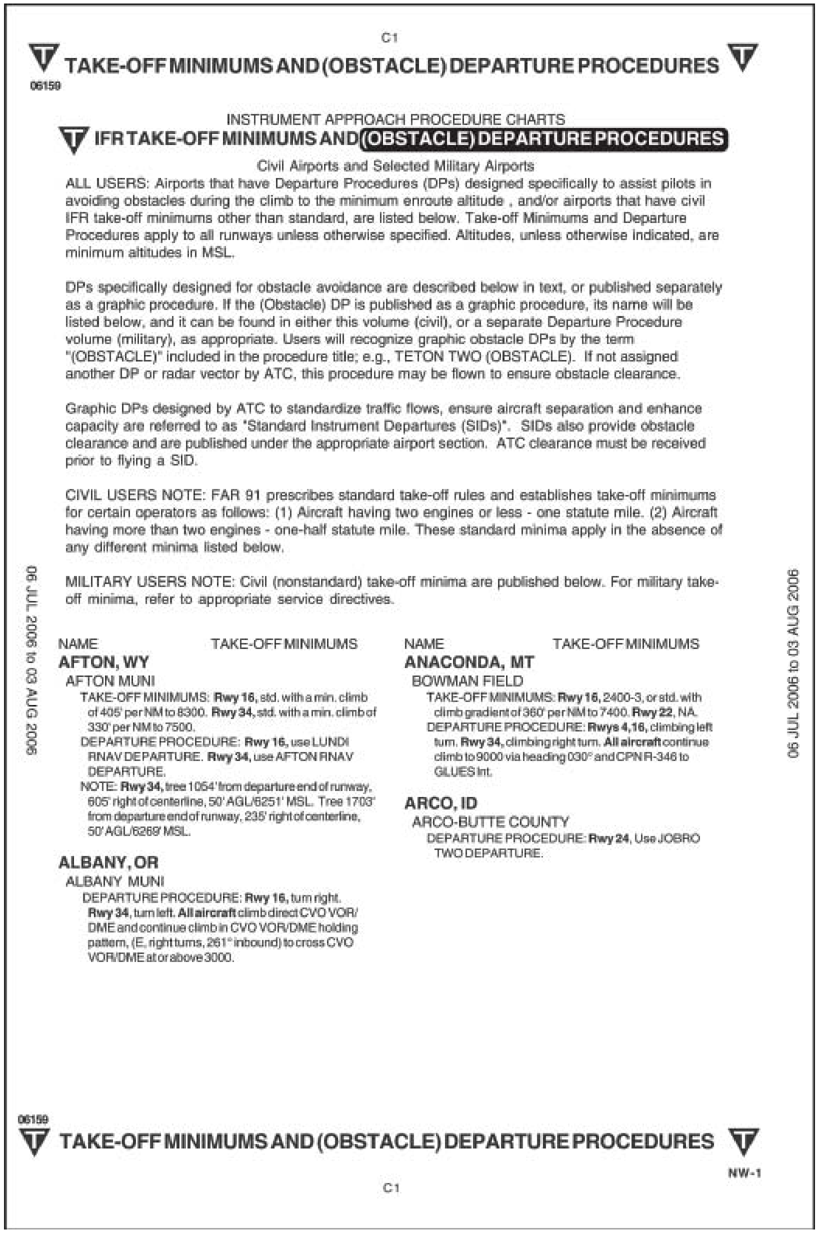
In addition to the NACG, other governmental and corporate entities produce approach procedures. The United States military IAPs are established and published by the Department of Defense and are available to the public upon request. Special IAPs are approved by the FAA for individual operators and are not available to the general public. Foreign country standard IAPs are established and published according to the individual country's publication procedures. The information presented in the following sections will highlight features of the United States Terminal Procedures Publications.

The instrument approach chart is divided into six main sections, which include the margin identification, pilot briefing (and notes), plan view, profile view, landing minimums, and airport diagram. *[Figure 8-10]* An examination of each section follows.

Margin Identification

The margin identification, at the top and bottom of the chart, depicts the airport location and procedure identification. The civil approach plates are organized by city, then airport name and state. For example, Orlando Executive in Orlando, Florida is alphabetically listed under "O" for Orlando. Military approaches are organized by airport name first.

The chart's amendment status appears below the city and state in the bottom margin. The amendment number is followed by the five-digit julian-date of the last chart change."05300" is read, "the 300th day of 2005". At the center of the top margin is the FAA chart reference number and the approving authority. At the bottom center, the airport's latitude and longitude coordinates are provided.



C1

TAKE-OFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES

06159

INSTRUMENT APPROACH PROCEDURE CHARTS

IFR TAKE-OFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES

Civil Airports and Selected Military Airports

ALL USERS: Airports that have Departure Procedures (DPs) designed specifically to assist pilots in avoiding obstacles during the climb to the minimum enroute altitude , and/or airports that have civil IFR take-off minimums other than standard, are listed below. Take-off Minimums and Departure Procedures apply to all runways unless otherwise specified. Altitudes, unless otherwise indicated, are minimum altitudes in MSL.

DPs specifically designed for obstacle avoidance are described below in text, or published separately as a graphic procedure. If the (Obstacle) DP is published as a graphic procedure, its name will be listed below, and it can be found in either this volume (civil), or a separate Departure Procedure volume (military), as appropriate. Users will recognize graphic obstacle DPs by the term "(OBSTACLE)" included in the procedure title; e.g., TETON TWO (OBSTACLE). If not assigned another DP or radar vector by ATC, this procedure may be flown to ensure obstacle clearance.

Graphic DPs designed by ATC to standardize traffic flows, ensure aircraft separation and enhance capacity are referred to as "Standard Instrument Departures (SIDs)". SIDs also provide obstacle clearance and are published under the appropriate airport section. ATC clearance must be received prior to flying a SID.

CIVIL USERS NOTE: FAR 91 prescribes standard take-off rules and establishes take-off minimums for certain operators as follows: (1) Aircraft having two engines or less - one statute mile. (2) Aircraft having more than two engines - one-half statute mile. These standard minima apply in the absence of any different minima listed below.

MILITARY USERS NOTE: Civil (nonstandard) take-off minima are published below. For military take-off minima, refer to appropriate service directives.

06 JUL 2006 to 03 AUG 2006

NAME TAKE-OFF MINIMUMS

AFTON, WY

AFTON MUNI

TAKE-OFF MINIMUMS: **Rwy 16,** std. with a min. climb of 405' per NM to 8300. **Rwy 34,** std. with a min. climb of 330' per NM to 7500.

DEPARTURE PROCEDURE: **Rwy 16,** use LUNDI RNAV DEPARTURE. **Rwy 34,** use AFTON RNAV DEPARTURE.

NOTE: **Rwy 34,** tree 1054' from departure end of runway, 605' right of centerline, 50' AGL/6251' MSL. Tree 1703' from departure end of runway, 235' right of centerline, 50' AGL/6269' MSL.

ALBANY, OR

ALBANY MUNI

DEPARTURE PROCEDURE: **Rwy 16,** turn right. **Rwy 34,** turn left. **All aircraft** climb direct CVO VOR/DME and continue climb in CVO VOR/DME holding pattern, (E, right turns, 261° inbound) to cross CVO VOR/DME at or above 3000.

NAME TAKE-OFF MINIMUMS

ANACONDA, MT

BOWMAN FIELD

TAKE-OFF MINIMUMS: **Rwy 16,** 2400-3, or std. with climb gradient of 360' per NM to 7400. **Rwy 22,** NA.

DEPARTURE PROCEDURE: **Rwys 4,16,** climbing left turn. **Rwy 34,** climbing right turn. **All aircraft** continue climb to 9000 via heading 030° and CPN R-346 to GLUES Int.

ARCO, ID

ARCO-BUTTE COUNTY

DEPARTURE PROCEDURE: **Rwy 24,** Use JOBRO TWO DEPARTURE.

06 JUL 2006 to 03 AUG 2006

06159

TAKE-OFF MINIMUMS AND (OBSTACLE) DEPARTURE PROCEDURES

NW-1

C1

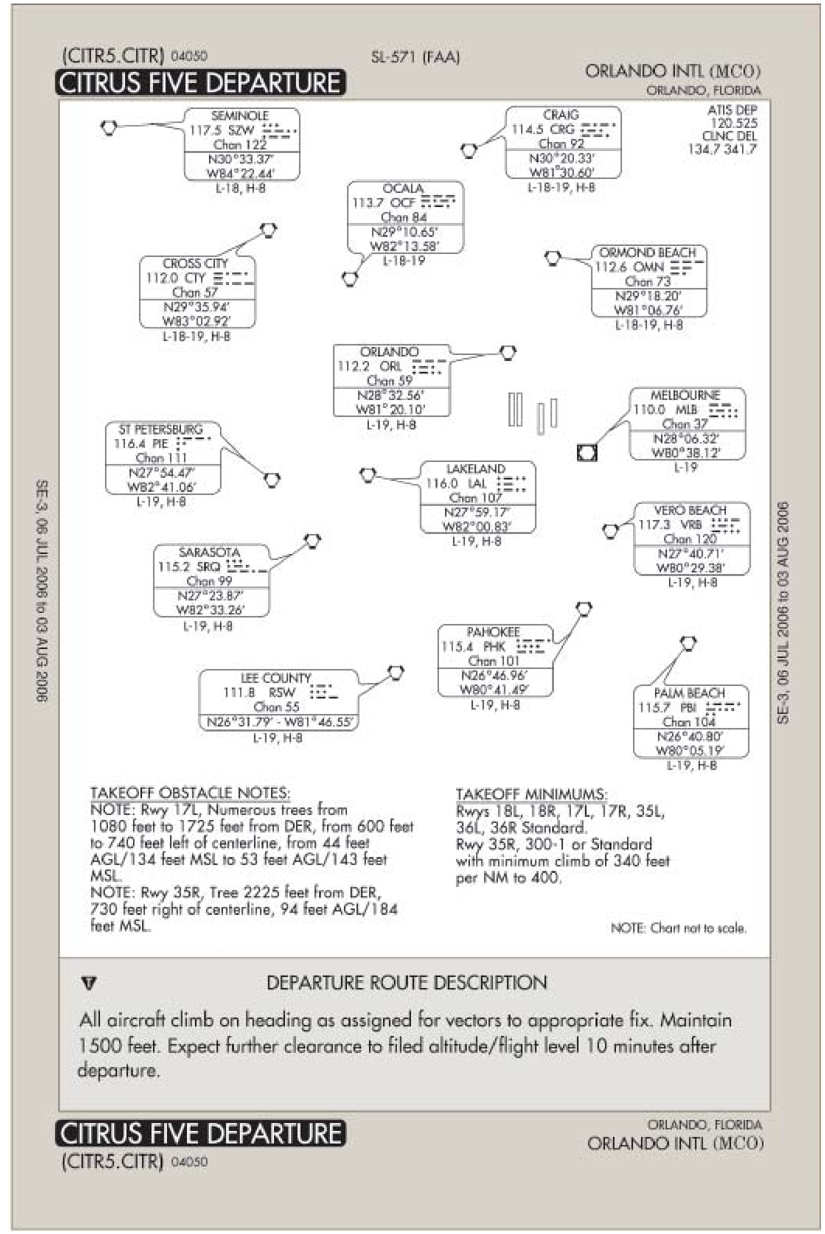
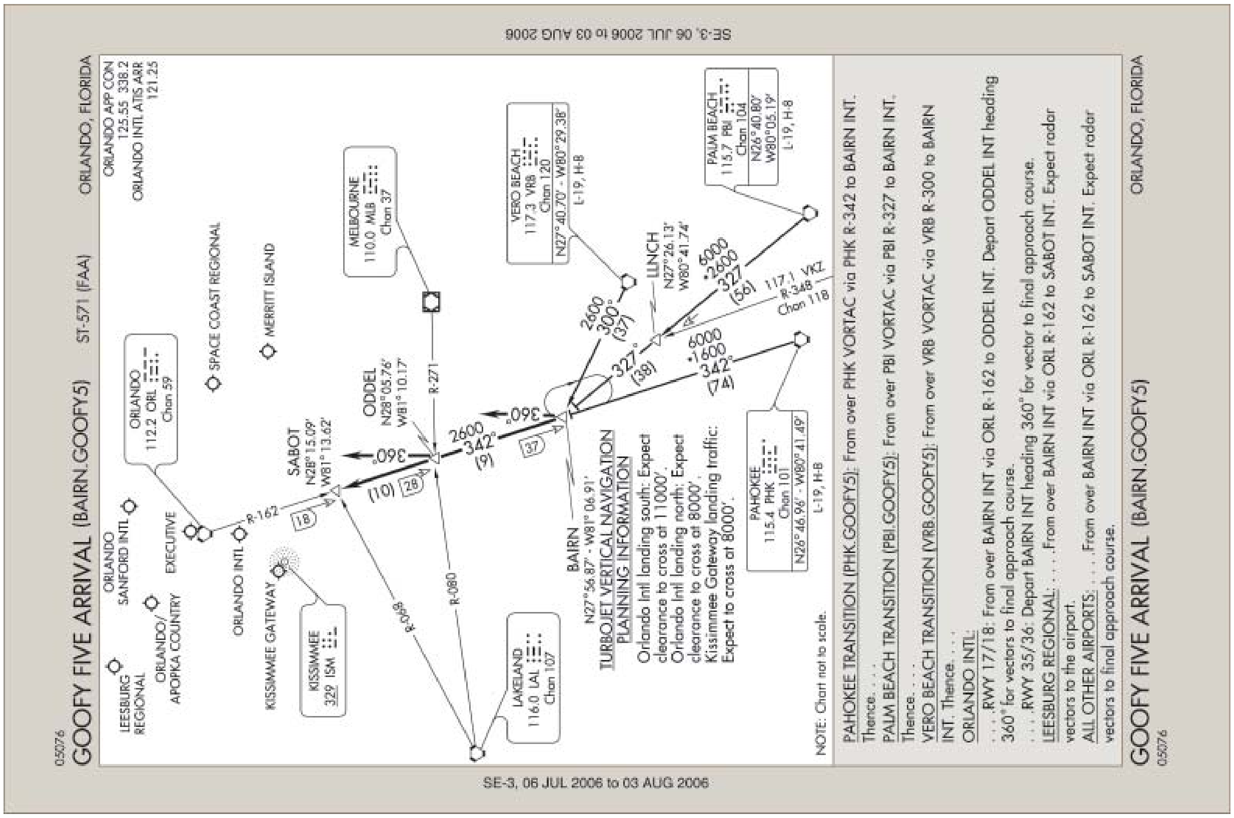


Figure 8-8. *Obstacle Departure Procedures (ODP) and Standard Instrument Departures (SID).*



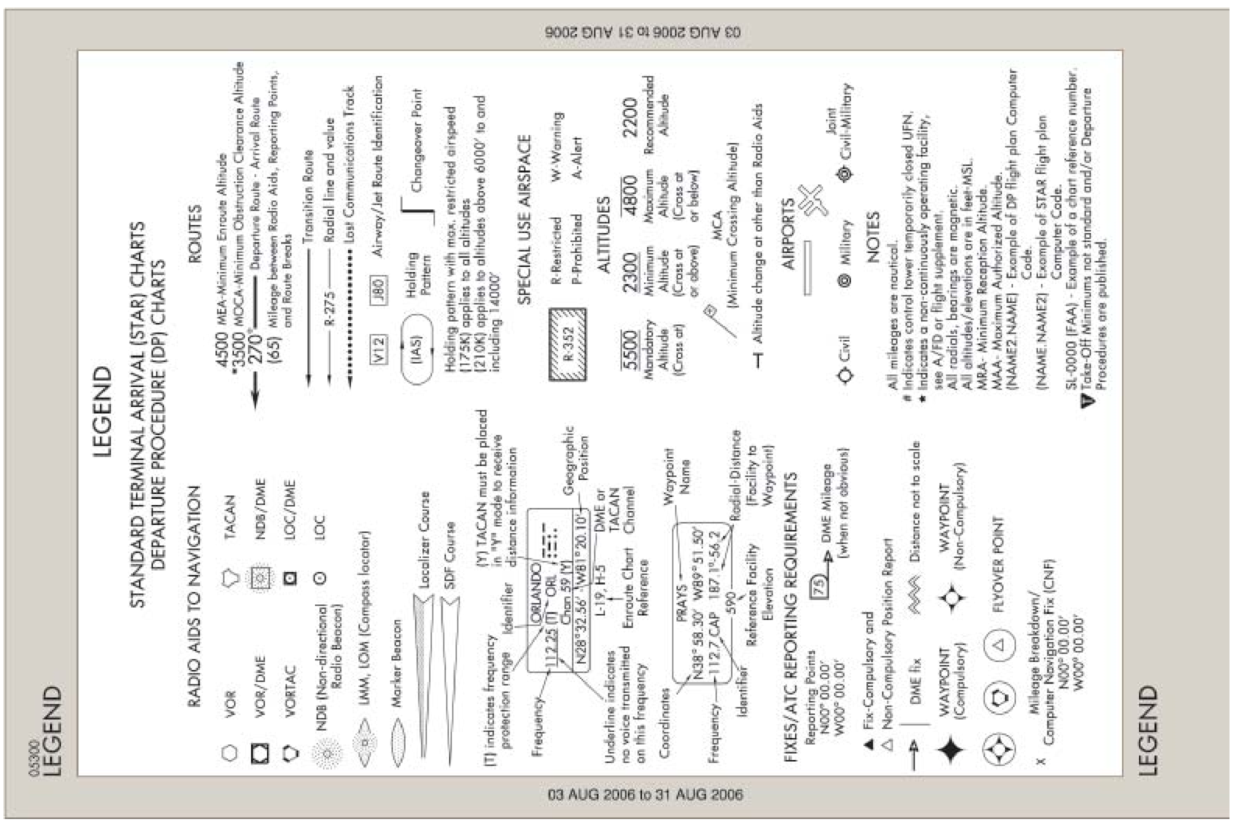


Figure 8-9. *DP Chart Legend and STAR.*

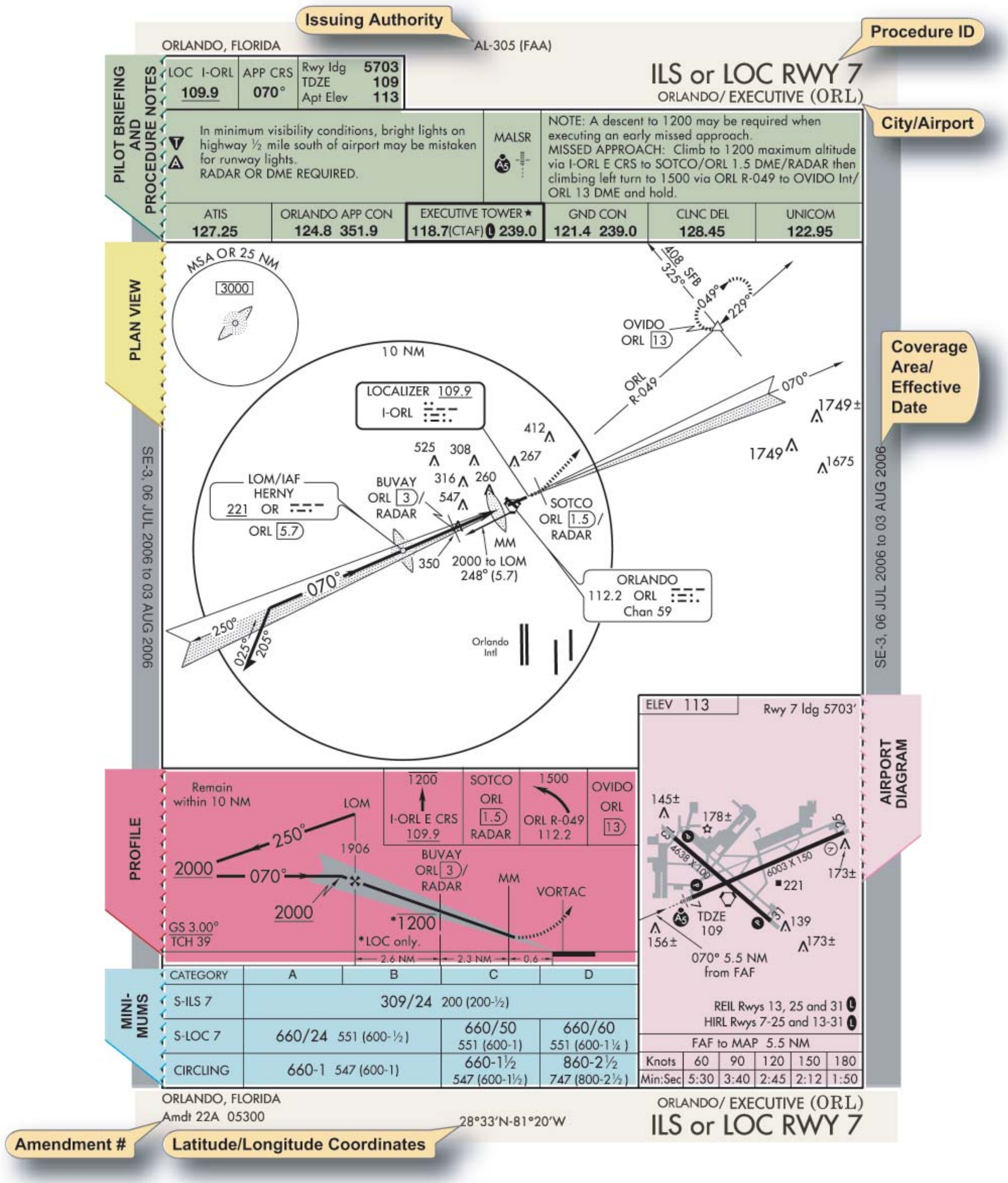


Figure 8-10. *Instrument Approach Chart.*

The procedure chart title (top and bottom margin area of *Figure 8-10*) is derived from the type of navigational facility providing final approach course guidance. A runway number is listed when the approach course is aligned within 30º of the runway centerline. This type of approach allows a straight-in landing under the right conditions. The type of approach followed by a letter identifies approaches that do not have straight-in landing minimums. Examples include procedure titles at the same airport, which have only circling minimums. The first approach of this type created at the airport will be labeled with the letter A, and the lettering will continue in alphabetical order (e.g., "VOR-A or "LDA-B"). The letter designation signifies the expectation is for the procedure to culminate in a circling approach to land. As a general rule, circling-only approaches are designed for one of the two following reasons:

- The final approach course alignment with the runway centerline exceeds 30º.
- The descent gradient is greater than 400 feet per NM from the FAF to the threshold crossing height (TCH). When this maximum gradient is exceeded, the circling-only approach procedure may be designed to meet the gradient criteria limits.

Further information on this topic can be found in the Instrument Procedures Handbook, Chapter 5, under Approach Naming Conventions.

To distinguish between the left, right, and center runways, an "L," "R," or "C" follows the runway number (e.g., "ILS RWY 16R"). In some cases, an airport might have more than one circling approach, shown as VOR-A, VOR/DME-B, etc.

More than one navigational system separated by a slash indicates more than one type of equipment is required to execute the final approach (e.g., VOR/DME RWY 31). More than one navigational system separated by "or" indicates either type of equipment may be used to execute the final approach (e.g., VOR or GPS RWY 15). Multiple approaches of the same type, to the same runway and using the same guidance, have an additional letter from the end of the alphabet, number, or term in the title (e.g., ILS Z RWY 28, SILVER ILS RWY 28, or ILS 2 RWY 28). VOR/DME RNAV approaches are identified as VOR/DME RNAV RWY (runway number). Helicopters have special IAPs, designated with COPTER in the procedure identification (e.g., COPTER LOC/DME 25L). Other types of navigation systems may be required to execute other portions of the approach prior to intercepting the final approach segment or during the missed approach.

The Pilot Briefing

The pilot briefing is located at the top of the chart and provides the pilot with information required to complete the published approach procedure. Included in the pilot briefing are the NAVAID providing approach guidance, its frequency, the final approach course, and runway information. A notes section contains additional procedural information. For example, a procedural note might indicate restrictions for circling maneuvers. Some other notes might concern a local altimeter setting and the resulting change in the minimums. The use of RADAR may also be noted in this section. Additional notes may be found in the plan view.

When a triangle containing a "T" (T) appears in the notes section, it signifies the airport has nonstandard IFR takeoff minimums. Pilots should refer to the DPs section of the TPP to determine takeoff minimums.

When a triangle containing an "A" (A) appears in the notes section, it signifies the airport has nonstandard IFR alternate minimums. Civil pilots should refer to the Alternate Minimums Section of the TPP to determine alternate minimums. Military pilots should refer to appropriate regulations.

When a triangle containing an "A" NA (A NA) appears in the notes area, it signifies that Alternate Minimums are Not Authorized due to unmonitored facility or the absence of weather reporting service.

Communication frequencies are listed in the order in which they would be used during the approach. Frequencies for weather and related facilities are included, where applicable, such as automatic terminal information service (ATIS), automated surface observing system (ASOS), automated weather observation system (AWOS), and AFSSs.

The Plan View

The plan view provides a graphical overhead view of the procedure, and depicts the routes that guide the pilot from the en route segments to the initial approach fix (IAF). *[Figure 8-10]* During the initial approach, the aircraft has departed the en route phase of flight and is maneuvering to enter an intermediate or final segment of the instrument approach. An initial approach can be made along prescribed routes within the terminal area, which may be along an arc, radial, course, heading, radar vector, or a combination thereof. Procedure turns and high altitude teardrop penetrations are initial approach segments. Features of the plan view, including the procedure turn, obstacle elevation, minimum safe altitude (MSA), and procedure track, are depicted in *Figure 8-11*. Terrain will be depicted in the plan view portion of all IAPs if the terrain within the plan view exceeds 4,000 feet above the airport elevation, or if within a 6 nautical mile radius of the airport reference point the terrain rises at least 2,000 feet above the airport elevation.

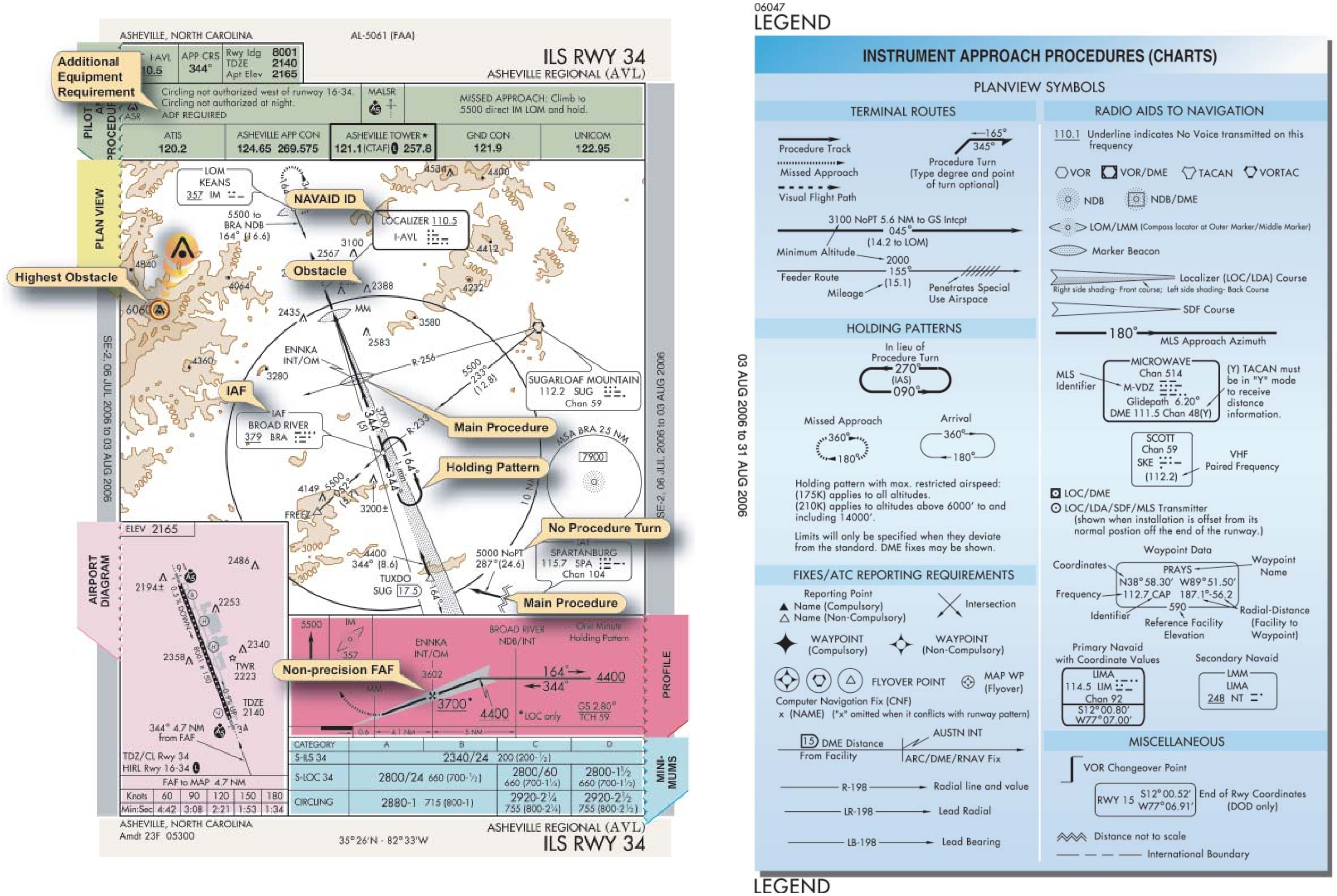


Figure 8-11. *IAP Plan View and Symbol Legends.*

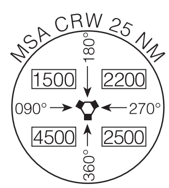
Some NACG charts contain a reference or distance circle with a specified radius (10 NM is most common). Normally, approach features within the plan view are shown to scale; however, only the data within the reference circle is always drawn to scale.

Concentric dashed circles, or concentric rings around the distance circle, are used when the information necessary to the procedure will not fit to scale within the limits of the plan view area. They serve as a means to systematically arrange this information in its relative position outside and beyond the reference circle. These concentric rings are labeled en route facilities and feeder facilities.

The primary airport depicted in the plan view is drawn with enough detail to show the runway orientation and final approach course alignment. Airports other than the primary approach airport are not normally depicted in the NACG plan view.

Known spot elevations are indicated on the plan view with a dot in MSL altitude. The largest dot and number combination indicates the highest elevation. An inverted "V" with a dot in the center depicts an obstacle. The highest obstacle is indicated with a bolder, larger version of the same symbol. *[Figure 8-11]*

The MSA circle appears in the plan view, except in approaches for which the Terminal Arrival Area (TAA) format is used or appropriate NAVAIDs (e.g., VOR or NDB) are unavailable. The MSA is provided for emergency purposes only and guarantees 1,000 feet obstruction clearance in the sector indicated with reference to the bearings in the circle. For conventional navigation systems, the MSA is normally based on the primary omnidirectional facility (NAVAID) on which the IAP is predicated. The MSA depiction on the approach chart contains the facility identifier of the NAVAID used to determine the MSA altitudes. For RNAV approaches, the MSA is based on the runway waypoint for straight-in approaches, or the airport waypoint for circling approaches. For GPS approaches, the MSA center header will be the missed approach waypoint. The MSL altitudes appear in boxes within the circle, which is typically a 25 NM radius unless otherwise indicated. The MSA circle header refers to the letter identifier of the NAVAID or waypoint that describes the center of the circle.



NAVAIDs necessary for the completion of the instrument procedure include the facility name, letter identifier, and Morse code sequence. They may also furnish the frequency, Morse code, and channel. A heavy-lined NAVAID box depicts the primary NAVAID used for the approach. An "I" in front of the NAVAID identifier (in *Figure 8-11*, "I-AVL") listed in the NAVAID box indicates a localizer. The requirement for an ADF, DME, or RADAR in the approach is noted in the plan view.

Intersections, fixes, radials, and course lines describe route and approach sequencing information. The main procedure or final approach course is a thick, solid line. A DME arc, which is part of the main procedure course, is also represented as a thick, solid line. A feeder route is depicted with a medium line and provides heading, altitude, and distance information. (All three components must be designated on the chart to provide a navigable course.) Radials, such as lead radials, are shown by thin lines. The missed approach track is drawn using a thin, hash marked line with a directional arrow. A visual flight path segment appears as a thick dashed line with a directional arrow. Visual Flight Path IAFs are charted IAF when associated with a NAVAID or when freestanding.

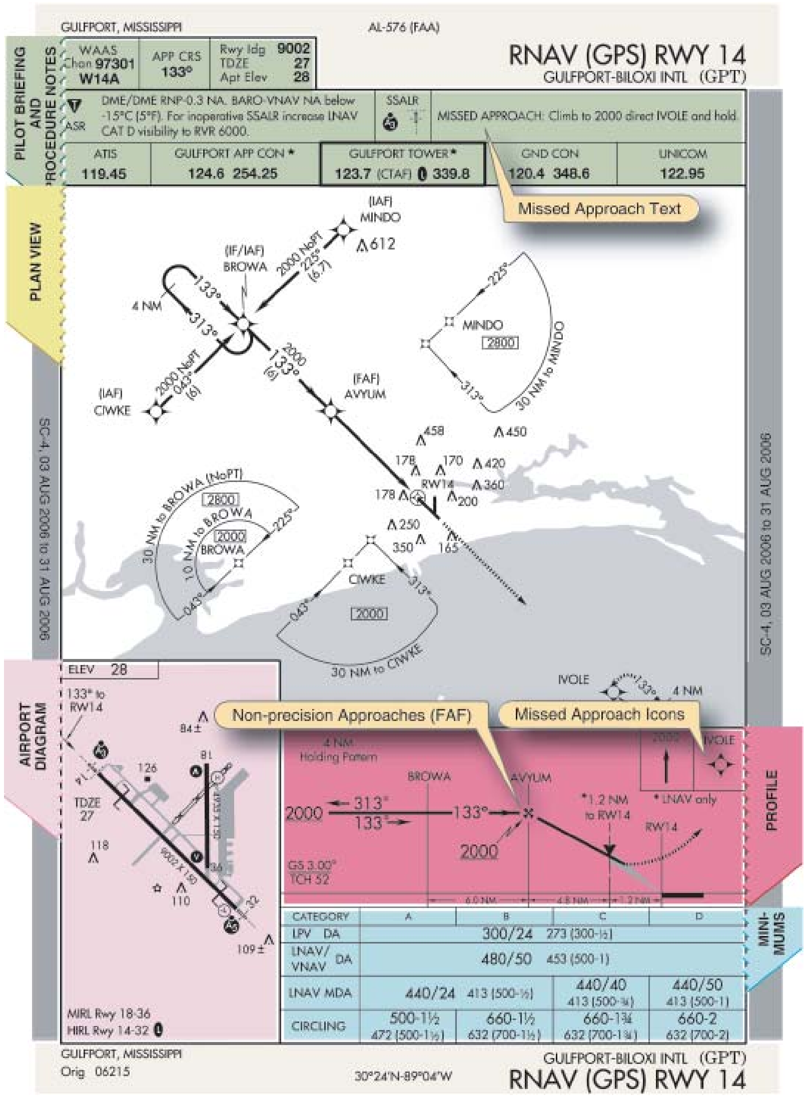
The missed approach holding pattern track is represented with a thin-dashed line. When collocated, the missed approach holding pattern and procedure turn holding pattern are indicated as a solid, black line. Arrival holding patterns are depicted as thin, solid lines.

Terminal Arrival Area (TAA)

The design objective of the TAA procedure is to provide a transition method for arriving aircraft with GPS/RNAV equipment. TAAs will also eliminate or reduce the need for feeder routes, departure extensions, and procedure turns or course reversal. The TAA is controlled airspace established in conjunction with the standard or modified RNAV approach configurations.

The standard TAA has three areas: straight-in, left base, and right base. The arc boundaries of the three areas of the TAA are published portions of the approach and allow aircraft to transition from the en route structure direct to the nearest IAF. When crossing the boundary of each of these areas or when released by ATC within the area, the pilot is expected to proceed direct to the appropriate waypoint IAF for the approach area being flown. A pilot has the option in all areas of proceeding directly to the holding pattern.

The TAA has a "T" structure that normally provides a NoPT for aircraft using the approach. *[Figure 8-12]* The TAA provides the pilot and air traffic controller with an efficient method for routing traffic from the en route to the terminal structure. The basic "T" contained in the TAA normally aligns the procedure on runway centerline, with the missed



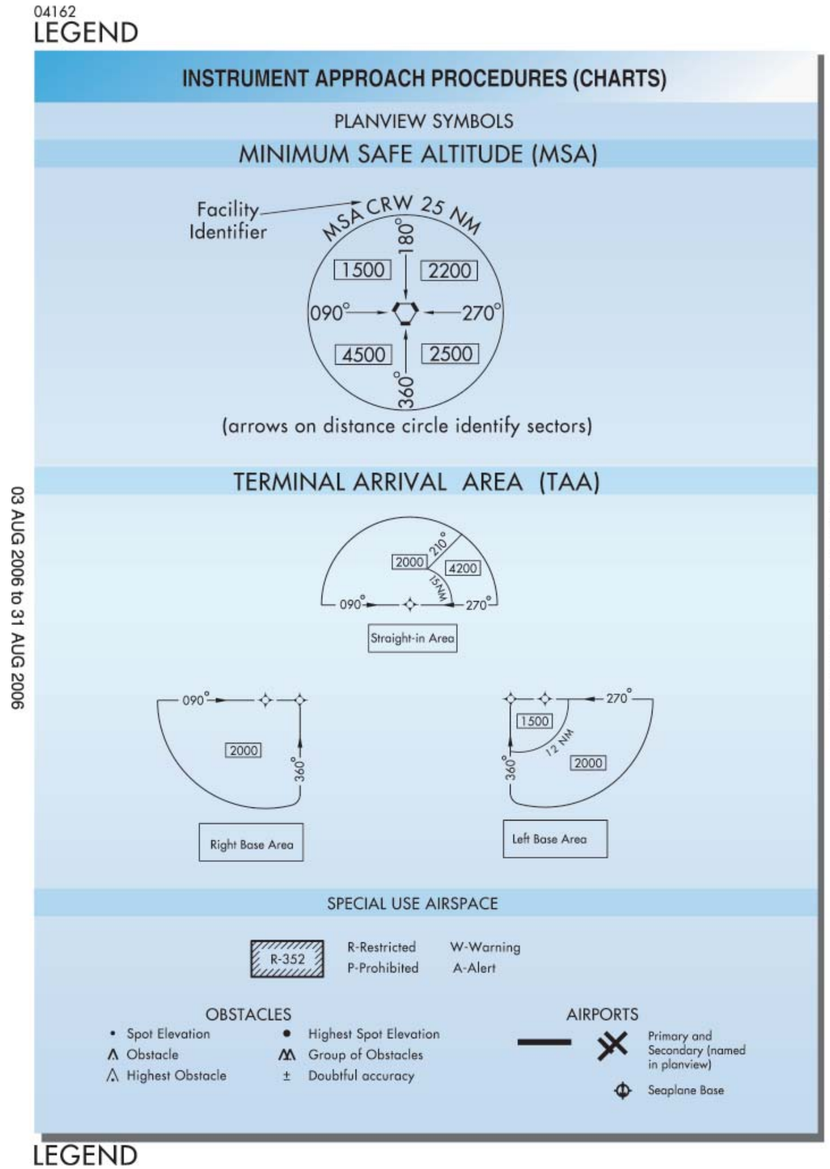


Figure 8-12. *Basic "T" Design of Terminal Arrival Area (TAA) and Legend.*

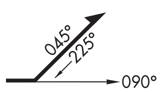
approach point (MAP) located at the threshold, the FAF 5 NM from the threshold, and the intermediate fix (IF) 5 NM from the FAF.

In order to accommodate descent from a high en route altitude to the initial segment altitude, a hold in lieu of a procedure turn provides the aircraft with an extended distance for the necessary descent gradient. The holding pattern constructed for this purpose is always established on the center IAF waypoint. Other modifications may be required for parallel runways, or special operational requirements. When published, the RNAV chart will depict the TAA through the use of icons representing each TAA associated with the RNAV procedure. These icons are depicted in the plan view of the approach, generally arranged on the chart in accordance with their position relative to the aircraft's arrival from the en route structure.

Course Reversal Elements in Plan View and Profile View

Course reversals included in an IAP are depicted in one of three different ways: a 45°/180° procedure turn, a holding pattern in lieu of procedure turn, or a teardrop procedure. The maneuvers are required when it is necessary to reverse direction to establish the aircraft inbound on an intermediate or final approach course. Components of the required procedure are depicted in the plan view and the profile view. The maneuver must be completed within the distance and at the minimum altitude specified in the profile view. Pilots should coordinate with the appropriate ATC facility relating to course reversal during the IAP.

Procedure Turns

A procedure turn barbed arrow 

indicates the direction or side of the outbound course on which the procedure turn is made. *[Figure 8-13]* Headings are provided for course reversal using the 45° procedure turn. However, the point at which the turn may be commenced, and the type and rate of turn is left to the discretion of the pilot. Some of the options are the 45° procedure turn, the racetrack pattern, the teardrop procedure turn, or the 80°/260° course reversal. The absence of the procedure turn barbed arrow in the plan view indicates that a procedure turn is not authorized for that procedure. A maximum procedure turn speed of not greater than 200 knots indicated airspeed (KIAS) should be observed when turning outbound over the IAF and throughout the procedure turn maneuver to ensure staying within the obstruction clearance area. The normal procedure turn distance is 10 NM. This may be reduced to a minimum of 5 NM where only Category A or helicopter aircraft are operated, or increased to as much as 15 NM to accommodate high performance aircraft. Descent below the procedure turn altitude begins after the aircraft is established on the inbound course.

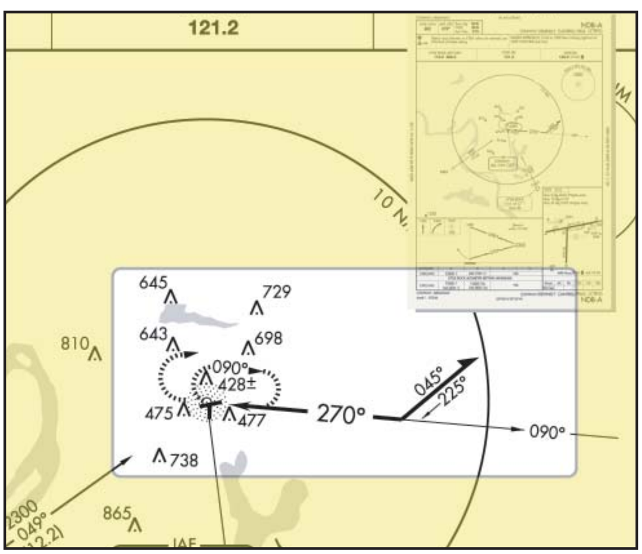


Figure 8-13. *45° Procedure Turn.*

The procedure turn is *not* required when the symbol "NoPT" appears, when radar vectoring to the final approach is provided, when conducting a timed approach, or when the procedure turn is not authorized. Pilots should contact the appropriate ATC facility when in doubt if a procedure turn is required.

Holding in Lieu of Procedure Turn

A holding pattern in lieu of a procedure turn may be specified for course reversal in some procedures. *[Figure 8-14]* In such cases, the holding pattern is established over an intermediate fix or a final approach fix (FAF). The holding pattern distance

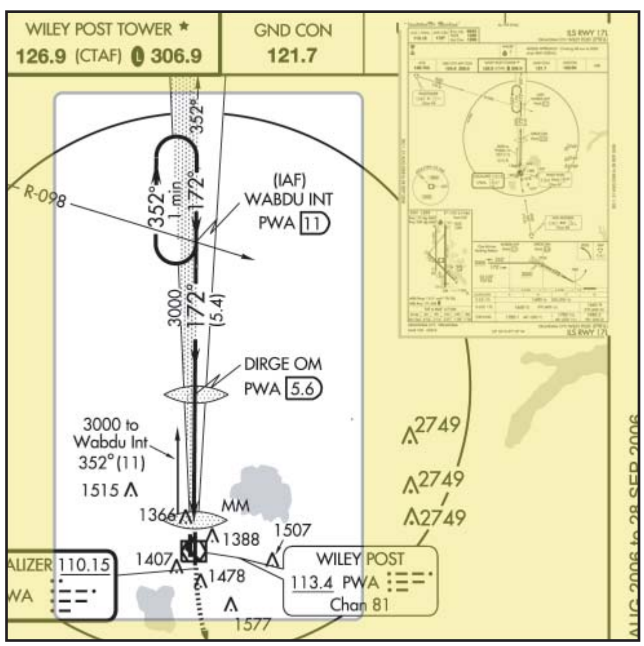


Figure 8-14. *Holding in Lieu of Procedure Turn.*

or time specified in the profile view must be observed. Maximum holding airspeed limitations as set forth for all holding patterns apply. The holding pattern maneuver is completed when the aircraft is established on the inbound course after executing the appropriate entry. 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 neither 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. When holding in lieu of a procedure turn, the holding pattern must be followed, except when RADAR VECTORING to the final approach course is provided or when NoPT is shown on the approach course.

Teardrop Procedure

When a teardrop procedure turn is depicted and a course reversal is required, unless otherwise authorized by ATC, this type of procedure must be executed. *[Figure 8-15]* The teardrop procedure consists of departure from an IAF on the published outbound course followed by a turn toward and intercepting the inbound course at or prior to the intermediate fix or point. Its purpose is to permit an aircraft to reverse direction and lose considerable altitude within reasonably limited airspace. Where no fix is available to mark the beginning of the intermediate segment, it shall be assumed to commence at a point 10 NM prior to the FAF. When the facility is located on the airport, an aircraft is considered to be on final approach upon completion of the penetration turn. However, the final approach segment begins on the final approach course 10 NM from the facility.

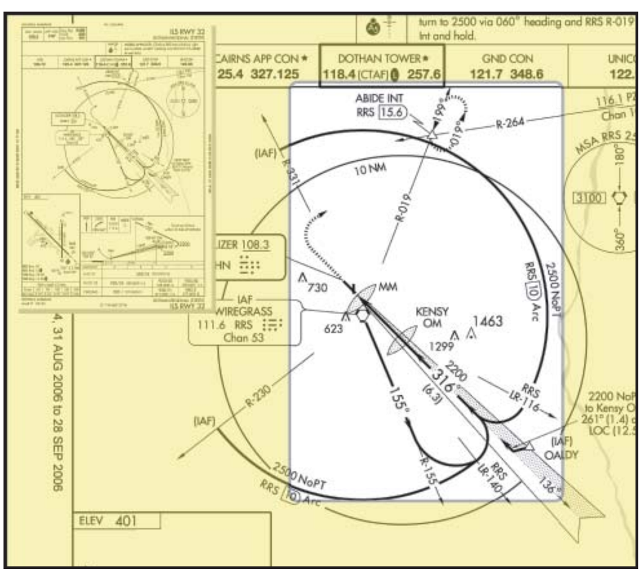


Figure 8-15. *Teardrop Procedure.*

The Profile View

The profile view is a depiction of the procedure from the side and illustrates the vertical approach path altitudes, headings, distances, and fixes. *[Figures 8-10, 8-11,* and *8-12]* The view includes the minimum altitude and the maximum distance for the procedure turn, altitudes over prescribed fixes, distances between fixes, and the missed approach procedure. The profile view aids in the pilot's interpretation of the IAP. The profile view is not drawn to scale. *[Figures 8-10, 8-11, 8-12,* and *8-16]*

The precision approach glide slope (GS) intercept altitude is a minimum altitude for GS interception after completion of the procedure turn, illustrated by an altitude number and "zigzag" line. It applies to precision approaches, and except where otherwise prescribed, also applies as a minimum altitude for crossing the FAF when the GS is inoperative or not used. Precision approach profiles also depict the GS angle of descent, threshold-crossing height (TCH), and GS altitude at the outer marker (OM).

For nonprecision approaches, a final descent is initiated and the final segment begins at either the FAF or the final approach point (FAP). The FAF is identified by use of the Maltese cross symbol in the profile view. *[Figure 8-11]* When no FAF is depicted, the final approach point is the point at which the aircraft is established inbound on the final approach course. *[Figure 8-16]*

Stepdown fixes in nonprecision procedures are provided between the FAF and the airport for authorizing a lower minimum descent altitude (MDA) after passing an obstruction. Stepdown fixes can be identified by NAVAID, NAVAID fix, waypoint or radar, and are depicted by a hash marked line. Normally, there is only one stepdown fix between the FAF and the MAP, but there can be several. If the stepdown fix cannot be identified for any reason, the minimum altitude at the stepdown fix becomes the MDA for the approach. However, circling minimums apply if they are higher than the stepdown fix minimum altitude, and a circling approach is required.

The visual descent point (VDP) is a defined point on the final approach course of a nonprecision straight-in approach procedure. A normal descent from the MDA to the runway touchdown point may be commenced, provided visual reference is established. The VDP is identified on the profile view of the approach chart by the symbol "V." *[Figure 8-12]*

The MAP varies depending upon the approach flown. For the ILS, the MAP is at the decision altitude/decision height (DA/DH). For nonprecision procedures, the pilot determines

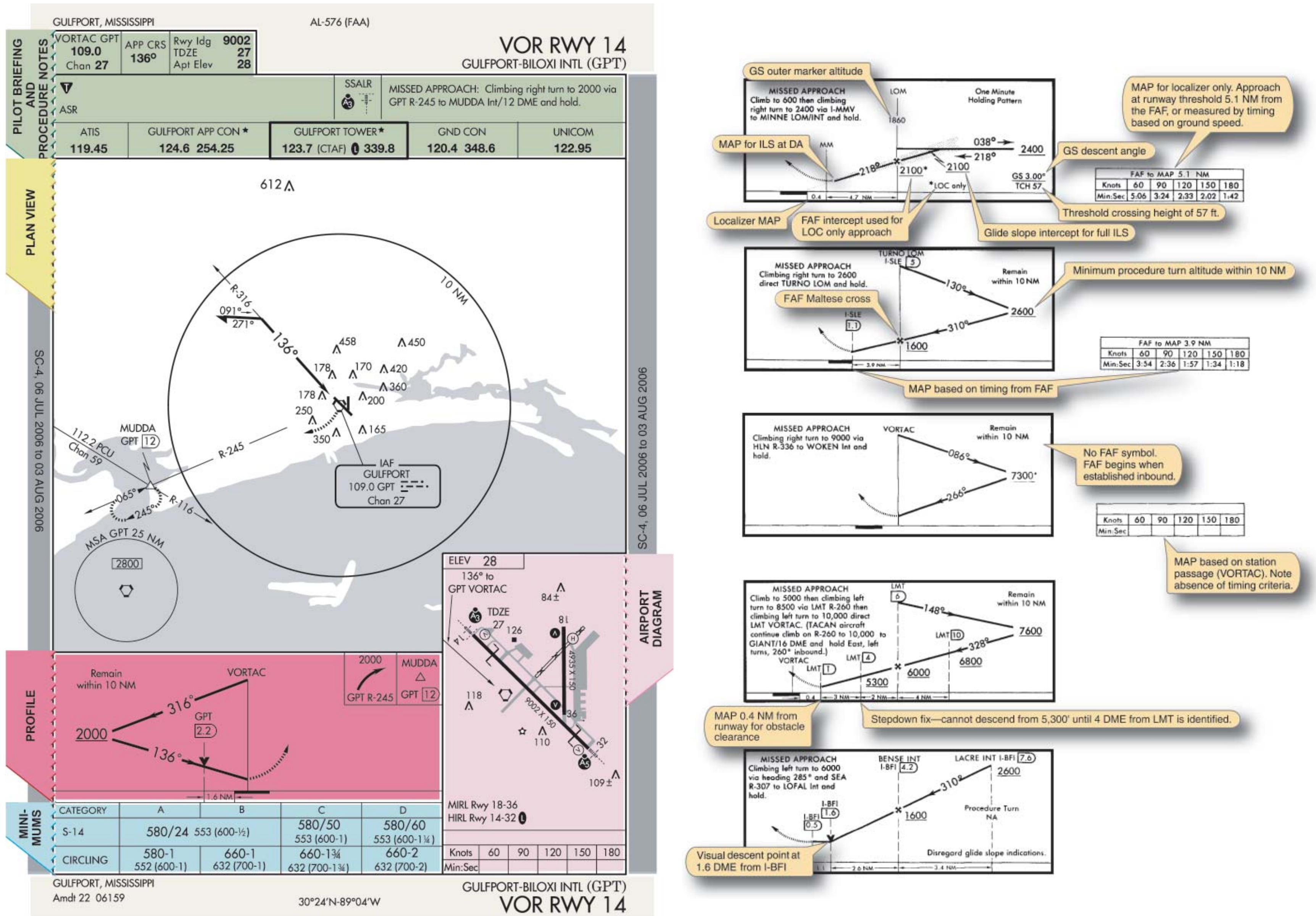


Figure 8-16. *More IAP Profile View Features.*

the MAP by timing from FAF when the approach aid is away from the airport, by a fix or NAVAID when the navigation facility is located on the field, or by waypoints as defined by GPS or VOR/DME RNAV. The pilot may execute the MAP early, but pilots should, unless otherwise cleared by ATC, fly the IAP as specified on the approach plate to the MAP at or above the MDA or DA/DH before executing a turning maneuver.

A complete description of the missed approach procedure appears in the pilot briefing section. *[Figure 8-16]* Icons indicating what is to be accomplished at the MAP are located in the profile view. When initiating a missed approach, the pilot will be directed to climb straight ahead (e.g., "Climb to 2,000") or commence a turning climb to a specified altitude (e.g., "Climbing right turn to 2,000"). In some cases, the procedure will direct the pilot to climb straight ahead to an initial altitude, then turn or enter a climbing turn to the holding altitude (e.g., "Climb to 900, then climbing right turn to 2,500 direct ABC VOR and hold").

When the missed approach procedure specifies holding at a facility or fix, the pilot proceeds according to the missed approach track and pattern depicted on the plan view. An alternate missed approach procedure may also be issued by ATC. The textual description will also specify the NAVAID(s) or radials that identify the holding fix.

The profile view also depicts minimum, maximum, recommended, and mandatory block altitudes used in approaches. The minimum altitude is depicted with the altitude underscored. $\underline{2500}$ On final approach, aircraft are required to maintain an altitude at or above the depicted altitude until reaching the subsequent fix. The maximum altitude will be depicted with the altitude overscored, $\overline{4300}$ and aircraft must remain at or below the depicted altitude. Mandatory altitudes will be depicted with the altitude both underscored and overscored, $\overline{\underline{5500}}$ and altitude is to be maintained at the depicted value. Recommended altitudes are advisory altitudes and are neither over- nor underscored. When an over- or underscore spans two numbers, a mandatory block altitude is indicated, and aircraft are required to maintain altitude within the range of the two numbers. *[Figures 8-11* and *8-12]*

The Vertical Descent Angle (VDA) found on nonprecision approach charts provides the pilot with information required to establish a stabilized approach descent from the FAF or stepdown fix to the threshold crossing height (TCH). *[Figure 8-17]* Pilots can use the published angle and estimated or actual ground speed to find a target rate of descent using the rate of descent table in the back of the TPP.

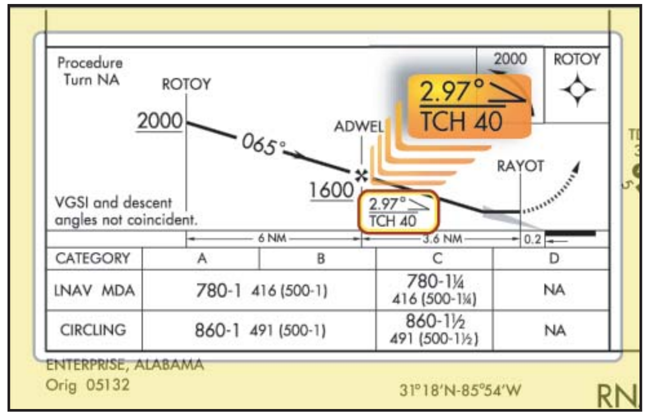


Figure 8-17. *Vertical Descent Angle (VDA).*

Landing Minimums

The minimums section sets forth the lowest altitude and visibility requirements for the approach, whether precision or nonprecision, straight-in or circling, or radar vectored. When a fix is incorporated in a nonprecision final segment, two sets of minimums may be published, depending upon how the fix can be identified. Two sets of minimums may also be published when a second altimeter source is used in the procedure. The minimums ensure that final approach obstacle clearance is provided from the start of the final segment to the runway or MAP, whichever occurs last. The same minimums apply to both day and night operations unless different minimums are specified in the Notes section of the pilot briefing. Published circling minimums provide obstacle clearance when pilots remain within the appropriate area of protection. *[Figure 8-18]*

Minimums are specified for various aircraft approach categories based upon a value 1.3 times the stalling speed of the aircraft in the landing configuration at maximum certified gross landing weight. If it is necessary to maneuver at speeds in excess of the upper limit of a speed range for a category, the minimums for the next higher category should be used. For example, an aircraft that falls into category A, but is circling to land at a speed in excess of 91 knots, should use approach category B minimums when circling to land. *[Figure 8-19]*

The minimums for straight-in and circling appear directly under each aircraft category. *[Figure 8-19]* When there is no solid division line between minimums for each category on the rows for straight-in or circling, the minimums apply to the two or more categories.

The terms used to describe the minimum approach altitudes differ between precision and nonprecision approaches.

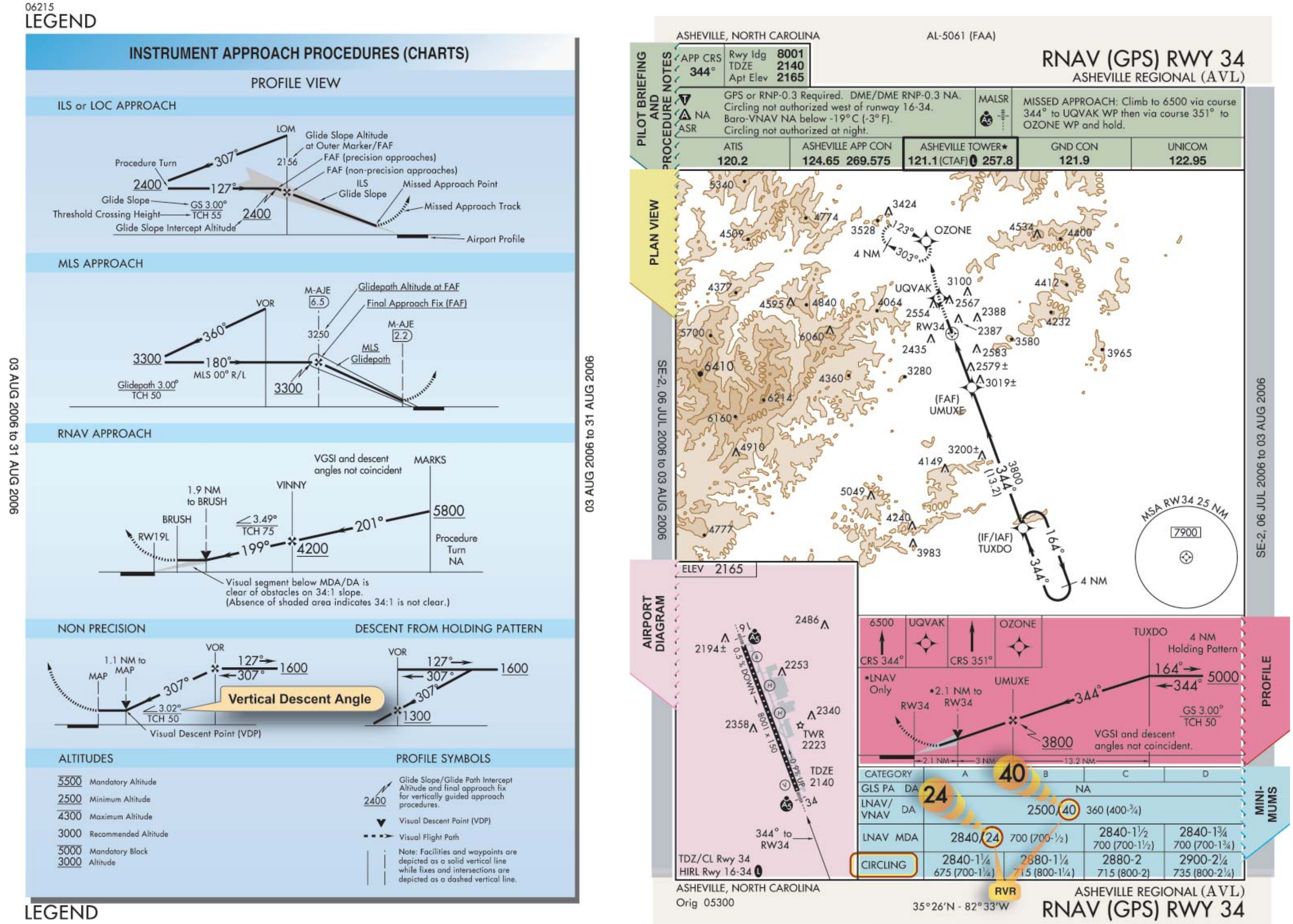


Figure 8-18. *IAP Profile Legend.*

DESCENT TABLE 99028

RATE OF DESCENT TABLE

A rate of descent table is provided for use in planning and executing precision 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.

03 AUG 2006 to 31 AUG 2006

ANGLE OF DESCENT (degrees and tenths)	FEET /NM	GROUND SPEED (knots)										
		30	45	60	75	90	105	120	135	150	165	180
2.0	210	105	160	210	265	320	370	425	475	530	585	635
2.5	265	130	200	265	330	395	465	530	595	665	730	795
VERTICAL PATH ANGLE 2.7	287	143	215	287	358	430	501	573	645	716	788	860
2.8	297	149	223	297	371	446	520	594	669	743	817	891
2.9	308	154	231	308	385	462	539	616	693	769	846	923
3.0	318	159	239	318	398	478	557	637	716	796	876	955
3.1	329	165	247	329	411	494	576	658	740	823	905	987
3.2	340	170	255	340	425	510	594	679	764	849	934	1019
3.3	350	175	263	350	438	526	613	701	788	876	963	1051
3.4	361	180	271	361	451	541	632	722	812	902	993	1083
3.5	370	185	280	370	465	555	650	740	835	925	1020	1110
4.0	425	210	315	425	530	635	740	845	955	1060	1165	1270
4.5	475	240	355	475	595	715	835	955	1075	1190	1310	1430
5.0	530	265	395	530	660	795	925	1060	1190	1325	1455	1590
5.5	580	290	435	580	730	875	1020	1165	1310	1455	1600	1745
6.0	635	315	475	635	795	955	1110	1270	1430	1590	1745	1950
6.5	690	345	515	690	860	1030	1205	1375	1550	1720	1890	2065
7.0	740	370	555	740	925	1110	1295	1480	1665	1850	2035	2220
7.5	795	395	595	795	990	1190	1390	1585	1785	1985	2180	2380
8.0	845	425	635	845	1055	1270	1480	1690	1905	2115	2325	2540
8.5	900	450	675	900	1120	1345	1570	1795	2020	2245	2470	2695
9.0	950	475	715	950	1190	1425	1665	1900	2140	2375	2615	2855
9.5	1005	500	750	1005	1255	1505	1755	2005	2255	2510	2760	3010
10.0	1055	530	790	1055	1320	1585	1845	2110	2375	2640	2900	3165
10.5	1105	555	830	1105	1385	1660	1940	2215	2490	2770	3045	3320
11.0	1160	580	870	1160	1450	1740	2030	2320	2610	2900	3190	3480
11.5	1210	605	910	1210	1515	1820	2120	2425	2725	3030	3335	3635
12.0	1260	630	945	1260	1575	1890	2205	2520	2835	3150	3465	3780

03 AUG 2006 to 31 AUG 2006

DESCENT TABLE 99028

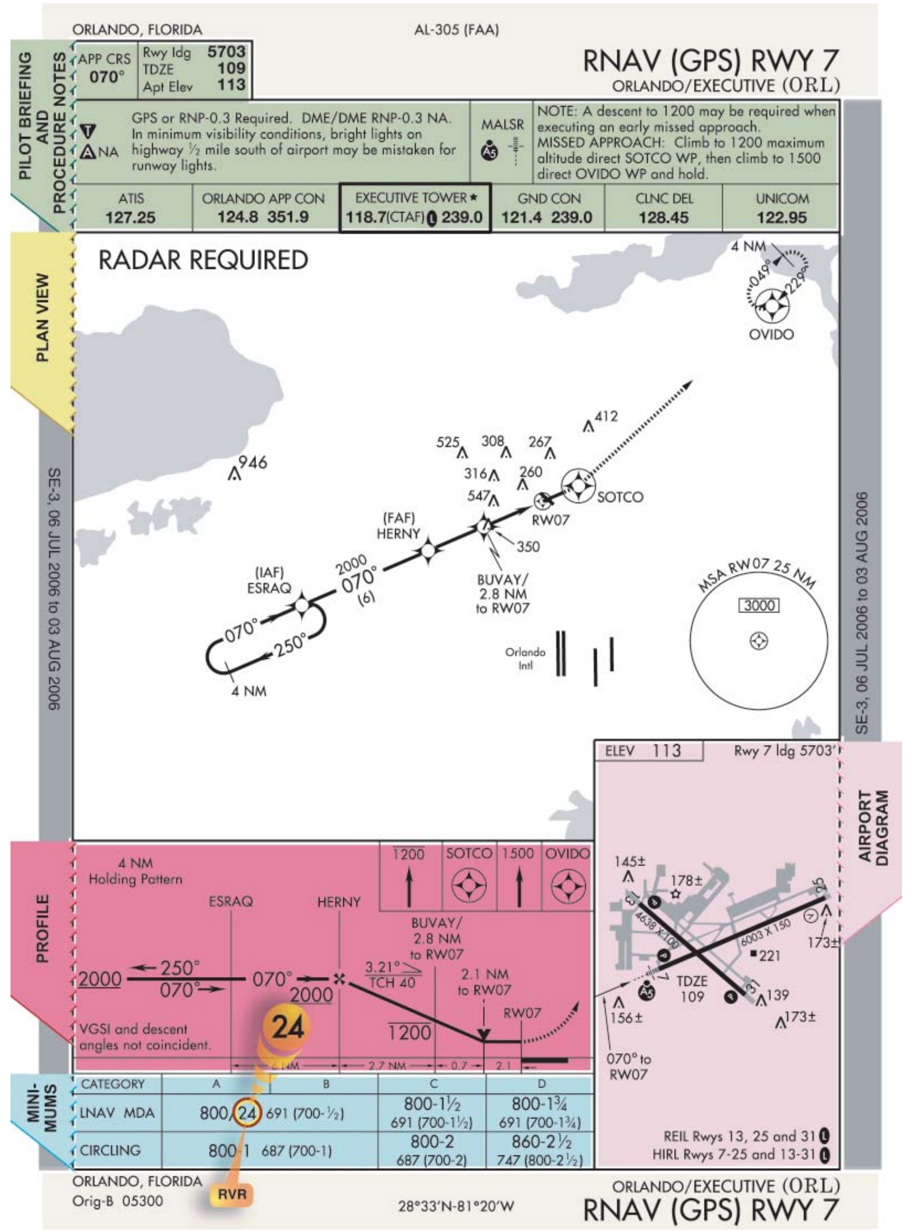


Figure 8-19. *Descent Rate Table.*

05300
TERMS/LANDING MINIMA DATA
IFR LANDING MINIMA

The United States Standard for Terminal Instrument Procedures (TERPS) is the approved criteria for formulating instrument approach procedures. Landing minima are established for six aircraft approach categories (ABCDE and COPTER). In the absence of COPTER MINIMA, helicopters may use the CAT A minimums of other procedures. The standard format for RNAV minima and landing minima portrayal follows:

RNAV (GPS) MINIMA

CATEGORY	A	B	C	D
LPV DA	1540/24 258 (300-½)			
LNAV/VNAV DA	1600/24 318 (400-½)			1600/40 318 (400-¾)
LNAV MDA	1840/24 558 (600-½)		1840/50 558 (600-1)	1840/60 558 (600-1¼)
CIRCLING	1840-1 545 (600-1)		1840-1½ 545 (600-1½)	1860-2 565 (600-2)

NOTE: The W symbol indicates outages of the WAAS vertical guidance may occur daily at this location due to initial system limitations. WAAS NOTAMS for vertical outages are not provided for this approach. Use LNAV minima for flight planning at these locations, whether as a destination or alternate. For flight operations at these locations, when the WAAS avionics indicate that LNAV/VNAV or LPV service is available, then vertical guidance may be used to complete the approach using the displayed level of service. Should an outage occur during the procedure, reversion to LNAV minima may be required. As the WAAS coverage is expanded, the W will be removed.

RNAV minimums are dependent on navigation equipment capability, as stated in the applicable AFM, AFMS, or other FAA approved document, and as outlined below.

GLS (GLobal Navigation Satellite System (GNSS) Landing System)

The GLS (NA) minima line will be removed from existing RNAV (GPS) approach charts when LPV minima is published.

LPV (An Approach Procedure with Vertical Guidance (APV) based on WAAS lateral and vertical guidance)

Must have WAAS avionics approved for LPV approach.

LNAV/VNAV (Lateral navigation/Vertical navigation)

Must have either:
a.) WAAS avionics approved for LNAV/VNAV approach, or
b.) A certified Baro-VNAV system with an IFR approach approved GPS,or
c.) A certified Baro-VNAV system with an IFR approach approved WAAS, or
d.) An approach certified RNP-0.3 system with barometric vertical guidance (Baro-VNAV).
Other RNAV systems require special approval.
NOTES:
1. LNAV-VNAV minima not applicable for Baro-VNAV equipment if chart is annotated "Baro-VNAV NA" or when below the minimum published temperature, e.g., Baro-VNAV NA below -17°C(2°F).
2. DME/DME based RNP-0.3 systems may be used only when a chart note indicates DME/DME availability; e.g., "DME/DME RNP-0.3 Authorized." Specific DME facilities may be required; e.g., "DME/DME RNP-0.3 Authorized. ABC, XYZ required."

LNAV (Lateral navigation)

Must have IFR approach approved GPS, WAAS, or RNP-0.3 system.Other RNAV systems require special approval.
NOTE: DME/DME based RNP-0.3 systems may be used only when a chart note indicates DME/DME availability; e.g., "DME/DME RNP-0.3 Authorized." Specific DME facilities may be required; e.g., "DME/DME RNP-0.3 Authorized. ABC, XYZ required."

LANDING MINIMA FORMAT

In this example airport elevation is 1179, and runway touchdown zone elevation is 1152.

CATEGORY	A	B	C	D
S-ILS 27	1352/24		200 (200-½)	
S-LOC 27	1440/24	288	(300-½)	1440/50 288 (300-1)
CIRCLING	1540-1 361 (400-1)	1640-1 461 (500-1)	1640-1½ 461 (500-1½)	1740-2 561 (600-2)

Straight-in ILS to Runway 27
Straight-in with Glide Slope Inoperative or not used to Runway 27
DA
Visibility (RVR 100s of feet)
HAT
Aircraft Approach Category
All minima in parentheses not applicable to Civil Pilots.
Military Pilots refer to appropriate regulations.
MDA
HAA
Visibility in Statute Miles

03 AUG 2006 to 31 AUG 2006

TERMS/LANDING MINIMA DATA

05300
TERMS/LANDING MINIMA DATA
COPTER MINIMA ONLY

CATEGORY	COPTER
H-176°	680-½ 363 (400-½)

Copter Approach Direction
Height of MDA/DA Above Landing Area (HAL)

No circling minimums are provided

RADAR MINIMA

PAR (c)	10 2.5°/42/1000	ABCDE	**195**/16	100	(100-¼)				
(d)	28 2.5°/48/1068	ABCDE	**187**/16	100	(100-¼)				
ASR	10	ABC	**560**/40	463	(500-¾)	D	**560**/50	463	(500-1)
		E	**580**/60	463	(500-1¼)				
	28	AB	**600**/50	513	(600-1)	C	**600**/60	513	(600-1¼)
		DE	**600**-1½	513	(600-1½)				
CIR (b)	10	AB	**560**-1¼	463	(500-1¼)	C	**560**-1½	463	(500-1½)
	28	AB	**600**-1¼	503	(600-1¼)	C	**600**-1½	503	(600-1½)
	10, 28	DE	**660**-2	563	(600-2)				

Visibility (RVR 100s of feet)
All minima step in parentheses not applicable to Civil Pilots. Military Pilots refer to appropriate regulations.
Visibility in Statute Miles

Radar Minima:
1. Minima shown are the lowest permitted by established criteria. Pilots should consult applicable directives for their category of aircraft.
2. The circling MDA and weather minima to be used are those for the runway to which the final approach is flown - not the landing runway. In the above RADAR MINIMA example, a category C aircraft flying a radar approach to runway 10, circling to land on runway 28, must use an MDA of 560 feet with weather minima of 500-1½ .

▲ Alternate Minimums not standard. Civil users refer to tabulation. USA/USN/USAF pilots refer to appropriate regulations.
▲ NA Alternate minimums are Not Authorized due to unmonitored facility or absence of weather reporting service.
▼ Take-off Minimums not standard and/or Departure Procedures are published. Refer to tabulation.

AIRCRAFT APPROACH CATEGORIES

Aircraft approach category indicates a grouping of aircraft based on a speed of VREF, if specified, or if VREF not specified, 1.3 VSO at the maximum certificated landing weight. VREF, VSO, and the maximum certificated landing weight are those values as established for the aircraft by the certification authority of the country of registry. Helicopters are Category A aircraft. An aircraft shall fit in only one category. However, if it is necessary to operate at a speed in excess of the upper limit of the speed range for an aircraft's category, the minimums for the category for that speed shall be used. For example, an airplane which fits into Category B, but is circling to land at a speed of 145 knots, shall use the approach Category D minimums. As an additional example, a Category A airplane (or helicopter) which is operating at 130 knots on a straight-in approach shall use the approach Category C minimums. See following category limits:

MANEUVERING TABLE

Approach Category	A	B	C	D	E
Speed (Knots)	0-90	91-120	121-140	141-165	Abv 165

Comparable Values of RVR and Visibility

The following table shall be used for converting RVR to ground or flight visibility. For converting RVR values that fall between listed values, use the next higher RVR value; do not interpolate. For example, when converting 1800 RVR, use 2400 RVR with the resultant visibility of 1/2 mile.

RVR (feet)	Visibility (statute miles)	RVR (feet)	Visibility (statute miles)
1600	¼	4500	⅞
2400	½	5000	1
3200	⅝	6000	1¼
4000	¾		

03 AUG 2006 to 31 AUG 2006

TERMS/LANDING MINIMA DATA

Figure 8-20. *Terms/Landing Minima Data.*

Precision approaches use decision height (DH), which is referenced to the height above threshold elevation (HAT). Nonprecision approaches use MDA, referenced to "feet MSL." The MDA is also referenced to HAT for straight-in approaches, or height above airport (HAA) for circling approaches. On NACG charts, the figures listed parenthetically are for military operations and are not used in civil aviation.

Visibility figures are provided in statute miles or runway visual range (RVR), which is reported in hundreds of feet. RVR is measured by a transmissometer, which represents the horizontal distance measured at points along the runway. It is based on the sighting of either high intensity runway lights or on the visual contrast of other targets, whichever yields the greater visual range. RVR is horizontal visual range, not slant visual range, and is used in lieu of prevailing visibility in determining minimums for a particular runway. It is illustrated in hundreds of feet if less than a mile (i.e., "24" is an RVR of 2,400 feet). *[Figures 8-19* and *8-20]*

Visibility figures are depicted after the DA/DH or MDA in the minimums section. If visibility in statute miles is indicated, an altitude number, hyphen, and a whole or fractional number appear; for example, 530-1, which indicates "530 feet MSL" and 1 statute mile visibility. This is the descent minimum for the approach. The RVR value is separated from the minimum altitude with a slash, such as "1065/24," which indicates 1,065 feet MSL and an RVR of 2,400 feet. If RVR is prescribed for the procedure, but not available, a conversion table is used to provide the equivalent visibility in this case, of 1/2 statute mile visibility. *[Figure 8-20]* The conversion table is also available in the TPP.

When an alternate airport is required, standard IFR alternate minimums apply. For aircraft other than helicopters, precision approach procedures require a 600-feet ceiling and two statute miles visibility; nonprecision approaches require an 800-feet ceiling and two statute miles visibility. Helicopter alternate minimums are a ceiling that is 200 feet above the minimum for the approach to be flown and visibility of at least one statute mile, but not less than the minimum visibility for the approach to be flown. When a black triangle with a white "A" appears in the notes section of the pilot briefing, it indicates non-standard IFR alternate minimums exist for the airport. If an "NA" appears after the "A," A NA then alternate minimums are not authorized. This information is found in the beginning of the TPP.

In addition to the COPTER approaches, instrument-equipped helicopters may fly standard approach procedures. The required visibility minimum may be reduced to one-half the published visibility minimum for category A aircraft, but in no case may it be reduced to less than 1/4 mile or 1,200 feet RVR.

Two terms are specific to helicopters. Height above landing (HAL) means height above a designated helicopter landing area used for helicopter IAPs. "Point in space approach" refers to a helicopter IAP to a MAP more than 2,600 feet from an associated helicopter landing area.

Airport Sketch /Airport Diagram

The airport sketch, located on the bottom right side of the chart, includes many helpful features. IAPs for some of the larger airports devote an entire page to an airport diagram. Airport sketch information concerning runway orientation, lighting, final approach bearings, airport beacon, and obstacles all serve to guide the pilot in the final phases of flight. See *Figure 8-21* for a legend of airport diagram/airport sketch features (see also *Figure 8-10* for an example of an airport diagram).

The airport elevation is indicated in a separate box at the top left of the airport sketch. The touchdown zone elevation (TDZE), which is the highest elevation within the first 3,000 feet of the runway, is designated at the approach end of the procedure's runway.

Beneath the airport sketch is a time and speed table when applicable. The table provides the distance and the amount of time required to transit the distance from the FAF to the MAP for selected groundspeeds.

The approach lighting systems and the visual approach lights are depicted on the airport sketch. White on black symbols V are used for identifying pilot-controlled lighting (PCL). Runway lighting aids are also noted (e.g., REIL, HIRL), as is the runway centerline lighting (RCL). *[Figure 8-22]*

The airport diagram shows the paved runway configuration in solid black, while the taxiways and aprons are shaded gray. Other runway environment features are shown, such as the runway identification, dimensions, magnetic heading, displaced threshold, arresting gear, usable length, and slope.

Inoperative Components

Certain procedures can be flown with inoperative components. According to the Inoperative Components Table, for example, an ILS approach with a malfunctioning Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR = MALS with RAIL) can be flown if the minimum visibility is increased by 1/4 mile. *[Figure 8-23]* A note in this section might read, "Inoperative Table does not apply to ALS or HIRL Runway 13L."

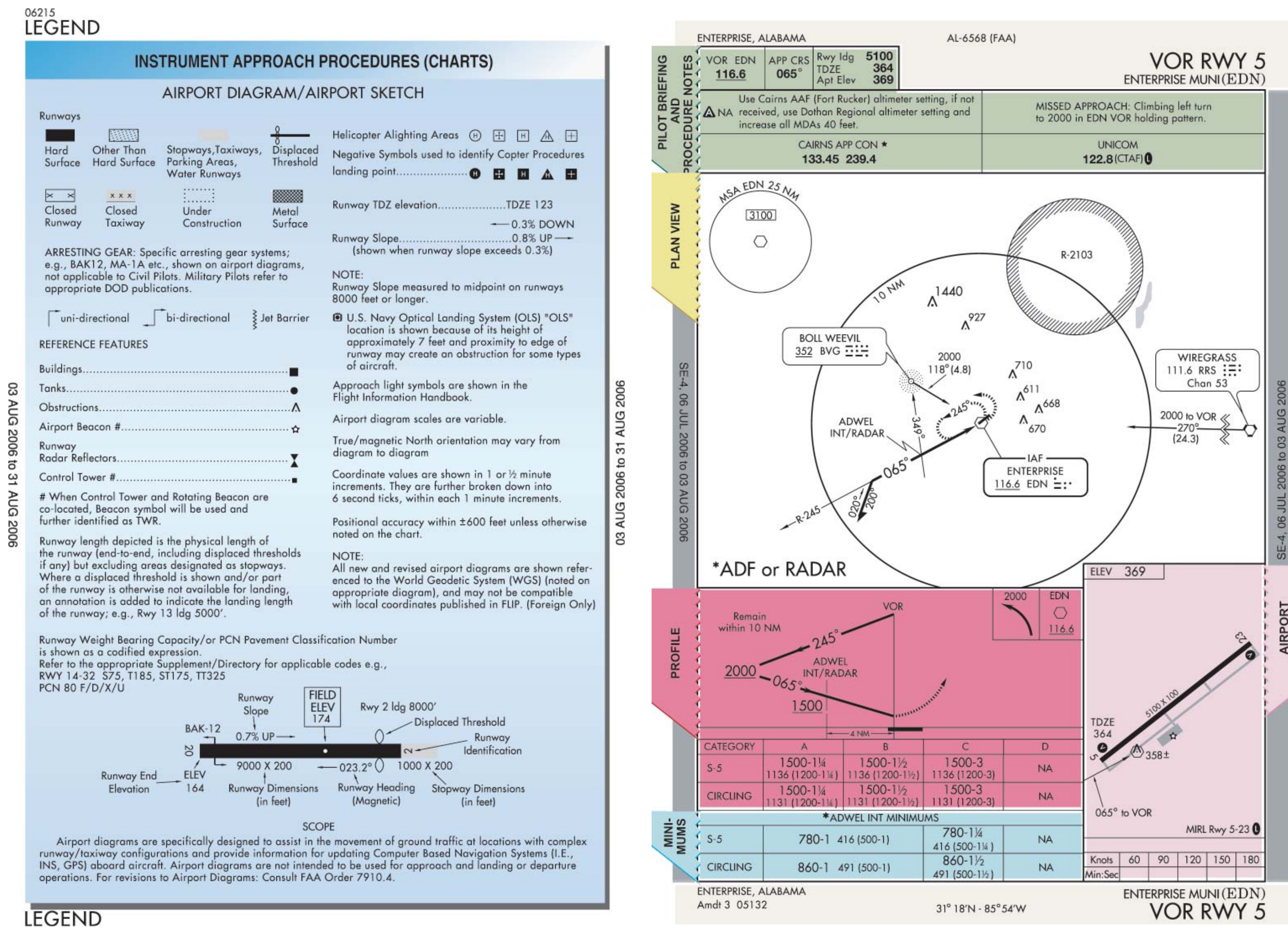
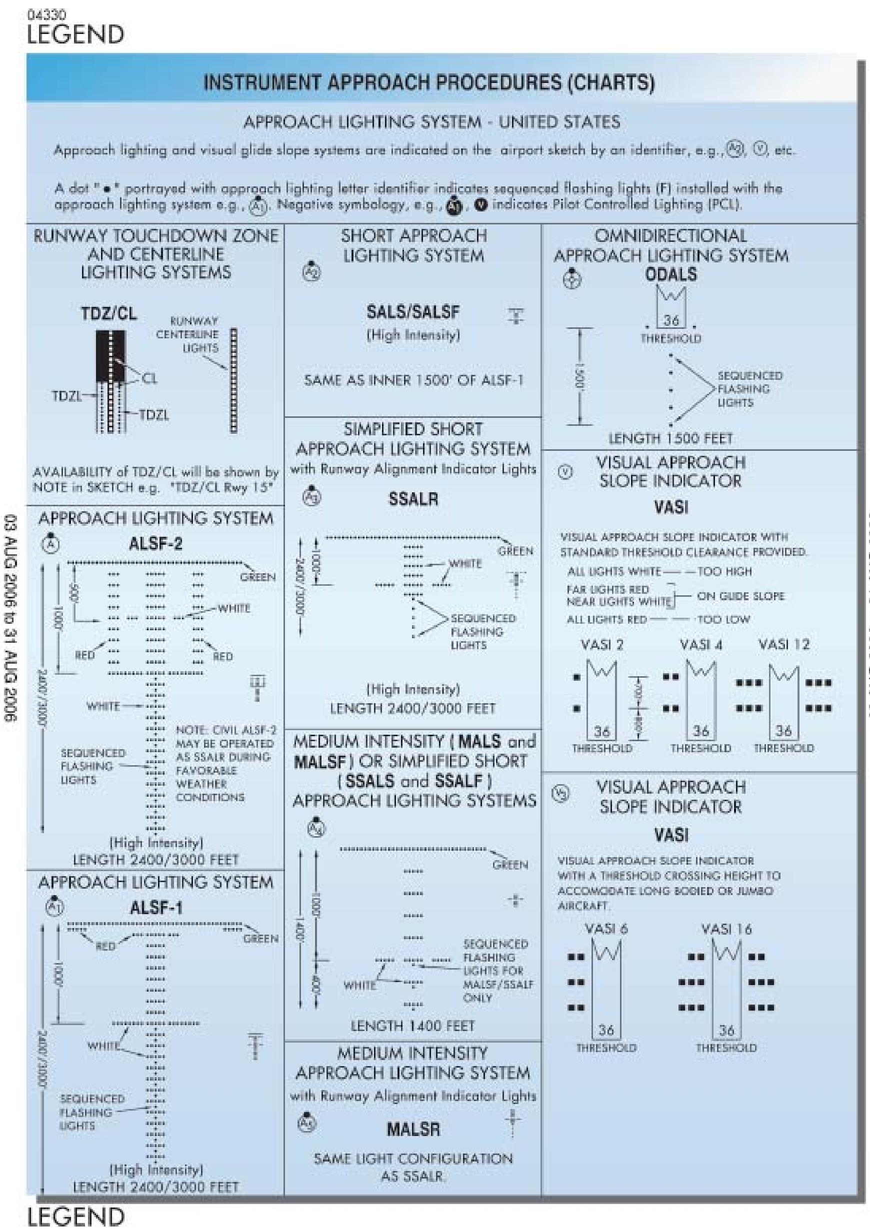


Figure 8-21. *Airport Legend and Diagram.*



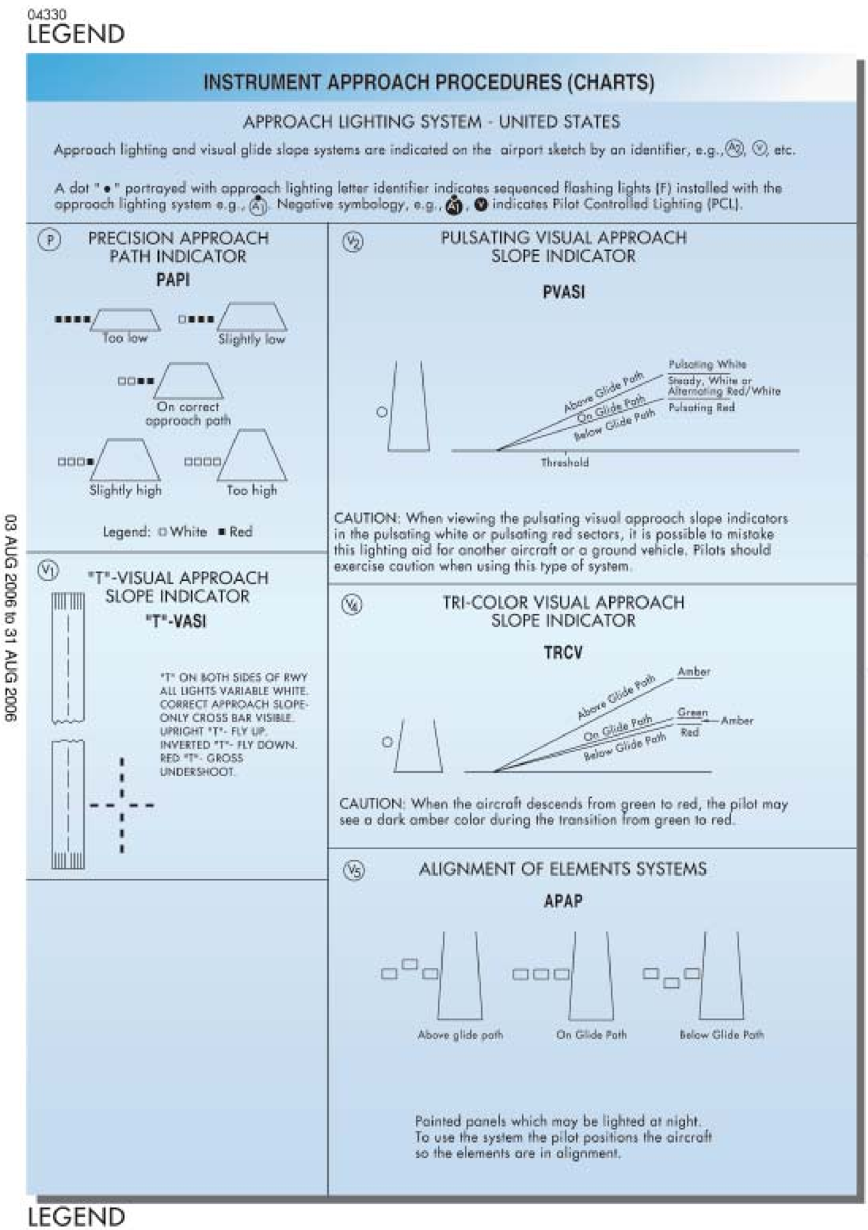


Figure 8-22. *Approach Lighting Legend.*

INOP COMPONENTS
06215

INOPERATIVE COMPONENTS OR VISUAL AIDS TABLE

Landing minimums published on instrument approach procedure charts are based upon full operation of all components and visual aids associated with the particular instrument approach chart being used. Higher minimums are required with inoperative components or visual aids as indicated below. If more than one component is inoperative, each minimum is raised to the highest minimum required by any single component that is inoperative. ILS glide slope inoperative minimums are published on the instrument approach charts as localizer minimums. This table may be amended by notes on the approach chart. Such notes apply only to the particular approach category(ies) as stated. See legend page for description of components indicated below.

(1) ILS, MLS, PAR, and RNAV (RNP; LPV; LNAV/VNAV lines of minima)

Inoperative Component or Aid	Approach Category	Increase Visibility
ALSF 1 & 2, MALSR, & SSALR	ABCD	1/4 mile

(2) ILS with visibility minimum of 1,800 RVR

ALSF 1 & 2, MALSR, & SSALR	ABCD	To 4000 RVR
TDZL RCLS	ABCD	To 2400 RVR
RVR	ABCD	To 1/2 mile

(3) VOR, VOR/DME, TACAN, LOC, LOC/DME, LDA, LDA/DME, SDF, SDF/DME, GPS, ASR and RNAV (LNAV line of minima)

Inoperative Visual Aid	Approach Category	Increase Visibility
ALSF 1 & 2, MALSR, & SSALR	ABCD	1/2 mile
SSALS,MALS, & ODALS	ABC	1/4 mile

(4) NDB

ALSF 1 & 2, MALSR, & SSALR	C	1/2 mile
	ABD	1/4 mile
MALS, SSALS, ODALS	ABC	1/4 mile

03 AUG 2006 to 31 AUG 2006

03 AUG 2006 to 31 AUG 2006

CORRECTIONS, COMMENTS AND/OR PROCUREMENT

FOR CHANGES, ADDITIONS, OR RECOMMENDATIONS ON PROCEDURAL ASPECTS CONTACT:

FAA, Aeronautical Information Services, ATO-R
800 Independence Avenue, SW
Washington, DC 20591
Telephone 1-866-295-8236

FOR CHARTING ERRORS CONTACT:

FAA, National Aeronautical Charting Office, ATO-W
SSMC-4, Sta. #2335
1305 East West Highway
Silver Spring, MD 20910-3281
Telephone 1-800-626-3677
Email 9-AMC-Aerochart@faa.gov

FOR PROCUREMENT CONTACT:

FAA, National Aeronautical Charting Office
Distribution Division, ATO-W
10201 Good Luck Road
Glenn Dale, MD 20769-9700
Online at www.naco.faa.gov
Email 9-AMC-Chartsales@faa.gov
Telephone 1-800-638-8972
Fax 301-436-6829
or any authorized chart agent

Frequently asked questions (FAQ) are answered on our website at www.naco.faa.gov. See the FAQs prior to contact via toll free number or email.

Request for the creation or revisions to Airport Diagrams should be in accordance with FAA Order 7910.4.

INOP COMPONENTS
06215

Figure 8-23. *IAP Inoperative Components Table.*

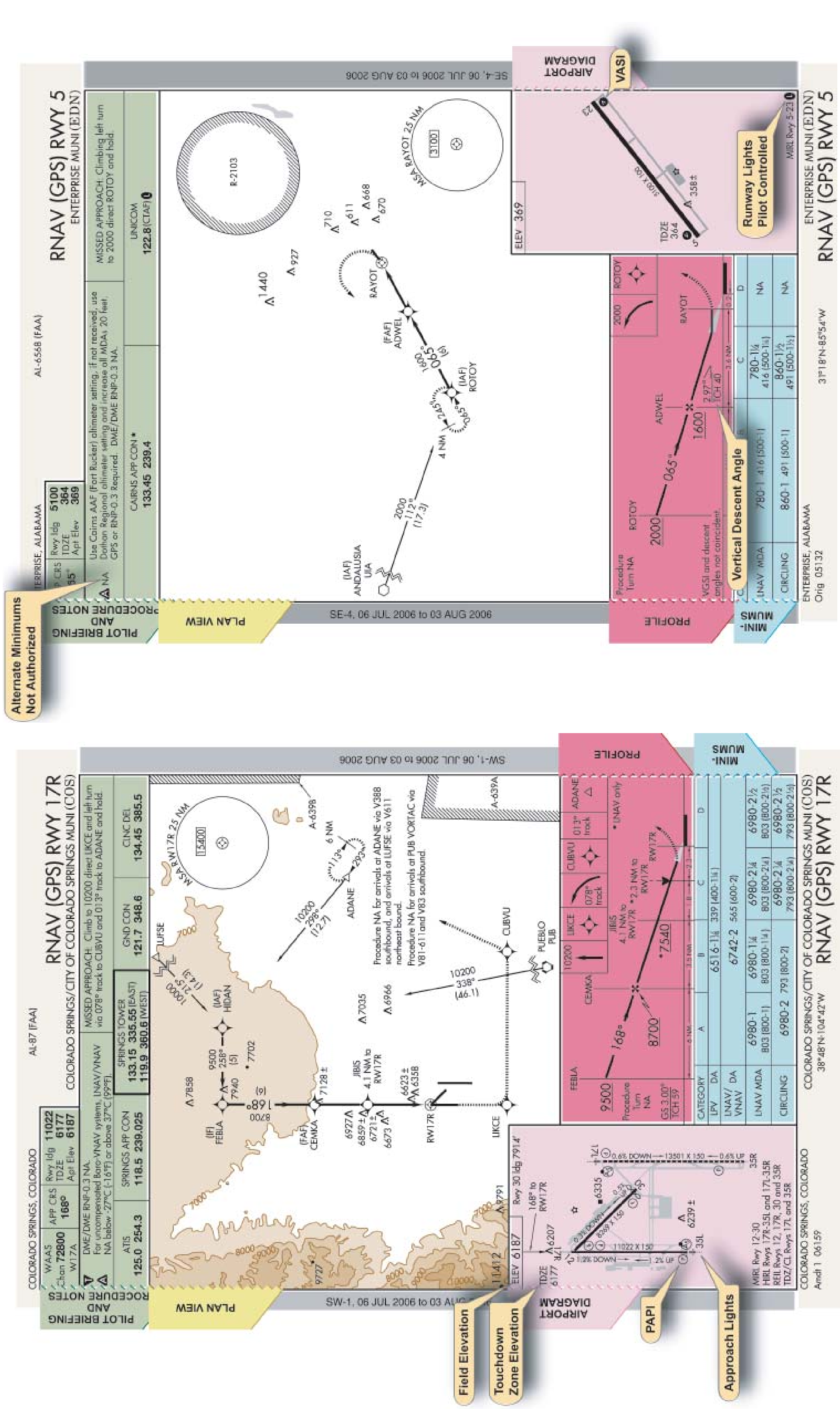


Figure 8-24. *RNAV Instrument Approach Charts.*

RNAV Instrument Approach Charts

To avoid unnecessary duplication and proliferation of approach charts, approach minimums for unaugmented GPS, Wide Area Augmentation System (WAAS), Local Area Augmentation System (LAAS), will be published on the same approach chart as lateral navigation/vertical navigation (LNAV/VNAV). Other types of equipment may be authorized to conduct the approach based on the minima notes in the front of the TPP approach chart books. Approach charts titled "RNAV RWY XX" may be used by aircraft with navigation systems that meet the required navigational performance (RNP) values for each segment of the approach. *[Figure 8-24]*

The chart may contain as many as four lines of approach minimums: global landing system (GLS), WAAS and LAAS, LNAV/VNAV, LNAV, and circling. LNAV/VNAV is an instrument approach with lateral and vertical guidance with integrity limits similar to barometric vertical navigation (BARO VNAV).

RNAV procedures that incorporate a final approach stepdown fix may be published without vertical navigation on a separate chart also titled RNAV. During a transition period when GPS procedures are undergoing revision to a new title, both RNAV and GPS approach charts and formats will be published. ATC clearance for the RNAV procedure will authorize a properly certificated pilot to utilize any landing minimums for which the aircraft is certified.

Chart terminology will change slightly to support the new procedure types:

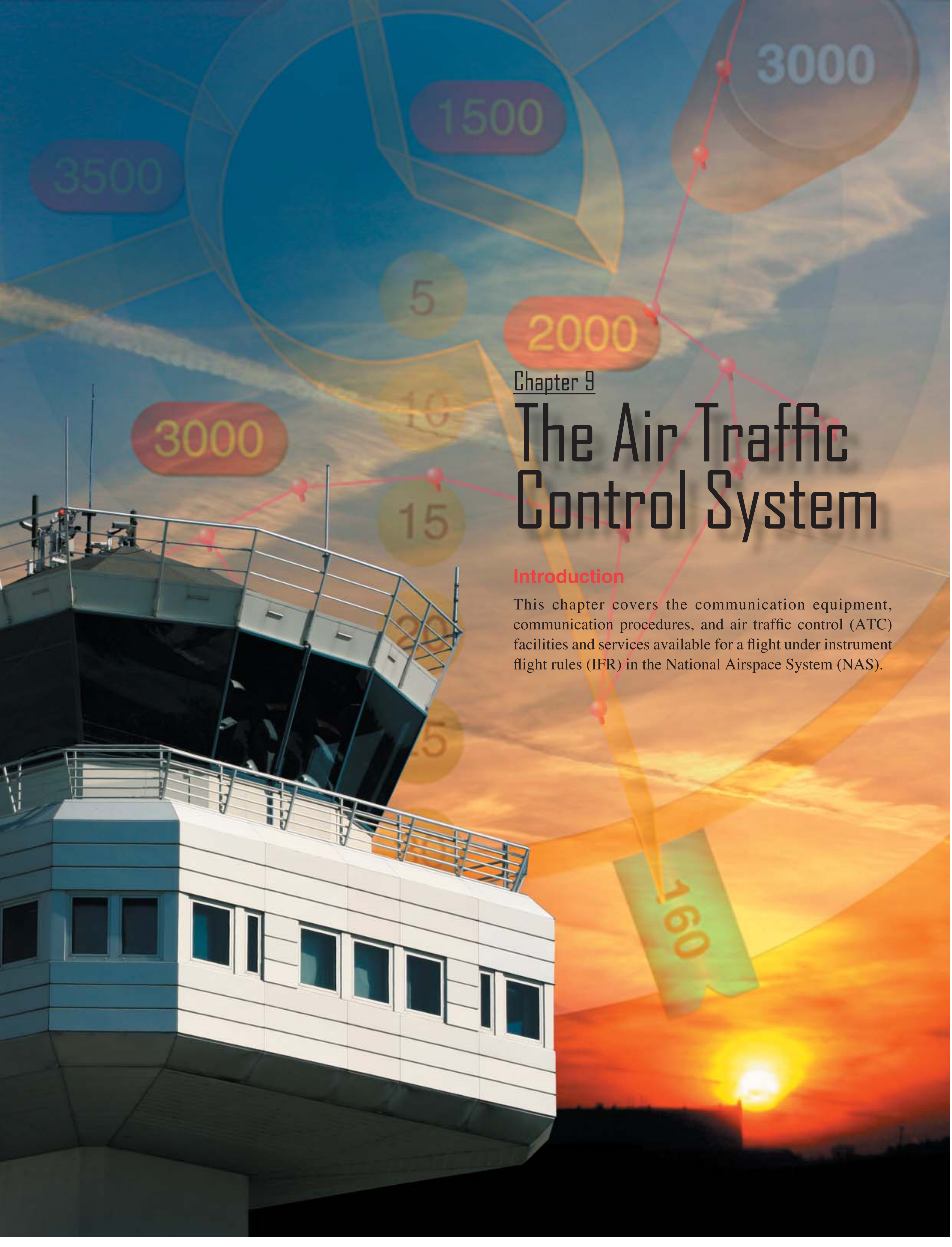
1. DA replaces the term DH. DA conforms to the international convention where altitudes relate to MSL and heights relate to AGL. DA will eventually be published for other types of IAPs with vertical guidance, as well. DA indicates to the pilot that the published descent profile is flown to the DA (MSL), where a missed approach will be initiated if visual references for landing are not established. Obstacle clearance is provided to allow a momentary descent below DA while transitioning from the final approach to the missed approach. The aircraft is expected to follow the missed approach instructions while continuing along the published final approach course to at least the published runway threshold waypoint or MAP (if not at the threshold) before executing any turns.
2. MDA will continue to be used only for the LNAV and circling procedures.
3. Threshold crossing height (TCH) has been traditionally used in precision approaches as the height of the GS above threshold. With publication of LNAV/VNAV minimums and RNAV descent angles, including graphically depicted descent profiles, TCH also applies to the height of the "descent angle," or glide path, at the threshold. Unless otherwise required for larger type aircraft, which may be using the IAP, the typical TCH will be 30 to 50 feet.

The minima format changes slightly:

1. Each line of minima on the RNAV IAP will be titled to reflect the RNAV system applicable (e.g., GLS, LNAV/VNAV, and LNAV). Circling minima will also be provided.
2. The minima title box will also indicate the nature of the minimum altitude for the IAP. For example: DA will be published next to the minima line title for minimums supporting vertical guidance, and MDA will be published where the minima line supports only lateral guidance. During an approach where an MDA is used, descent below MDA is not authorized.
3. Where two or more systems share the same minima, each line of minima will be displayed separately.

For more information concerning government charts, the NACG can be contacted by telephone, or via their internet address at:

National Aeronautical Charting Group
Telephone 800-626-3677
http://naco.faa.gov/



Chapter 9

The Air Traffic Control System

Introduction

This chapter covers the communication equipment, communication procedures, and air traffic control (ATC) facilities and services available for a flight under instrument flight rules (IFR) in the National Airspace System (NAS).

Communication Equipment

Navigation/Communication (NAV/COM) Equipment

Civilian pilots communicate with ATC on frequencies in the very high frequency (VHF) range between 118.000 and 136.975 MHz. To derive full benefit from the ATC system, radios capable of 25 kHz spacing are required (e.g., 134.500, 134.575, 134.600). If ATC assigns a frequency that cannot be selected, ask for an alternative frequency.

Figure 9-1 illustrates a typical radio panel installation, consisting of a communications transceiver on the left and a navigational receiver on the right. Many radios allow the pilot to have one or more frequencies stored in memory and one frequency active for transmitting and receiving (called simplex operation). It is possible to communicate with some automated flight service stations (AFSS) by transmitting on 122.1 MHz (selected on the communication radio) and receiving on a VHF omnidirectional range (VOR) frequency (selected on the navigation radio). This is called duplex operation.

An audio panel allows a pilot to adjust the volume of the selected receiver(s) and to select the desired transmitter. *[Figure 9-2]* The audio panel has two positions for receiver selection, cabin speaker, and headphone (some units might have a center "off" position). Use of a hand-held microphone and the cabin speaker introduces the distraction of reaching for and hanging up the microphone. A headset with a boom microphone is recommended for clear communications. The microphone should be positioned close to the lips to reduce

Figure 9-1. *Typical NAV/COM Installation.*

Figure 9-2. *Audio Panel.*

Figure 9-3. *Boom Microphone, Headset, and Push-To-Talk Switch.*

the possibility of ambient flight deck noise interfering with transmissions to the controller. Headphones deliver the received signal directly to the ears; therefore, ambient noise does not interfere with the pilot's ability to understand the transmission. *[Figure 9-3]*

Switching the transmitter selector between COM1 and COM2 changes both transmitter and receiver frequencies. It is necessary only when a pilot wants to monitor one frequency while transmitting on another. One example is listening to automatic terminal information service (ATIS) on one receiver while communicating with ATC on the other. Monitoring a navigation receiver to check for proper identification is another reason to use the switch panel.

Most audio switch panels also include a marker beacon receiver. All marker beacons transmit on 75 MHz, so there is no frequency selector.

Figure 9-4 illustrates an increasingly popular form of NAV/COM radio; it contains a global positioning system (GPS) receiver and a communications transceiver. Using its navigational capability, this unit can determine when a flight crosses an airspace boundary or fix and can automatically select the appropriate communications frequency for that location in the communications radio.

Figure 9-4. *Combination GPS-Com Unit.*

Radar and Transponders

ATC radars have a limited ability to display primary returns, which is energy reflected from an aircraft's metallic structure. Their ability to display secondary returns (transponder replies to ground interrogation signals) makes possible the many advantages of automation.

A transponder is a radar beacon transmitter/receiver installed in the instrument panel. ATC beacon transmitters send out interrogation signals continuously as the radar antenna rotates. When an interrogation is received by a transponder, a coded reply is sent to the ground station where it is displayed on the controller's scope. A reply light on the transponder panel flickers every time it receives and replies to a radar interrogation. Transponder codes are assigned by ATC.

When a controller asks a pilot to "ident" and the ident button is pushed, the return on the controller's scope is intensified for precise identification of a flight. When requested, briefly push the ident button to activate this feature. It is good practice for pilots to verbally confirm that they have changed codes or pushed the ident button.

Mode C (Altitude Reporting)

Primary radar returns indicate only range and bearing from the radar antenna to the target; secondary radar returns can display altitude, Mode C, on the control scope if the aircraft is equipped with an encoding altimeter or blind encoder. In either case, when the transponder's function switch is in the ALT position the aircraft's pressure altitude is sent to the controller. Adjusting the altimeter's Kollsman window has no effect on the altitude read by the controller.

Transponders, when installed, must be ON at all times when operating in controlled airspace; altitude reporting is required by regulation in Class B and Class C airspace and inside a 30-mile circle surrounding the primary airport in Class B airspace. Altitude reporting should also be ON at all times.

Communication Procedures

Clarity in communication is essential for a safe instrument flight. This requires pilots and controllers to use terms that are understood by both—the Pilot/Controller Glossary in the Aeronautical Information Manual (AIM) is the best source of terms and definitions. The AIM is revised twice a year and new definitions are added, so the glossary should be reviewed frequently. Because clearances and instructions are comprised largely of letters and numbers, a phonetic pronunciation guide has been developed for both. *[Figure 9-5]*

ATCs must follow the guidance of the Air Traffic Control Manual when communicating with pilots. The manual presents the controller with different situations and prescribes precise terminology that must be used. This is advantageous for pilots because once they have recognized a pattern or format they can expect future controller transmissions to follow that format. Controllers are faced with a wide variety of communication styles based on pilot experience, proficiency, and professionalism.

Pilots should study the examples in the AIM, listen to other pilots communicate, and apply the lessons learned to their own communications with ATC. Pilots should ask for clarification of a clearance or instruction. If necessary, use plain English to ensure understanding, and expect the controller to reply in the same way. A safe instrument flight is the result of cooperation between controller and pilot.

Communication Facilities

The controller's primary responsibility is separation of aircraft operating under IFR. This is accomplished with ATC facilities which include the AFSS, airport traffic control tower (ATCT), terminal radar approach control (TRACON), and air route traffic control center (ARTCC).

Automated Flight Service Stations (AFSS)

A pilot's first contact with ATC is usually through AFSS, either by radio or telephone. AFSSs provide pilot briefings, receive and process flight plans, relay ATC clearances, originate Notices to Airmen (NOTAMs), and broadcast aviation weather. Some facilities provide En Route Flight Advisory Service (EFAS), take weather observations, and advise United States Customs and Immigration of international flights.

Telephone contact with Flight Service can be obtained by dialing 1-800-WX-BRIEF. This number can be used anywhere in the United States and connects to the nearest AFSS based on the area code from which the call originates. There are a variety of methods of making radio contact: direct transmission, remote communication outlets (RCOs), ground communication outlets (GCOs), and by using duplex transmissions through navigational aids (NAVAIDs). The best source of information on frequency usage is the Airport/Facility Directory (A/FD) and the legend panel on sectional charts also contains contact information.

Character	Morse Code	Telephony	Phonic (Pronunciation)
A	•—	Alfa	(AL-FAH)
B	—•••	Bravo	(BRAH-VOH)
C	—•—•	Charlie	(CHAR-LEE) or (SHAR-LEE)
D	—••	Delta	(DELL-TAH)
E	•	Echo	(ECK-OH)
F	••—•	Foxtrot	(FOKS-TROT)
G	——•	Golf	(GOLF)
H	••••	Hotel	(HOH-TEL)
I	••	India	(IN-DEE-AH)
J	•———	Juliett	(JEW-LEE-ETT)
K	—•—	Kilo	(KEY-LOH)
L	•—••	Lima	(LEE-MAH)
M	——	Mike	(MIKE)
N	—•	November	(NO-VEM-BER)
O	———	Oscar	(OSS-CAH)
P	•——•	Papa	(PAH-PAH)
Q	——•—	Quebec	(KEH-BECK)
R	•—•	Romeo	(ROW-ME-OH)
S	•••	Sierra	(SEE-AIR-RAH)
T	—	Tango	(TANG-GO)
U	••—	Uniform	(YOU-NEE-FORM) or (OO-NEE-FORM)
V	•••—	Victor	(VIK-TAH)
W	•——	Whiskey	(WISS-KEY)
X	—••—	Xray	(ECKS-RAY)
Y	—•——	Yankee	(YANG-KEY)
Z	——••	Zulu	(ZOO-LOO)
1	•————	One	(WUN)
2	••———	Two	(TOO)
3	•••——	Three	(TREE)
4	••••—	Four	(FOW-ER)
5	•••••	Five	(FIFE)
6	—••••	Six	(SIX)
7	——•••	Seven	(SEV-EN)
8	———••	Eight	(AIT)
9	————•	Nine	(NI-NER)
0	—————	Zero	(ZEE-RO)

Figure 9-5. *Phonetic Pronunciation Guide.*

The briefer sends a flight plan to the host computer at the ARTCC (Center). After processing the flight plan, the computer will send flight strips to the tower, to the radar facility that will handle the departure route, and to the Center controller whose sector the flight first enters. *Figure 9-6* shows a typical strip. These strips are delivered approximately 30 minutes prior to the proposed departure time. Strips are delivered to en route facilities 30 minutes before the flight is expected to enter their airspace. If a flight plan is not opened, it will "time out" 2 hours after the proposed departure time.

When departing an airport in Class G airspace, a pilot receives an IFR clearance from the AFSS by radio or telephone. It contains either a clearance void time, in which case an aircraft must be airborne prior to that time, or a release time. Pilots should not take-off prior to the release time. Pilots can help the controller by stating how soon they expect to be airborne. If the void time is, for example, 10 minutes past the hour and an aircraft is airborne at exactly 10 minutes past the hour, the clearance is void—a pilot must take off prior to the void time. A specific void time may be requested when filing a flight plan.

ATC Towers

Several controllers in the tower cab are involved in handling an instrument flight. Where there is a dedicated clearance delivery position, that frequency is found in the A/FD and on the instrument approach chart for the departure airport. Where there is no clearance delivery position, the ground controller performs this function. At the busiest airports, pre-taxi clearance is required; the frequency for pre-taxi clearance can be found in the A/FD. Taxi clearance should be requested not more than 10 minutes before proposed taxi time.

It is recommended that pilots read their IFR clearance back to the clearance delivery controller. Instrument clearances can be overwhelming when attempting to copy them verbatim, but they follow a format that allows a pilot to be prepared when responding "Ready to copy." The format is: clearance limit (usually the destination airport); route, including any departure procedure; initial altitude; frequency (for departure control); and transponder code. With the exception of the transponder code, a pilot knows most of these items before engine start. One technique for clearance copying is writing C-R-A-F-T.

Assume an IFR flight plan has been filed from Seattle, Washington to Sacramento, California via V-23 at 7,000 feet. Traffic is taking off to the north from Seattle-Tacoma (Sea-Tac) airport and, by monitoring the clearance delivery frequency, a pilot can determine the departure procedure being assigned to southbound flights. The clearance limit is the destination airport, so write "SAC" after the letter C. Write "SEATTLE TWO – V23" after R for Route, because departure control issued this departure to other flights. Write "7" after the A, the departure control frequency printed on the approach charts for Sea-Tac after F, and leave the space after the letter T blank—the transponder code is generated by computer and can seldom be determined in advance. Then, call clearance delivery and report "Ready to copy."

As the controller reads the clearance, check it against what is already written down; if there is a change, draw a line through that item and write in the changed item. Chances are the changes are minimal, and most of the clearance is copied before keying the microphone. Still, it is worthwhile to develop clearance shorthand to decrease the verbiage that must be copied (see Appendix 1).

Pilots are required to have either the text of a departure procedure (DP) or a graphic representation (if one is available), and should review it before accepting a clearance. This is another reason to find out ahead of time which DP is in use. If the DP includes an altitude or a departure control frequency, those items are not included in the clearance.

The last clearance received supersedes all previous clearances. For example, if the DP says "Climb and maintain 2,000 feet, expect higher in 6 miles," but upon contacting the departure controller a new clearance is received: "Climb and maintain 8,000 feet," the 2,000 feet restriction has been canceled. This rule applies in both terminal and Center airspace.

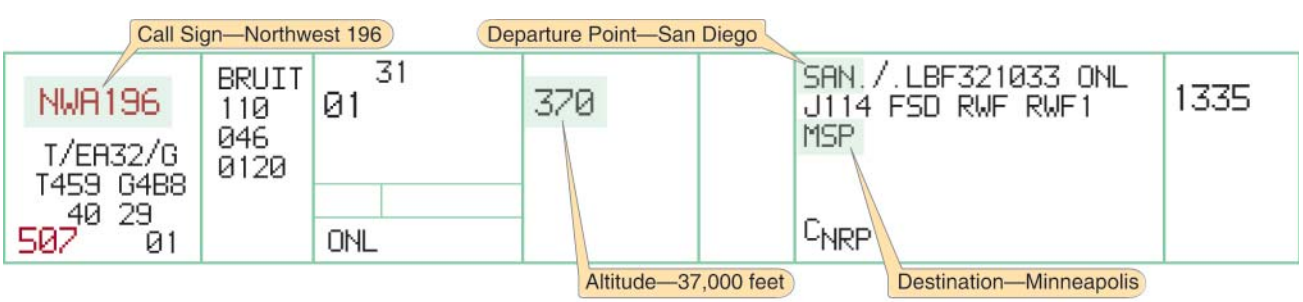


Figure 9-6. *Flight Strip.*

When reporting ready to copy an IFR clearance before the strip has been received from the Center computer, pilots are advised "clearance on request." The controller initiates contact when it has been received. This time can be used for taxi and pre-takeoff checks.

The local controller is responsible for operations in the Class D airspace and on the active runways. At some towers, designated as IFR towers, the local controller has vectoring authority. At visual flight rules (VFR) towers, the local controller accepts inbound IFR flights from the terminal radar facility and cannot provide vectors. The local controller also coordinates flights in the local area with radar controllers. Although Class D airspace normally extends 2,500 feet above field elevation, towers frequently release the top 500 feet to the radar controllers to facilitate overflights. Accordingly, when a flight is vectored over an airport at an altitude that appears to enter the tower controller's airspace, there is no need to contact the tower controller—all coordination is handled by ATC.

The departure radar controller may be in the same building as the control tower, but it is more likely that the departure radar position is remotely located. The tower controller will not issue a takeoff clearance until the departure controller issues a release.

Terminal Radar Approach Control (TRACON)

TRACONs are considered terminal facilities because they provide the link between the departure airport and the en route structure of the NAS. Terminal airspace normally extends 30 nautical miles (NM) from the facility, with a vertical extent of 10,000 feet; however, dimensions vary widely. Class B and Class C airspace dimensions are provided on aeronautical charts. At terminal radar facilities the airspace is divided into sectors, each with one or more controllers, and each sector is assigned a discrete radio frequency. All terminal facilities are approach controls and should be addressed as "Approach" except when directed to do otherwise (e.g., "Contact departure on 120.4").

Terminal radar antennas are located on or adjacent to the airport. *Figure 9-7* shows a typical configuration. Terminal controllers can assign altitudes lower than published procedural altitudes called minimum vectoring altitudes (MVAs). These altitudes are not published or accessible to pilots, but are displayed at the controller's position, as shown in *Figure 9-8*. However, when pilots are assigned an altitude that seems to be too low, they should query the controller before descending.

When a pilot accepts a clearance and reports ready for takeoff, a controller in the tower contacts the TRACON for a release. An aircraft is not cleared for takeoff until the departure controller can fit the flight into the departure flow. A pilot may have to hold for release. When takeoff clearance is received, the departure controller is aware of the flight and is waiting for a call. All of the information the controller needs is on the departure strip or the computer screen there is no need to repeat any portion of the clearance to that controller. Simply establish contact with the facility when instructed to do so by the tower controller. The terminal facility computer picks up the transponder and initiates tracking as soon as it detects the

Figure 9-7. *Combined Radar and Beacon Antenna.*

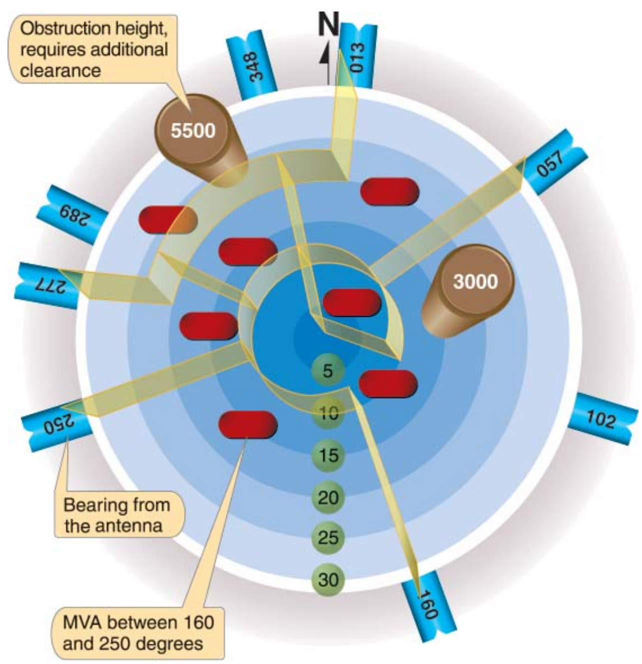


Figure 9-8. *Minimum Vectoring Altitude Chart.*

assigned code. For this reason, the transponder should remain on standby until takeoff clearance has been received.

The aircraft appears on the controller's radar display as a target with an associated data block that moves as the aircraft moves through the airspace. The data block includes aircraft identification, aircraft type, altitude, and airspeed.

A TRACON controller uses Airport Surveillance Radar (ASR) to detect primary targets and Automated Radar Terminal Systems (ARTS) to receive transponder signals; the two are combined on the controller's scope. *[Figure 9-9]*

At facilities with ASR-3 equipment, radar returns from precipitation are not displayed as varying levels of intensity, and controllers must rely on pilot reports and experience to provide weather avoidance information. With ASR-9 equipment, the controller can select up to six levels of intensity. Light precipitation does not require avoidance tactics but precipitation levels of moderate, heavy or extreme should cause pilots to plan accordingly. Along with precipitation the pilot must additionally consider the temperature, which if between -20° and +5° C will cause icing even during light precipitation. The returns from higher levels of intensity may obscure aircraft data blocks, and controllers may select the higher levels only on pilot request. When uncertainty exists about the weather ahead, ask the controller if the facility can display intensity levels—pilots of small aircraft should avoid intensity levels 3 or higher.

Tower En Route Control (TEC)

At many locations, instrument flights can be conducted entirely in terminal airspace. These TEC routes are generally for aircraft operating below 10,000 feet, and they can be found in the A/FD. Pilots desiring to use TEC should include that designation in the remarks section of the flight plan.

Pilots are not limited to the major airports at the city pairs listed in the A/FD. For example, a tower en route flight from an airport in New York (NYC) airspace could terminate at any airport within approximately 30 miles of Bradley International (BDL) airspace, such as Hartford (HFD). *[Figure 9-10]*

A valuable service provided by the automated radar equipment at terminal radar facilities is the Minimum Safe Altitude Warnings (MSAW). This equipment predicts an aircraft's position in 2 minutes based on present path of flight—the controller issues a safety alert if the projected path encounters terrain or an obstruction. An unusually rapid descent rate on a nonprecision approach can trigger such an alert.

Air Route Traffic Control Center (ARTCC)

ARTCC facilities are responsible for maintaining separation between IFR flights in the en route structure. Center radars (Air Route Surveillance Radar (ARSR)) acquire and track transponder returns using the same basic technology as terminal radars. *[Figure 9-11]*

Earlier Center radars display weather as an area of slashes (light precipitation) and Hs (moderate rainfall), as illustrated in *Figure 9-12*. Because the controller cannot detect higher levels of precipitation, pilots should be wary of areas showing moderate rainfall. Newer radar displays show weather as three levels of blue. Controllers can select the level of weather to be displayed. Weather displays of higher levels of intensity can make it difficult for controllers to see aircraft data blocks, so pilots should not expect ATC to keep weather displayed continuously.

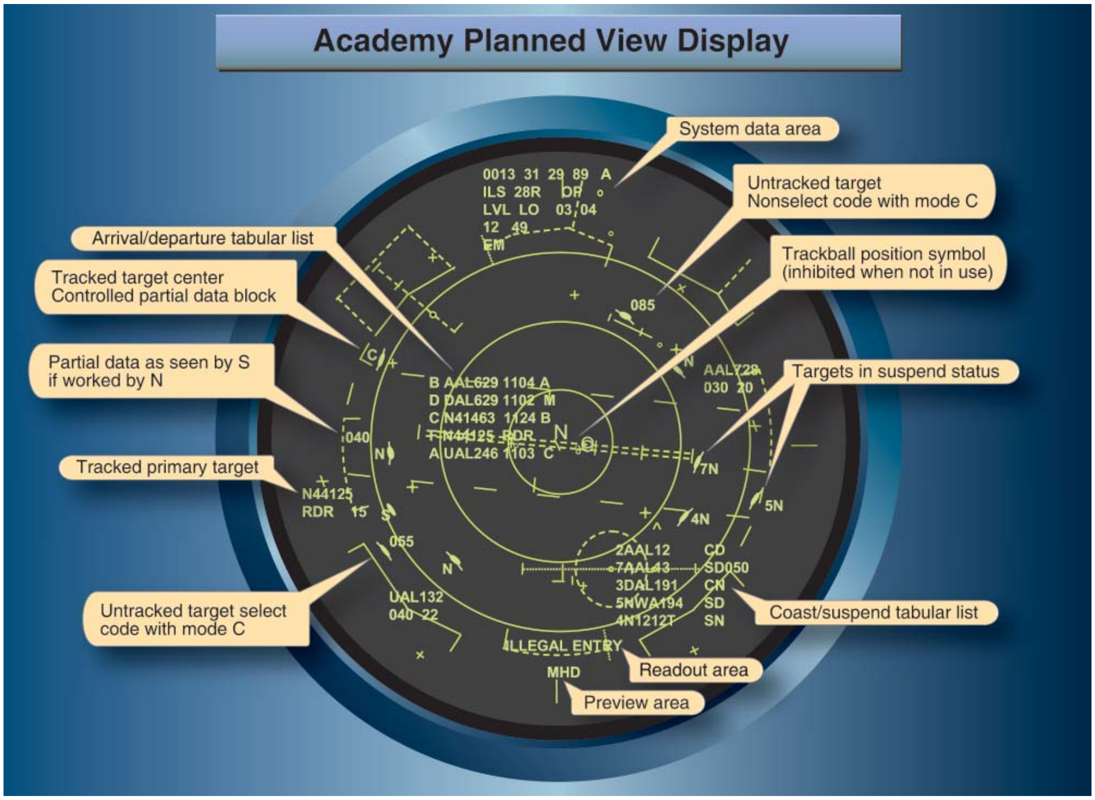
Center airspace is divided into sectors in the same manner as terminal airspace; additionally, most Center airspace is divided by altitudes into high and low sectors. Each sector has a dedicated team of controllers and a selection of radio frequencies, because each Center has a network of remote transmitter/receiver sites. All Center frequencies can be found in the back of the A/FD in the format shown in *Figure 9-13;* they are also found on en route charts.

Each ARTCC's area of responsibility covers several states; when flying from the vicinity of one remote communication site toward another, expect to hear the same controller on different frequencies.

Center Approach/Departure Control

The majority of airports with instrument approaches do not lie within terminal radar airspace, and when operating to or from these airports pilots communicate directly with the Center controller. Departing from a tower-controlled airport, the tower controller provides instructions for contacting the appropriate Center controller. When departing an airport without an operating control tower, the clearance includes instructions such as "Upon entering controlled airspace, contact Houston Center on 126.5." Pilots are responsible for terrain clearance until reaching the controller's MVA. Simply hearing "Radar contact" does not relieve a pilot of this responsibility.

If obstacles in the departure path require a steeper-than-standard climb gradient (200 FPNM), then the controller advises the pilot. However, it is the pilot's responsibility to check the departure airport listing in the A/FD to determine if there are trees or wires in the departure path. When in doubt, ask the controller for the required climb gradient.



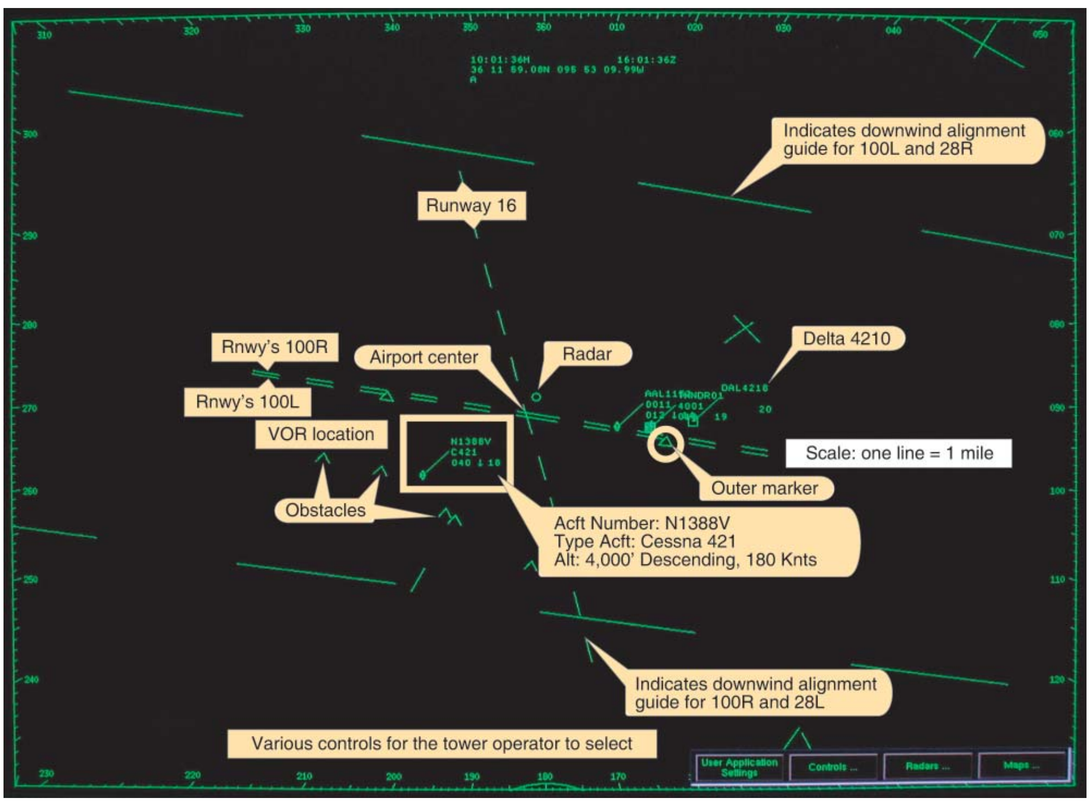
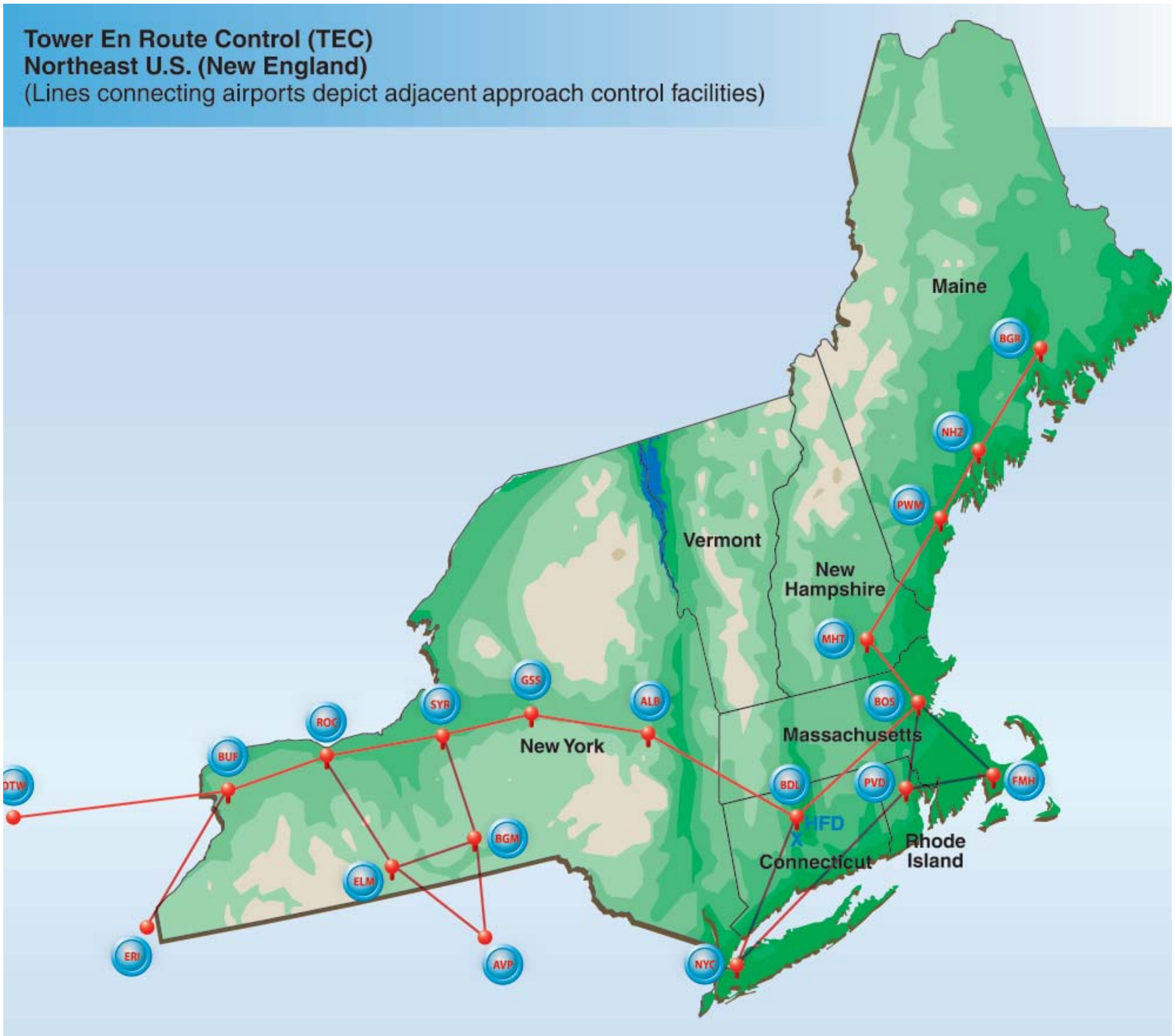


Figure 9-9. *The top image is a display as seen by controllers in an Air Traffic Facility. The one illustrated is an ARTS III (Automated Radar Terminal System). The display shown provides an explanation of the symbols in the graphic. The lower figure is an example of the Digital Bright Radar Indicator Tower Equipment (DBRITE) screen as seen by tower personnel. It provides tower controllers with a visual display of the airport surveillance radar, beacon signals, and data received from ARTS III. The display shown provides an explanation of the symbols in the graphic.*



New York/Kennedy	....	SAX V249 SBJ V30 ETX (Non jet/Non turboprop)	8000	Allentown
	....	DIXIE V229 ACY (Props only)	6000	Atlantic City
	....	DIXIE V1 HOWIE (Jets only)	8000	Atlantic City
	....	DIXIE V1 V308 OTT (Props only)	6000	Andrews AFB
	....	DIXIE V16 ENO V268 SWANN (Props only)	6000	Baltimore
	....	COL	2000	Belmar
	....	BDR MAD V475 V188 TMU	9000	Block Island
	....	BDR V229 HFD V3 WOONS	9000	Boston
	....	BDR V229 HFD HFD053 DREEM	9000	Boston (North)
	....	BDR BDR014 JUDDS V419 BRISS	9000	Bradley
	....	BDR BDR014 JUDDS V419 BRISS (Jets only)	10000	Bradley

Legend Radar Approach Control Area

Figure 9-10. *A Portion of the New York Area Tower En Route List. (From the A/FD)*

Figure 9-11. *Center Radar Displays.*

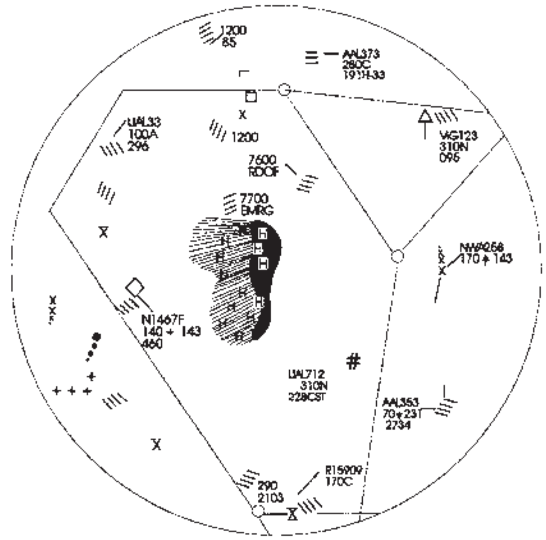


Figure 9-12. *A Center Controller's Scope.*

A common clearance in these situations is "When able, proceed direct to the Astoria VOR…" The words "when able" mean to proceed to the waypoint, intersection, or NAVAID when the pilot is able to navigate directly to that point using onboard available systems providing proper guidance, usable signal, etc. If provided such guidance while flying VFR, the pilot remains responsible for terrain and obstacle clearance. Using the standard climb gradient, an aircraft is 2 miles from the departure end of the runway before it is safe to turn (400 feet above ground level (AGL)). When a Center controller issues a heading, a direct route, or says "direct when able," the controller becomes responsible for terrain and obstruction clearance.

Another common Center clearance is "Leaving (altitude) fly (heading) or proceed direct when able." This keeps the terrain/obstruction clearance responsibility in the flight deck until above the minimum IFR altitude. A controller cannot issue an IFR clearance until an aircraft is above the minimum IFR altitude unless it is able to climb in VFR conditions.

On a Center controller's scope, 1 NM is about 1/28 of an inch. When a Center controller is providing Approach/Departure control services at an airport many miles from the radar antenna, estimating headings and distances is very difficult. Controllers providing vectors to final must set the range on their scopes to not more than 125 NM to provide the greatest possible accuracy for intercept headings. Accordingly, at locations more distant from a Center radar antenna, pilots should expect a minimum of vectoring.

®FORT WORTH CENTER				
H–2–3–4, L–4–6–13–14–15–17 (KZFW)				134.4
Abilene	–134.25	127.45		
Ardmore	–132.975	128.1		
Big Spring	–133.7			
Blue Ridge	–127.6	124.87		
Brownwood	–127.45			
Clinton-Sherman	–132.45	128.4	126.3	
Cumby	–132.85	132.02	126.57	
Dublin	–135.375	128.32	127.15	
El Dorado	–133.875	128.2		
Frankston	–135.25	134.025		
Gainsville	–134.15	126.77		
Hobbs	–133.1			
Keller	–135.275	134.15	133.25	
Lubbock	–133.35	127.7	126.45	
Marshall	–135.1	128.125		
McAlester	–135.45	132.2		
Midland (Site A)	–133.1	132.075		
Mineral Wells	–135.6	127.0		
Monroe	–135.1			
Oklahoma City	–133.9	132.45		
Paducah	–134.55	133.5	133.35	126.45
Paris	–127.6			
Plainview	–126.45			
San Angelo	–132.075	126.15		
Scurry	–135.75	126.725		
Shreveport	–135.1	132.275		
Texarkana	–134.475	133.95	126.57	
Tyler	–135.25	134.025		
Waco	–133.3			
Wichita Falls	–(Site Nr1)	- 134.55	132.925	
Wichita Falls	–(Site Nr2)	- 133.5	127.95	

Figure 9-13. *Center Symbology.*

ATC Inflight Weather Avoidance Assistance

ATC Radar Weather Displays

ATC radar systems are able to display areas of precipitation by sending out a beam of radio energy that is reflected back to the radar antenna when it strikes an object or moisture which may be in the form of rain drops, hail, or snow. The larger the object, or the denser its reflective surface, the stronger the return will be. Radar weather processors indicate the intensity of reflective returns in terms of decibels with respect to the radar reflectively factor (dBZ).

ATC systems cannot detect the presence or absence of clouds. ATC radar systems can often determine the intensity of a precipitation area, but the specific character of that area (snow, rain, hail, VIRGA, etc.) cannot be determined. For this reason, ATC refers to all weather areas displayed on ATC radar scopes as "precipitation."

All ATC facilities using radar weather processors with the ability to determine precipitation intensity describes the intensity to pilots as:

1. "LIGHT" (< 30 dBZ)
2. "MODERATE" (30 to 40 dBZ)
3. "HEAVY" (>40 to 50 dBZ)
4. "EXTREME" (>50 dBZ)

ARTCC controllers do not use the term "LIGHT" because their systems do not display "LIGHT" precipitation intensities. ATC facilities that, due to equipment limitations, cannot display the intensity levels of precipitation, will describe the location of the precipitation area by geographic position, or position relative to the aircraft. Since the intensity level is not available, the controller states, "INTENSITY UNKNOWN."

ARTCC facilities normally use a Weather and Radar Processor (WARP) to display a mosaic of data obtained from multiple NEXRAD sites. The WARP processor is only used in ARTCC facilities.

There is a time delay between actual conditions and those displayed to the controller. For example, the precipitation data on the ARTCC controller's display could be up to 6 minutes old. When the WARP is not available, a secondary system, the narrowband ARSR is utilized. The ARSR system can display two distinct levels of precipitation intensity that is described to pilots as "MODERATE" (30 to 40 dBZ) and "HEAVY to EXTREME" (>40 dBZ).

ATC radar systems cannot detect turbulence. Generally, turbulence can be expected to occur as the rate of rainfall or intensity of precipitation increases. Turbulence associated with greater rates of rainfall/precipitation is normally more severe than any associated with lesser rates of rainfall/precipitation. Turbulence should be expected to occur near convective activity, even in clear air. Thunderstorms are a form of convective activity that implies severe or greater turbulence. Operation within 20 miles of thunderstorms should be approached with great caution, as the severity of turbulence can be markedly greater than the precipitation intensity might indicate.

Weather Avoidance Assistance

ATC's first duty priority is to separate aircraft and issue safety alerts. ATC provides additional services to the extent possible, contingent upon higher priority duties and other factors including limitations of radar, volume of traffic, frequency congestion, and workload. Subject to the above factors/limitations, controllers issue pertinent information on weather or chaff areas; and if requested, assist pilots, to the extent possible, in avoiding areas of precipitation. Pilots should respond to a weather advisory by acknowledging the advisory and, if desired, requesting an alternate course of action, such as:

1. Request to deviate off course by stating the direction and number of degrees or miles needed to deviate from the original course;
2. Request a change of altitude; or
3. Request routing assistance to avoid the affected area. Because ATC radar systems cannot detect the presence or absence of clouds and turbulence, such assistance conveys no guarantee that the pilot will not encounter hazards associated with convective activity. Pilots wishing to circumnavigate precipitation areas by a specific distance should make their desires clearly known to ATC at the time of the request for services. Pilots must advise ATC when they can resume normal navigation.

IFR pilots shall not deviate from their assigned course or altitude without an ATC clearance. Plan ahead for possible course deviations because hazardous convective conditions can develop quite rapidly. This is important to consider because the precipitation data displayed on ARTCC radar scopes can be up to 6 minutes old and thunderstorms can develop at rates exceeding 6,000 feet per minute (fpm). When encountering weather conditions that threaten the safety of the aircraft, the pilot may exercise emergency authority as stated in 14 CFR part 91, section 91.3 should an immediate deviation from the assigned clearance be necessary and time does not permit approval by ATC.

Generally, when weather disrupts the flow of air traffic, greater workload demands are placed on the controller. Requests for deviations from course and other services should be made as far in advance as possible to better assure the controller's ability to approve these requests promptly. When requesting approval to detour around weather activity, include the following information to facilitate the request:

1. The proposed point where detour commences;
2. The proposed route and extent of detour (direction and distance);
3. The point where original route will be resumed;
4. Flight conditions (IMC or VMC);
5. Whether the aircraft is equipped with functioning airborne radar; and
6. Any further deviation that may become necessary.

To a large degree, the assistance that might be rendered by ATC depends upon the weather information available to controllers. Due to the extremely transitory nature of hazardous weather, the controller's displayed precipitation information may be of limited value.

Obtaining IFR clearance or approval to circumnavigate hazardous weather can often be accommodated more readily in the en route areas away from terminals because there is usually less congestion and, therefore, greater freedom of action. In terminal areas, the problem is more acute because of traffic density, ATC coordination requirements, complex departure and arrival routes, and adjacent airports. As a consequence, controllers are less likely to be able to accommodate all requests for weather detours in a terminal area. Nevertheless, pilots should not hesitate to advise controllers of any observed hazardous weather and should specifically advise controllers if they desire circumnavigation of observed weather.

Pilot reports (PIREPs) of flight conditions help define the nature and extent of weather conditions in a particular area. These reports are disseminated by radio and electronic means to other pilots. Provide PIREP information to ATC regarding pertinent flight conditions, such as:

1. Turbulence;
2. Visibility;
3. Cloud tops and bases; and
4. The presence of hazards such as ice, hail, and lightning.

Approach Control Facility

An approach control facility is a terminal ATC facility that provides approach control service in the terminal area. Services are provided for arriving and departing VFR and IFR aircraft and, on occasion, en route aircraft. In addition, for airports with parallel runways with ILS or LDA approaches, the approach control facility provides monitoring of the approaches.

Approach Control Advances

Precision Runway Monitor (PRM)

Over the past few years, a new technology has been installed at airports that permits a decreased separation distance between parallel runways. The system is called a Precision Runway Monitor (PRM) and is comprised of high-update radar, high-resolution ATC displays, and PRM-certified controllers. *[Figure 9-14]*

Figure 9-14. *High Resolution ATC Displays Used in PRM.*

Precision Runway Monitor (PRM) Radar

The PRM uses a Monopulse Secondary Surveillance Radar (MSSR) that employs electronically scanned antennas. Because the PRM has no scan rate restrictions, it is capable of providing a faster update rate (up to 0.5 second) over conventional systems, thereby providing better target presentation in terms of accuracy, resolution, and track prediction. The system is designed to search, track, process, and display SSR-equipped aircraft within airspace of over 30 miles in range and over 15,000 feet in elevation. Visual and audible alerts are generated to warn controllers to take corrective actions.

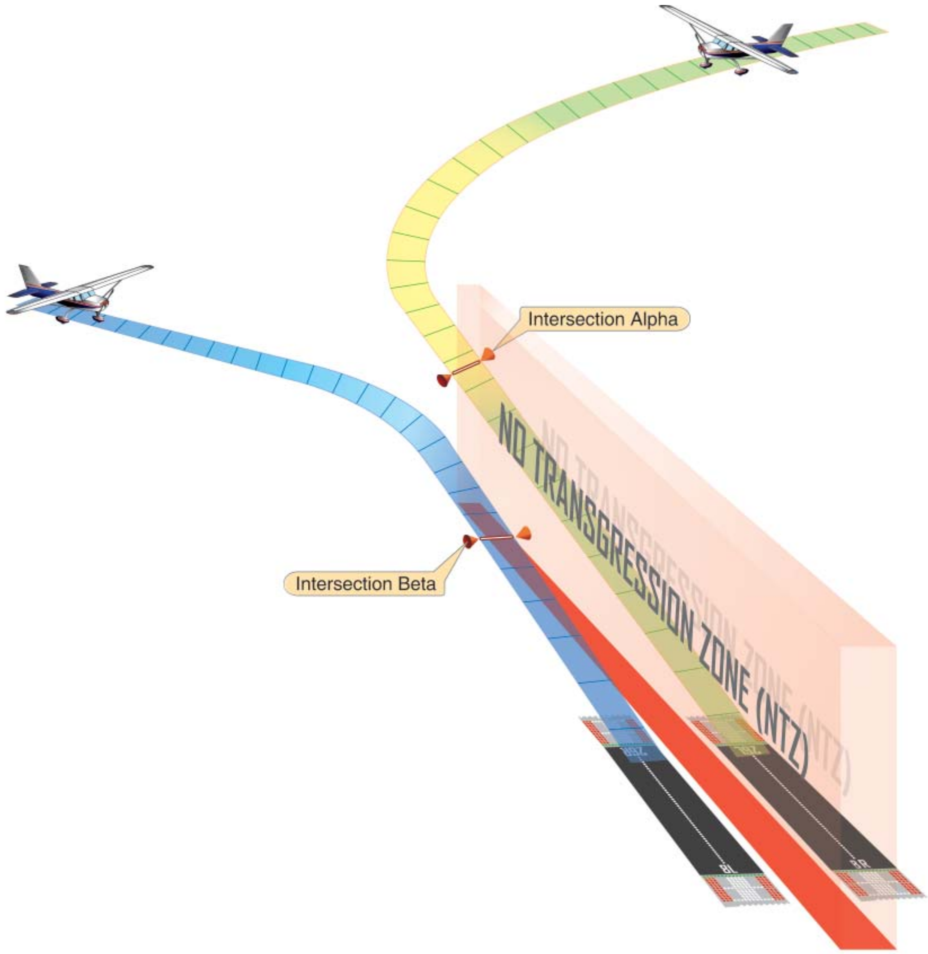


Figure 9-15. *Aircraft Management Using PRM. (Note the no transgression zone (NTZ) and how the aircraft are separated.)*

PRM Benefits

Typically, PRM is used with dual approaches with centerlines separated less than 4,300 feet but not less than 3,000 feet (under most conditions). *[Figure 9-15]* Separating the two final approach courses is a No Transgression Zone (NTZ) with surveillance of that zone provided by two controllers, one for each active approach. The system tracking software provides PRM monitor controllers with aircraft identification, position, speed, projected position, as well as visual and aural alerts.

Control Sequence

The IFR system is flexible and accommodating if pilots do their homework, have as many frequencies as possible written down before they are needed, and have an alternate in mind if the flight cannot be completed as planned. Pilots should familiarize themselves with all the facilities and services available along the planned route of flight. *[Figure 9-16]* Always know where the nearest VFR conditions can be found, and be prepared to head in that direction if the situation deteriorates.

A typical IFR flight, with departure and arrival at airports with control towers, would use the ATC facilities and services in the following sequence:

1. AFSS: Obtain a weather briefing for a departure, destination and alternate airports, and en route conditions, and then file a flight plan by calling 1-800-WX-BRIEF.
2. ATIS: Preflight complete, listen for present conditions and the approach in use.
3. Clearance Delivery: Prior to taxiing, obtain a departure clearance.
4. Ground Control: Noting that the flight is IFR, receive taxi instructions.
5. Tower: Pre-takeoff checks complete, receive clearance to takeoff.
6. Departure Control: Once the transponder "tags up" with the ARTS, the tower controller instructs the pilot to contact Departure to establish radar contact.

7. ARTCC: After departing the departure controller's airspace, aircraft is handed off to Center, who coordinates the flight while en route. Pilots may be in contact with multiple ARTCC facilities; they coordinate the hand-offs.
8. EFAS/HIWAS: Coordinate with ATC before leaving their frequency to obtain inflight weather information.
9. ATIS: Coordinate with ATC before leaving their frequency to obtain ATIS information.
10. Approach Control: Center hands off to approach control where pilots receive additional information and clearances.
11. Tower: Once cleared for the approach, pilots are instructed to contact tower control; the flight plan is canceled by the tower controller upon landing.

A typical IFR flight, with departure and arrival at airports without operating control towers, would use the ATC facilities and services in the following sequence:

1. AFSS: Obtain a weather briefing for departure, destination, and alternate airports, and en route conditions, and then file a flight plan by calling 1-800-WX-BRIEF. Provide the latitude/longitude description for small airports to ensure that Center is able to locate departure and arrival locations.
2. AFSS or UNICOM: ATC clearances can be filed and received on the UNICOM frequency if the licensee has made arrangements with the controlling ARTCC; otherwise, file with AFSS via telephone. Be sure all preflight preparations are complete before filing. The clearance includes a clearance void time. Pilots must be airborne prior to the void time.
3. ARTCC: After takeoff, establish contact with Center. During the flight, pilots may be in contact with multiple ARTCC facilities; ATC coordinates the hand-offs.
4. EFAS/HIWAS: Coordinate with ATC before leaving their frequency to obtain in-flight weather information.
5. Approach Control: Center hands off to approach control where pilots receive additional information and clearances. If a landing under visual meteorological conditions (VMC) is possible, pilots may cancel their IFR clearance before landing.

Letters of Agreement (LOA)

The ATC system is indeed a system, and very little happens by chance. As a flight progresses, controllers in adjoining sectors or adjoining Centers coordinate its handling by telephone or by computer. Where there is a boundary between the airspace controlled by different facilities, the location and altitude for hand-off is determined by Letters of Agreement (LOA) negotiated between the two facility managers. This information is not available to pilots in any Federal Aviation Administration (FAA) publication. For this reason, it is good practice to note on the en route chart the points at which hand-offs occur. Each time a flight is handed-off to a different facility, the controller knows the altitude and location—this was part of the hand-off procedure.

Communications Facility	Description	Frequency
Airport Advisory Area "[AFSS name] RADIO"	AFSS personnel provide traffic advisories to pilots operating within 10 miles of the airport.	123.6 MHz.
UNICOM "[airport name] UNICOM"	Airport advisories from an airport without an operating control tower or AFSS.	Listed in A/FD under the city name; also on sectional charts in airport data block.
Air Route Traffic Control Center (ARTCC) "CENTER"	En route radar facilities that maintain separation between IFR flights, and between IFR flights and known VFR flights. Centers provide VFR traffic advisories on a workload permitting basis.	Listed in A/FD and on instrument enroute charts.
Approach/Departure Control "[airport name] APPROACH" (unless otherwise advised)	Positions at a terminal radar facility responsible for handling of IFR flights to and from the primary airport (where Class B airspace exists).	Listed in A/FD; also on sectional charts in the communications panel and on terminal area charts.
Automatic Terminal Information Service (ATIS)	Continuous broadcast of audio tape prepared by ATC controller containing wind direction and velocity, temperature, altimeter setting, runway and approach in use, and other information of interest to pilots.	Listed in A/FD under the city name; also on sectional charts in airport data block and in the communications panel, and on terminal area charts.
Clearance Delivery "[airport name] CLEARANCE"	Control tower position responsible for transmitting departure clearances to IFR flights.	Listed on instrument approach procedure charts.
Common Traffic Advisory Frequency (CTAF)	CTAF provides a single frequency for pilots in the area to use for contacting the facility and/or broadcasting their position and intentions to other pilots.	Listed in A/FD; also on sectional charts in the airport data block (followed by a white C on a blue or magenta background). At airports with no tower, CTAF is 122.9, the "MULTICOM" frequency.
Automated Flight Service Station (AFSS) "[facility name] RADIO"	Provides information and services to pilots, using remote communications outlets (RCOs) and ground communications outlets (GCOs).	Listed in A/FD and sectional charts, both under city name and in a separate listing of AFSS frequencies. On sectional charts, listed above the VOR boxes, or in separate boxes when remote.
Ground Control "[airport name] GROUND"	At tower-controlled airports, a position in the tower responsible for controlling aircraft taxiing to and from the runways.	Listed in A/FD under city name.
Hazardous Inflight Weather Advisory Service (HIWAS)	Continuous broadcast of forecast hazardous weather conditions on selected NAVAIDs. No communication capability.	Black circle with white "H" in VOR frequency box; notation in A/FD airport listing under "Radio Aids to Navigation."
MULTICOM "[airport name] TRAFFIC"	Intended for use by pilots at airports with no radio facilities. Pilots should use self-announce procedures given in the AIM.	122.9 MHz. A/FD shows 122.9 as CTAF; also on sectional charts 122.9 is followed by a white C on a dark background, indicating CTAF.
Tower "[airport name] TOWER"	"Local" controller responsible for operations on the runways and in Class B, C, or D airspace surrounding the airport.	Listed in A/FD under city name; also on sectional and terminal control area charts in the airport data block and communications panel.
En Route Flight Advisory Service (EFAS) "FLIGHT WATCH"	For inflight weather information.	122.0 MHz (0600-2200 local time)

Figure 9-16. *ATC Facilities, Services, and Radio Call Signs.*

Chapter 10

IFR Flight

Introduction

This chapter is a discussion of conducting a flight under instrument flight rules (IFR). It also explains the sources for flight planning, the conditions associated with instrument flight, and the procedures used for each phase of IFR flight: departure, en route, and approach. The chapter concludes with an example of an IFR flight which applies many of the procedures discussed in the chapter.

Sources of Flight Planning Information

The following resources are available for a pilot planning a flight conducted under instrument flight rules (IFR).

National Aeronautical Charting Group (NACG) publications:

- IFR en route charts
- area charts
- United States (U.S.) Terminal Procedures Publications (TPP)

The Federal Aviation Administration (FAA) publications:

- AIM
- Airport/Facility Directory (A/FD)
- Notices to Airmen Publication (NTAP) for flight planning in the National Airspace System (NAS)

Pilots should also consult the Pilot's Operating Handbook/ Airplane Flight Manual (POH/AFM) for flight planning information pertinent to the aircraft to be flown.

A review of the contents of all the listed publications will help determine which material should be referenced for each flight. As a pilot becomes more familiar with these publications, the flight planning process becomes quicker and easier.

Aeronautical Information Manual (AIM)

The AIM provides the aviation community with basic flight information and air traffic control (ATC) procedures used in the United States NAS. An international version called the Aeronautical Information Publication contains parallel information, as well as specific information on the international airports used by the international community.

Airport/Facility Directory (A/FD)

The A/FD contains information on airports, communications, and navigation aids pertinent to IFR flight. It also includes very-high frequency omnidirectional range (VOR) receiver checkpoints, automated flight service station (AFSS), weather service telephone numbers, and air route traffic control center (ARTCC) frequencies. Various special notices essential to flight are also included, such as land-and-hold-short operations (LAHSO) data, the civil use of military fields, continuous power facilities, and special flight procedures.

In the major terminal and en route environments, preferred routes have been established to guide pilots in planning their routes of flight, to minimize route changes, and to aid in the orderly management of air traffic using the federal airways. The A/FD lists both high and low altitude preferred routes.

Notices to Airmen Publication (NTAP)

The NTAP is a publication containing current Notices to Airmen (NOTAMs) which are essential to the safety of flight, as well as supplemental data affecting the other operational publications listed. It also includes current Flight Data Center (FDC) NOTAMs, which are regulatory in nature, issued to establish restrictions to flight or to amend charts or published instrument approach procedures (IAPs).

POH/AFM

The POH/AFM contain operating limitations, performance, normal and emergency procedures, and a variety of other operational information for the respective aircraft. Aircraft manufacturers have done considerable testing to gather and substantiate the information in the aircraft manual. Pilots should refer to it for information relevant to a proposed flight.

IFR Flight Plan

As specified in Title 14 of the Code of Federal Regulations (14 CFR) part 91, no person may operate an aircraft in controlled airspace under IFR unless that person has filed an IFR flight plan. Flight plans may be submitted to the nearest AFSS or air traffic control tower (ATCT) either in person, by telephone (1-800-WX-BRIEF), by computer (using the direct user access terminal system (DUATS)), or by radio if no other means are available. Pilots should file IFR flight plans at least 30 minutes prior to estimated time of departure to preclude possible delay in receiving a departure clearance from ATC. The AIM provides guidance for completing and filing FAA Form 7233-1, Flight Plan. These forms are available at flight service stations (FSSs), and are generally found in flight planning rooms at airport terminal buildings. *[Figure 10-1]*

Filing in Flight

IFR flight plans may be filed from the air under various conditions, including:

1. A flight outside controlled airspace before proceeding into IFR conditions in controlled airspace.
2. A VFR flight expecting IFR weather conditions en route in controlled airspace.

In either of these situations, the flight plan may be filed with the nearest AFSS or directly with the ARTCC. A pilot who files with the AFSS submits the information normally entered during preflight filing, except for "point of departure," together with present position and altitude. AFSS then relays this information to the ARTCC. The ARTCC will then clear the pilot from present position or from a specified navigation fix.

A pilot who files directly with the ARTCC reports present position and altitude, and submits only the flight plan information normally relayed from the AFSS to the ARTCC. Be aware that traffic saturation frequently prevents ARTCC personnel from accepting flight plans by radio. In such cases, a pilot is advised to contact the nearest AFSS to file the flight plan.

Cancelling IFR Flight Plans

An IFR flight plan may be cancelled any time a pilot is operating in VFR conditions outside Class A airspace by stating "cancel my IFR flight plan" to the controller or air-to-ground station. After cancelling an IFR flight plan, the pilot should change to the appropriate air-to-ground frequency, transponder code as directed, and VFR altitude/flight level.

ATC separation and information services (including radar services, where applicable) are discontinued when an IFR flight plan is cancelled. If VFR radar advisory service is desired, a pilot must specifically request it. Be aware that other procedures may apply when cancelling an IFR flight plan within areas such as Class C or Class B airspace.

When operating on an IFR flight plan to an airport with an operating control tower, a flight plan is cancelled automatically upon landing. If operating on an IFR flight plan to an airport without an operating control tower, the pilot is responsible for cancelling the flight plan. This can be done by telephone after landing if there is no operating FSS or other means of direct communications with ATC. When there is no FSS or air-to-ground communications are not possible below a certain altitude, a pilot may cancel an IFR flight plan while still airborne and able to communicate with ATC by radio. If using this procedure, be certain the remainder of the flight can be conducted under VFR. It is essential that IFR flight plans be cancelled expeditiously. This allows other IFR traffic to utilize the airspace.

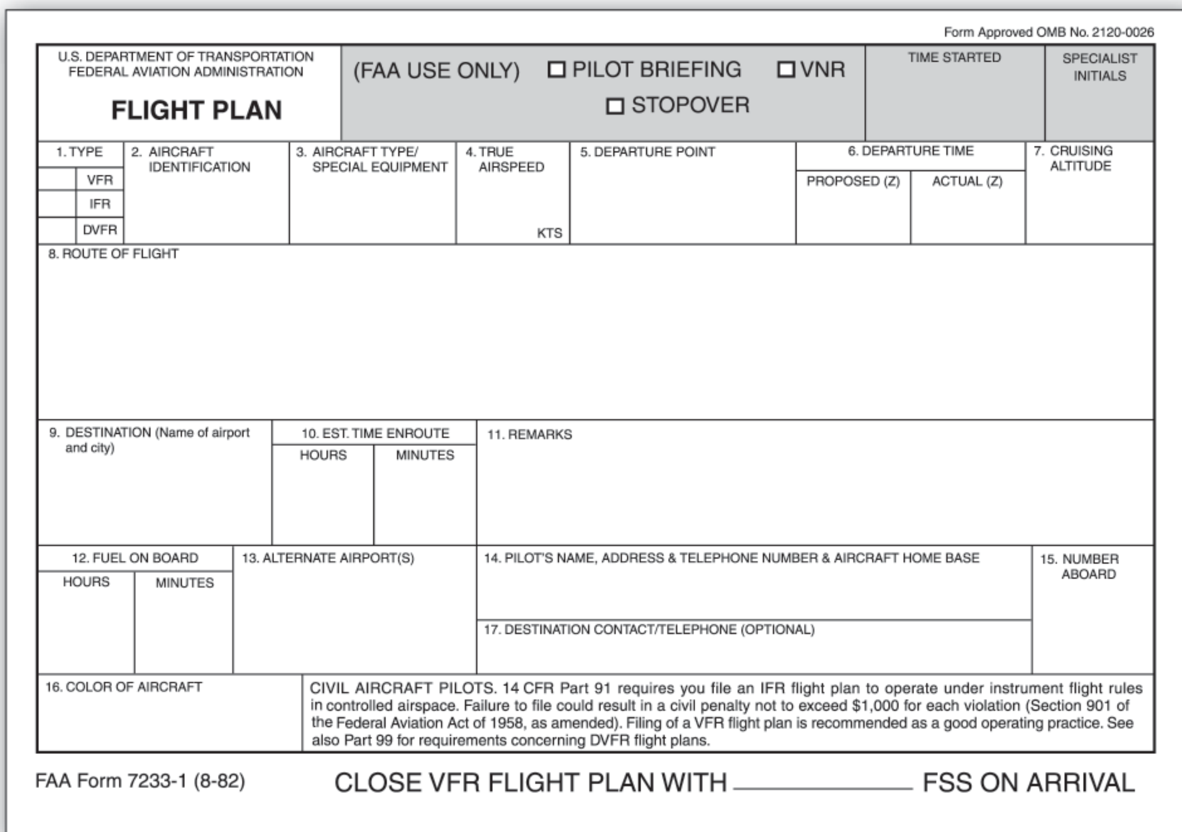
Clearances

An ATC clearance allows an aircraft to proceed under specified traffic conditions within controlled airspace for the purpose of providing separation between known aircraft.

Examples

A flight filed for a short distance at a relatively low altitude in an area of low traffic density might receive a clearance as follows:

> "Cessna 1230 Alpha, cleared to Doeville airport direct, cruise 5,000."



Form Approved OMB No. 2120-0026

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FLIGHT PLAN

(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR ☐ STOPOVER | TIME STARTED | SPECIALIST INITIALS

1. TYPE: VFR / IFR / DVFR
2. AIRCRAFT IDENTIFICATION
3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT
4. TRUE AIRSPEED — KTS
5. DEPARTURE POINT
6. DEPARTURE TIME — PROPOSED (Z) / ACTUAL (Z)
7. CRUISING ALTITUDE
8. ROUTE OF FLIGHT
9. DESTINATION (Name of airport and city)
10. EST. TIME ENROUTE — HOURS / MINUTES
11. REMARKS
12. FUEL ON BOARD — HOURS / MINUTES
13. ALTERNATE AIRPORT(S)
14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE
15. NUMBER ABOARD
16. COLOR OF AIRCRAFT
17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)

CIVIL AIRCRAFT PILOTS. 14 CFR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.

FAA Form 7233-1 (8-82) CLOSE VFR FLIGHT PLAN WITH ______ FSS ON ARRIVAL

Figure 10-1. *Flight Plan Form.*

The term "cruise" in this clearance means a pilot is authorized to fly at any altitude from the minimum IFR altitude up to and including 5,000 feet, and may level off at any altitude within this block of airspace. A climb or descent within the block may be made at the pilot's discretion. However, once a pilot reports leaving an altitude within the block, the pilot may not return to that altitude without further ATC clearance.

When ATC issues a cruise clearance in conjunction with an unpublished route, an appropriate crossing altitude will be specified to ensure terrain clearance until the aircraft reaches a fix, point, or route where the altitude information is available. The crossing altitude ensures IFR obstruction clearance to the point at which the aircraft enters a segment of a published route or IAP.

Once a flight plan is filed, ATC will issue the clearance with appropriate instructions, such as the following:

> "Cessna 1230 Alpha is cleared to Skyline airport via the Crossville 055 radial, Victor 18, maintain 5,000. Clearance void if not off by 1330."

Or a more complex clearance, such as:

> "Cessna 1230 Alpha is cleared to Wichita Mid-continent airport via Victor 77, left turn after takeoff, proceed direct to the Oklahoma City VORTAC. Hold west on the Oklahoma City 277 radial, climb to 5,000 in holding pattern before proceeding on course. Maintain 5,000 to CASHION intersection. Climb to and maintain 7,000. Departure control frequency will be 121.05, Squawk 0412."

Clearance delivery may issue the following "abbreviated clearance" which includes a departure procedure (DP):

> "Cessna 1230 Alpha, cleared to La Guardia as filed, RINGOES 8 departure Phillipsburg transition, maintain 8,000. Departure control frequency will be 120.4, Squawk 0700."

This clearance may be readily copied in shorthand as follows:

> "CAF RNGO8 PSB M80 DPC 120.4 SQ 0700."

The information contained in this DP clearance is abbreviated using clearance shorthand (see appendix 1). The pilot should know the locations of the specified navigation facilities, together with the route and point-to-point time, before accepting the clearance.

The DP enables a pilot to study and understand the details of a departure before filing an IFR flight plan. It provides the information necessary to set up communication and navigation equipment and be ready for departure before requesting an IFR clearance.

Once the clearance is accepted, a pilot is required to comply with ATC instructions. A clearance different from that issued may be requested if the pilot considers another course of action more practicable or if aircraft equipment limitations or other considerations make acceptance of the clearance inadvisable.

A pilot should also request clarification or amendment, as appropriate, any time a clearance is not fully understood or considered unacceptable for safety of flight. The pilot is responsible for requesting an amended clearance if ATC issues a clearance that would cause a pilot to deviate from a rule or regulation or would place the aircraft in jeopardy.

Clearance Separations

ATC will provide the pilot on an IFR clearance with separation from other IFR traffic. This separation is provided:

1. Vertically—by assignment of different altitudes.
2. Longitudinally—by controlling time separation between aircraft on the same course.
3. Laterally—by assignment of different flight paths.
4. By radar—including all of the above.

ATC does not provide separation for an aircraft operating:

1. Outside controlled airspace.
2. On an IFR clearance:
    a) With "VFR-On-Top" authorized instead of a specific assigned altitude.
    b) Specifying climb or descent in "VFR conditions."
    c) At any time in VFR conditions, since uncontrolled VFR flights may be operating in the same airspace.

In addition to heading and altitude assignments, ATC will occasionally issue speed adjustments to maintain the required separations. For example:

> "Cessna 30 Alpha, slow to 100 knots."

A pilot who receives speed adjustments is expected to maintain that speed plus or minus 10 knots. If for any reason the pilot is not able to accept a speed restriction, the pilot should advise ATC.

At times, ATC may also employ visual separation techniques to keep aircraft safely separated. A pilot who obtains visual contact with another aircraft may be asked to maintain visual separation or to follow the aircraft. For example:

"Cessna 30 Alpha, maintain visual separation with that traffic, climb and maintain 7,000."

The pilot's acceptance of instructions to maintain visual separation or to follow another aircraft is an acknowledgment that the aircraft will be maneuvered as necessary, to maintain safe separation. It is also an acknowledgment that the pilot accepts the responsibility for wake turbulence avoidance.

In the absence of radar contact, ATC will rely on position reports to assist in maintaining proper separation. Using the data transmitted by the pilot, the controller follows the progress of each flight. ATC must correlate the pilots' reports to provide separation; therefore, the accuracy of each pilot's report can affect the progress and safety of every other aircraft operating in the area on an IFR flight plan.

Departure Procedures (DPs)

Instrument departure procedures are preplanned instrument flight rule (IFR) procedures, which provide obstruction clearance from the terminal area to the appropriate en route structure and provide the pilot with a way to depart the airport and transition to the en route structure safely. Pilots operating under 14 CFR part 91 are strongly encouraged to file and fly a DP when one is available. *[Figure 10-2]*

There are two types of DPs, Obstacle Departure Procedures (ODP), printed either textually or graphically, and Standard Instrument Departures (SID), always printed graphically. All DPs, either textual or graphic, may be designed using either conventional or RNAV criteria. RNAV procedures will have RNAV printed in the title, e.g., SHEAD TWO DEPARTURE (RNAV).

Obstacle Departure Procedures (ODP)

ODPs provide obstruction clearance via the least onerous route from the terminal area to the appropriate en route structure. ODPs are recommended for obstruction clearance and may be flown without ATC clearance unless an alternate departure procedure (SID or radar vector) has been specifically assigned by ATC. Graphic ODPs will have (OBSTACLE) printed in the procedure title, e.g., GEYSR THREE DEPARTURE (OBSTACLE), CROWN ONE DEPARTURE (RNAV)(OBSTACLE).

Standard Instrument Departures

Standard Instrument Departures (SID) are air traffic control (ATC) procedures printed for pilot/controller use in graphic form to provide obstruction clearance and a transition from the terminal area to the appropriate en route structure. SIDs are primarily designed for system enhancement and to reduce pilot/controller workload. ATC clearance must be received prior to flying a SID.

ODPs are found in section C of each booklet published regionally by the NACG, TPP, along with "IFR Take-off Minimums" while SIDs are collocated with the approach procedures for the applicable airport. Additional information on the development of DPs can be found in paragraph 5-2-7 of the AIM. However, the following points are important to remember.

1. The pilot of IFR aircraft operating from locations where DP procedures are effective may expect an ATC clearance containing a DP. The use of a DP requires pilot possession of at least the textual description of the approved DP.
2. If a pilot does not possess a preprinted DP or for any other reason does not wish to use a DP, he or she is expected to advise ATC. Notification may be accomplished by filing "NO DP" in the remarks section of the filed flight plan, or by advising ATC.
3. If a DP is accepted in a clearance, a pilot must comply with it.

Radar Controlled Departures

On IFR departures from airports in congested areas, a pilot will normally receive navigational guidance from departure control by radar vector. When a departure is to be vectored immediately following takeoff, the pilot will be advised before takeoff of the initial heading to be flown. This information is vital in the event of a loss of two-way radio communications during departure.

The radar departure is normally simple. Following takeoff, contact departure control on the assigned frequency when advised to do so by the control tower. At this time departure control verifies radar contact, and gives headings, altitude, and climb instructions to move an aircraft quickly and safely out of the terminal area. A pilot is expected to fly the assigned headings and altitudes until informed by the controller of the aircraft's position with respect to the route given in the clearance, whom to contact next, and to "resume own navigation."

Departure control will provide vectors to either a navigation facility, or an en route position appropriate to the departure clearance, or transfer to another controller with further radar surveillance capabilities. *[Figure 10-2]*

A radar controlled departure does not relieve the pilot of responsibilities as pilot-in-command. Be prepared before takeoff to conduct navigation according to the ATC clearance, with navigation receivers checked and properly tuned. While under radar control, monitor instruments to ensure continuous orientation to the route specified in the clearance, and record the time over designated checkpoints.

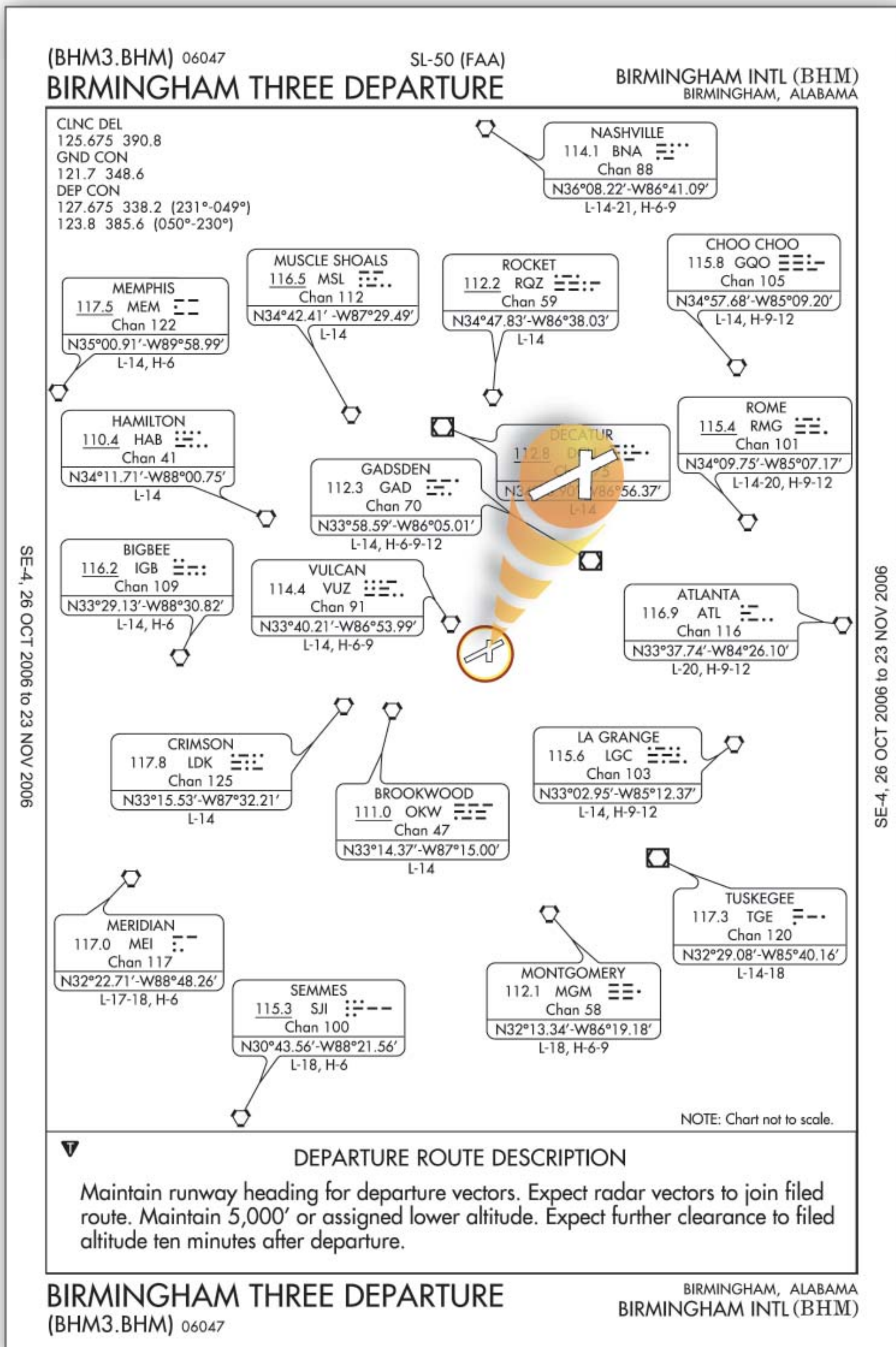


Figure 10-2. *Departure Procedure (DP).*

Departures From Airports Without an Operating Control Tower

When departing from airports that have neither an operating tower nor an FSS, a pilot should telephone the flight plan to the nearest ATC facility at least 30 minutes before the estimated departure time. If weather conditions permit, depart VFR and request IFR clearance as soon as radio contact is established with ATC.

If weather conditions make it undesirable to fly VFR, telephone clearance request. In this case, the controller would probably issue a short-range clearance pending establishment of radio contact, and might restrict the departure time to a certain period. For example:

> "Clearance void if not off by 0900."

This would authorize departure within the allotted period and permit a pilot to proceed in accordance with the clearance. In the absence of any specific departure instructions, a pilot would be expected to proceed on course via the most direct route.

En Route Procedures

Procedures en route will vary according to the proposed route, the traffic environment, and the ATC facilities controlling the flight. Some IFR flights are under radar surveillance and controlled from departure to arrival, and others rely entirely on pilot navigation.

Where ATC has no jurisdiction, it does not issue an IFR clearance. It has no control over the flight, nor does the pilot have any assurance of separation from other traffic.

ATC Reports

All pilots are required to report unforecast weather conditions or other information related to safety of flight to ATC. The pilot-in-command of each aircraft operated in controlled airspace under IFR shall report as soon as practical to ATC any malfunctions of navigational, approach, or communication equipment occurring in flight:

1. Loss of VOR, tactical air navigation (TACAN) or automatic direction finder (ADF) receiver capability.
2. Complete or partial loss of instrument landing system (ILS) receiver capability.
3. Impairment of air-to-ground communications capability.

The pilot-in-command shall include within the report (1) Aircraft identification, (2) Equipment affected, (3) Degree to which the pilot to operate under IFR within the ATC system is impaired, and (4) Nature and extent of assistance desired from ATC.

Position Reports

Position reports are required over each compulsory reporting point (shown on the chart as a solid triangle) along the route being flown regardless of altitude, including those with a VFR-on-top clearance. Along direct routes, reports are required of all IFR flights over each point used to define the route of flight. Reports at reporting points (shown as an open triangle) are made only when requested by ATC. A pilot should discontinue position reporting over designated reporting points when informed by ATC that the aircraft is in "RADAR CONTACT." Position reporting should be resumed when ATC advises "RADAR CONTACT LOST" or "RADAR SERVICE TERMINATED."

Position reports should include the following items:

1. Identification
2. Position
3. Time
4. Altitude or flight level (include actual altitude or flight level when operating on a clearance specifying VFR-on-top)
5. Type of flight plan (not required in IFR position reports made directly to ARTCCs or approach control)
6. ETA and name of next reporting point
7. The name only of the next succeeding reporting point along the route of flight
8. Pertinent remarks

En route position reports are submitted normally to the ARTCC controllers via direct controller-to-pilot communications channels, using the appropriate ARTCC frequencies listed on the en route chart.

Whenever an initial contact with a controller is to be followed by a position report, the name of the reporting point should be included in the call-up. This alerts the controller that such information is forthcoming. For example:

> "Atlanta Center, Cessna 1230 Alpha at JAILS intersection."
>
> "Cessna 1230 Alpha Atlanta Center."
>
> "Atlanta Center, Cessna 1230 Alpha at JAILS intersection, 5,000, estimating Monroeville at 1730."

Additional Reports

In addition to required position reports, the following reports should be made to ATC without a specific request.

1. At all times:
    a) When vacating any previously assigned altitude or flight level for a newly assigned altitude or flight level
    b) When an altitude change will be made if operating on a clearance specifying VFR-on-top
    c) When unable to climb/descend at a rate of at least 500 feet per minute (fpm)
    d) When an approach has been missed (Request clearance for specific action (to alternative airport, another approach, etc.))
    e) Change in average true airspeed (at cruising altitude) when it varies by 5 percent or ten knots (whichever is greater) from that filed in the flight plan
    f) The time and altitude upon reaching a holding fix or point to which cleared
    g) When leaving any assigned holding fix or point

       NOTE - The reports in (f) and (g) may be omitted by pilots of aircraft involved in instrument training at military terminal area facilities when radar service is being provided.
    h) Any loss in controlled airspace of VOR, TACAN, ADF, low frequency navigation receiver capability, GPS anomalies while using installed IFR-certified GPS/GNSS receivers, complete or partial loss of ILS receiver capability, or impairment of air/ground communications capability. Reports should include aircraft identification, equipment affected, degree to which the capability to operate under IFR in the ATC system is impaired, and the nature and extent of assistance desired from ATC.
    i) Any information relating to the safety of flight.
2. When not in radar contact:
    a) When leaving the final approach fix inbound on final approach (nonprecision approach), or when leaving the outer marker or fix used in lieu of the outer marker inbound on final approach (precision approach).
    b) A corrected estimate at any time it becomes apparent that an estimate as previously submitted is in error in excess of 3 minutes.

Any pilot who encounters weather conditions that have not been forecast, or hazardous conditions which have been forecast, is expected to forward a report of such weather to ATC.

Planning the Descent and Approach

ATC arrival procedures and flight deck workload are affected by weather conditions, traffic density, aircraft equipment, and radar availability.

When landing at an airport with approach control services and where two or more IAPs are published, information on the type of approach to expect will be provided in advance of arrival or vectors will be provided to a visual approach. This information will be broadcast either on automated terminal information service (ATIS) or by a controller. It will not be furnished when the visibility is 3 miles or more and the ceiling is at or above the highest initial approach altitude established for any low altitude IAP for the airport.

The purpose of this information is to help the pilot plan arrival actions; however, it is not an ATC clearance or commitment and is subject to change. Fluctuating weather, shifting winds, blocked runway, etc., are conditions that may result in changes to the approach information previously received. It is important for a pilot to advise ATC immediately if he or she is unable to execute the approach or prefers another type of approach.

If the destination is an airport without an operating control tower, and has automated weather data with broadcast capability, the pilot should monitor the automated surface observing system/automated weather observing system (ASOS/AWOS) frequency to ascertain the current weather for the airport. ATC should be advised that weather information has been received and what the pilot's intentions are.

When the approach to be executed has been determined, the pilot should plan for and request a descent to the appropriate altitude prior to the initial approach fix (IAF) or transition route depicted on the IAP. When flying the transition route, a pilot should maintain the last assigned altitude until ATC gives the instructions "cleared for the approach." Lower altitudes can be requested to bring the transition route altitude closer to the required altitude at the initial approach fix. When ATC uses the phrase "at pilot's discretion" in the altitude information of a clearance, the pilot has the option to start a descent at any rate, and may level off temporarily at any intermediate altitude. However, once an altitude has been vacated, return to that altitude is not authorized without a clearance. When ATC has not used the term "at pilot's discretion" nor imposed any descent restrictions, initiate descent promptly upon acknowledgment of the clearance.

Descend at an optimum rate (consistent with the operating characteristics of the aircraft) to 1,000 feet above the assigned altitude. Then attempt to descend at a rate of between 500 and

1,500 fpm until the assigned altitude is reached. If at anytime a pilot is unable to maintain a descent rate of at least 500 fpm, advise ATC. Also advise ATC if it is necessary to level off at an intermediate altitude during descent. An exception to this is when leveling off at 10,000 feet mean sea level (MSL) on descent, or 2,500 feet above airport elevation (prior to entering a Class B, Class C, or Class D surface area) when required for speed reduction.

Standard Terminal Arrival Routes (STARs)

Standard terminal arrival routes (as described in Chapter 8) have been established to simplify clearance delivery procedures for arriving aircraft at certain areas having high density traffic. A STAR serves a purpose parallel to that of a DP for departing traffic. *[Figure 10-3]* The following points regarding STARs are important to remember:

1. All STARs are contained in the TPP, along with the IAP charts for the destination airport. The AIM also describes STAR procedures.
2. If the destination is a location for which STARs have been published, a pilot may be issued a clearance containing a STAR whenever ATC deems it appropriate. To accept the clearance, a pilot must possess at least the approved textual description.
3. It is the pilot's responsibility to either accept or refuse an issued STAR. If a STAR will not or cannot be used, advise ATC by placing "NO STAR" in the remarks section of the filed flight plan or by advising ATC.
4. If a STAR is accepted in a clearance, compliance is mandatory.

Substitutes for Inoperative or Unusable Components

The basic ground components of an ILS are the localizer, glide slope, outer marker, middle marker, and inner marker (when installed). A compass locator or precision radar may be substituted for the outer or middle marker. Distance measuring equipment (DME), VOR, or nondirectional beacon (NDB) fixes authorized in the standard IAP or surveillance radar may be substituted for the outer marker.

Additionally, IFR-certified global positioning system (GPS) equipment, operated in accordance with Advisory Circular (AC) 90-94, Guidelines for Using Global Positioning System Equipment for IFR En Route and Terminal Operations and for Nonprecision Instrument Approaches in the United States National Airspace System, may be substituted for ADF and DME equipment, except when flying NDB IAP. Specifically, GPS can be substituted for ADF and DME equipment when:

1. Flying a DME arc;
2. Navigating TO/FROM an NDB;
3. Determining the aircraft position over an NDB;
4. Determining the aircraft position over a fix made up of a crossing NDB bearing;
5. Holding over an NDB;
6. Determining aircraft position over a DME fix.

Holding Procedures

Depending upon traffic and weather conditions, holding may be required. Holding is a predetermined maneuver which keeps aircraft within a specified airspace while awaiting further clearance from ATC. A standard holding pattern uses right turns, and a nonstandard holding pattern uses left turns. The ATC clearance will always specify left turns when a nonstandard pattern is to be flown.

Standard Holding Pattern (No Wind)

In a standard holding pattern with no winds, *[Figure 10-4]* the aircraft follows the specified course inbound to the holding fix, turns 180° to the right, flies a parallel straight course outbound for 1 minute, turns 180° to the right, and flies the inbound course to the fix.

Standard Holding Pattern (With Wind)

A standard symmetrical holding pattern cannot be flown when winds exist. In those situations, the pilot is expected to:

1. Compensate for the effect of a known wind except when turning.
2. Adjust outbound timing to achieve a 1-minute (1-1/2 minutes above 14,000 feet) inbound leg.

Figure 10-5 illustrates the holding track followed with a left crosswind. The effect of wind is counteracted by applying drift corrections to the inbound and outbound legs and by applying time allowances to the outbound leg.

Holding Instructions

If an aircraft arrives at a clearance limit before receiving clearance beyond the fix, ATC expects the pilot to maintain the last assigned altitude and begin holding in accordance with the charted holding pattern. If no holding pattern is charted and holding instructions have not been issued, enter a standard holding pattern on the course on which the aircraft approached the fix and request further clearance as soon as possible. Normally, when no delay is anticipated, ATC will issue holding instructions at least 5 minutes before the

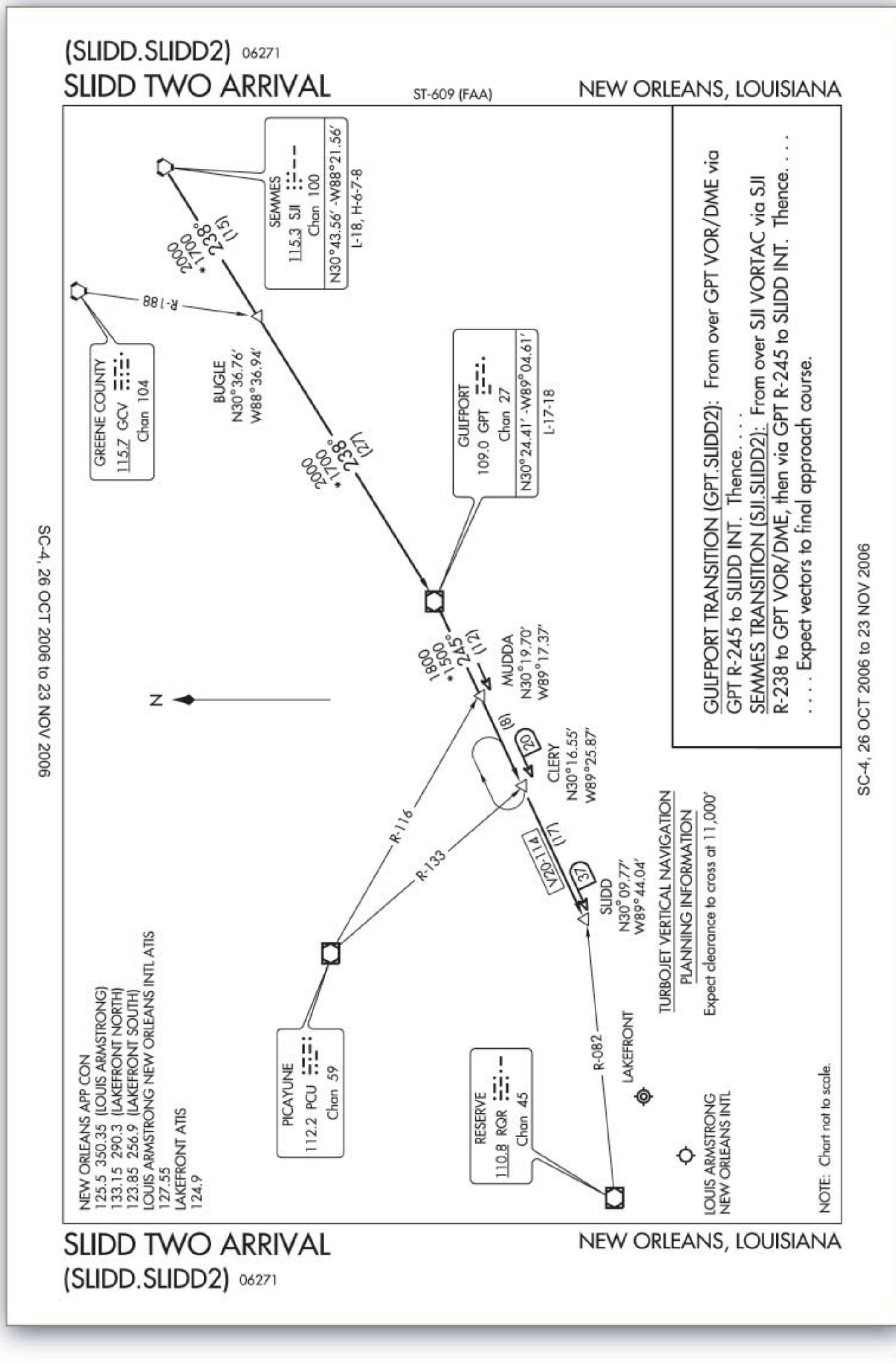


Figure 10-3. *Standard Terminal Arrival Route (STAR).*

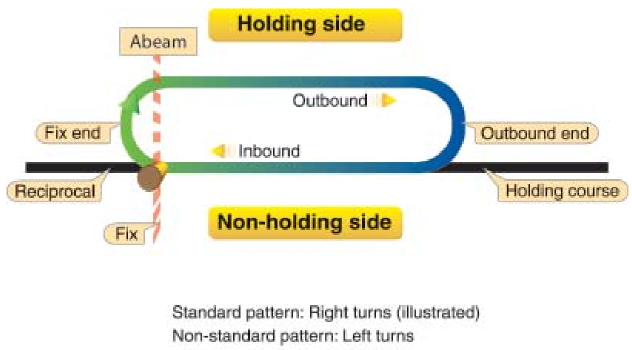


Figure 10-4. *Standard Holding Pattern—No Wind.*

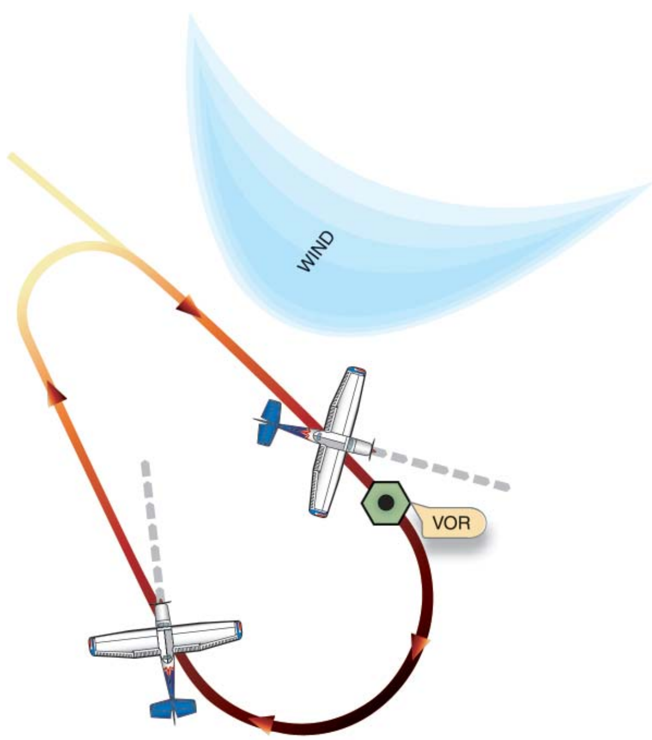


Figure 10-5. *Drift Correction in Holding Pattern.*

estimated arrival at the fix. Where a holding pattern is not charted, the ATC clearance will specify the following:

1. Direction of holding from the fix in terms of the eight cardinal compass points (N, NE, E, SE, etc.)
2. Holding fix (the fix may be omitted if included at the beginning of the transmission as the clearance limit)
3. Radial, course, bearing, airway, or route on which the aircraft is to hold.
4. Leg length in miles if DME or area navigation (RNAV) is to be used (leg length will be specified in minutes on pilot request or if the controller considers it necessary).
5. Direction of turn, if left turns are to be made, because the pilot requests or the controller considers it necessary.
6. Time to expect-further-clearance (EFC) and any pertinent additional delay information.

ATC instructions will also be issued whenever:

1. It is determined that a delay will exceed 1 hour.
2. A revised EFC is necessary.
3. In a terminal area having a number of navigation aids and approach procedures, a clearance limit may not indicate clearly which approach procedures will be used. On initial contact, or as soon as possible thereafter, approach control will advise the pilot of the type of approach to expect.
4. Ceiling and/or visibility is reported as being at or below the highest "circling minimums" established for the airport concerned. ATC will transmit a report of current weather conditions and subsequent changes, as necessary.
5. An aircraft is holding while awaiting approach clearance, and the pilot advises ATC that reported weather conditions are below minimums applicable to the operation. In this event, ATC will issue suitable instructions to aircraft desiring either to continue holding while awaiting weather improvement or proceed to another airport.

Standard Entry Procedures

The entry procedures given in the AIM evolved from extensive experimentation under a wide range of operational conditions. The standardized procedures should be followed to ensure that an aircraft remains within the boundaries of the prescribed holding airspace.

When a speed reduction is required, start the reduction when 3 minutes or less from the holding fix. Cross the holding fix initially at or below the maximum holding airspeed (MHA). The purpose of the speed reduction is to prevent overshooting the holding airspace limits, especially at locations where adjacent holding patterns are close together.

All aircraft may hold at the following altitudes and maximum holding airspeeds:

Altitude Mean Sea Level (MSL)	*Airspeed (KIAS)*
Up to 6,000 feet	200
6,001 – 14,000 feet	230
14,001 feet and above	265

The following are exceptions to the maximum holding airspeeds:

1. Holding patterns from 6,001 to 14,000 feet may be restricted to a maximum airspeed of 210 knots indicated airspeed (KIAS). This nonstandard pattern is depicted by an icon.
2. Holding patterns may be restricted to a maximum airspeed of 175 KIAS. This nonstandard pattern is depicted by an icon. Holding patterns restricted to 175 KIAS are generally found on IAPs applicable to category A and B aircraft only.
3. Holding patterns at Air Force airfields only—310 KIAS maximum, unless otherwise depicted.
4. Holding patterns at Navy airfields only—230 KIAS maximum, unless otherwise depicted.
5. The pilot of an aircraft unable to comply with maximum airspeed restrictions should notify ATC.

While other entry procedures may enable the aircraft to enter the holding pattern and remain within protected airspace, the parallel, teardrop, and direct entries are the procedures for entry and holding recommended by the FAA. Additionally, paragraph 5-3-7 in the AIM should be reviewed. *[Figure 10-6]*

1. Parallel Procedure. When approaching the holding fix from anywhere in sector (a), the parallel entry procedure would be to turn to a heading to parallel the holding course outbound on the nonholding side for 1 minute, turn in the direction of the holding pattern through more than 180°, and return to the holding fix or intercept the holding course inbound.
2. Teardrop Procedure. When approaching the holding fix from anywhere in sector (b), the teardrop entry procedure would be to fly to the fix, turn outbound to a heading for a 30° teardrop entry within the pattern (on the holding side) for a period of 1 minute, then turn in the direction of the holding pattern to intercept the inbound holding course.
3. Direct Entry Procedure. When approaching the holding fix from anywhere in sector (c), the direct entry procedure would be to fly directly to the fix and turn to follow the holding pattern.

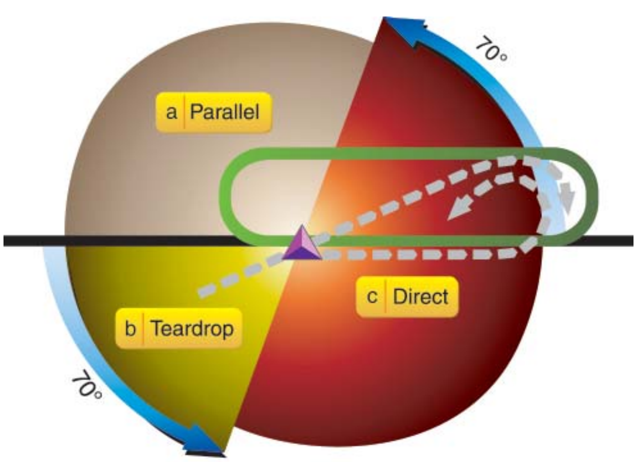


Figure 10-6. *Holding Pattern Entry Procedures.*

A pilot should make all turns during entry and while holding at:

1. 3° per second, or
2. 30° bank angle, or
3. A bank angle provided by a flight director system.

Time Factors

The holding pattern entry time reported to ATC is the initial time of arrival over the fix. Upon entering a holding pattern, the initial outbound leg is flown for 1 minute at or below 14,000 feet MSL, and for 1-1/2 minutes above 14,000 feet MSL. Timing for subsequent outbound legs should be adjusted as necessary to achieve proper inbound leg time. The pilot should begin outbound timing over or abeam the fix, whichever occurs later. If the abeam position cannot be determined, start timing when the turn to outbound is completed. *[Figure 10-7]*

Time leaving the holding fix must be known to ATC before succeeding aircraft can be cleared to the vacated airspace. Leave the holding fix:

1. When ATC issues either further clearance en route or approach clearance;
2. As prescribed in 14 CFR part 91 (for IFR operations; two-way radio communications failure, and responsibility and authority of the pilot-in-command); or
3. After the IFR flight plan has been cancelled, if the aircraft is holding in VFR conditions.

DME Holding

The same entry and holding procedures apply to DME holding, but distances (nautical miles) are used instead of time values. The length of the outbound leg will be specified by the controller, and the end of this leg is determined by the DME readout.

Approaches

Compliance With Published Standard Instrument Approach Procedures

Compliance with the approach procedures shown on the approach charts provides necessary navigation guidance information for alignment with the final approach courses,

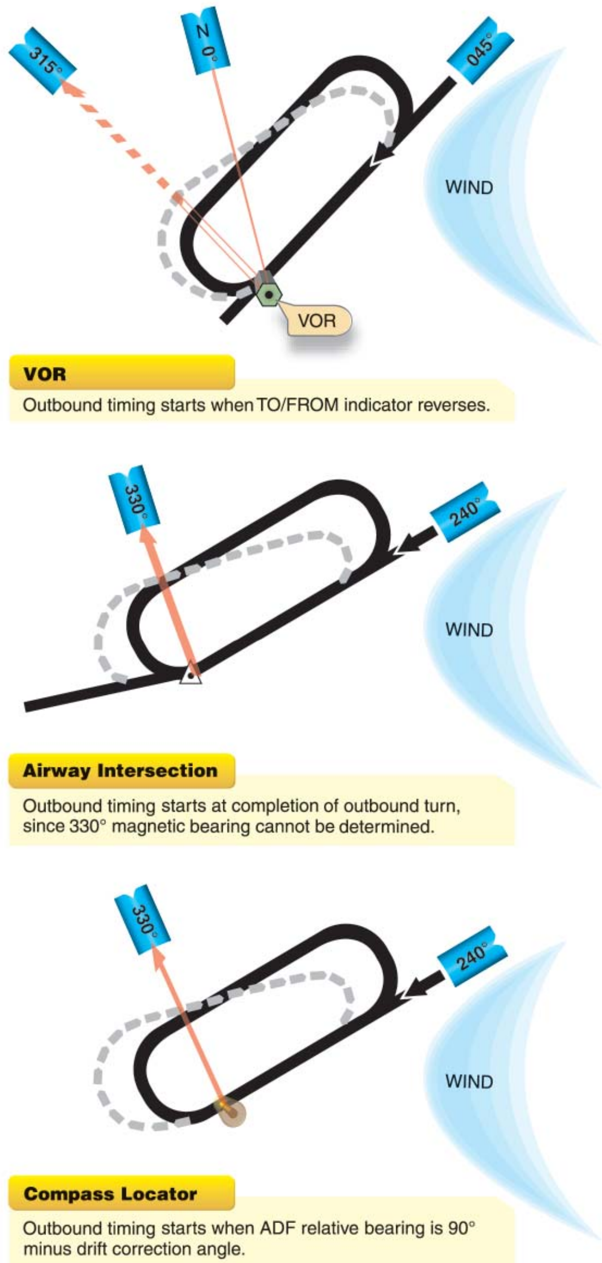


Figure 10-7. *Holding—Outbound Timing.*

as well as obstruction clearance. Under certain conditions, a course reversal maneuver or procedure turn may be necessary. However, this procedure is not authorized when:

1. The symbol "NoPT" appears on the approach course on the plan view of the approach chart.
2. Radar vectoring is provided to the final approach course.
3. A holding pattern is published in lieu of a procedure turn.
4. Executing a timed approach from a holding fix.
5. Otherwise directed by ATC.

Instrument Approaches to Civil Airports

Unless otherwise authorized, when an instrument letdown to an airport is necessary, the pilot should use a standard IAP prescribed for that airport. IAPs are depicted on IAP charts and are found in the TPP.

ATC approach procedures depend upon the facilities available at the terminal area, the type of instrument approach executed, and the existing weather conditions. The ATC facilities, navigation aids (NAVAIDs), and associated frequencies appropriate to each standard instrument approach are given on the approach chart. Individual charts are published for standard approach procedures associated with the following types of facilities:

1. Nondirectional beacon (NDB)
2. Very-high frequency omnirange (VOR)
3. Very-high frequency omnirange with distance measuring equipment (VORTAC or VOR/DME)
4. Localizer (LOC)
5. Instrument landing system (ILS)
6. Localizer-type directional aid (LDA)
7. Simplified directional facility (SDF)
8. Area navigation (RNAV)
9. Global positioning system (GPS)

An IAP can be flown in one of two ways: as a full approach or with the assistance of radar vectors. When the IAP is flown as a full approach, pilots conduct their own navigation using the routes and altitudes depicted on the instrument approach chart. A full approach allows the pilot to transition from the en route phase, to the instrument approach, and then to a landing with minimal assistance from ATC. This type of procedure may be requested by the pilot but is most often used in areas without radar coverage. A full approach also provides the pilot with a means of completing an instrument approach in the event of a communications failure.

When an approach is flown with the assistance of radar vectors, ATC provides guidance in the form of headings and altitudes which position the aircraft to intercept the final approach. From this point, the pilot resumes navigation, intercepts the final approach course, and completes the approach using the IAP chart. This is often a more expedient method of flying the approach, as opposed to the full approach, and allows ATC to sequence arriving traffic. A pilot operating in radar contact can generally expect the assistance of radar vectors to the final approach course.

Approach to Airport Without an Operating Control Tower

Figure 10-8 shows an approach procedure at an airport without an operating control tower. When approaching such a facility, the pilot should monitor the AWOS/ASOS if available for the latest weather conditions. When direct communication between the pilot and controller is no longer required, the ARTCC or approach controller will issue a clearance for an instrument approach and advise "change to advisory frequency approved." When the aircraft arrives on a "cruise" clearance, ATC will not issue further clearance for approach and landing.

If an approach clearance is required, ATC will authorize the pilot to execute his or her choice of standard instrument approach (if more than one is published for the airport) with the phrase "Cleared for the approach" and the communications frequency change required, if any. From this point on, there will be no contact with ATC. The pilot is responsible for closing the IFR flight plan before landing, if in VFR conditions, or by telephone after landing.

Unless otherwise authorized by ATC, a pilot is expected to execute the complete IAP shown on the chart.

Approach to Airport With an Operating Tower, With No Approach Control

When an aircraft approaches an airport with an operating control tower, but no approach control, ATC will issue a clearance to an approach/outer fix with the appropriate information and instructions as follows:

1. Name of the fix
2. Altitude to be maintained
3. Holding information and expected approach clearance time, if appropriate
4. Instructions regarding further communications, including:
    a) facility to be contacted
    b) time and place of contact
    c) frequency/ies to be used

If ATIS is available, a pilot should monitor that frequency for information such as ceiling, visibility, wind direction and velocity, altimeter setting, instrument approach, and runways in use prior to initial radio contact with the tower. If ATIS is not available, ATC will provide weather information from the nearest reporting station.

Approach to an Airport With an Operating Tower, With an Approach Control

Where radar is approved for approach control service, it is used to provide vectors in conjunction with published IAPs. Radar vectors can provide course guidance and expedite traffic to the final approach course of any established IAP. *Figure 10-9* shows an IAP chart with maximum ATC facilities available.

Approach control facilities that provide this radar service operate in the following manner:

1. Arriving aircraft are either cleared to an outer fix most appropriate to the route being flown with vertical separation and, if required, given holding information; or,
2. When radar hand-offs are effected between ARTCC and approach control, or between two approach control facilities, aircraft are cleared to the airport, or to a fix so located that the hand-off will be completed prior to the time the aircraft reaches the fix.
    a) When the radar hand-offs are utilized, successive arriving flights may be handed off to approach control with radar separation in lieu of vertical separation.
    b) After hand-off to approach control, an aircraft is vectored to the appropriate final approach course.
3. Radar vectors and altitude/flight levels are issued as required for spacing and separating aircraft; do not deviate from the headings issued by approach control.
4. Aircraft are normally informed when it becomes necessary to be vectored 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 will be vectored across the final approach course, the pilot should query the controller. The pilot is not expected to turn inbound on the final approach course unless an approach clearance has been issued. This clearance is normally issued with the final vector for interception of the final approach course, and the vector enables the pilot to establish the aircraft on the final approach course prior to reaching the final approach fix.
5. Once the aircraft is established inbound on the final approach course, radar separation is maintained with other aircraft, and the pilot is expected to complete the approach using the NAVAID designated in the clearance (ILS, VOR, NDB, GPS, etc.) as the primary means of navigation.

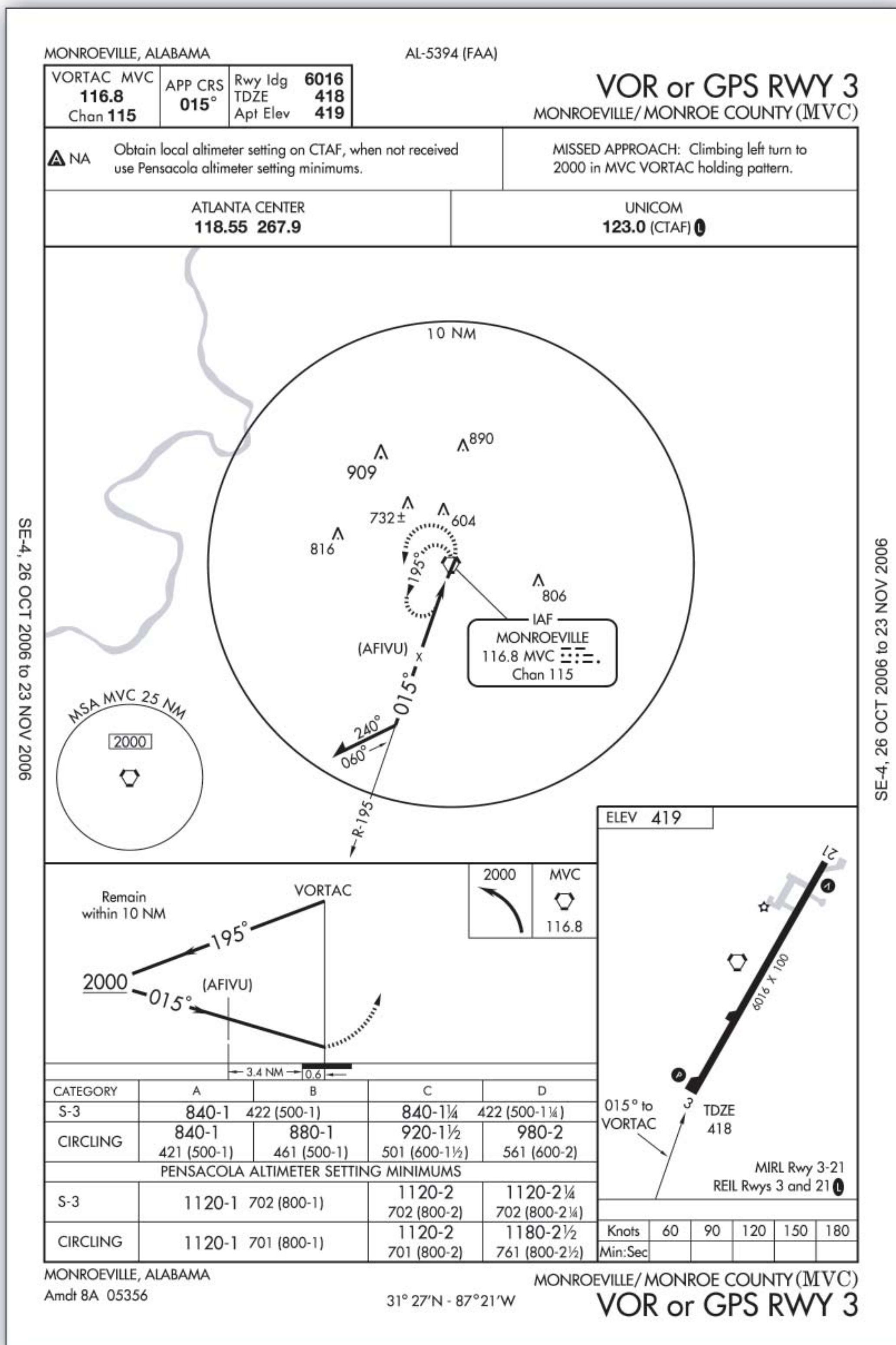


Figure 10-8. *Monroeville, AL (MVC) VOR or GPS Rwy 3 Approach: An Approach Procedure at an Airport Without an Operating Control Tower.*

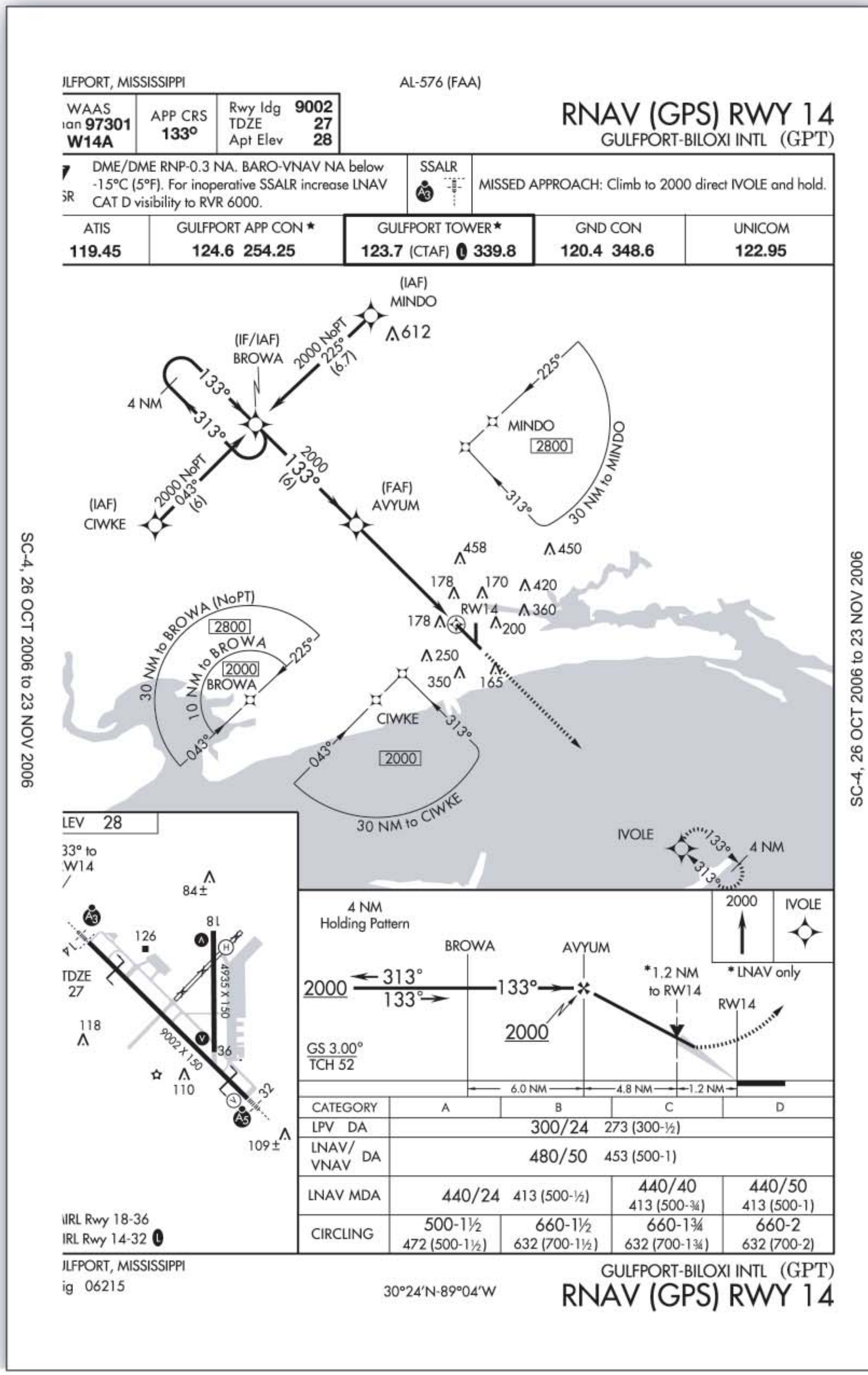


Figure 10-9. *Gulfport, MS (GPT) ILS or LOC Rwy 14 Approach: An Instrument Procedure Chart With Maximum ATC Facilities Available.*

6. After passing the final approach fix inbound, the pilot is expected to proceed direct to the airport and complete the approach, or to execute the published missed approach procedure.
7. Radar service is automatically terminated when the landing is completed or when the pilot is instructed to change to advisory frequency at uncontrolled airports, whichever occurs first.

Radar Approaches

With a radar approach, the pilot receives course and altitude guidance from a controller who monitors the progress of the flight with radar. This is an option should the pilot experience an emergency or distress situation.

The only airborne radio equipment required for radar approaches is a functioning radio transmitter and receiver. The radar controller vectors the aircraft to align it with the runway centerline. The controller continues the vectors to keep the aircraft on course until the pilot can complete the approach and landing by visual reference to the surface. There are two types of radar approaches: Precision (PAR) and Surveillance (ASR).

A radar approach may be given to any aircraft upon request and may be offered to pilots of aircraft in distress or to expedite traffic; however, an ASR might not be approved unless there is an ATC operational requirement, or in an unusual or emergency situation. Acceptance of a PAR or ASR by a pilot does not waive the prescribed weather minimums for the airport or for the particular aircraft operator concerned. The decision to make a radar approach when the reported weather is below the established minimums rests with the pilot.

PAR and ASR minimums are published on separate pages in the FAA Terminal Procedures Publication (TPP). *Figure 10-10.*

Precision Approach (PAR) is one in which a controller provides highly accurate navigational guidance in azimuth and elevation to a pilot.

The controller gives the pilot headings to fly that direct the aircraft to, and keep the aircraft aligned with, the extended centerline of the landing runway. The pilot is told to anticipate glide path interception approximately 10 to 30 seconds before it occurs and when to start descent. The published decision height (DH) will be given only if the pilot requests it. If the aircraft is observed to deviate above or below the glide path, the pilot is given the relative amount of deviation by use of terms "slightly" or "well" and is expected to adjust the aircraft's rate of descent/ascent to return to the glide path. Trend information is also issued with respect to the elevation of the aircraft and may be modified by the terms "rapidly" and "slowly"; e.g., "well above glide path, coming down rapidly."

Range from touchdown is given at least once each mile. If an aircraft is observed by the controller to proceed outside of specified safety zone limits in azimuth and/or elevation and continue to operate outside these prescribed limits, the pilot will be directed to execute a missed approach or to fly a

RADAR MINS N6

06271

RADAR INSTRUMENT APPROACH MINIMUMS

TROY, AL Amdt. 7, DEC 22, 2005 (FAA) ELEV **397**

TROY MUNI

RADAR[1]- 121.1 319.25

	RWY	GS/TCH/RPI	CAT	DA/ MDA-VIS	HAT/ HAA	CEIL-VIS	CAT	DA/ MDA-VIS	HAT/ HAA	CEIL-VIS
PAR	7	2.9/51/	ABCD	**642**-1	250	(300-1)				
ASR	7		AB	**920**-1	528	(600-1)	C	**920**-1½	528	(600-1½)
			D	**920**-1¾	528	(600-1¾)				
CIRCLING			AB	**940**-1	543	(600-1)	C	**960**-1½	563	(600-1½)
			D	**980**-2	583	(600-2)				

When control tower closed, procedure not authorized.
[1]Opr by US Army 1430-2230Z++ Mon-Fri exc hol.

Figure 10-10. *Radar Instrument Approach Minimums for Troy, AL.*

specified course unless the pilot has the runway environment (runway, approach lights, etc.) in sight. Navigational guidance in azimuth and elevation is provided to the pilot until the aircraft reaches the published DH. Advisory course and glide path information is furnished by the controller until the aircraft passes over the landing threshold. At this point the pilot is advised of any deviation from the runway centerline. Radar service is automatically terminated upon completion of the approach.

Surveillance Approach (ASR) is one in which a controller provides navigational guidance in azimuth only.

The controller furnishes the pilot with headings to fly to align the aircraft with the extended centerline of the landing runway. Since the radar information used for a surveillance approach is considerably less precise than that used for a precision approach, the accuracy of the approach will not be as great and higher minimums will apply. Guidance in elevation is not possible but the pilot will be advised when to commence descent to the Minimum Descent Altitude (MDA) or, if appropriate, to an intermediate step-down fix Minimum Crossing Altitude and subsequently to the prescribed MDA. In addition, the pilot will be advised of the location of the Missed Approach Point (MAP) prescribed for the procedure and the aircraft's position each mile on final from the runway, airport or heliport or MAP, as appropriate.

If requested by the pilot, recommended altitudes will be issued at each mile, based on the descent gradient established for the procedure, down to the last mile that is at or above the MDA. Normally, navigational guidance will be provided until the aircraft reaches the MAP.

Radar service is automatically terminated at the completion of a radar approach.

No-Gyro Approach is available to a pilot under radar control who experiences circumstances wherein the directional gyro or other stabilized compass is inoperative or inaccurate. When this occurs, the pilot should so advise ATC and request a no-gyro vector or approach. The pilot of an aircraft not equipped with a directional gyro or other stabilized compass who desires radar handling may also request a no-gyro vector or approach. The pilot should make all turns at standard rate and should execute the turn immediately upon receipt of instructions. For example, "TURN RIGHT," "STOP TURN." When a surveillance or precision approach is made, the pilot will be advised after the aircraft has been turned onto final approach to make turns at half standard rate.

Radar Monitoring of Instrument Approaches

PAR facilities operated by the FAA and the military services at some joint-use (civil and military) and military installations monitor aircraft on instrument approaches and issue radar advisories to the pilot when weather is below VFR minimums (1,000 and 3), at night, or when requested by a pilot. This service is provided only when the PAR Final Approach Course coincides with the final approach of the navigational aid and only during the operational hours of the PAR. The radar advisories serve only as a secondary aid since the pilot has selected the navigational aid as the primary aid for the approach.

Prior to starting final approach, the pilot will be advised of the frequency on which the advisories will be transmitted. If, for any reason, radar advisories cannot be furnished, the pilot will be so advised.

Advisory information, derived from radar observations, includes information on:

1. Passing the final approach fix inbound (nonprecision approach) or passing the outer marker or fix used in lieu of the outer marker inbound (precision approach).
2. Trend advisories with respect to elevation and/or azimuth radar position and movement will be provided.
3. If, after repeated advisories, the aircraft proceeds outside the PAR safety limit or if a radical deviation is observed, the pilot will be advised to execute a missed approach unless the prescribed visual reference with the surface is established.

Radar service is automatically terminated upon completion of the approach. *[Figure 10-11]*

Timed Approaches From a Holding Fix

Timed approaches from a holding fix are conducted when many aircraft are waiting for an approach clearance. Although the controller will not specifically state "timed approaches are in progress," the assigning of a time to depart the FAF inbound (nonprecision approach), or the outer marker or fix used in lieu of the outer marker inbound (precision approach), indicates that timed approach procedures are being utilized.

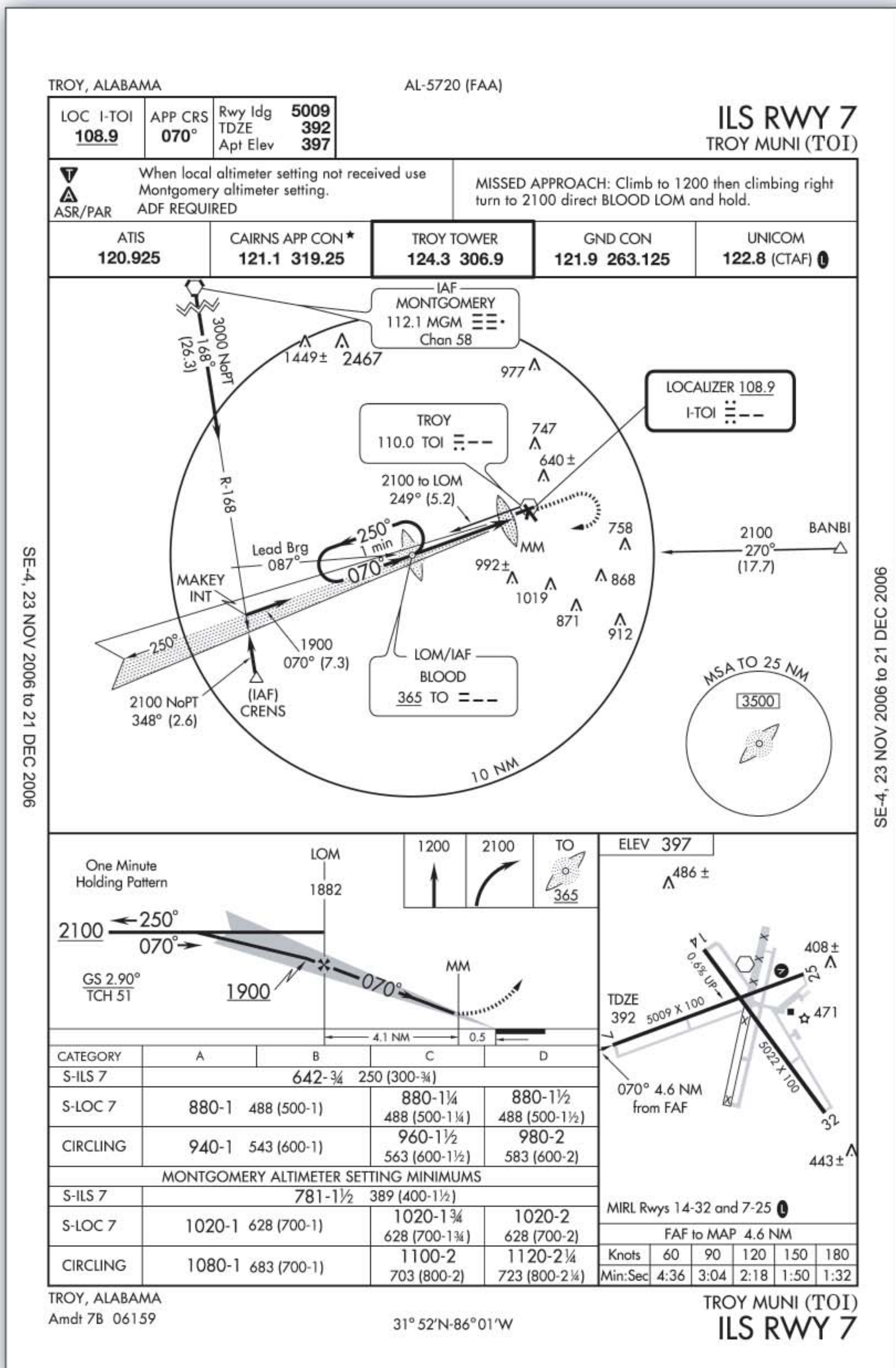


Figure 10-11. *ILS RWY 7 Troy, AL.*

In lieu of holding, the controller may use radar vectors to the final approach course to establish a distance between aircraft that will ensure the appropriate time sequence between the FAF and outer marker, or fix used in lieu of the outer marker and the airport. Each pilot in the approach sequence will be given advance notice of the time they should leave the holding point on approach to the airport. When a time to leave the holding point is received, the pilot should adjust the flight path in order to leave the fix as closely as possible to the designated time.

Timed approaches may be conducted when the following conditions are met:

1. A control tower is in operation at the airport where the approaches are conducted.
2. Direct communications are maintained between the pilot and the Center or approach controller until the pilot is instructed to contact the tower.
3. If more than one missed approach procedure is available, none require a course reversal.
4. If only one missed approach procedure is available, the following conditions are met:
    a) Course reversal is not required; and
    b) Reported ceiling and visibility are equal to or greater than the highest prescribed circling minimums for the IAP.
5. When cleared for the approach, pilots should not execute a procedure turn.

Approaches to Parallel Runways

Procedures permit ILS instrument approach operations to dual or triple parallel runway configurations. A parallel approach is an ATC procedure that permits parallel ILS approach to airports with parallel runways separated by at least 2,500 feet between centerlines. Wherever parallel approaches are in progress, pilots are informed that approaches to both runways are in use.

Simultaneous approaches are permitted to runways:

1. With centerlines separated by 4,300 to 9,000 feet;
2. That are equipped with final monitor controllers;
3. That require radar monitoring to ensure separation between aircraft on the adjacent parallel approach course.

The approach procedure chart will include the note "simultaneous approaches authorized RWYS 14L and 14R," identifying the appropriate runways. When advised that simultaneous parallel approaches are in progress, pilots must advise approach control immediately of malfunctioning or inoperative components.

Parallel approach operations demand heightened pilot situational awareness. The close proximity of adjacent aircraft conducting simultaneous parallel approaches mandates strict compliance with all ATC clearances and approach procedures. Pilots should pay particular attention to the following approach chart information: name and number of the approach, localizer frequency, inbound course, glide slope intercept altitude, DA/DH, missed approach instructions, special notes/procedures, and the assigned runway location and proximity to adjacent runways. Pilots also need to exercise strict radio discipline, which includes continuous monitoring of communications and the avoidance of lengthy, unnecessary radio transmissions.

Side-Step Maneuver

ATC may authorize a side-step maneuver to either one of two parallel runways that are separated by 1,200 feet or less, followed by a straight-in landing on the adjacent runway. Aircraft executing a side-step maneuver will be cleared for a specified nonprecision approach and landing on the adjacent parallel runway. For example, "Cleared ILS runway 7 left approach, side-step to runway 7 right." The pilot is expected to commence the side-step maneuver as soon as possible after the runway or runway environment is in sight. Landing minimums to the adjacent runway will be based on nonprecision criteria and therefore higher than the precision minimums to the primary runway, but will normally be lower than the published circling minimums.

Circling Approaches

Landing minimums listed on the approach chart under "CIRCLING" apply when it is necessary to circle the airport, maneuver for landing, or when no straight-in minimums are specified on the approach chart. *[Figure 10-11]*

The circling minimums published on the instrument approach chart provide a minimum of 300 feet of obstacle clearance in the circling area. *[Figure 10-12]* During a circling approach, the pilot should maintain visual contact with the runway of intended landing and fly no lower than the circling minimums until positioned to make a final descent for a landing. It is important to remember that circling minimums are only minimums. If the ceiling allows it, fly at an altitude that more nearly approximates VFR traffic pattern altitude. This will make any maneuvering safer and bring the view of the landing runway into a more normal perspective.

Figure 10-13 shows patterns that can be used for circling approaches. Pattern "A" can be flown when the final approach

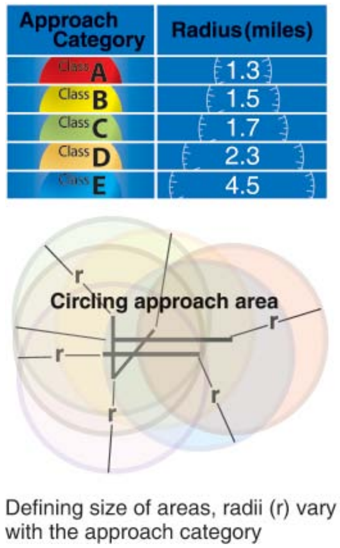


Figure 10-12. *Circling Approach Area Radii.*

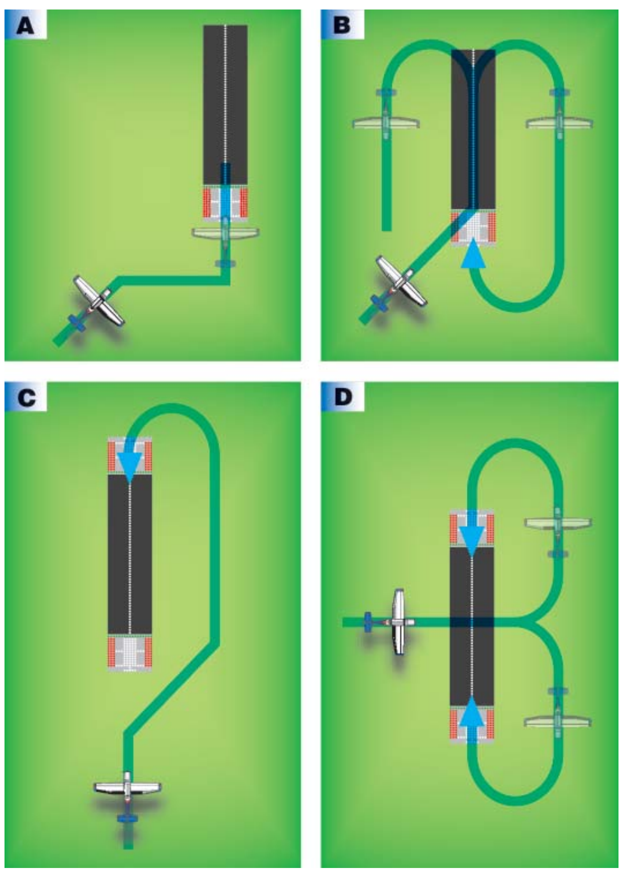


Figure 10-13. *Circling Approaches.*

course intersects the runway centerline at less than a 90° angle, and the runway is in sight early enough to establish a base leg. If the runway becomes visible too late to fly pattern "A," circle as shown in "B." Fly pattern "C" if it is desirable to land opposite the direction of the final approach, and the runway is sighted in time for a turn to downwind leg. If the runway is sighted too late for a turn to downwind, fly pattern "D." Regardless of the pattern flown, the pilot must maneuver the aircraft to remain within the designated circling area. Refer to section A ("Terms and Landing Minima Data") in the front of each TPP for a description of circling approach categories.

The criteria for determining the pattern to be flown are based on personal flying capabilities and knowledge of the performance characteristics of the aircraft. In each instance, the pilot must consider all factors: airport design, ceiling and visibility, wind direction and velocity, final approach course alignment, distance from the final approach fix to the runway, and ATC instructions.

IAP Minimums

Pilots may not operate an aircraft at any airport below the authorized MDA or continue an approach below the authorized DA/DH unless:

1. The aircraft is continuously in a position from which a descent to a landing on the intended runway can be made at a normal descent rate using normal maneuvers;
2. The flight visibility is not less than that prescribed for the approach procedure being used; and
3. At least one of the following visual references for the intended runway is visible and identifiable to the pilot:
    a) Approach light system
    b) Threshold
    c) Threshold markings
    d) Threshold lights
    e) Runway end identifier lights (REIL)
    f) Visual approach slope indicator (VASI)
    g) Touchdown zone or touchdown zone markings
    h) Touchdown zone lights
    i) Runway or runway markings
    j) Runway lights

Missed Approaches

A missed approach procedure is formulated for each published instrument approach and allows the pilot to return to the airway structure while remaining clear of obstacles. The procedure is shown on the approach chart in text and graphic form. Since the execution of a missed approach occurs when the flight deck workload is at a maximum, the procedure should be studied and mastered before beginning the approach.

When a missed approach procedure is initiated, a climb pitch attitude should be established while setting climb power. Configure the aircraft for climb, turn to the appropriate heading, advise ATC that a missed approach is being executed, and request further clearances.

If the missed approach is initiated prior to reaching the missed approach point (MAP), unless otherwise cleared by ATC, continue to fly the IAP as specified on the approach chart. Fly to the MAP at or above the MDA or DA/DH before beginning a turn.

If visual reference is lost while circling-to-land from an instrument approach, execute the appropriate missed approach procedure. Make the initial climbing turn toward the landing runway and then maneuver to intercept and fly the missed approach course.

Pilots should immediately execute the missed approach procedure:

1. Whenever the requirements for operating below DA/DH or MDA are not met when the aircraft is below MDA, or upon arrival at the MAP and at any time after that until touchdown;
2. Whenever an identifiable part of the airport is not visible to the pilot during a circling maneuver at or above MDA; or
3. When so directed by ATC.

Landing

According to 14 CFR part 91, no pilot may land when the flight visibility is less than the visibility prescribed in the standard IAP being used. ATC will provide the pilot with the current visibility reports appropriate to the runway in use. This may be in the form of prevailing visibility, runway visual value (RVV), or runway visual range (RVR). However, only the pilot can determine if the flight visibility meets the landing requirements indicated on the approach chart. If the flight visibility meets the minimum prescribed for the approach, then the approach may be continued to a landing. If the flight visibility is less than that prescribed for the approach, then the pilot must execute a missed approach, regardless of the reported visibility.

The landing minimums published on IAP charts are based on full operation of all components and visual aids associated with the instrument approach chart being used. Higher minimums are required with inoperative components or visual aids. For example, if the ALSF-1 approach lighting system were inoperative, the visibility minimums for an ILS would need to be increased by one-quarter mile. If more than one component is inoperative, each minimum is raised to the highest minimum required by any single component that is inoperative. ILS glide slope inoperative minimums are published on instrument approach charts as localizer minimums. Consult the "Inoperative Components or Visual Aids Table" (printed on the inside front cover of each TPP), for a complete description of the effect of inoperative components on approach minimums.

Instrument Weather Flying

Flying Experience

The more experience a pilot has in VFR and IFR flight, the more proficient a pilot becomes. VFR experience can be gained by flying in terminal areas with high traffic activity. This type of flying forces the pilot to polish the skill of dividing his or her attention between aircraft control, navigation, communications, and other flight deck duties. IFR experience can be gained through night flying which also promotes both instrument proficiency and confidence. The progression from flying at night under clear, moonlit conditions to flying at night without moonlight, natural horizon, or familiar landmarks teaches a pilot to trust the aircraft instruments with minimal dependence upon what can be seen outside the aircraft. It is a pilot's decision to proceed with an IFR flight or to wait for more acceptable weather conditions.

Recency of Experience

Currency as an instrument pilot is an equally important consideration. No person may act as pilot in command of an aircraft under IFR or in weather conditions less than VFR minimums unless he or she has met the requirements of part 91. Remember, these are minimum requirements.

Airborne Equipment and Ground Facilities

Regulations specify minimum equipment for filing an IFR flight plan. It is the pilot's responsibility to determine the adequacy of the aircraft and navigation/communication (NAV/COM) equipment for the proposed IFR flight. Performance limitations, accessories, and general condition of the equipment are directly related to the weather, route, altitude, and ground facilities pertinent to the flight, as well as to the flight deck workload.

Weather Conditions

In addition to the weather conditions that might affect a VFR flight, an IFR pilot must consider the effects of other weather phenomena (e.g., thunderstorms, turbulence, icing, and visibility).

Turbulence

Inflight turbulence can range from occasional light bumps to extreme airspeed and altitude variations that make aircraft control difficult. To reduce the risk factors associated with turbulence, pilots must learn methods of avoidance, as well as piloting techniques for dealing with an inadvertent encounter.

Turbulence avoidance begins with a thorough preflight weather briefing. Many reports and forecasts are available to assist the pilot in determining areas of potential turbulence. These include the Severe Weather Warning (WW), SIGMET (WS), Convective SIGMET (WST), AIRMET (WA), Severe Weather Outlook (AC), Center Weather Advisory (CWA), Area Forecast (FA), and Pilot Reports (UA or PIREPs). Since thunderstorms are always indicative of turbulence, areas of known and forecast thunderstorm activity will always be of interest to the pilot. In addition, clear air turbulence (CAT) associated with jet streams, strong winds over rough terrain, and fast moving cold fronts are good indicators of turbulence.

Pilots should be alert while in flight for the signposts of turbulence. For example, clouds with vertical development such as cumulus, towering cumulus, and cumulonimbus are indicators of atmospheric instability and possible turbulence. Standing lenticular clouds lack vertical development but indicate strong mountain wave turbulence. While en route, pilots can monitor hazardous inflight weather advisory service (HIWAS) broadcast for updated weather advisories, or contact the nearest AFSS or En Route Flight Advisory Service (EFAS) for the latest turbulence-related PIREPs.

To avoid turbulence associated with strong thunderstorms, circumnavigate cells by at least 20 miles. Turbulence may also be present in the clear air above a thunderstorm. To avoid this, fly at least 1,000 feet above the top for every 10 knots of wind at that level, or fly around the storm. Finally, do not underestimate the turbulence beneath a thunderstorm. Never attempt to fly under a thunderstorm. The possible results of turbulence and wind shear under the storm could be disastrous.

When moderate to severe turbulence is encountered, aircraft control is difficult, and a great deal of concentration is required to maintain an instrument scan. *[Figure 10-14]* Pilots should immediately reduce power and slow the aircraft to the recommended turbulence penetration speed as described in the POH/AFM. To minimize the load factor imposed on the aircraft, the wings should be kept level and the aircraft's pitch attitude should be held constant. The aircraft is allowed to fluctuate up and down, because maneuvering to maintain a constant altitude only increases the stress on the aircraft. If necessary, the pilot should advise ATC of the fluctuations and request a block altitude clearance. In addition, the power should remain constant at a setting that will maintain the recommended turbulence penetration airspeed.

Figure 10-14. *Maintaining an instrument scan in severe turbulence can be difficult.*

The best source of information on the location and intensity of turbulence are PIREPs. Therefore, pilots are encouraged to familiarize themselves with the turbulence reporting criteria found in the AIM, which also describes the procedure for volunteering PIREPs relating to turbulence.

Structural Icing

The very nature of flight in Instrument Meteorological Conditions means operating in visible moisture such as clouds. At the right temperatures, this moisture can freeze on the aircraft, causing increased weight, degraded performance, and unpredictable aerodynamic characteristics. Understanding, avoidance, and early recognition followed by prompt action are the keys to avoiding this potentially hazardous situation.

Structural icing refers to the accumulation of ice on the exterior of the aircraft and is broken down into three classifications: rime ice, clear ice, and mixed ice. For ice to form, there must be moisture present in the air, and the air must be cooled to a temperature of 0° C (32° F) or less. Aerodynamic cooling can lower the surface temperature of an airfoil and cause ice to form on the airframe even though the ambient temperature is slightly above freezing.

Rime ice forms if the droplets are small and freeze immediately when contacting the aircraft surface. This type of ice usually forms on areas such as the leading edges of wings or struts. It has a somewhat rough-looking appearance and a milky-white color.

Clear ice is usually formed from larger water droplets or freezing rain that can spread over a surface. This is the most dangerous type of ice since it is clear, hard to see, and can change the shape of the airfoil.

Mixed ice is a mixture of clear ice and rime ice. It has the bad characteristics of both types and can form rapidly. Ice particles become embedded in clear ice, building a very rough accumulation. The table in *Figure 10-15* lists the temperatures at which the various types of ice will form.

Outside Air Temperature Range	Icing Type
0 °C to -10 °C	Clear
-10 °C to -15 °C	Mixed clear and rime
-15 °C to -20°C	Rime

Figure 10-15. *Temperature Ranges for Ice Formation.*

Structural icing is a condition that can only get worse. Therefore, during an inadvertent icing encounter, it is important the pilot act to prevent additional ice accumulation. Regardless of the level of anti-ice or deice protection offered by the aircraft, the first course of action should be to leave the area of visible moisture. This might mean descending to an altitude below the cloud bases, climbing to an altitude that is above the cloud tops, or turning to a different course. If this is not possible, then the pilot must move to an altitude where the temperature is above freezing. Pilots should report icing conditions to ATC and request new routing or altitude if icing will be a hazard. Refer to the AIM for information on reporting icing intensities.

Fog

Instrument pilots must learn to anticipate conditions leading to the formation of fog and take appropriate action early in the progress of the flight. Before a flight, close examination of current and forecast weather should alert the pilot to the possibility of fog formation. When fog is a consideration, pilots should plan adequate fuel reserves and alternate landing sites. En route, the pilot must stay alert for fog formation through weather updates from EFAS, ATIS, and ASOS/AWOS sites.

Two conditions will lead to the formation of fog. Either the air is cooled to saturation, or sufficient moisture is added to the air until saturation occurs. In either case, fog can form when the temperature/dewpoint spread is 5° or less. Pilots planning to arrive at their destination near dusk with decreasing temperatures should be particularly concerned about the possibility of fog formation.

Volcanic Ash

Volcanic eruptions create volcanic ash clouds containing an abrasive dust that poses a serious safety threat to flight operations. Adding to the danger is the fact that these ash clouds are not easily discernible from ordinary clouds when encountered at some distance from the volcanic eruption.
When an aircraft enters a volcanic ash cloud, dust particles and smoke may become evident in the cabin, often along with the odor of an electrical fire. Inside the volcanic ash cloud, the aircraft may also experience lightning and St. Elmo's fire on the windscreen. The abrasive nature of the volcanic ash can pit the windscreens, thus reducing or eliminating forward visibility. The pitot-static system may become clogged, causing instrument failure. Severe engine damage is probable in both piston and jet-powered aircraft.

Every effort must be made to avoid volcanic ash. Since volcanic ash clouds are carried by the wind, pilots should plan their flights to remain upwind of the ash-producing volcano. Visual detection and airborne radar are not considered a reliable means of avoiding volcanic ash clouds. Pilots witnessing volcanic eruptions or encountering volcanic ash should immediately pass this information along in the form of a pilot report. The National Weather Service monitors volcanic eruptions and estimates ash trajectories. This information is passed along to pilots in the form of SIGMETs.

As for many other hazards to flight, the best source of volcanic information comes from PIREPs. Pilots who witness a volcanic eruption or encounter volcanic ash in flight should immediately inform the nearest agency. Volcanic Ash Forecast Transport and Dispersion (VAFTAD) charts are also available; these depict volcanic ash cloud locations in the atmosphere following an eruption, and also forecast dispersion of the ash concentrations over 6- and 12-hour time intervals. See AC 00-45, Aviation Weather Services.

Thunderstorms

A thunderstorm packs just about every weather hazard known to aviation into one vicious bundle. Turbulence, hail, rain, snow, lightning, sustained updrafts and downdrafts, and icing conditions are all present in thunderstorms. Do not take off in the face of an approaching thunderstorm or fly an aircraft that is not equipped with thunderstorm detection in clouds or at night in areas of suspected thunderstorm activity. *[Figure 10-16]*

There is no useful correlation between the external visual appearance of thunderstorms and the severity or amount of turbulence or hail within them. All thunderstorms should be considered hazardous, and thunderstorms with tops above 35,000 feet should be considered extremely hazardous.

Figure 10-16. *A thunderstorm packs just about every weather hazard known to aviation into one vicious bundle.*

Weather radar, airborne or ground based, will normally reflect the areas of moderate to heavy precipitation (radar does not detect turbulence). The frequency and severity of turbulence generally increases with the radar reflectivity closely associated with the areas of highest liquid water content of the storm. A flight path through an area of strong or very strong radar echoes separated by 20 to 30 miles or less may not be considered free of severe turbulence.

The probability of lightning strikes occurring to aircraft is greatest when operating at altitudes where temperatures are between -5 ° C and +5 ° C. In addition, an aircraft flying in the clear air near a thunderstorm is also susceptible to lightning strikes. Thunderstorm avoidance is always the best policy.

Wind Shear

Wind shear can be defined as a change in wind speed and/or wind direction in a short distance. It can exist in a horizontal or vertical direction and occasionally in both. Wind shear can occur at all levels of the atmosphere but is of greatest concern during takeoffs and landings. It is typically associated with thunderstorms and low-level temperature inversions; however, the jet stream and weather fronts are also sources of wind shear.

As *Figure 10-17* illustrates, while an aircraft is on an instrument approach, a shear from a tailwind to a headwind causes the airspeed to increase and the nose to pitch up with a corresponding balloon above the glide path. A shear from a headwind to a tailwind has the opposite effect, and the aircraft will sink below the glide path.

A headwind shear followed by a tailwind/downdraft shear is particularly dangerous because the pilot has reduced power and lowered the nose in response to the headwind shear. This leaves the aircraft in a nose-low, power-low configuration when the tailwind shear occurs, which makes recovery more difficult, particularly near the ground. This type of wind shear scenario is likely while making an approach in the face of an oncoming thunderstorm. Pilots should be alert for indications of wind shear early in the approach phase and be ready to initiate a missed approach at the first indication. It may be impossible to recover from a wind shear encounter at low altitude.

To inform pilots of hazardous wind shear activity, some airports have installed a Low-Level Wind Shear Alert System (LLWAS) consisting of a centerfield wind indicator and several surrounding boundary-wind indicators. With

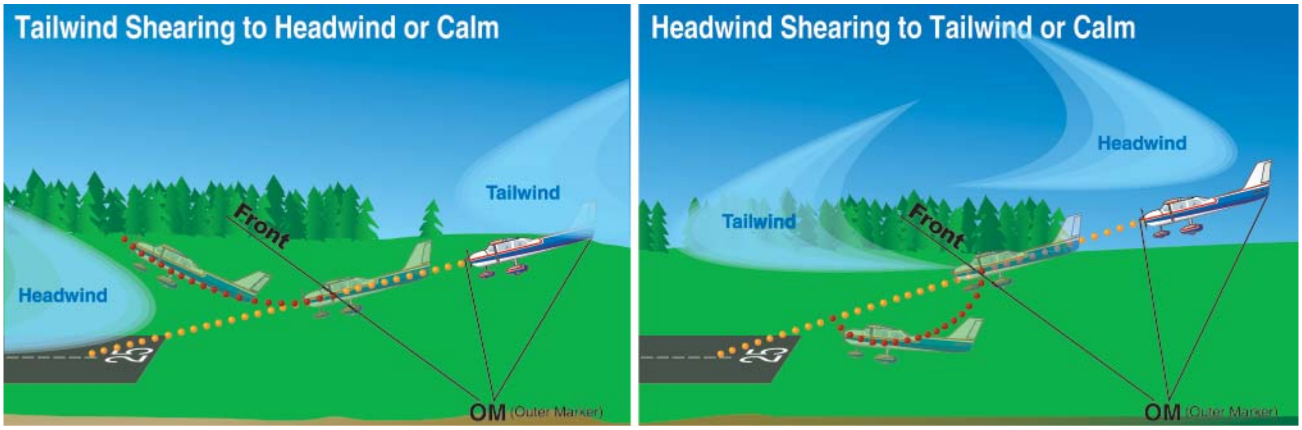


Figure 10-17. *Glide slope Deviations Due to Wind Shear Encounter.*

this system, controllers are alerted of wind discrepancies (an indicator of wind shear possibility) and provide this information to pilots. A typical wind shear alert issued to a pilot would be:

> "Runway 27 arrival, wind shear alert, 20 knot loss 3 mile final, threshold wind 200 at 15"

In plain language, the controller is advising aircraft arriving on runway 27 that at about 3 miles out they can expect a wind shear condition that will decrease their airspeed by 20 knots and possibly encounter turbulence. Additionally, the airport surface winds for landing runway 27 are reported as 200° at 15 knots.

Pilots encountering wind shear are encouraged to pass along pilot reports. Refer to AIM for additional information on wind shear PIREPs.

VFR-On-Top

Pilots on IFR flight plans operating in VFR weather conditions may request VFR-on-top in lieu of an assigned altitude. This permits them to select an altitude or flight level of their choice (subject to any ATC restrictions).

Pilots desiring to climb through a cloud, haze, smoke, or other meteorological formation and then either cancel their IFR flight plan or operate VFR-on-top may request a climb to VFR-on-top. The ATC authorization will contain a top report (or a statement that no top report is available) and a request to report upon reaching VFR-on-top. Additionally, the ATC authorization may contain a clearance limit, routing, and an alternative clearance if VFR-on-top is not reached by a specified altitude.

A pilot on an IFR flight plan, operating in VFR conditions, may request to climb/descend in VFR conditions. When operating in VFR conditions with an ATC authorization to "maintain VFR-on-top/maintain VFR conditions," pilots on IFR flight plans must:

1. Fly at the appropriate VFR altitude as prescribed in 14 CFR part 91.
2. Comply with the VFR visibility and distance-from-cloud criteria in 14 CFR part 91.
3. Comply with instrument flight rules applicable to this flight (minimum IFR altitudes, position reporting, radio communications, course to be flown, adherence to ATC clearance, etc.).

Pilots operating on a VFR-on-top clearance should advise ATC before any altitude change to ensure the exchange of accurate traffic information.

ATC authorization to "maintain VFR-on-top" is not intended to restrict pilots to operating only above an obscuring meteorological formation (layer). Rather, it permits operation above, below, between layers, or in areas where there is no meteorological obstruction. It is imperative pilots understand, however, that clearance to operate "VFR-on-top/VFR conditions" does not imply cancellation of the IFR flight plan.

Pilots operating VFR-on-top/VFR conditions may receive traffic information from ATC on other pertinent IFR or VFR aircraft. However, when operating in VFR weather conditions, it is the pilot's responsibility to be vigilant to see and avoid other aircraft.

This clearance must be requested by the pilot on an IFR flight plan. VFR-on-top is not permitted in certain areas, such as Class A airspace. Consequently, IFR flights operating VFR-on-top must avoid such airspace.

VFR Over-The-Top

VFR over-the-top must not be confused with VFR-on-top. VFR-on-top is an IFR clearance that allows the pilot to fly VFR altitudes. VFR over-the-top is strictly a VFR operation in which the pilot maintains VFR cloud clearance requirements while operating on top of an undercast layer. This situation might occur when the departure airport and the destination airport are reporting clear conditions, but a low overcast layer is present in between. The pilot could conduct a VFR departure, fly over the top of the undercast in VFR conditions, then complete a VFR descent and landing at the destination. VFR cloud clearance requirements would be maintained at all times, and an IFR clearance would not be required for any part of the flight.

Conducting an IFR Flight

To illustrate some of the concepts introduced in this chapter, follow along on a typical IFR flight from the Birmingham International Airport (BHM), Birmingham, Alabama to Gulfport-Biloxi International Airport (GPT), Gulfport, Mississippi. *[Figure 10-18]* For this trip, a Cessna 182 with a call sign of N1230A will be flown. The aircraft is equipped with dual navigation and communication radios, a transponder, and a GPS system approved for IFR en route, terminal, and approach operations.

Preflight

The success of the flight depends largely upon the thoroughness of the preflight planning. The evening before the flight, pay close attention to the weather forecast and begin planning the flight.

The Weather Channel indicates a large, low-pressure system has settled in over the Midwest, pulling moisture up from the Gulf of Mexico and causing low ceilings and visibility with little chance for improvement over the next couple of days. To begin planning, gather all the necessary charts and materials, and verify everything is current. This includes en route charts, approach charts, DPs, STAR charts, the GPS database, as well as an A/FD, some navigation logs, and the aircraft's POH/AFM. The charts cover both the departure and arrival airports and any contingency airports that will be needed if the flight cannot be completed as planned. This is also a good time for the pilot to consider recent flight experience, pilot proficiency, fitness, and personal weather minimums to fly this particular flight.

Check the A/FD to become familiar with the departure and arrival airport, and check for any preferred routing between BHM and GPT. Next, review the approach charts and any DP or STAR that pertains to the flight. Finally, review the en route charts for potential routing, paying close attention to the minimum en route and obstacle clearance altitudes.

After this review, select the best option. For this flight, the Birmingham Three Departure *[Figure 10-2]* to Brookwood VORTAC, V 209 to Kewanee VORTAC, direct to Gulfport using GPS would be a logical route. An altitude of 4,000 feet meets all the regulatory requirements and falls well within the performance capabilities of the aircraft.

Next, call 1-800-WX-BRIEF to obtain an outlook-type weather briefing for the proposed flight. This provides forecast conditions for departure and arrival airports, as well as the en route portion of the flight including forecast winds aloft. This also is a good opportunity to check the available NOTAMs.

The weather briefer confirms the predictions of the weather channel giving forecast conditions that are at or near minimum landing minimums at both BHM and GPT for the proposed departure time. The briefer provides NOTAM information for GPT indicating that the localizer to runway 32 is scheduled to be out of service and that runway 18/36 is closed until further notice. Also check for temporary flight restrictions (TFRs) along the proposed route.

After receiving a weather briefing, continue flight planning and begin to transfer some preliminary information onto the navigation log, listing each fix along the route and the distances, frequencies, and altitudes. Consolidating this information onto an organized navigation log will keep the workload to a minimum during the flight.

Next, obtain a standard weather briefing online for the proposed route. A check of current conditions indicates low IFR conditions at both the departure airport and the destination, with visibility of one-quarter mile:

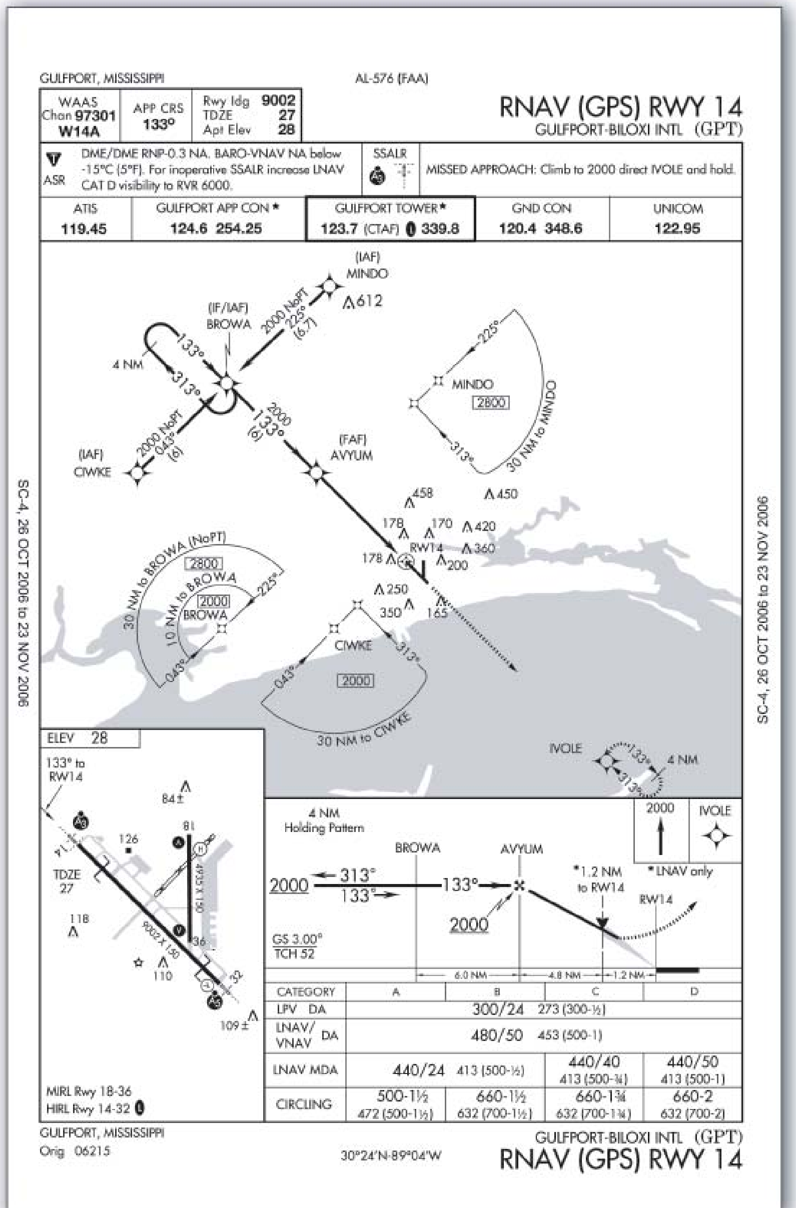
SURFACE WEATHER OBSERVATIONS
METAR KBHM 111155Z VRB04KT ¼ SM FG –RA VV004 06/05 A2994 RMK A02 SLP140

METAR KGPT 111156Z 24003KT ¼ SM FG OVC001 08/07 A2962 RMK A02 SLP033

The small temperature/dewpoint spread is causing the low visibility and ceilings. Conditions should improve later in the day as temperatures increase. A check of the terminal forecast confirms this theory:

TERMINAL FORECASTS
TAF KBHM 111156Z 111212 VRB04KT ¼ SM FG VV004 TEMPO1316 ¾ SM OVC004

FM1600 VRB05KT 2SM BR OVC007 TEMPO 1720 3SM DZ BKN009



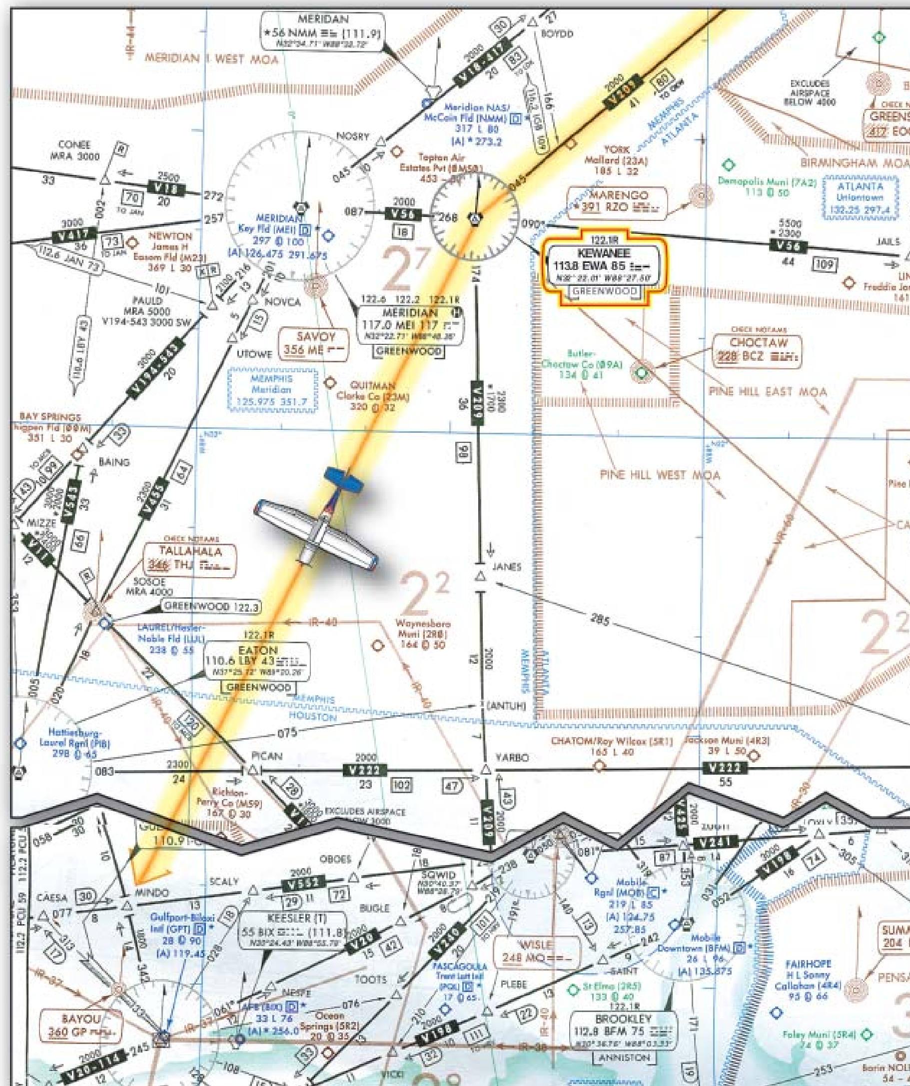


Figure 10-18. *Route Planning.*

FM2000 22008KT 3SM –RA OVC015 TEMP 2205 3SM –RA OVC025 FM0500 23013KT P6SM OVC025

FM0800 23013KT P6SM BKN030 PROB40 1012 2SM BR OVC030

TAF KGPT 111153Z 111212 24004KT ¼ SM FG OVC001 BECMG 1317 3SM BR 0VC004

FM1700 24010KT 4SM –RA OVC006 FM0400 24010 5SM SCT080 TEMPO 0612 P6SM SKC

In addition to the terminal forecast, the area forecast also indicates gradual improvement along the route. Since the terminal forecast only provides information for a 5-mile radius around a terminal area, checking the area forecast provides a better understanding of the overall weather picture along the route, as well as potential hazards:

SYNOPSIS AND VFR CLOUDS/WEATHER FORECASTS
SYNOPSIS… AREA OF LOW PRESSURE CNTD OV AL RMNG GENLY STNRY BRNGNG MSTR AND WD SPRD IFR TO E TN. ALF…LOW PRES TROF ACRS CNTR PTN OF THE DFW FA WILL GDLY MOV EWD DURG PD.

NRN LA, AR, NRN MS
SWLY WND THRUT THE PD. 16Z CIG OVC006. SCT –SHRA. OTLK… IFR SRN ½ … CIG SCT – BKN015 TOPS TO FL250 SWLY WND THRUT THE PD. 17Z AGL BKN040. OTLK…MVFR CIG VIS.

LA MS CSTL WTRS
CIG OVC001 – OVC006. TOPS TO FL240. VIS ¼ - ¾ SM FG. SWLY WND. 16Z CIG OVC010 VIS 2 SM BR. OCNL VIS 3-5SM –RN BR OVC009. OTLK…MVFR CIG VIS.

FL
CIG BKN020 TOPS TO FL180. VIS 1–3 SM BR. SWLY WND. 18Z BRK030. OTLK…MVFR CIG.

At this time, there are no SIGMETs or PIREPs reported. However, there are several AIRMETs, one for IFR conditions, one for turbulence that covers the entire route, and another for icing conditions which covers an area just north of the route:

WAUS44 KKCI 111150

DFWS WA 0111150

AIRMET SIERRA FOR IFR VALID UNTIL 111800

AIRMET IFR...OK TX LA AR MS AL FL

TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.

NON MSL HGHTS DENOTED BY AGL OR CIG.

A recheck of NOTAMs for Gulfport confirms that the localizer to runway 32 is out of service until further notice and runway 18/36 is closed. If runway 6 is planned for the departure, confirm that the climb restriction for the departure can be met.

GPT 12/006 GPT LOC OS UFN

GPT 12/008 GPT MIRL RWY 18/36 OS UFN

Since the weather is substantially better to the east, Pensacola Regional Airport is a good alternate with current conditions and a forecast of marginal VFR.

METAR KPNS 111150Z 21010Z 3SM BKN014 OVC025 09/03 A2973

TAF KPNS 111152Z 111212 22010KT 3 SM BR OVC020 BECMG 1317 4 SM BR OVC025

FM1700 23010KT 4SM –RA OVC030

FM 0400 25014KT 5SM OVC050 TEMPO1612 P6SM OVC080

If weather minimums are below a pilot's personal minimums, a delay in departure to wait for improved conditions is a good decision. This time can be used to complete the navigation log which is the next step in planning an IFR flight. *[Figure 10-19]*

Use the POH/AFM to compute a true airspeed, cruise power setting, and fuel burn based on the forecast temperatures aloft and cruising pressure altitude. Also, compute weight-and-balance information and determine takeoff and landing distances. There will be a crosswind if weather conditions require a straight-in landing on runway 14 at GPT. Therefore, compute the landing distance assuming a 10-knot crosswind and determine if the runway length is adequate to allow landing. Determine the estimated flight time and fuel burn using the winds aloft forecast and considering Pensacola Regional Airport as an alternate airport. With full tanks, the flight can be made nonstop with adequate fuel for flight to the destination, alternate, and the reserve requirement.

Next, check the surface analysis chart which shows where the pressure systems will be found. The weather depiction chart shows areas of IFR conditions and can be used to find areas

FLIGHT LOG

TIME		DISTANCE	FUEL	
TAKE OFF	LANDING	TOTAL	REQUIRED	AVAILABLE
1600 E		228	51 Gal	87 Gal

ROUTE (Check Point)	IDENT / FREQ	MAG CRSE	LEG / REMAINING	ETE / ATE	ETE / ATE	ALTITUDE / GND SPD	REMARKS
Brookwood	OKW / 111.0	230	31 / 197	+16 /	16:16 /	4000 / 120	3 Gal
Kewanee	EWA / 113.8	225	80 / 117	+40 /	16:56 /	4000 / 120	8 Gal
Mindo	/	195	110 / 17	+54 /	17:50 /	4000 / 125	12 Gal
Appr	/		17 / 0	+08 /	17:58 /	/	2 Gal
	/		/	118 / 1+58	/	/	
Rascagoula Regional	PNS /	085	91 / 0	+35 /	/	3000 / 158	18 Gal
	/		/	/	/	/	

ATIS

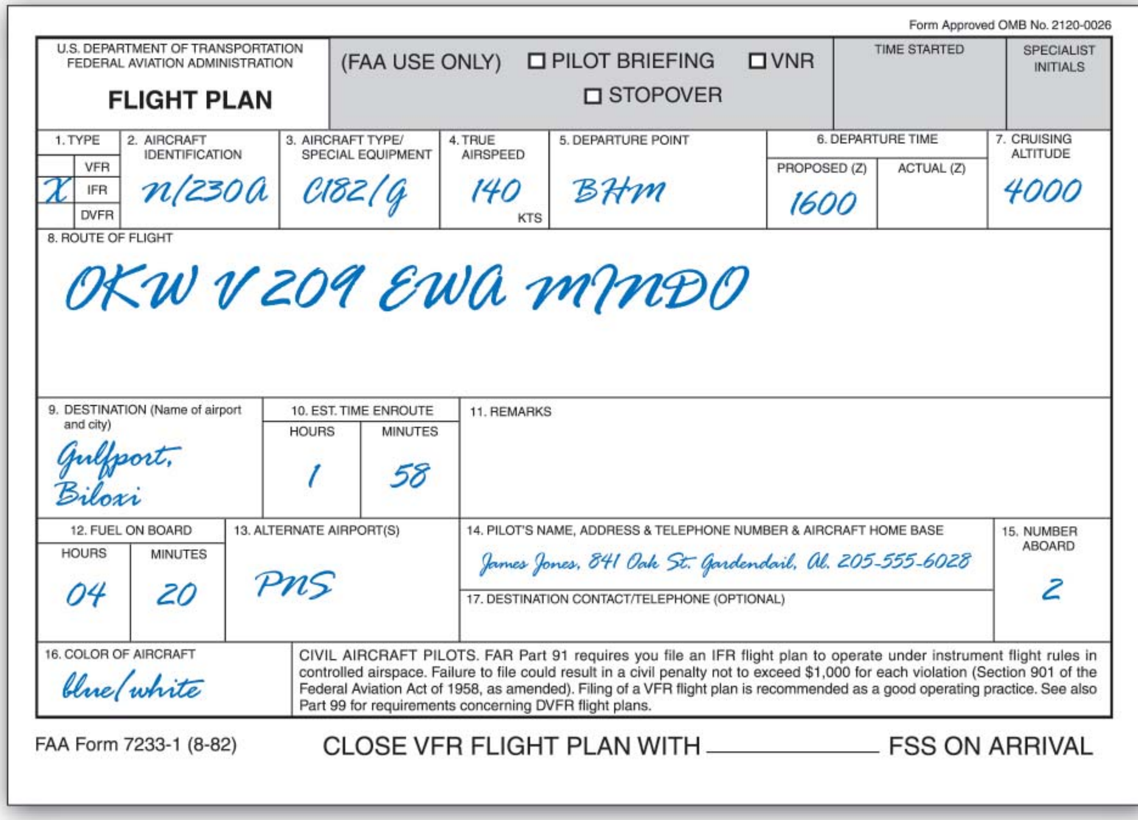
DEPERTURE		ARRIVAL	
INFORMATION		INFORMATION	
CEILING		CEILING	
VISIBILITY		VISIBILITY	
TEMP / DEWPOINT	/	TEMP / DEWPOINT	/
WINDS		WINDS	
ALTIMETER		ALTIMETER	
RWY IN USE		RWY IN USE	
REMARKS		REMARKS	

Figure 10-19. *Navigation Log.*

of improving conditions. These charts provide information a pilot will need should a diversion to VFR conditions be required. For this flight, the radar depicts precipitation along the route, and the latest satellite photo confirms what the weather depiction chart showed.

When the navigation log is finished, complete the flight plan in preparation for filing with flight service. *[Figure 10-20]*

Call an AFSS for an updated weather briefing, Birmingham INTL airport is now reporting 700 overcast with 3 miles visibility, and Gulfport-Biloxi is now 400 overcast with 2 miles visibility. The alternate, Pensacola Regional Airport, continues to report adequate weather conditions with 2,000 overcast and 3 miles visibility in light rain.



Form Approved OMB No. 2120-0026

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FLIGHT PLAN

(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR ☐ STOPOVER | TIME STARTED | SPECIALIST INITIALS

1. TYPE: VFR / X IFR / DVFR
2. AIRCRAFT IDENTIFICATION: n/230a
3. AIRCRAFT TYPE/SPECIAL EQUIPMENT: C182/G
4. TRUE AIRSPEED: 140 KTS
5. DEPARTURE POINT: BHM
6. DEPARTURE TIME: PROPOSED (Z) 1600; ACTUAL (Z)
7. CRUISING ALTITUDE: 4000
8. ROUTE OF FLIGHT: OKW V 209 EWA MINDO
9. DESTINATION (Name of airport and city): Gulfport, Biloxi
10. EST. TIME ENROUTE: HOURS 1; MINUTES 58
11. REMARKS
12. FUEL ON BOARD: HOURS 04; MINUTES 20
13. ALTERNATE AIRPORT(S): PNS
14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE: James Jones, 841 Oak St. Gardendail, Al. 205-555-6028
15. NUMBER ABOARD: 2
16. COLOR OF AIRCRAFT: blue/white
17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)

CIVIL AIRCRAFT PILOTS. FAR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.

FAA Form 7233-1 (8-82) CLOSE VFR FLIGHT PLAN WITH ______ FSS ON ARRIVAL

Figure 10-20. *Flight Plan Form.*

Several pilot reports have been submitted for light icing conditions; however, all the reports are north of the route of flight and correspond to the AIRMET that was issued earlier. No pilot reports have included cloud tops, but the area forecast predicted cloud tops to flight level 240. Since the weather conditions appear to be improving, a flight plan can be filed using the completed form.

Analyze the latest weather minimums to determine if they exceed personal minimums. With the absence of icing reported along the route and steadily rising temperatures, structural icing should not be a problem. Make a note to do an operational check of the pitot heat during preflight and to take evasive action immediately should even light icing conditions be encountered in flight. This may require returning to BHM or landing at an intermediate spot before reaching GPT. The go/no-go decision will be constantly reevaluated during the flight.

Once at the airport, conduct a thorough preflight inspection. A quick check of the logbooks indicates all airworthiness requirements have been met to conduct this IFR flight including an altimeter, static, and transponder test within the preceding 24 calendar months. In addition, a log on the clipboard indicates the VOR system has been checked within the preceding 30 days. Turn on the master switch and pitot heat, and quickly check the heating element before it becomes too hot. Then, complete the rest of the walk-around procedure. Since this will be a flight in actual IFR conditions, place special emphasis on IFR equipment during the walk-around, including the alternator belt and antennas. After completing the preflight, organize charts, pencils, paper, and navigation log in the flight deck for quick, easy access. This is also the time to enter the planned flight into the GPS.

Departure

After starting the engine, tune in ATIS and copy the information to the navigation log. The conditions remain the same as the updated weather briefing with the ceiling at 700 overcast, and visibility at 3 miles. Call clearance delivery to receive a clearance:

> "Clearance Delivery, Cessna 1230A IFR to Gulfport Biloxi with information Kilo, ready to copy."

> "Cessna 1230A is cleared to Gulfport-Biloxi via the Birmingham Three Departure, Brookwood, Victor 209 Kewanee then direct Mindo, Gulfport. Climb and maintain 4,000. Squawk 0321."

Read back the clearance and review the DP. Although a departure frequency was not given in the clearance, note that on the DP, the departure control frequency is listed as 123.8 for the southern sector. Since a departure from runway 24 is anticipated, note the instruction to climb to 2,100 prior to turning. After tuning in the appropriate frequencies and setting up navigation equipment for the departure routing, contact ground control (noting that this is IFR) and receive the following clearance:

> "Cessna 1230A taxi to runway 24 via taxiway Mike."

Read back the clearance and aircraft call sign. After a review of the taxi instructions on the airport diagram, begin to taxi and check the flight instruments for proper indications.

Hold short of runway 24 and complete the before takeoff checklist and engine run-up. Advise the tower when ready for takeoff. The tower gives the following clearance:

> "Cessna 30A cleared for takeoff runway 24. Caution wake turbulence from 737 departing to the northwest."

Taxi into position. Note the time off on the navigation log, verify that the heading indicator and magnetic compass are in agreement, the transponder is in the ALT position, all the necessary lights, equipment, and pitot heat are on. Start the takeoff roll. To avoid the 737's wake turbulence, make note of its lift off point and take off prior to that point.

En Route

After departure, climb straight ahead to 2,100 feet as directed by the Birmingham Three Departure. While continuing a climb to the assigned altitude of 4,000 feet, the following instructions are received from the tower:

> "Cessna 30A contact Departure."

Acknowledge the clearance and contact departure on the frequency designated by the DP. State the present altitude so the departure controller can check the encoded altitude against indicated altitude:

> "Birmingham Departure Cessna 1230A climbing through 2,700 heading 240."

Departure replies:

> "Cessna 30A proceed direct to Brookwood and resume own navigation. Contact Atlanta Center on 134.05."

Acknowledge the clearance, contact Atlanta Center and proceed direct to Brookwood VORTAC, using the IFR-approved GPS equipment. En route to Kewanee, VORTAC Atlanta Center issues the following instructions:

> "Cessna 1230A contact Memphis Center on 125.975."

Acknowledge the instructions and contact Memphis Center with aircraft ID and present altitude. Memphis Center acknowledges contact:

> "Cessna 1230A, Meridian altimeter is 29.87. Traffic at your 2 o'clock and 6 miles is a King Air at 5,000 climbing to 12,000."

Even when on an IFR flight plan, pilots are still responsible for seeing and avoiding other aircraft. Acknowledge the call from Memphis Center and inform them of negative contact with traffic due to IMC.

> "Roger, altimeter setting 29.87. Cessna 1230A is in IMC negative contact with traffic."

Continue the flight, and at each fix note the arrival time on the navigation log to monitor progress.

To get an update of the weather at the destination and issue a pilot report, contact the FSS servicing the area. To find the nearest AFSS, locate a nearby VOR and check above the VOR information box for a frequency. In this case, the nearest VOR is Kewanee VORTAC which lists a receive-only frequency of 122.1 for Greenwood FSS. Request a frequency change from Memphis and then attempt to contact Greenwood on 122.1 while listening over the Kewanee VORTAC frequency of 113.8:

> "Greenwood Radio Cessna 1230A receiving on frequency 113.8, over."

> "Cessna 30A, this is Greenwood, go ahead."

> "Greenwood Radio, Cessna 30A is currently 30 miles south of the Kewanee VORTAC at 4,000 feet en route to Gulfport. Requesting an update of en route conditions and current weather at GPT, as well as PNS."

> "Cessna 30A, Greenwood Radio, current weather at Gulfport is 400 overcast with 3 miles visibility in light rain. The winds are from 140 at 7 and the altimeter is 29.86. Weather across your route is generally IFR in light rain with ceilings ranging from 300 to 1,000 overcast with visibilities between 1 and 3 miles. Pensacola weather is much better with ceilings now at 2,500 and visibility 6 miles. Checking current NOTAMs at GPT shows the localizer out of service and runway 18/36 closed."

"Roger, Cessna 30A copies the weather. I have a PIREP when you are ready to copy."

"Cessna 30A go ahead with your PIREP."

"Cessna 30A is a Cessna 182 located on the Kewanee 195° radial at 30 miles level at 4,000 feet. I am currently in IMC conditions with a smooth ride. Outside air temperature is plus 1° Celsius. Negative icing."

"Cessna 30A thank you for the PIREP."

With the weather check and PIREP complete, return to Memphis Center:

"Memphis Center, Cessna 1230A is back on your frequency."

"Cessna 1230A, Memphis Center, roger, contact Houston Center now on frequency 126.8."

"Roger, contact Houston Center frequency 126.8, Cessna 1230A."

"Houston Center, Cessna 1230A level at 4,000 feet."

"Cessna 30A, Houston Center area altimeter 29.88."

Arrival

40 miles north of Gulfport, tune in ATIS on number two communication radio. The report reveals there has been no change in the weather and ATIS is advertising ILS runway 14 as the active approach.

Houston Center completes a hand off to Gulfport approach control with instructions to contact approach:

"Gulfport Approach, Cessna 1230A level 4,000 feet with information TANGO. Request GPS Runway 14 approach."

"Cessna 30A, Gulfport Approach, descend and maintain 3,000 feet."

"Descend to 3,000, Cessna 30A."

Begin a descent to 3,000 and configure your navigation radios for the approach. The GPS will automatically change from the en route mode to the terminal mode. This change will affect the sensitivity of the CDI. Tune in the VORTAC frequency of 109.0 on the number one navigation radio, and set in the final approach course of 133° on the OBS. This setup will help with situational awareness should the GPS lose signal.

"Cessna 30A your position is 7 miles from MINDO, maintain 3,000 feet until MINDO, cleared for the GPS runway 14 approach."

Read back the clearance and concentrate on flying the aircraft. At MINDO descend to 2,000 as depicted on the approach chart. At BROWA turn to the final approach course of 133°. Just outside the Final Approach Way Point (FAWP) AVYUM, the GPS will change to the approach mode and the CDI will become even more sensitive. Gulfport approach control issues instructions to contact Gulfport tower:

"Cessna 30A contact Tower on 123.7."

"123.7, Cessna 30A."

"Tower, Cessna 1230A outside AVYUM on the GPS runway 14."

"Cessna 30A Gulfport Tower, the ceiling is now 600 overcast and the visibility is 4 miles."

"Cleared to land runway 14, Cessna 30A."

Continue the approach, complete the appropriate checklists, cross AVYUM, and begin the final descent. At 700 feet MSL visual contact with the airport is possible. Slow the aircraft and configure it to allow a normal descent to landing. As touch down is completed, Gulfport Tower gives further instructions:

"Cessna 30A turn left at taxiway Bravo and contact ground on 120.4."

"Roger, Cessna 30A."

Taxi clear of the runway and complete the appropriate checklists. The Tower will automatically cancel the IFR flight plan.

Chapter 11

Emergency Operations

Introduction

Changing weather conditions, air traffic control (ATC), the aircraft, and the pilot are all variables that make instrument flying an unpredictable and challenging operation. The safety of the flight depends upon the pilot's ability to manage these variables while maintaining positive aircraft control and adequate situational awareness. This chapter discusses the recognition and suggested remedies for such abnormal and emergency events related to unforecasted, adverse weather; aircraft system malfunctions; communication/navigation system malfunctions; and loss of situational awareness.

Unforecast Adverse Weather

Inadvertent Thunderstorm Encounter

A pilot should avoid flying through a thunderstorm of any intensity. However, certain conditions may be present that could lead to an inadvertent thunderstorm encounter. For example, flying in areas where thunderstorms are embedded in large cloud masses may make thunderstorm avoidance difficult, even when the aircraft is equipped with thunderstorm detection equipment. Therefore, pilots must be prepared to deal with an inadvertent thunderstorm penetration. At the very least, a thunderstorm encounter subjects the aircraft to turbulence that could be severe. The pilot and passengers should tighten seat belts and shoulder harnesses and secure any loose items in the cabin.

As with any emergency, the first order of business during an inadvertent thunderstorm encounter must be to fly the aircraft. The pilot workload is heavy; therefore, increased concentration is necessary to maintain an instrument scan. If a pilot inadvertently enters a thunderstorm, it is better to maintain a course straight through the thunderstorm rather than turning around. A straight course minimizes the amount of time in the thunderstorm and turning maneuvers only increase structural stress on the aircraft.

Reduce power to a setting that maintains a speed at the recommended turbulence penetration speed as described in the Pilot's Operating Handbook/Airplane Flight Manual (POH/AFM), and try to minimize additional power adjustments. Concentrate on maintaining a level attitude while allowing airspeed and altitude to fluctuate. Similarly, if using the autopilot, disengage the altitude hold and speed hold modes, as they only increase the aircraft's maneuvering—thereby increasing structural stress.

During a thunderstorm encounter, the potential for icing also exists. As soon as possible, turn on anti-icing/deicing equipment and carburetor heat, if equipped. Icing can be rapid at any altitude and may lead to power failure and/or loss of airspeed indication.

Lightning is also present in a thunderstorm and can temporarily blind a pilot. To reduce this risk, turn up flight deck lights to the highest intensity, concentrate on the flight instruments, and resist the urge to look outside.

Inadvertent Icing Encounter

Because icing is unpredictable in nature, pilots may find themselves in icing conditions even though they have done everything practicable to avoid it. In order to stay alert to this possibility while operating in visible moisture, pilots should monitor the outside air temperature (OAT).

The effects of ice on aircraft are cumulative—thrust is reduced, drag increases, lift lessens, and weight increases. The results are an increase in stall speed and a deterioration of aircraft performance. In extreme cases, two to three inches of ice can form on the leading edge of the airfoil in less than 5 minutes. It takes only 1/2 inch of ice to reduce the lifting power of some aircraft by 50 percent and increases the frictional drag by an equal percentage.

A pilot can expect icing when flying in visible precipitation, such as rain or cloud droplets, and the temperature is between +02 and -10° Celsius. When icing is detected, a pilot should do one of two things, particularly if the aircraft is not equipped with deicing equipment: leave the area of precipitation or go to an altitude where the temperature is above freezing. This "warmer" altitude may not always be a lower altitude. Proper preflight action includes obtaining information on the freezing level and the above-freezing levels in precipitation areas.

If neither option is available, consider an immediate landing at the nearest suitable airport. Even if the aircraft is equipped with anti-icing/deicing equipment, it is not designed to allow aircraft to operate indefinitely in icing conditions. Anti-icing/deicing equipment gives a pilot more time to get out of the icing conditions. Report icing to ATC and request new routing or altitude. Be sure to report the type of aircraft, and use the following terms when reporting icing to ATC:

1. Trace. Ice becomes perceptible. Rate of accumulation is slightly greater than sublimation. Deicing/anti-icing equipment is not utilized unless encountered for an extended period of time (over 1 hour).
2. Light. The rate of accumulation may create a problem if flight is prolonged in this environment (over 1 hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if deicing/anti-icing equipment is used.
3. Moderate. The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or flight diversion is necessary.
4. Severe. The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate flight diversion is necessary.

Early ice detection is critical and is particularly difficult during night flight. Use a flashlight to check for ice accumulation on the wings. At the first indication of ice accumulation, take action to get out of the icing conditions. Refer to the POH/AFM for the proper use of anti-icing/deicing equipment.

Figure 11-1. *St. Elmo's Fire is harmless but may affect both communication and navigation radios, especially the lower frequencies such as those used on the ADF.*

Precipitation Static

Precipitation static, often referred to as P-static, occurs when accumulated static electricity is discharged from the extremities of the aircraft. This discharge has the potential to create problems for the instrument pilot. These problems range from the serious, such as erroneous magnetic compass readings and the complete loss of very high frequency (VHF) communications to the annoyance of high-pitched audio squealing and St. Elmo's fire. *[Figure 11-1]*

Precipitation static is caused when an aircraft encounters airborne particles during flight (e.g., rain or snow), and develops a negative charge. It can also result from atmospheric electric fields in thunderstorm clouds. When a significant negative voltage level is reached, the aircraft discharges it, which can create electrical disturbances. This electrical discharge builds with time as the aircraft flies in precipitation. It is usually encountered in rain, but snow can cause the same effect. As the static buildup increases, the effectiveness of both communication and navigation systems decreases to the point of potential unusability.

To reduce the problems associated with P-static, the pilot should ensure the aircraft's static wicks are properly maintained and accounted for. Broken or missing static wicks should be replaced before an instrument flight. *[Figure 11-2]*

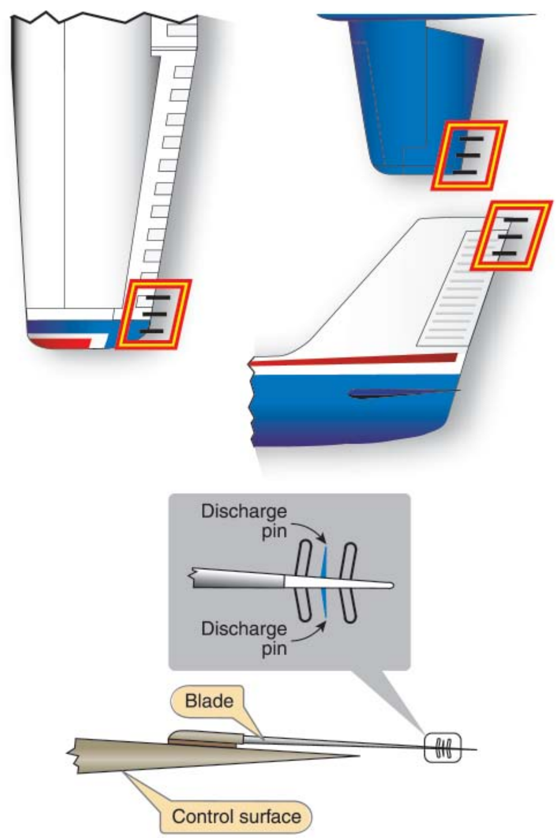


Figure 11-2. *One example of a static wick installed on aircraft control surface to bleed off static charges built up during flight. This will prevent static buildup and St. Elmo's fire by allowing the static electricity to dissipate harmlessly.*

Aircraft System Malfunctions

Preventing aircraft system malfunctions that might lead to an inflight emergency begins with a thorough preflight inspection. In addition to those items normally checked prior to a visual flight rules (VFR) flight, pilots intending to fly under instrument flight rules (IFR) should pay particular attention to the alternator belt, antennas, static wicks, anti-icing/deicing equipment, pitot tube, and static ports.

During taxi, verify the operation and accuracy of all flight instruments. In addition, during the run-up, verify that the operation of the pneumatic system(s) is within acceptable parameters. It is critical that all systems are determined to be operational before departing into IFR conditions.

Electronic Flight Display Malfunction

When a pilot becomes familiar and comfortable with the new electronic displays, he or she also tends to become more reliant on the system. The system then becomes a primary source of navigation and data acquisition instead of the supplementary source of data as initially intended.

Complete reliance on the moving map for navigation becomes a problem during a failure of one, more, or all of the flight display screens. Under these conditions, the systems revert to a composite mode (called reversionary), which eliminates the moving map display and combines the PFD with the engine indicating system. *[Figure 11-3]* If a pilot has relied on the display for navigation information and situational awareness, he or she lacks any concept of critical data such as the aircraft's position, the nearest airport, or proximity to other aircraft.

The electronic flight display is a supplementary source of navigation data and does not replace en route charts. To maintain situational awareness, a pilot must follow the flight on the en route chart while monitoring the PFD. It is important for the pilot to know the location of the closest airport as well as surrounding traffic relative to the location of his or her aircraft. This information becomes critical should the electronic flight display fail.

For the pilot who utilizes the electronic database as a substitute for the Airport Facilities Directory, screen failure or loss of electrical power can mean the pilot is no longer able to access airport information. Once the pilot loses the ability to call up airport information, aeronautical decision-making is compromised.

Alternator/Generator Failure

Depending upon the aircraft being flown, an alternator failure is indicated in different ways. Some aircraft use an ammeter

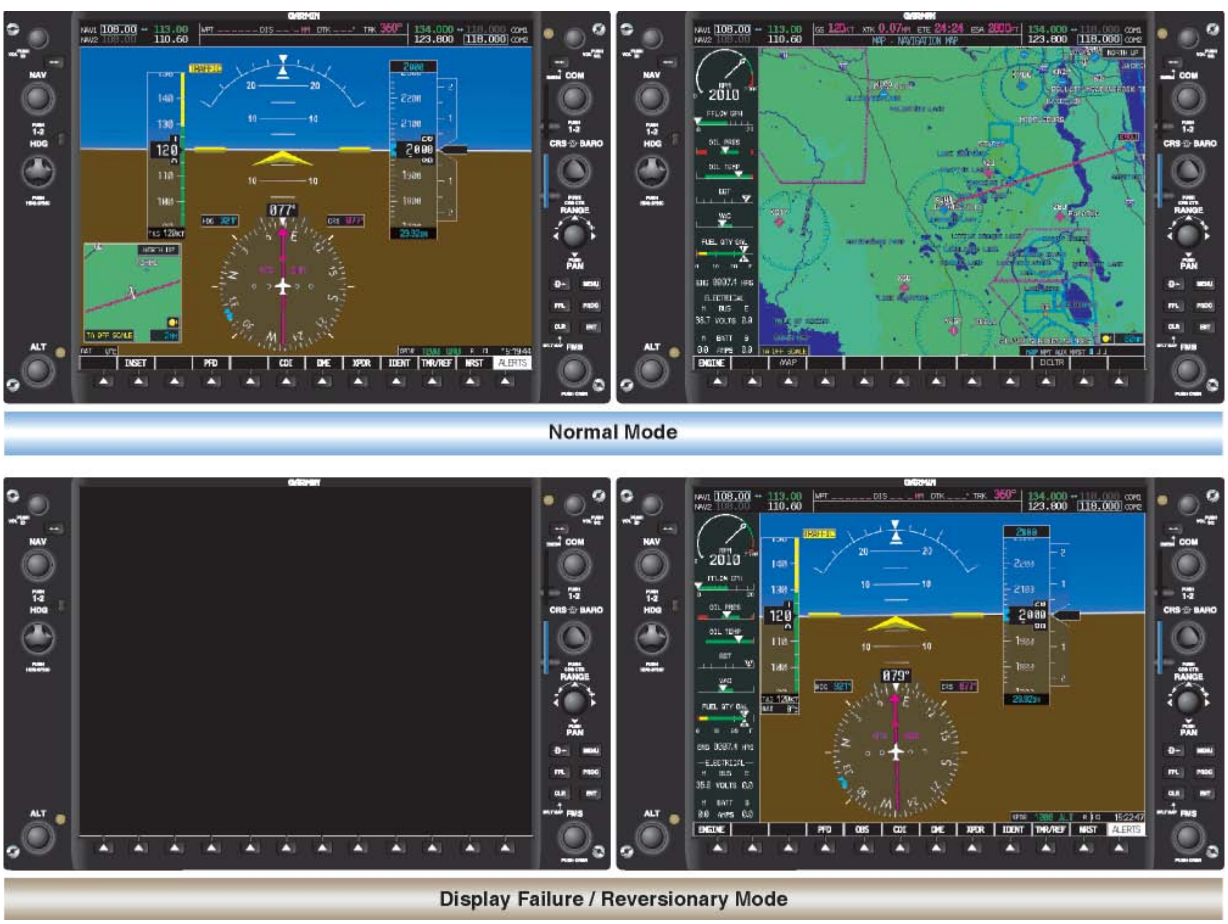


Figure 11-3. *G1000 PFD display in normal mode and in the reversionary mode activated upon system failure.*

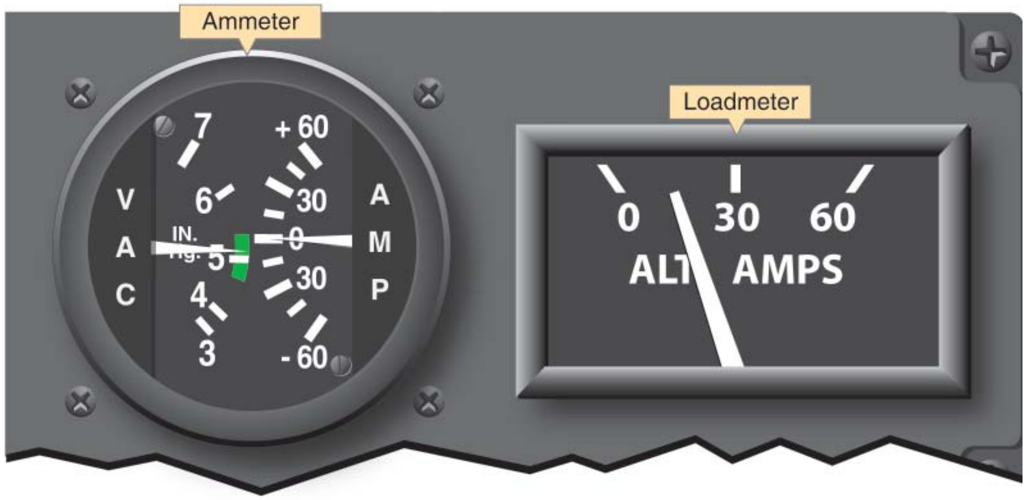


Figure 11-4. *Ammeter (left) and Loadmeter (right).*

that indicates the state of charge or discharge of the battery. *[Figure 11-4]* A positive indication on the ammeter indicates a charge condition; a negative indication reveals a discharge condition. Other aircraft use a load meter to indicate the load being carried by the alternator. *[Figure 11-4]*

Sometimes an indicator light is also installed in the aircraft to alert the pilot to an alternator failure. On some aircraft such as the Cessna 172, the light is located on the lower left side making it difficult to see its illumination if charts are open Ensure that these safety indicators are visible during flight.

When a loss of the electrical charging system is experienced, the pilot has approximately 40 minutes of battery life remaining before the system fails entirely. The time mentioned is an approximation and should not be relied upon as specific to all aircraft. In addition, the battery charge that exists in a battery may not be full, altering the time available before electrical exhaustion occurs. At no time should a pilot consider continuing a flight once the electrical charging system has failed. Land at the nearest suitable airport.

Techniques for Electrical Usage

Master Battery Switch

One technique for conserving the main battery charge is to fly the aircraft to the airport of intended landing while operating with minimal power. If a two-position battery master/alternator rocker switch *[Figure 11-5]* is installed, it can be utilized to isolate the main battery from the electrical system and conserve power.

Operating on the Main Battery

While en route to the airport of intended landing, reduce the electrical load as much as practical. Turn off all unnecessary electrical items such as duplicate radios, non-essential lighting, etc. If unable to turn off radios, lights, etc. manually, consider pulling circuit breakers to isolate those pieces of equipment from the electrical system. Maximum time of useful voltage may be between 30 and 40 minutes and is influenced by many factors, which degrade the useful time.

Loss of Alternator/Generator for Electronic Flight Instrumentation

With the increase in electrical components being installed in modern technically advanced aircraft, the power supply and the charging system need increased attention and understanding. Traditional round dial aircraft do not rely as heavily on electrical power for the primary six-pack instrumentation. Modern electronic flight displays utilize the electrical system to power the AHRS, ADC, engine indicating system (EIS), etc. A loss of an alternator or generator was considered an abnormality in traditionally equipped aircraft;

Figure 11-5. *Double Rocker Switch Seen on Many Aircraft.*

however, a failure of this magnitude is considered an emergency in technically advanced aircraft.

Due to the increased demand for electrical power, it is necessary for manufacturers to install a standby battery in conjunction with the primary battery. The standby battery is held in reserve and kept charged in case of a failure of the charging system and a subsequent exhaustion of the main battery. The standby battery is brought online when the main battery voltage is depleted to a specific value, approximately 19 volts. Generally, the standby battery switch must be in the ARM position for this to occur but pilots should refer to the aircraft flight manual for specifics on an aircraft's electrical system. The standby battery powers the essential bus and allows the primary flight display (PFD) to be utilized.

The essential bus usually powers the following components:

1. AHRS (Attitude and Heading Reference System)
2. ADC (Air Data Computer)
3. PFD (Primary Flight Display)
4. Navigation Radio #1
5. Communication Radio #1
6. Standby Indicator Light

Techniques for Electrical Usage

Standby Battery

One technique for conserving the main battery charge is to fly the aircraft to the airport of intended landing while using the standby battery. A two-position battery master/alternator rocker switch is installed on most aircraft with electronic flight displays, which can be utilized to isolate the main battery from the electrical system. By switching the MASTER side off, the battery is taken offline and the standby battery comes online to power the essential bus. However, the standby battery switch must be in the ARM position for this to occur. *[Figure 11-6]* Utilization of the standby battery first reserves the main battery for use when approaching to land. With this technique, electrical power may be available for the use of flaps, gear, lights, etc. Do not rely on any power to be available after the standby battery has exhausted itself. Once the charging system has failed, flight with a powered electrical system is not guaranteed.

Operating on the Main Battery

While en route to the airport of intended landing, reduce the electrical load as much as practical. Turn off all unnecessary electrical items such as duplicate radios, non-essential lighting, etc. If unable to turn off radios, lights, etc., manually, consider pulling circuit breakers to isolate those pieces of equipment from the electrical system. Keep in mind that once the standby battery has exhausted its charge, the flight deck may become very dark depending on what time of day the failure occurs. The priority during this emergency situation is landing the aircraft as soon as possible without jeopardizing safety.

A standby attitude indicator, altimeter, airspeed indicator (ASI) and magnetic compass are installed in each aircraft for use when the PFD instrumentation is unavailable. *[Figure 11-7]* These would be the only instruments left available to the pilot. Navigation would be limited to pilotage and dead reckoning unless a hand-held transceiver with a GPS/navigation function is onboard.

Once an alternator failure has been detected, the pilot must reduce the electrical load on the battery and land as soon as practical. Depending upon the electrical load and condition of the battery, there may be sufficient power available for 45 minutes of flight—or for only a matter of minutes. Pilots should also know which systems on the aircraft are electric and those that continue to operate without electrical power. Pilots can attempt to troubleshoot alternator failure by following the established alternator failure procedure published in the POH/AFM. If the alternator cannot be reset, advise ATC of the situation and inform them of the impending electrical failure.

Analog Instrument Failure

A warning indicator or an inconsistency between indications on the attitude indicator and the supporting performance

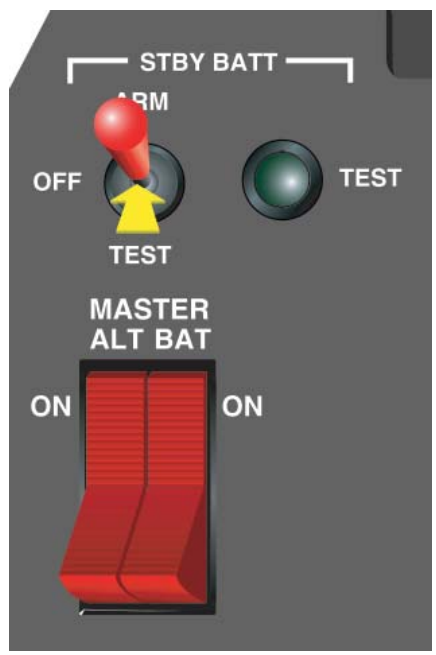


Figure 11-6. *Note the double rocker switch and the standby battery switch in this aircraft. The standby battery must be armed to work correctly; arming should be done prior to departure.*

Figure 11-7. *Emergency Instrumentation Available to the Pilot on Electronic Flight Instrumented Aircraft.*

instruments usually identifies system or instrument failure. Aircraft control must be maintained while identifying the failed component(s). Expedite the cross-check and include all flight instruments. The problem may be individual instrument failure or a system failure affecting multiple instruments.

One method of identification involves an immediate comparison of the attitude indicator with the rate-of-turn indicator and vertical speed indicator (VSI). Along with providing pitch-and-bank information, this technique compares the static system with the suction or pressure system and the electrical system. Identify the failed component(s) and use the remaining functional instruments to maintain aircraft control.

Attempt to restore the inoperative component(s) by checking the appropriate power source, changing to a backup or alternate system, and resetting the instrument if possible. Covering the failed instrument(s) may enhance a pilot's ability to maintain aircraft control and navigate the aircraft. Usually, the next step is to advise ATC of the problem and, if necessary, declare an emergency before the situation deteriorates beyond the pilot's ability to recover.

Pneumatic System Failure

One possible cause of instrument failure is a loss of the suction or pressure source. This pressure or suction is supplied by a vacuum pump mechanically driven off the engine. Occasionally these pumps fail, leaving the pilot with inoperative attitude and heading indicators.

Figure 11-8 illustrates inoperative vacuum driven attitude and heading indicators which can fail progressively. As the gyroscopes slow down they may wander, which, if connected to the autopilot and/or flight director, can cause incorrect movement or erroneous indications. In *Figure 11-8,* the aircraft is actually level and at 2,000 feet MSL. It is not in a turn to the left which the pilot may misinterpret if he or she fails to see the off or failed flags. If that occurs, the pilot may transform a normally benign situation into a hazardous situation. Again, good decision-making by the pilot only occurs after a careful analysis of systems.

Many small aircraft are not equipped with a warning system for vacuum failure; therefore, the pilot should monitor the system's vacuum/pressure gauge. This can be a hazardous situation with the potential to lead the unsuspecting pilot into a dangerous unusual attitude which would require a partial panel recovery. It is important that pilots practice instrument flight without reference to the attitude and heading indicators in preparation for such a failure.

Pitot/Static System Failure

A pitot or static system failure can also cause erratic and unreliable instrument indications. When a static system

Figure 11-8. *Vacuum Failure.*

problem occurs, it affects the ASI, altimeter, and the VSI. In most aircraft, provisions have been made for the pilot to select an alternate static source. Check the POH/AFM for the location and operation of the alternate static source. In the absence of an alternate static source, in an unpressurized aircraft, the pilot could break the glass on the VSI. The VSI is not required for instrument flight, and breaking the glass provides the altimeter and the ASI a source of static pressure. This procedure could cause additional instrument errors.

Communication/Navigation System Malfunction

Avionics equipment has become very reliable, and the likelihood of a complete communications failure is remote. However, each IFR flight should be planned and executed in anticipation of a two-way radio failure. At any given point during a flight, the pilot must know exactly what route to fly, what altitude to fly, and when to continue beyond a clearance limit. Title 14 of the Code of Federal Regulations (14 CFR) part 91 describes the procedures to be followed in case of a two-way radio communications failure. If operating in VFR conditions at the time of the failure, the pilot should continue the flight under VFR and land as soon as practicable. If the failure occurs in IFR conditions, or if VFR conditions cannot be maintained, the pilot must continue the flight:

1. Along the route assigned in the last ATC clearance received;
2. If being radar vectored, by the direct route from the point of radio failure to the fix, route, or airway specified in the vector clearance;
3. In the absence of an assigned route, by the route that ATC has advised may be expected in a further clearance; or
4. In the absence of an assigned route or a route that ATC has advised may be expected in a further clearance, by the route filed in the flight plan.

The pilot should maintain the highest of the following altitudes or flight levels for the route segment being flown:

1. The altitude or flight level assigned in the last ATC clearance received;
2. The minimum altitude (converted, if appropriate, to minimum flight level as prescribed in part 91 for IFR operations); or
3. The altitude or flight level ATC has advised may be expected in a further clearance.

In addition to route and altitude, the pilot must also plan the progress of the flight to leave the clearance limit.

1. When the clearance limit is a fix from which an approach begins, commence descent or descent and approach as close as possible to the expect-further-clearance time if one has been received. If an expect-further-clearance time has not been received, commence descent or descent and approach as close as possible to the estimated time of arrival as calculated from the filed or amended (with ATC) estimated time en route.

2. If the clearance limit is not a fix from which an approach begins, leave the clearance limit at the expect-further-clearance time if one has been received. If no expect-further-clearance time has been received, leave the clearance limit upon arrival over it, and proceed to a fix from which an approach begins and commence descent or descent and approach as close as possible to the estimated time of arrival as calculated from the filed or amended (with ATC) estimated time en route. *[Figure 11-8]*

While following these procedures, set the transponder to code 7600 and use all means possible to reestablish two-way radio communication with ATC. This includes monitoring navigational aids (NAVAIDs), attempting radio contact with other aircraft, and attempting contact with a nearby automated flight service station (AFSS).

GPS Nearest Airport Function

Procedures for accessing the nearest airport information vary by the type of display installed in an aircraft. Pilots can obtain information relative to the nearest airport by using the PFD, MFD, or the nearest function on the GPS receiver. The following examples are based on a popular system. Pilots should become familiar with the operational characteristics of the equipment to be used.

Nearest Airports Using the PFD

With the advancements in electronic databases, diverting to alternate airports has become easier. Simply by pressing a soft key on the PFD, pilots can access information for up to 25 of the nearest airports that meet the criteria set in the systems configuration page. *[Figure 11-9]* Pilots are able to specify what airports are acceptable for their aircraft requirements based on landing surface and length of runway.

When the text box opens, the flashing cursor is located over the nearest airport that meets the criteria set in the auxiliary setup page as shown in *Figure 11-10*. Scrolling through the 25 airports is accomplished by turning the outer FMS knob, which is located on the lower right corner of the display screen. Turning the FMS knob clockwise moves the blinking cursor to the next closest airport. By continuing to turn the knob, the pilot is able to scroll through all 25 nearest airports. Each airport box contains the information illustrated in *Figure 11-11,* which the pilot can utilize to determine which airport best suits their individual needs.

Additional Information for a Specific Airport

In addition to the information that is presented on the first screen, the pilot can view additional information as shown in *Figure 11-12* by highlighting the airport identifier and then pressing the enter key.

Figure 11-9. *The default soft key menu that is displayed on the PFD contains a "NRST" (Nearest Airport) soft key. Pressing this soft key opens a text box which displays the nearest 25 airports.*

Figure 11-10. *An enlargement of the box shown in the lower right of Figure 11-9. Note that KGNV would be flashing.*

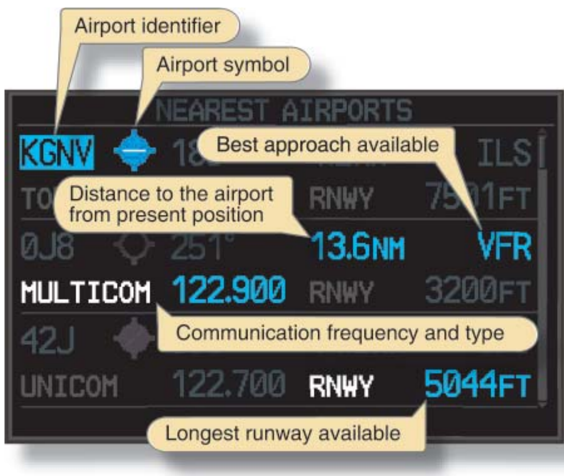


Figure 11-11. *Information shown on the nearest airport page.*

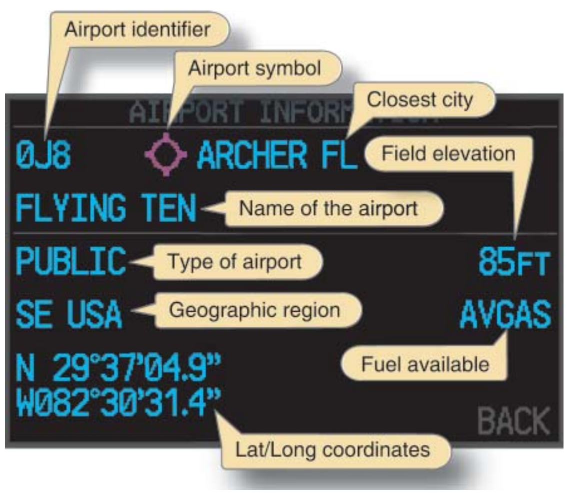


Figure 11-12. *Information shown on the additional information page that will aid the pilot in making a more informed decision about which airport to choose when diverting.*

From this menu or the previous default nearest airport screen, the pilot is able to activate the Direct-To function, which provides a direct GPS course to the airport. In addition, the pilot can auto-tune communication frequencies by highlighting the appropriate frequency and then pressing the enter key. The frequency is placed in the stand-by box of either COM1 or COM2, whichever frequency has the cyan box around it.

Nearest Airports Using the MFD

A second way to determine the nearest airport is by referencing the NRST Page Group located on the MFD. This method provides additional information to the pilot; however, it may require additional steps to view. *[Figure 11-13]*

Navigating the MFD Page Groups

Most display systems are designed for ease of navigation through the different screens on the MFD. Notice the various page groups in the lower right-hand corner of the MFD screen. Navigation through these four page groups is accomplished by turning the outer FMS knob clockwise. *[Figure 11-14]*

Within each page group are specific pages that provide additional information pertaining to that specific group. Once the desired page group and page is selected, the MFD remains in that configuration until the page is changed or the CLR button is depressed for more than 2 seconds. Holding the CLR button returns the display to the default moving map page.

Nearest Airport Page Group

The nearest airport page contains specific areas of interest for the airport selected. *[Figure 11-15]* The pilot is furnished information regarding runways, frequencies, and types of approaches available.

Nearest Airports Page Soft Keys

Figure 11-16 illustrates four specific soft keys that allow the pilot to access independent windows of the airport page. Selection of each of these windows can also be accomplished by utilizing the MENU hard key.

The soft keys and functions are as follows: Scroll through each section with the cursor, then press enter to accept the selection.

1. APT. Allows the user access to scroll through the 25 nearest airports. The white arrow indicates which airport is selected. The INFORMATION window is slaved to the white arrow. The INFORMATION window decodes the airport identifier. Scroll through the 25 airports by turning the outer FMS knob.

Figure 11-13. *The MFD is another means of viewing the nearest airports.*

2. RNWY. Moves the cursor into the Runways section and allows the user to scroll through the available runways at a specific airport that is selected in conjunction with the APT soft key. A green arrow indicates additional runways to view.
3. FREQ. Moves the cursor into the Frequencies section and allows the pilot to highlight and auto-tune the frequency into the selected standby box.
4. APR. Moves the cursor into the Approach section and allows the pilot to review approaches and load them into the flight plan. When the APR soft key is selected, an additional soft key appears. The LD APR (Load Approach) soft key must be pressed once the desired instrument approach procedure has been highlighted. Once the soft key is pressed, the screen changes to the PROC Page Group. From this page the pilot is able to choose the desired approach, the transition, and choose the option to activate the approach or just load it into the flight plan.

Situational Awareness

Situational awareness (SA) is not simply a mental picture of aircraft location; rather, it is an overall assessment of each element of the environment and how it affects a flight. On one end of the SA spectrum is a pilot who is knowledgeable of every aspect of the flight; consequently, this pilot's decision-making is proactive. With good SA, this pilot is able to make decisions well ahead of time and evaluate several different options. On the other end of the SA spectrum is a pilot who is missing important pieces of the puzzle: "I knew exactly where I was when I ran out of fuel." Consequently, this pilot's decision-making is reactive. With poor SA, a pilot

Figure 11-14. *Page Groups. As the FMS outer knob is rotated, the current page group is indicated by highlighting the specific group indicator. Notice that the MAP page group is highlighted.*

Figure 11-15. *The page group of nearest airports has been selected.*

lacks a vision of future events and is forced to make decisions quickly, often with limited options.

During a typical IFR flight, a pilot operates at varying levels of SA. For example, a pilot may be cruising to his or her destination with a high level of SA when ATC issues an unexpected standard terminal arrival route (STAR). Since the pilot was not expecting the STAR and is not familiar with it, SA is lowered. However, after becoming familiar with the STAR and resuming normal navigation, the pilot returns to a higher level of SA.

Factors that reduce SA include: distractions, unusual or unexpected events, complacency, high workload, unfamiliar situations, and inoperative equipment. In some situations, a loss of SA may be beyond a pilot's control. For example, a pneumatic system failure and associated loss of the attitude and heading indicators could cause a pilot to find his or her aircraft in an unusual attitude. In this situation, established procedures must be used to regain SA.

Pilots should be alert to a loss of SA anytime they are in a reactive mindset. To regain SA, reassess the situation and seek additional information from other sources, such as the navigation instruments or ATC.

Summary

Electronic flight displays have been dramatically improved regarding how information is displayed and what information is available to a pilot. With only the push of a button, a pilot is able to access information that was traditionally contained in multiple publications. (Electronic databases have replaced paper manuals and reduced the clutter in the flight deck.)

Multi-Function Displays (MFD) are capable of displaying moving maps that mirror sectional charts. These detailed displays depict all airspace including permanent temporary flight restrictions (TFRs).

In fact, MFDs have become so descriptive that many pilots fall into the trap of relying solely on the moving maps for navigation. In addition, pilots are drawing upon the database to familiarize themselves with departure and destination airport information.

Pilots are relying heavily on the electronic database for their flight planning and have moved away from the traditional method of cross-country flight planning. It is imperative to understand that the electronic flight display adds to the overall quality of the flight experience, but can also lead to

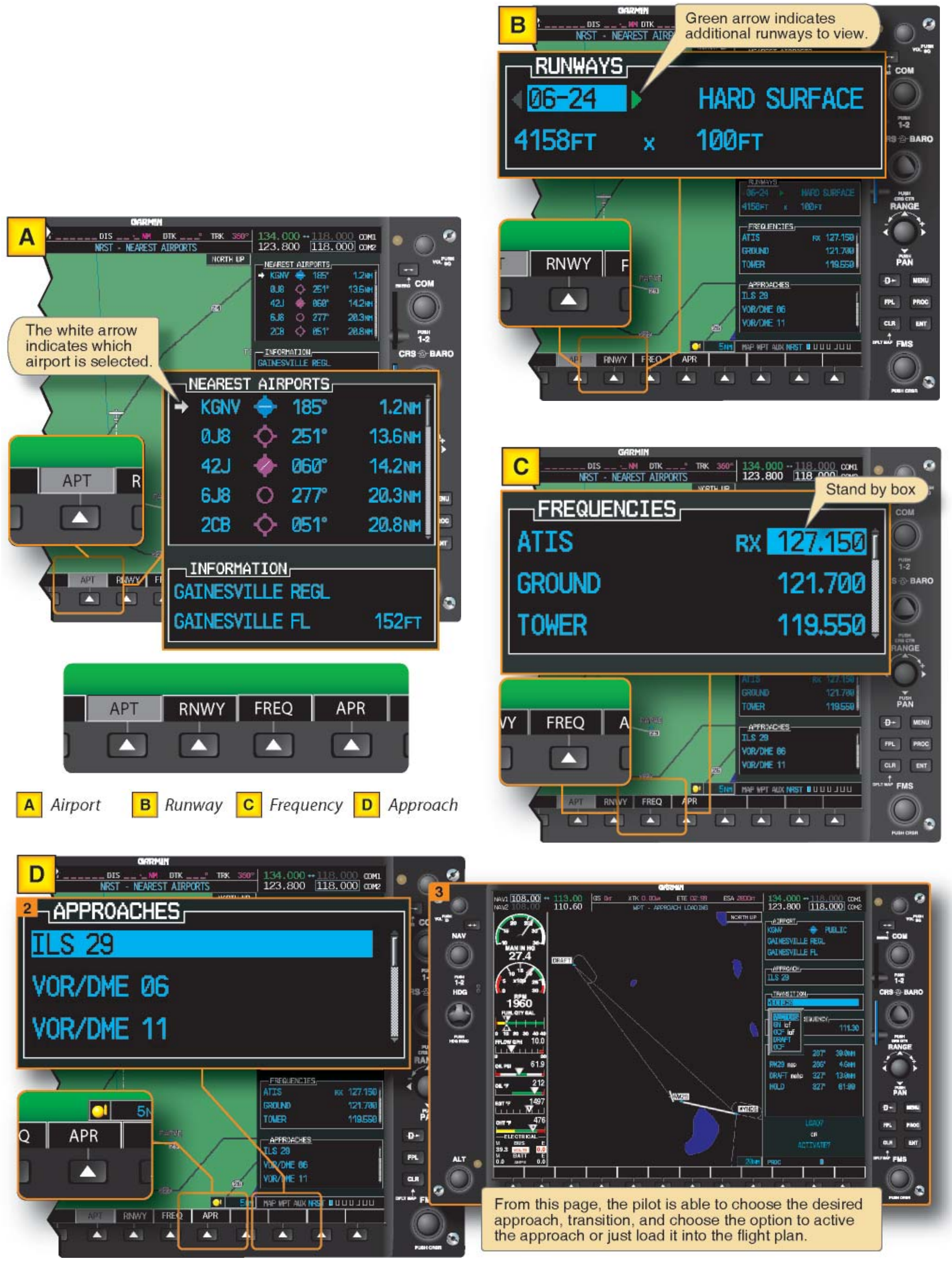


Figure 11-16. *The four soft keys at the bottom of the MFD are airport (A), runway (B), frequency (C), and approach (D).*

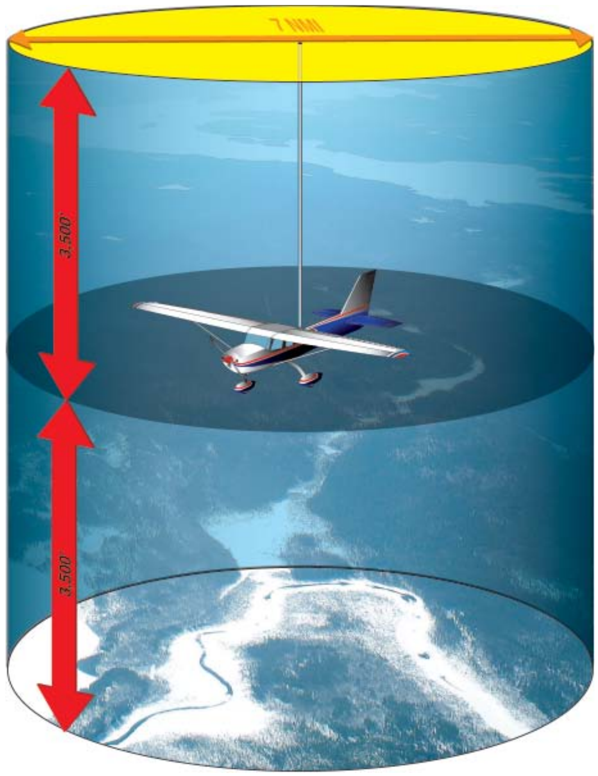


Figure 11-17. *The Area Surrounding the Aircraft for Coverage Using TIS.*

catastrophe if not utilized properly. At no time is the moving map meant to substitute for a VFR sectional or Low Altitude En Route chart.

Traffic Avoidance

Electronic flight displays have the capability of displaying transponder-equipped aircraft on the MFD as well as the inset map on the PFD. However, due to the limitations of the systems, not all traffic is displayed. Some TIS units display only eight intruding targets within the service volume. The normal service volume has altitude limitations of 3,500 feet below the aircraft to 3,500 feet above the aircraft. The lateral limitation is 7 NM. *[Figure 11-17]* Pilots unfamiliar with the limitations of the system may rely on the aural warnings to alert them to approaching traffic.

In addition to an outside visual scan of traffic, a pilot should incorporate any Traffic Information electronically displayed such as TIS. This innovation in traffic alerting reinforces and adds synergy to the ability to see and avoid. However, it is an aid and not a replacement for the responsibilities of the pilot. Systems such as TIS provide a visual representation of nearby traffic and displays a symbol on the moving map display with relative information about altitude, vertical trends, and direction of flight. *[Figure 11-18]*

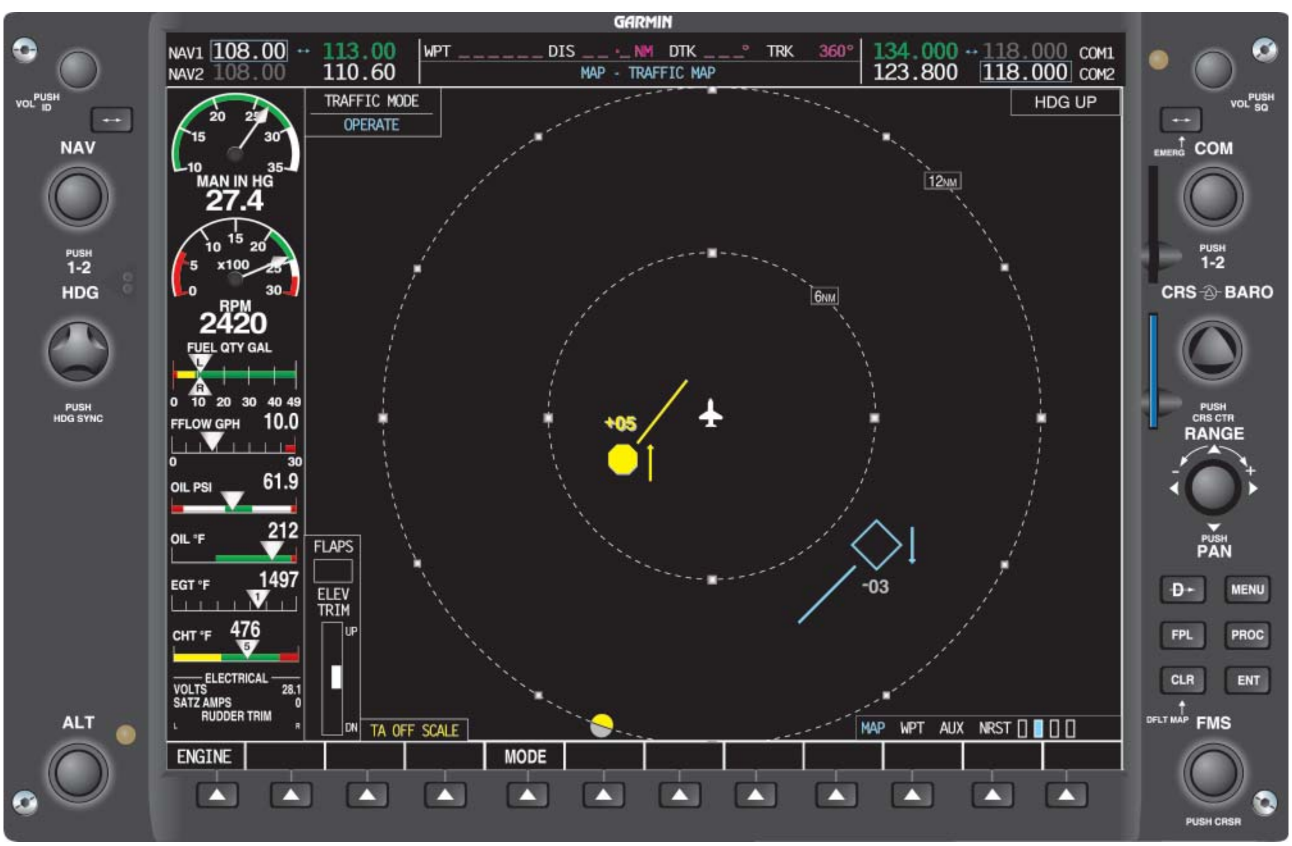


Figure 11-18. *A Typical Display on Aircraft MFD When Using TIS.*

It is important to remember that most systems display only a specific maximum number of targets allowed. Therefore, it does not mean that the targets displayed are the only aircraft in the vicinity. The system displays only the closest aircraft. In addition, the system does not display aircraft that are not equipped with transponders. The display may not show any aircraft; however, a Piper Cub with no transponder could be flying in the area. TIS coverage can be sporadic and is not available in some areas of the United States. Traffic advisory software is to be utilized only for increased situational awareness and not the sole means of traffic avoidance. There is no substitute for a good visual scan of the surrounding sky.

Appendix A

Clearance Shorthand

The following shorthand system is recommended by the Federal Aviation Administration (FAA). Applicants for the instrument rating may use any shorthand system, in any language, which ensures accurate compliance with air traffic control (ATC) instructions. No shorthand system is required by regulation and no knowledge of shorthand is required for the FAA Knowledge Test; however, because of the vital need for reliable communication between the pilot and controller, clearance information should be unmistakably clear.

The following symbols and contractions represent words and phrases frequently used in clearances. Most are used regularly by ATC personnel. By practicing this shorthand, omitting the parenthetical words, you will be able to copy long clearances as fast as they are read.

Example: CAF ~~M~~→ RH RV V18 ↑40 SQ 0700 DPC 120.4
Cleared as filed, maintain runway heading for radar vector to Victor 18, climb to 4,000, squawk 0700, departure control frequency is 120.4.

Words and Phrases	Shorthand
Above	ABV
Above (Altitude, Hundreds of Feet)	$\underline{70}$
Adjust speed to 250 knots	250 K
Advise	ADZ
After (Passing)	<
Airway (Designation)	V26
Airport	A
Alternate Instructions	( )
Altitude 6,000–17,000	60-170
And	&
Approach	AP
Approach Control	APC
Area Navigation	RNAV
Arriving	↓
At	@
At or Above	$\underline{\uparrow}$
At or Below	$\overline{\downarrow}$
(ATC) Advises	CA
(ATC) Clears or Cleared	C
(ATC) Requests	CR
Back Course	BC
Bearing	BR
Before (Reaching, Passing)	>
Below	BLO
Below (Altitude, Hundreds of Feet)	$\overline{70}$
Center	CTR
Clearance Void if Not Off By (Time)	v<
Cleared as Filed	CAF
Cleared to Airport	A
Cleared to Climb/Descend at Pilot's Discretion	PD
Cleared to Cross	X
Cleared to Depart From the Fix	D
Cleared to the Fix	F
Cleared to Hold and Instructions Issued	H
Cleared to Land	L
Cleared to the Outer Marker	O
Climb to (Altitude, Hundreds of Feet)	↑70
Contact Approach	CT
Contact (Denver) Approach Control	(den
Contact (Denver) Center	(DEN
Course	CRS
Cross	X
Cruise	→
Delay Indefinite	DLI
Depart (Direction, if Specified)	T→( )
Departure Control	DPC
Descend To (Altitude, Hundreds of Feet)	↓70
Direct	DR
Direction (Bound)	
Eastbound	EB
Westbound	WB
Northbound	NB
Southbound	SB
Inbound	IB
Outbound	OB
DME Fix (Mile)	21
Each	EA
Enter Control Area	
Estimated Time of Arrival	ETA
Expect	EX
Expect-Further-Clearance	EFC

Fan Marker	FM
Final	F
Final Approach	FA
Flight Level	FL
Flight Planned Route	FPR
For Further Clearance	FFC
For Further Headings	FFH
From	FM
Ground	GND
GPS Approach	GPS
Heading	HDG
Hold (Direction)	H-W
Holding Pattern	⬭
ILS Approach	ILS
Increase Speed 30 Knots	+30 K
Initial Approach	I
Instrument Departure Procedure	DP
Intersection	XN
Join or Intercept Airway/Jet Route/Track or Course	$\overline{>}$
Left Turn After Takeoff	↶
Locator Outer Marker	LOM
Magnetic	M
Maintain	~~M~~→
Maintain VFR Conditions On Top	<u>VFR</u>
Middle Compass Locator	ML
Middle Marker	MM
Missed Approach	MA
Nondirectional Beacon Approach	NDB
Out of (Leave) Control Area	△↗
Outer Marker	OM
Over (Station)	<u>OKC</u>
On Course	OC
Precision Approach Radar	PAR
Procedure Turn	PT
Radar Vector	RV
Radial (080° Radial)	080R
Reduce Speed 20 Knots	-20 K
Remain This Frequency	RTF
Remain Well to Left Side	LS
Remain Well to Right Side	RS
Report Crossing	RX
Report Departing	RD
Report Leaving	RL
Report on Course	R-CRS
Report Over	RO
Report Passing	RP
Report Reaching	RR
Report Starting Procedure Turn	RSPT
Reverse Course	RC
Right Turn After Takeoff	↷
Runway Heading	RH
Runway (Number)	RY18
Squawk	SQ
Standby	STBY
Straight-in Approach	SI
Surveillance Radar Approach	ASR
Takeoff (Direction)	T→N
Tower	Z
Turn Left	TL
Turn Right	TR
Until	/
Until Advised (By)	UA
Until Further Advised	UFA
VFR Conditions On Top	OTP
Via	VIA
Victor (Airway Number)	V14
Visual Approach	VA
VOR	⊙
VOR Approach	VR
VORTAC	Ⓣ
While in Control Area	△

Appendix B

Instrument Training Lesson Guide

Introduction

Flight instructors may use this guide in the development of lesson plans. The lessons are arranged in a logical learning sequence and use the building-block technique. Each lesson includes ground training appropriate to the flight portion of the lesson. It is vitally important that the flight instructor brief the student on the objective of the lesson and how it will be accomplished. Debriefing the student's performance is also necessary to motivate further progress. To ensure steady progress, student pilots should master the objective of each lesson before advancing to the next lesson. Lessons should be arranged to take advantage of each student's knowledge and skills.

Flight instructors must monitor progress closely during training to guide student pilots in how to properly divide their attention. The importance of this division of attention or "cross-check" cannot be overemphasized. Cross-check and proper instrument interpretation are essential components of "attitude instrument flying" that enables student pilots to accurately visualize the aircraft's attitude at all times.

When possible, each lesson should incorporate radio communications, basic navigation, and emergency procedures so the student pilot is exposed to the entire IFR experience with each flight. Cross-reference the Instrument Training Lesson Guide with this handbook and the Instrument Practical Test Standards for a comprehensive instrument rating training program.

Lesson 1—Ground and flight evaluation of student's knowledge and performance

Aircraft systems
Aircraft performance
Preflight planning
Use of checklists
Basic flight maneuvers
Radio communications procedures
Navigation systems

Lesson 2—Preflight preparation and flight by reference to instruments

Ground Training

Instrument system preflight procedures
Attitude instrument flying
Fundamental instrument skills
Instrument cross-check techniques

Flight Training

Aircraft and instrument preflight inspection
Use of checklists
Fundamental instrument skills
Basic flight maneuvers
Instrument approach (demonstrated)
Postflight procedures

Lesson 3—Flight instruments and human factors

Ground Training

Human factors
Flight instruments and systems
Aircraft systems
Navigation instruments and systems

Flight Training

Aircraft and instrument preflight inspection
Radio communications
Checklist procedures
Attitude instrument flying
Fundamental instrument skills
Basic flight maneuvers
Spatial disorientation demonstration
Navigation systems
Postflight procedures

Lesson 4—Attitude instrument flying

Ground Training

Human factors
Flight instruments and systems

Aircraft systems
Navigation instruments and systems
Attitude instrument flying
Fundamental instrument skills
Basic flight maneuvers

Flight Training

Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Attitude instrument flying
Fundamental instrument skills
Basic flight maneuvers
Spatial disorientation
Navigation
Postflight procedures

Lesson 5—Aerodynamic factors and basic flight maneuvers

Ground Training

Basic aerodynamic factors
Basic instrument flight patterns
Emergency procedures

Flight Training

Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Basic instrument flight patterns
Emergency procedures
Navigation
Postflight procedures

Lesson 6—Partial panel operations

Ground Training

ATC system
Flight instruments
Partial panel operations

Flight Training

Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Basic instrument flight patterns
Emergency procedures
Partial panel practice
Navigation
Postflight procedures

Lesson 7—Recovery from unusual attitudes

Ground Training

Attitude instrument flying
ATC system
NAS overview

Flight Training

Preflight
Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Instrument takeoff
Navigation
Partial panel practice
Recovery from unusual attitudes
Postflight procedures

Lesson 8—Navigation systems

Ground Training

ATC clearances
Departure procedures
IFR en route charts

Flight Training

Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Intercepting and tracking
Holding
Postflight procedures

Lesson 9—Review and practice

Ground Training

Aerodynamic factors
Flight instruments and systems
Attitude instrument flying
Navigation systems
NAS
ATC
Emergency procedures

Flight Training

Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Review and practice as determined by the flight instructor

Instrument takeoff
Radio communications
Navigation systems
Emergency procedures
Postflight procedures

Lessons 10 through 19—Orientation, intercepting, tracking, and holding using each navigation system installed in the aircraft

Ground Training

Preflight planning
Navigation systems
NAS
ATC
Emergencies

Flight Training

Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Departure procedures
En route navigation
Terminal operations
Partial panel operation
Instrument approach
Missed approach
Approach to a landing
Postflight procedures

Lessons 20 and 21—Cross-country flights

Ground Training

Preflight planning
Aircraft performance
Navigation systems
NAS
ATC
Emergencies

Flight Training

Emergency procedures
Partial panel operation
Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Departure procedures
En route navigation
Terminal operations
Instrument approach
Missed approach
Approach to a landing
Postflight procedures

Lessons 22 and 23—Review and practice

Ground Training

Human factors
Aerodynamic factors
Flight instruments and systems
Attitude instrument flying
Basic flight maneuvers
Navigation systems
NAS
ATC
Emergency operations

Flight Training

Aircraft and instrument preflight inspection
Checklist procedures
Radio communications
Review and practice as determined by the flight instructor
Instrument takeoff
Partial panel operations
Unusual attitude recoveries
Radio communications
Navigation systems
Emergency procedures
Postflight procedures

Lessons 24 and subsequent—Practical test preparation

Ground Training

Title 14 of the Code of Federal Regulations (14 CFR) parts 61, 71, 91, 95, and 97
Instrument Flying Handbook
Practical test standards
Administrative requirements
Equipment requirements
Applicant's requirements

Flight Training

Review and practice until the student can consistently perform all required tasks in accordance with the appropriate practical test standards.

NOTE: It is the recommending instructor's responsibility to ensure that the applicant meets 14 CFR part 61 requirements and is prepared for the practical test, including: training, knowledge, experience, and the appropriate instructor endorsements.

Glossary

Absolute accuracy. The ability to determine present position in space independently, and is most often used by pilots.

Absolute altitude. The actual distance between an aircraft and the terrain over which it is flying.

Absolute pressure. Pressure measured from the reference of zero pressure, or a vacuum.

A.C. Alternating current.

Acceleration error. A magnetic compass error apparent when the aircraft accelerates while flying on an easterly or westerly heading, causing the compass card to rotate toward North.

Accelerometer. A part of an inertial navigation system (INS) that accurately measures the force of acceleration in one direction.

ADF. See automatic direction finder.

ADI. See attitude director indicator.

ADM. See aeronautical decision-making.

ADS–B. See automatic dependent surveillance–broadcast.

Adverse yaw. A flight condition at the beginning of a turn in which the nose of the aircraft starts to move in the direction opposite the direction the turn is being made, caused by the induced drag produced by the downward-deflected aileron holding back the wing as it begins to rise.

Aeronautical decision-making (ADM). A systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances.

A/FD. See Airport/Facility Directory.

Agonic line. An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are in alignment, and along which there is no magnetic variation.

Aircraft approach category. A performance grouping of aircraft based on a speed of 1.3 times the stall speed in the landing configuration at maximum gross landing weight.

Air data computer (ADC). An aircraft computer that receives and processes pitot pressure, static pressure, and temperature to calculate very precise altitude, indicated airspeed, true airspeed, and air temperature.

AIRMET. Inflight weather advisory issued as an amendment to the area forecast, concerning weather phenomena of operational interest to all aircraft and that is potentially hazardous to aircraft with limited capability due to lack of equipment, instrumentation, or pilot qualifications.

Airport diagram. The section of an instrument approach procedure chart that shows a detailed diagram of the airport. This diagram includes surface features and airport configuration information.

Airport/Facility Directory (A/FD). An FAA publication containing information on all airports, communications, and NAVAIDs.

Airport surface detection equipment (ASDE). Radar equipment specifically designed to detect all principal features and traffic on the surface of an airport, presenting the entire image on the control tower console; used to augment visual observation by tower personnel of aircraft and/or vehicular movements on runways and taxiways.

Airport surveillance radar (ASR). Approach control radar used to detect and display an aircraft's position in the terminal area.

Airport surveillance radar approach. An instrument approach in which ATC issues instructions for pilot compliance based on aircraft position in relation to the final approach course and the distance from the end of the runway as displayed on the controller's radar scope.

Air route surveillance radar (ARSR). Air route traffic control center (ARTCC) radar used primarily to detect and display an aircraft's position while en route between terminal areas.

Air route traffic control center (ARTCC). Provides ATC service to aircraft operating on IFR flight plans within controlled airspace and principally during the en route phase of flight.

Airspeed indicator. A differential pressure gauge that measures the dynamic pressure of the air through which the aircraft is flying. Displays the craft's airspeed, typically in knots, to the pilot.

Air traffic control radar beacon system (ATCRBS). Sometimes called secondary surveillance radar (SSR), which utilizes a transponder in the aircraft. The ground equipment is an interrogating unit, in which the beacon antenna is mounted so it rotates with the surveillance antenna. The interrogating unit transmits a coded pulse sequence that actuates the aircraft transponder. The transponder answers the coded sequence by transmitting a preselected coded sequence back to the ground equipment, providing a strong return signal and positive aircraft identification, as well as other special data.

Airway. An airway is based on a centerline that extends from one navigation aid or intersection to another navigation aid (or through several navigation aids or intersections); used to establish a known route for en route procedures between terminal areas.

Alert area. An area in which there is a high volume of pilot training or an unusual type of aeronautical activity.

Almanac data. Information the global positioning system (GPS) receiver can obtain from one satellite which describes the approximate orbital positioning of all satellites in the constellation. This information is necessary for the GPS receiver to know what satellites to look for in the sky at a given time.

ALS. See approach lighting system.

Alternate airport. An airport designated in an IFR flight plan, providing a suitable destination if a landing at the intended airport becomes inadvisable.

Alternate static source valve. A valve in the instrument static air system that supplies reference air pressure to the altimeter, airspeed indicator, and vertical speed indicator if the normal static pickup should become clogged or iced over.

Altimeter setting. Station pressure (the barometric pressure at the location the reading is taken) which has been corrected for the height of the station above sea level.

AME. See aviation medical examiner.

Amendment status. The circulation date and revision number of an instrument approach procedure, printed above the procedure identification.

Ammeter. An instrument installed in series with an electrical load used to measure the amount of current flowing through the load.

Aneroid. The sensitive component in an altimeter or barometer that measures the absolute pressure of the air. It is a sealed, flat capsule made of thin disks of corrugated metal soldered together and evacuated by pumping all of the air out of it.

Aneroid barometer. An instrument that measures the absolute pressure of the atmosphere by balancing the weight of the air above it against the spring action of the aneroid.

Angle of attack. The acute angle formed between the chord line of an airfoil and the direction of the air striking the airfoil.

Anti-ice. Preventing the accumulation of ice on an aircraft structure via a system designed for that purpose.

Approach lighting system (ALS). Provides lights that will penetrate the atmosphere far enough from touchdown to give directional, distance, and glide path information for safe transition from instrument to visual flight.

Area chart. Part of the low-altitude en route chart series, this chart furnishes terminal data at a larger scale for congested areas.

Area navigation (RNAV). Allows a pilot to fly a selected course to a predetermined point without the need to overfly ground-based navigation facilities, by using waypoints.

ARSR. See air route surveillance radar.

ARTCC. See air route traffic control center.

ASDE. See airport surface detection equipment.

ASOS. See automated surface observing station.

ASR. See airport surveillance radar.

ATC. Air Traffic Control.

ATCRBS. See air traffic control radar beacon system.

ATIS. See automatic terminal information service.

Atmospheric propagation delay. A bending of the electromagnetic (EM) wave from the satellite that creates an error in the GPS system.

Attitude and heading reference systems (AHRS). System composed of three-axis sensors that provide heading, attitude, and yaw information for aircraft. AHRS are designed to replace traditional mechanical gyroscopic flight instruments and provide superior reliability and accuracy.

Attitude director indicator (ADI). An aircraft attitude indicator that incorporates flight command bars to provide pitch and roll commands.

Attitude indicator. The foundation for all instrument flight, this instrument reflects the airplane's attitude in relation to the horizon.

Attitude instrument flying. Controlling the aircraft by reference to the instruments rather than by outside visual cues.

Autokinesis. Nighttime visual illusion that a stationary light is moving, which becomes apparent after several seconds of staring at the light.

Automated Weather Observing System (AWOS). Automated weather reporting system consisting of various sensors, a processor, a computer-generated voice subsystem, and a transmitter to broadcast weather data.

Automated Surface Observing Station (ASOS). Weather reporting system which provides surface observations every minute via digitized voice broadcasts and printed reports.

Automatic dependent surveillance–broadcast (ADS-B). A device used in aircraft that repeatedly broadcasts a message that includes position (such as latitude, longitude, and altitude), velocity, and possibly other information.

Automatic direction finder (ADF). Electronic navigation equipment that operates in the low- and medium-frequency bands. Used in conjunction with the ground-based nondirectional beacon (NDB), the instrument displays the number of degrees clockwise from the nose of the aircraft to the station being received.

Automatic terminal information service (ATIS). The continuous broadcast of recorded non-control information in selected terminal areas. Its purpose is to improve controller effectiveness and relieve frequency congestion by automating repetitive transmission of essential but routine information.

Aviation medical examiner (AME). A physician with training in aviation medicine designated by the Civil Aerospace Medical Institute (CAMI).

AWOS. See automated weather observing system.

Azimuth card. A card that may be set, gyroscopically controlled, or driven by a remote compass.

Back course (BC). The reciprocal of the localizer course for an ILS. When flying a back-course approach, an aircraft approaches the instrument runway from the end at which the localizer antennas are installed.

Baro-aiding. A method of augmenting the GPS integrity solution by using a non-satellite input source. To ensure that baro-aiding is available, the current altimeter setting must be entered as described in the operating manual.

Barometric scale. A scale on the dial of an altimeter to which the pilot sets the barometric pressure level from which the altitude shown by the pointers is measured.

BC. See back course.

Block altitude. A block of altitudes assigned by ATC to allow altitude deviations; for example, "Maintain block altitude 9 to 11 thousand."

Cage. The black markings on the ball instrument indicating its neutral position.

Calibrated. The instrument indication compared with a standard value to determine the accuracy of the instrument.

Calibrated orifice. A hole of specific diameter used to delay the pressure change in the case of a vertical speed indicator.

Calibrated airspeed. The speed at which the aircraft is moving through the air, found by correcting IAS for instrument and position errors.

CAS. Calibrated airspeed.

CDI. Course deviation indicator.

Changeover point (COP). A point along the route or airway segment between two adjacent navigation facilities or waypoints where changeover in navigation guidance should occur.

Circling approach. A maneuver initiated by the pilot to align the aircraft with a runway for landing when a straight-in landing from an instrument approach is not possible or is not desirable.

Class A airspace. Airspace from 18,000 feet MSL up to and including FL 600, including the airspace overlying the waters within 12 NM of the coast of the 48 contiguous states and Alaska; and designated international airspace beyond 12 NM of the coast of the 48 contiguous states and Alaska within areas of domestic radio navigational signal or ATC radar coverage, and within which domestic procedures are applied.

Class B airspace. Airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of IFR operations or passenger numbers. The configuration of each Class B airspace is individually tailored and consists of a surface area and two or more layers, and is designed to contain all published instrument procedures once an aircraft enters the airspace. For all aircraft, an ATC clearance is required to operate in the area, and aircraft so cleared receive separation services within the airspace.

Class C airspace. Airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports having an operational control tower, serviced by radar approach control, and having a certain number of IFR operations or passenger numbers. Although the configuration of each Class C airspace area is individually tailored, the airspace usually consists of a 5 NM radius core surface area that extends from the surface up to 4,000 feet above the airport elevation, and a 10 NM radius shelf area that extends from 1,200 feet to 4,000 feet above the airport elevation.

Class D airspace. Airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored, and when instrument procedures are published, the airspace is normally designed to contain the procedures.

Class E airspace. Airspace that is not Class A, Class B, Class C, or Class D, and is controlled airspace.

Class G airspace. Airspace that is uncontrolled, except when associated with a temporary control tower, and has not been designated as Class A, Class B, Class C, Class D, or Class E airspace.

Clean configuration. A configuration in which all flight control surfaces have been placed to create minimum drag. In most aircraft this means flaps and gear retracted.

Clearance. ATC permission for an aircraft to proceed under specified traffic conditions within controlled airspace, for the purpose of providing separation between known aircraft.

Clearance delivery. Control tower position responsible for transmitting departure clearances to IFR flights.

Clearance limit. The fix, point, or location to which an aircraft is cleared when issued an air traffic clearance.

Clearance on request. An IFR clearance not yet received after filing a flight plan.

Clearance void time. Used by ATC, the time at which the departure clearance is automatically canceled if takeoff has not been made. The pilot must obtain a new clearance or cancel the IFR flight plan if not off by the specified time.

Clear ice. Glossy, clear, or translucent ice formed by the relatively slow freezing of large, supercooled water droplets.

Compass course. A true course corrected for variation and deviation errors.

Compass locator. A low-power, low- or medium-frequency (L/MF) radio beacon installed at the site of the outer or middle marker of an ILS.

Compass rose. A small circle graduated in 360° increments, printed on navigational charts to show the amount of compass variation at different locations, or on instruments to indicate direction.

Computer navigation fix. A point used to define a navigation track for an airborne computer system such as GPS or FMS.

Concentric rings. Dashed-line circles depicted in the plan view of IAP charts, outside of the reference circle, that show en route and feeder facilities.

Cone of confusion. A cone-shaped volume of airspace directly above a VOR station where no signal is received, causing the CDI to fluctuate.

Control and performance. A method of attitude instrument flying in which one instrument is used for making attitude changes, and the other instruments are used to monitor the progress of the change.

Control display unit. A display interfaced with the master computer, providing the pilot with a single control point for all navigations systems, thereby reducing the number of required flight deck panels.

Controlled airspace. An airspace of defined dimensions within which ATC service is provided to IFR and VFR flights in accordance with the airspace classification. It includes Class A, Class B, Class C, Class D, and Class E airspace.

Control pressures. The amount of physical exertion on the control column necessary to achieve the desired attitude.

Convective weather. Unstable, rising air found in cumiliform clouds.

Convective SIGMET. Weather advisory concerning convective weather significant to the safety of all aircraft, including thunderstorms, hail, and tornadoes.

Coordinated flight. Flight with a minimum disturbance of the forces maintaining equilibrium, established via effective control use.

COP. See changeover point.

Coriolis illusion. The illusion of rotation or movement in an entirely different axis, caused by an abrupt head movement, while in a prolonged constant rate turn that has ceased stimulating the brain's motion sensing system.

Crew resource management (CRM). The effective use of all available resources—human, hardware, and information.

Critical areas. Areas where disturbances to the ILS localizer and glide slope courses may occur when surface vehicles or aircraft operate near the localizer or glide slope antennas.

CRM. See crew resource management.

Cross-check. The first fundamental skill of instrument flight, also known as "scan," the continuous and logical observation of instruments for attitude and performance information.

Cruise clearance. An ATC clearance issued to allow a pilot to conduct flight at any altitude from the minimum IFR altitude up to and including the altitude specified in the clearance. Also authorizes a pilot to proceed to and make an approach at the destination airport.

Current induction. An electrical current being induced into, or generated in, any conductor that is crossed by lines of flux from any magnet.

DA. See decision altitude.

D.C. Direct current.

Dark adaptation. Physical and chemical adjustments of the eye that make vision possible in relative darkness.

Deceleration error. A magnetic compass error that occurs when the aircraft decelerates while flying on an easterly or westerly heading, causing the compass card to rotate toward South.

Decision altitude (DA). A specified altitude in the precision approach, charted in feet MSL, at which a missed approach must be initiated if the required visual reference to continue the approach has not been established.

Decision height (DH). A specified altitude in the precision approach, charted in height above threshold elevation, at which a decision must be made either to continue the approach or to execute a missed approach.

Deice. The act of removing ice accumulation from an aircraft structure.

Density altitude. Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of an aircraft and its engines.

Departure procedure (DP). Preplanned IFR ATC departure, published for pilot use, in textual and graphic format.

Deviation. A magnetic compass error caused by local magnetic fields within the aircraft. Deviation error is different on each heading.

DGPS. Differential global positioning system.

DH. See decision height.

Differential Global Positioning System (DGPS). A system that improves the accuracy of Global Navigation Satellite Systems (GNSS) by measuring changes in variables to provide satellite positioning corrections.

Direct indication. The true and instantaneous reflection of aircraft pitch-and-bank attitude by the miniature aircraft, relative to the horizon bar of the attitude indicator.

Direct User Access Terminal System (DUATS). A system that provides current FAA weather and flight plan filing services to certified civil pilots, via personal computer, modem, or telephone access to the system. Pilots can request specific types of weather briefings and other pertinent data for planned flights.

Distance circle. See reference circle.

Distance measuring equipment (DME). A pulse-type electronic navigation system that shows the pilot, by an instrument-panel indication, the number of nautical miles between the aircraft and a ground station or waypoint.

DME. See distance measuring equipment.

DME arc. A flight track that is a constant distance from the station or waypoint.

DOD. Department of Defense.

Doghouse. A turn-and-slip indicator dial mark in the shape of a doghouse.

Domestic Reduced Vertical Separation Minimum (DRVSM). Additional flight levels between FL 290 and FL 410 to provide operational, traffic, and airspace efficiency.

Double gimbal. A type of mount used for the gyro in an attitude instrument. The axes of the two gimbals are at right angles to the spin axis of the gyro, allowing free motion in two planes around the gyro.

DP. See departure procedure.

Drag. The net aerodynamic force parallel to the relative wind, usually the sum of two components: induced drag and parasite drag.

Drag curve. The curve created when plotting induced drag and parasite drag.

DUATS. See direct user access terminal system.

Duplex. Transmitting on one frequency and receiving on a separate frequency.

Eddy currents. Current induced in a metal cup or disc when it is crossed by lines of flux from a moving magnet.

EFAS. See En Route Flight Advisory Service.

EFC. See expect-further-clearance.

Electronic flight display (EFD). For the purpose of standardization, any flight instrument display that uses LCD or other image-producing system (Cathode Ray Tube [CRT], etc.)

Elevator illusion. The sensation of being in a climb or descent, caused by the kind of abrupt vertical accelerations that result from up- or downdrafts.

Emergency. A distress or urgent condition.

Emphasis error. The result of giving too much attention to a particular instrument during the cross-check, instead of relying on a combination of instruments necessary for attitude and performance information.

EM wave. Electromagnetic wave.

Encoding altimeter. A special type of pressure altimeter used to send a signal to the air traffic controller on the ground, showing the pressure altitude the aircraft is flying.

En route facilities ring. Depicted in the plan view of IAP charts, a circle which designates NAVAIDs, fixes, and intersections that are part of the en route low altitude airway structure.

En Route Flight Advisory Service (EFAS). An en route weather-only AFSS service.

En route high-altitude charts. Aeronautical charts for en route instrument navigation at or above 18,000 feet MSL.

En route low-altitude charts. Aeronautical charts for en route IFR navigation below 18,000 feet MSL.

Equivalent airspeed. Airspeed equivalent to CAS in standard atmosphere at sea level. As the airspeed and pressure altitude increase, the CAS becomes higher than it should be, and a correction for compression must be subtracted from the CAS.

Expect-further-clearance (EFC). The time a pilot can expect to receive clearance beyond a clearance limit.

FAA. Federal Aviation Administration.

FAF. See final approach fix.

False horizon. Inaccurate visual information for aligning the aircraft, caused by various natural and geometric formations that disorient the pilot from the actual horizon.

Federal airways. Class E airspace areas that extend upward from 1,200 feet to, but not including, 18,000 feet MSL, unless otherwise specified.

Feeder facilities. Used by ATC to direct aircraft to intervening fixes between the en route structure and the initial approach fix.

Final approach. Part of an instrument approach procedure in which alignment and descent for landing are accomplished.

Final approach fix (FAF). The fix from which the IFR final approach to an airport is executed, and which identifies the beginning of the final approach segment. An FAF is designated on government charts by a Maltese cross symbol for nonprecision approaches, and a lightning bolt symbol for precision approaches.

Fixating. Staring at a single instrument, thereby interrupting the cross-check process.

FL. See flight level.

Flight configurations. Adjusting the aircraft control surfaces (including flaps and landing gear) in a manner that will achieve a specified attitude.

Flight director indicator (FDI). One of the major components of a flight director system, it provides steering commands that the pilot (or the autopilot, if coupled) follows.

Flight level (FL). A measure of altitude (in hundreds of feet) used by aircraft flying above 18,000 feet with the altimeter set at 29.92" Hg.

Flight management system (FMS). Provides pilot and crew with highly accurate and automatic long-range navigation capability, blending available inputs from long- and short-range sensors.

Flight path. The line, course, or track along which an aircraft is flying or is intended to be flown.

Flight patterns. Basic maneuvers, flown by reference to the instruments rather than outside visual cues, for the purpose of practicing basic attitude flying. The patterns simulate maneuvers encountered on instrument flights such as holding patterns, procedure turns, and approaches.

Flight strips. Paper strips containing instrument flight information, used by ATC when processing flight plans.

FMS. See flight management system.

Form drag. The drag created because of the shape of a component or the aircraft.

Fundamental skills. Pilot skills of instrument cross-check, instrument interpretation, and aircraft control.

Glide slope (GS). Part of the ILS that projects a radio beam upward at an angle of approximately 3° from the approach end of an instrument runway. The glide slope provides vertical guidance to aircraft on the final approach course for the aircraft to follow when making an ILS approach along the localizer path.

Glide slope intercept altitude. The minimum altitude of an intermediate approach segment prescribed for a precision approach that ensures obstacle clearance.

Global landing system (GLS). An instrument approach with lateral and vertical guidance with integrity limits (similar to barometric vertical navigation (BRO VNAV).

Global navigation satellite systems (GNSS). Satellite navigation systems that provide autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude) to within a few meters using time signals transmitted along a line of sight by radio from satellites.

GNSS. See global navigation satellite systems.

Global positioning system (GPS). Navigation system that uses satellite rather than ground-based transmitters for location information.

Goniometer. As used in radio frequency (RF) antenna systems, a direction-sensing device consisting of two fixed loops of wire oriented 90° from each other, which separately sense received signal strength and send those signals to two rotors (also oriented 90°) in the sealed direction-indicating instrument. The rotors are attached to the direction-indicating needle of the instrument and rotated by a small motor until minimum magnetic field is sensed near the rotors.

GPS. See global positioning system.

GPS Approach Overlay Program. An authorization for pilots to use GPS avionics under IFR for flying designated existing nonprecision instrument approach procedures, with the exception of LOC, LDA, and SDF procedures.

Graveyard spiral. The illusion of the cessation of a turn while still in a prolonged, coordinated, constant rate turn, which can lead a disoriented pilot to a loss of control of the aircraft.

Great circle route. The shortest distance across the surface of a sphere (the Earth) between two points on the surface.

Ground proximity warning system (GPWS). A system designed to determine an aircraft's clearance above the Earth and provides limited predictability about aircraft position relative to rising terrain.

Groundspeed. Speed over the ground, either closing speed to the station or waypoint, or speed over the ground in whatever direction the aircraft is going at the moment, depending upon the navigation system used.

GS. See glide slope.

GWPS. See ground proximity warning system.

HAA. See height above airport.

HAL. See height above landing.

HAT. See height above touchdown elevation.

Hazardous attitudes. Five aeronautical decision-making attitudes that may contribute to poor pilot judgment: antiauthority, impulsivity, invulnerability, machismo, and resignation.

Hazardous Inflight Weather Advisory Service (HIWAS). Service providing recorded weather forecasts broadcast to airborne pilots over selected VORs.

Head-up display (HUD). A special type of flight viewing screen that allows the pilot to watch the flight instruments and other data while looking through the windshield of the aircraft for other traffic, the approach lights, or the runway.

Height above airport (HAA). The height of the MDA above the published airport elevation.

Height above landing (HAL). The height above a designated helicopter landing area used for helicopter instrument approach procedures.

Height above touchdown elevation (HAT). The DA/DH or MDA above the highest runway elevation in the touchdown zone (first 3,000 feet of the runway).

HF. High frequency.

Hg. Abbreviation for mercury, from the Latin hydrargyrum.

HIWAS. See Hazardous Inflight Weather Advisory Service.

Holding. A predetermined maneuver that keeps aircraft within a specified airspace while awaiting further clearance from ATC.

Holding pattern. A racetrack pattern, involving two turns and two legs, used to keep an aircraft within a prescribed airspace with respect to a geographic fix. A standard pattern uses right turns; nonstandard patterns use left turns.

Homing. Flying the aircraft on any heading required to keep the needle pointing to the 0° relative bearing position.

Horizontal situation indicator (HSI). A flight navigation instrument that combines the heading indicator with a CDI, in order to provide the pilot with better situational awareness of location with respect to the courseline.

HSI. See horizontal situation indicator.

HUD. See head-up display.

Human factors. A multidisciplinary field encompassing the behavioral and social sciences, engineering, and physiology, to consider the variables that influence individual and crew performance for the purpose of optimizing human performance and reducing errors.

Hypoxia. A state of oxygen deficiency in the body sufficient to impair functions of the brain and other organs.

IAF. See initial approach fix.

IAP. See instrument approach procedures.

IAS. See indicated airspeed.

ICAO. See International Civil Aviation Organization.

Ident. Air Traffic Control request for a pilot to push the button on the transponder to identify return on the controller's scope.

IFR. See instrument flight rules.

ILS. See instrument landing system.

ILS categories. Categories of instrument approach procedures allowed at airports equipped with the following types of instrument landing systems:

> **ILS Category I:** Provides for approach to a height above touchdown of not less than 200 feet, and with runway visual range of not less than 1,800 feet.
>
> **ILS Category II:** Provides for approach to a height above touchdown of not less than 100 feet and with runway visual range of not less than 1,200 feet.
>
> **ILS Category IIIA:** Provides for approach without a decision height minimum and with runway visual range of not less than 700 feet.
>
> **ILS Category IIIB:** Provides for approach without a decision height minimum and with runway visual range of not less than 150 feet.
>
> **ILS Category IIIC:** Provides for approach without a decision height minimum and without runway visual range minimum.

IMC. See instrument meteorological conditions.

Indicated airspeed (IAS). Shown on the dial of the instrument airspeed indicator on an aircraft. Directly related to calibrated airspeed (CAS), IAS includes instrument errors and position error.

Indirect indication. A reflection of aircraft pitch-and-bank attitude by the instruments other than the attitude indicator.

Induced drag. Drag caused by the same factors that produce lift; its amount varies inversely with airspeed. As airspeed decreases, the angle of attack must increase, in turn increasing induced drag.

Induction icing. A type of ice in the induction system that reduces the amount of air available for combustion. The most commonly found induction icing is carburetor icing.

Inertial navigation system (INS). A computer-based navigation system that tracks the movement of an aircraft via signals produced by onboard accelerometers. The initial location of the aircraft is entered into the computer, and all subsequent movement of the aircraft is sensed and used to keep the position updated. An INS does not require any inputs from outside signals.

Initial approach fix (IAF). The fix depicted on IAP charts where the instrument approach procedure (IAP) begins unless otherwise authorized by ATC.

Inoperative components. Higher minimums are prescribed when the specified visual aids are not functioning; this information is listed in the Inoperative Components Table found in the United States Terminal Procedures Publications.

INS. See inertial navigation system.

Instantaneous vertical speed indicator (IVSI). Assists in interpretation by instantaneously indicating the rate of climb or descent at a given moment with little or no lag as displayed in a vertical speed indicator (VSI).

Instrument approach procedures (IAP). A series of predetermined maneuvers for the orderly transfer of an aircraft under IFR from the beginning of the initial approach to a landing or to a point from which a landing may be made visually.

Instrument flight rules (IFR). Rules and regulations established by the Federal Aviation Administration to govern flight under conditions in which flight by outside visual reference is not safe. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals.

Instrument landing system (ILS). An electronic system that provides both horizontal and vertical guidance to a specific runway, used to execute a precision instrument approach procedure.

Instrument meteorological conditions (IMC). Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling less than the minimums specified for visual meteorological conditions, requiring operations to be conducted under IFR.

Instrument takeoff. Using the instruments rather than outside visual cues to maintain runway heading and execute a safe takeoff.

Interference drag. Drag generated by the collision of airstreams creating eddy currents, turbulence, or restrictions to smooth flow.

International Civil Aviation Organization (ICAO). The United Nations agency for developing the principles and techniques of international air navigation, and fostering planning and development of international civil air transport.

International standard atmosphere (IAS). A model of standard variation of pressure and temperature.

Inversion illusion. The feeling that the aircraft is tumbling backwards, caused by an abrupt change from climb to straight-and-level flight while in situations lacking visual reference.

Inverter. A solid-state electronic device that converts D.C. into A.C. current of the proper voltage and frequency to operate A.C. gyro instruments.

Isogonic lines. Lines drawn across aeronautical charts to connect points having the same magnetic variation.

IVSI. See instantaneous vertical speed indicator.

Jet route. A route designated to serve flight operations from 18,000 feet MSL up to and including FL 450.

Jet stream. A high-velocity narrow stream of winds, usually found near the upper limit of the troposphere, which flows generally from west to east.

KIAS. Knots indicated airspeed.

Kollsman window. A barometric scale window of a sensitive altimeter used to adjust the altitude for the altimeter setting.

LAAS. See local area augmentation system.

Lag. The delay that occurs before an instrument needle attains a stable indication.

Land as soon as possible. ATC instruction to pilot. Land without delay at the nearest suitable area, such as an open field, at which a safe approach and landing is assured.

Land as soon as practical. ATC instruction to pilot. The landing site and duration of flight are at the discretion of the pilot. Extended flight beyond the nearest approved landing area is not recommended.

Land immediately. ATC instruction to pilot. The urgency of the landing is paramount. The primary consideration is to ensure the survival of the occupants. Landing in trees, water, or other unsafe areas should be considered only as a last resort.

LDA. See localizer-type directional aid.

Lead radial. The radial at which the turn from the DME arc to the inbound course is started.

Leans, the. A physical sensation caused by an abrupt correction of a banked attitude entered too slowly to stimulate the motion sensing system in the inner ear. The abrupt correction can create the illusion of banking in the opposite direction.

Lift. A component of the total aerodynamic force on an airfoil and acts perpendicular to the relative wind.

Lines of flux. Invisible lines of magnetic force passing between the poles of a magnet.

L/MF. See low or medium frequency.

LMM. See locator middle marker.

Load factor. The ratio of a specified load to the total weight of the aircraft. The specified load is expressed in terms of any of the following: aerodynamic forces, inertial forces, or ground or water reactions.

Loadmeter. A type of ammeter installed between the generator output and the main bus in an aircraft electrical system.

LOC. See localizer.

Local area augmentation system (LAAS). A differential global positioning system (DGPS) that improves the accuracy of the system by determining position error from the GPS satellites, then transmitting the error, or corrective factors, to the airborne GPS receiver.

Localizer (LOC). The portion of an ILS that gives left/right guidance information down the centerline of the instrument runway for final approach.

Localizer-type directional aid (LDA). A NAVAID used for nonprecision instrument approaches with utility and accuracy comparable to a localizer but which is not a part of a complete ILS and is not aligned with the runway. Some LDAs are equipped with a glide slope.

Locator middle marker (LMM). Nondirectional radio beacon (NDB) compass locator, collocated with a middle marker (MM).

Locator outer marker (LOM). NDB compass locator, collocated with an outer marker (OM).

LOM. See locator outer marker.

Long range navigation (LORAN). An electronic navigational system by which hyperbolic lines of position are determined by measuring the difference in the time of reception of synchronized pulse signals from two fixed transmitters. LORAN A operates in the 1750 to 1950 kHz frequency band. LORAN C and D operate in the 100 to 110 kHz frequency band.

LORAN. See long range navigation.

Low or medium frequency. A frequency range between 190–535 kHz with the medium frequency above 300 kHz. Generally associated with nondirectional beacons transmitting a continuous carrier with either a 400 or 1,020 Hz modulation.

Lubber line. The reference line used in a magnetic compass or heading indicator.

MAA. See maximum authorized altitude.

Mach number. The ratio of the true airspeed of the aircraft to the speed of sound in the same atmospheric conditions, named in honor of Ernst Mach, late 19th century physicist.

Mach meter. The instrument that displays the ratio of the speed of sound to the true airspeed an aircraft is flying.

Magnetic bearing (MB). The direction to or from a radio transmitting station measured relative to magnetic north.

Magnetic heading (MH). The direction an aircraft is pointed with respect to magnetic north.

Mandatory altitude. An altitude depicted on an instrument approach chart with the altitude value both underscored and overscored. Aircraft are required to maintain altitude at the depicted value.

Mandatory block altitude. An altitude depicted on an instrument approach chart with two underscored and overscored altitude values between which aircraft are required to maintain altitude.

MAP. See missed approach point.

Margin identification. The top and bottom areas on an instrument approach chart that depict information about the procedure, including airport location and procedure identification.

Marker beacon. A low-powered transmitter that directs its signal upward in a small, fan-shaped pattern. Used along the flight path when approaching an airport for landing, marker beacons indicate both aurally and visually when the aircraft is directly over the facility.

Maximum altitude. An altitude depicted on an instrument approach chart with overscored altitude value at which or below aircraft are required to maintain altitude.

Maximum authorized altitude (MAA). A published altitude representing the maximum usable altitude or flight level for an airspace structure or route segment.

MB. See magnetic bearing.

MCA. See minimum crossing altitude.

MDA. See minimum descent altitude.

MEA. See minimum en route altitude.

Mean sea level. The average height of the surface of the sea at a particular location for all stages of the tide over a 19-year period.

MFD. See multi-function display.

MH. See magnetic heading.

MHz. Megahertz.

Microwave landing system (MLS). A precision instrument approach system operating in the microwave spectrum which normally consists of an azimuth station, elevation station, and precision distance measuring equipment.

Mileage breakdown. A fix indicating a course change that appears on the chart as an "x" at a break between two segments of a federal airway.

Military operations area (MOA). Airspace established for the purpose of separating certain military training activities from IFR traffic.

Military training route (MTR). Airspace of defined vertical and lateral dimensions established for the conduct of military training at airspeeds in excess of 250 knots indicated airspeed (KIAS).

Minimum altitude. An altitude depicted on an instrument approach chart with the altitude value underscored. Aircraft are required to maintain altitude at or above the depicted value.

Minimum crossing altitude (MCA). The lowest allowed altitude at certain fixes an aircraft must cross when proceeding in the direction of a higher minimum en route altitude (MEA).

Minimum descent altitude (MDA). The lowest altitude (in feet MSL) to which descent is authorized on final approach, or during circle-to-land maneuvering in execution of a nonprecision approach.

Minimum en route altitude (MEA). The lowest published altitude between radio fixes that ensures acceptable navigational signal coverage and meets obstacle clearance requirements between those fixes.

Minimum obstruction clearance altitude (MOCA). The lowest published altitude in effect between radio fixes on VOR airways, off-airway routes, or route segments, which meets obstacle clearance requirements for the entire route segment and which ensures acceptable navigational signal coverage only within 25 statute (22 nautical) miles of a VOR.

Minimum reception altitude (MRA). The lowest altitude at which an airway intersection can be determined.

Minimum safe altitude (MSA). The minimum altitude depicted on approach charts which provides at least 1,000 feet of obstacle clearance for emergency use within a specified distance from the listed navigation facility.

Minimum vectoring altitude (MVA). An IFR altitude lower than the minimum en route altitude (MEA) that provides terrain and obstacle clearance.

Minimums section. The area on an IAP chart that displays the lowest altitude and visibility requirements for the approach.

Missed approach. A maneuver conducted by a pilot when an instrument approach cannot be completed to a landing.

Missed approach point (MAP). A point prescribed in each instrument approach at which a missed approach procedure shall be executed if the required visual reference has not been established.

Mixed ice. A mixture of clear ice and rime ice.

MLS. See microwave landing system.

MM. Middle marker.

MOA. See military operations area.

MOCA. See minimum obstruction clearance altitude.

Mode C. Altitude reporting transponder mode.

MRA. See minimum reception altitude.

MSA. See minimum safe altitude.

MSL. See mean sea level.

MTR. See military training route.

Multi-function display (MFD). Small screen (CRT or LCD) in an aircraft that can be used to display information to the pilot in numerous configurable ways. Often an MFD will be used in concert with a Primary Flight Display.

MVA. See minimum vectoring altitude.

NACG. See National Aeronautical Charting Group.

NAS. See National Airspace System.

National Airspace System (NAS). The common network of United States airspace—air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information; and manpower and material.

National Aeronautical Charting Group (NACG). A Federal agency operating under the FAA, responsible for publishing charts such as the terminal procedures and en route charts.

National Route Program (NRP). A set of rules and procedures designed to increase the flexibility of user flight planning within published guidelines.

National Security Area (NSA). Areas consisting of airspace of defined vertical and lateral dimensions established at locations where there is a requirement for increased security and safety of ground facilities. Pilots are requested to voluntarily avoid flying through the depicted NSA. When it is necessary to provide a greater level of security and safety, flight in NSAs may be temporarily prohibited. Regulatory prohibitions are disseminated via NOTAMs.

National Transportation Safety Board (NTSB). A United States Government independent organization responsible for investigations of accidents involving aviation, highways, waterways, pipelines, and railroads in the United States. NTSB is charged by congress to investigate every civil aviation accident in the United States.

NAVAID. Naviagtional aid.

NAV/COM. Navigation and communication radio.

NDB. See nondirectional radio beacon.

NM. Nautical mile.

NOAA. National Oceanic and Atmospheric Administration.

No-gyro approach. A radar approach that may be used in case of a malfunctioning gyro-compass or directional gyro. Instead of providing the pilot with headings to be flown, the controller observes the radar track and issues control instructions "turn right/left" or "stop turn," as appropriate.

Nondirectional radio beacon (NDB). A ground-based radio transmitter that transmits radio energy in all directions.

Nonprecision approach. A standard instrument approach procedure in which only horizontal guidance is provided.

No procedure turn (NoPT). Term used with the appropriate course and altitude to denote that the procedure turn is not required.

NoPT. See no procedure turn.

Notice to Airmen (NOTAM). A notice filed with an aviation authority to alert aircraft pilots of any hazards en route or at a specific location. The authority in turn provides means of disseminating relevant NOTAMs to pilots.

NRP. See National Route Program.

NSA. See National Security Area.

NTSB. See National Transportation Safety Board.

NWS. National Weather Service.

Obstacle departure procedures (ODP). Obstacle clearance protection provided to aircraft in instrument meteorological conditions (IMC).

ODP. See obstacle departure procedures.

OM. Outer marker.

Omission error. The failure to anticipate significant instrument indications following attitude changes; for example, concentrating on pitch control while forgetting about heading or roll information, resulting in erratic control of heading and bank.

Optical illusion. A misleading visual image. For the purpose of this handbook, the term refers to the brain's misinterpretation of features on the ground associated with landing, which causes a pilot to misread the spatial relationships between the aircraft and the runway.

Orientation. Awareness of the position of the aircraft and of oneself in relation to a specific reference point.

Otolith organ. An inner ear organ that detects linear acceleration and gravity orientation.

Outer marker. A marker beacon at or near the glide slope intercept altitude of an ILS approach. It is normally located four to seven miles from the runway threshold on the extended centerline of the runway.

Overcontrolling. Using more movement in the control column than is necessary to achieve the desired pitch-and bank condition.

Overpower. To use more power than required for the purpose of achieving a faster rate of airspeed change.

P-static. See precipitation static.

PAPI. See precision approach path indicator.

PAR. See precision approach radar.

Parasite drag. Drag caused by the friction of air moving over the aircraft structure; its amount varies directly with the airspeed.

PFD. See primary flight display.

PIC. See pilot-in-command.

Pilot-in-command (PIC). The pilot responsible for the operation and safety of an aircraft.

Pilot report (PIREP). Report of meteorological phenomena encountered by aircraft.

Pilot's Operating Handbook/Airplane Flight Manual (POH/AFM). FAA-approved documents published by the airframe manufacturer that list the operating conditions for a particular model of aircraft.

PIREP. See pilot report.

Pitot pressure. Ram air pressure used to measure airspeed.

Pitot-static head. A combination pickup used to sample pitot pressure and static air pressure.

Plan view. The overhead view of an approach procedure on an instrument approach chart. The plan view depicts the routes that guide the pilot from the en route segments to the IAF.

POH/AFM. See Pilot's Operating Handbook/Airplane Flight Manual.

Point-in-space approach. A type of helicopter instrument approach procedure to a missed approach point more than 2,600 feet from an associated helicopter landing area.

Position error. Error in the indication of the altimeter, ASI, and VSI caused by the air at the static system entrance not being absolutely still.

Position report. A report over a known location as transmitted by an aircraft to ATC.

Precession. The characteristic of a gyroscope that causes an applied force to be felt, not at the point of application, but 90° from that point in the direction of rotation.

Precipitation static (P-static). A form of radio interference caused by rain, snow, or dust particles hitting the antenna and inducing a small radio-frequency voltage into it.

Precision approach. A standard instrument approach procedure in which both vertical and horizontal guidance is provided.

Precision approach path indicator (PAPI). A system of lights similar to the VASI, but consisting of one row of lights in two- or four-light systems. A pilot on the correct glide slope will see two white lights and two red lights. See VASI.

Precision approach radar (PAR). A type of radar used at an airport to guide an aircraft through the final stages of landing, providing horizontal and vertical guidance. The radar operator directs the pilot to change heading or adjust the descent rate to keep the aircraft on a path that allows it to touch down at the correct spot on the runway.

Precision runway monitor (PRM). System allows simultaneous, independent Instrument Flight Rules (IFR) approaches at airports with closely spaced parallel runways.

Preferred IFR routes. Routes established in the major terminal and en route environments to increase system efficiency and capacity. IFR clearances are issued based on these routes, listed in the A/FD except when severe weather avoidance procedures or other factors dictate otherwise.

Pressure altitude. Altitude above the standard 29.92" Hg plane.

Prevailing visibility. The greatest horizontal visibility equaled or exceeded throughout at least half the horizon circle (which is not necessarily continuous).

Primary and supporting. A method of attitude instrument flying using the instrument that provides the most direct indication of attitude and performance.

Primary flight display (PFD). A display that provides increased situational awareness to the pilot by replacing the traditional six instruments used for instrument flight with an easy-to-scan display that provides the horizon, airspeed, altitude, vertical speed, trend, trim, rate of turn among other key relevant indications.

PRM. See precision runway monitor.

Procedure turn. A maneuver prescribed when it is necessary to reverse direction to establish an aircraft on the intermediate approach segment or final approach course.

Profile view. Side view of an IAP chart illustrating the vertical approach path altitudes, headings, distances, and fixes.

Prohibited area. Designated airspace within which flight of aircraft is prohibited.

Propeller/rotor modulation error. Certain propeller RPM settings or helicopter rotor speeds can cause the VOR course deviation indicator (CDI) to fluctuate as much as ±6°. Slight changes to the RPM setting will normally smooth out this roughness.

Rabbit, the. High-intensity flasher system installed at many large airports. The flashers consist of a series of brilliant blue-white bursts of light flashing in sequence along the approach lights, giving the effect of a ball of light traveling towards the runway.

Radar. Radio Detection And Ranging.

Radar approach. The controller provides vectors while monitoring the progress of the flight with radar, guiding the pilot through the descent to the airport/heliport or to a specific runway.

Radials. The courses oriented from a station.

Radio or radar altimeter. An electronic altimeter that determines the height of an aircraft above the terrain by measuring the time needed for a pulse of radio-frequency energy to travel from the aircraft to the ground and return.

Radio frequency (RF). A term that refers to alternating current (AC) having characteristics such that, if the current is input to antenna, an electromagnetic (EM) field is generated suitable for wireless broadcasting and/or communications.

Radio magnetic indicator (RMI). An electronic navigation instrument that combines a magnetic compass with an ADF or VOR. The card of the RMI acts as a gyro-stabilized magnetic compass, and shows the magnetic heading the aircraft is flying.

Radio wave. An electromagnetic wave (EM wave) with frequency characteristics useful for radio transmission.

RAIM. See receiver autonomous integrity monitoring.

Random RNAV routes. Direct routes, based on area navigation capability, between waypoints defined in terms of latitude/longitude coordinates, degree-distance fixes, or offsets from established routes/airways at a specified distance and direction.

Ranging signals. Transmitted from the GPS satellite, these allow the aircraft's receiver to determine range (distance) from each satellite.

RB. See relative bearing.
RBI. See relative bearing indicator.

RCO. See remote communications outlet.

Receiver autonomous integrity monitoring (RAIM). A system used to verify the usability of the received GPS signals and warns the pilot of any malfunction in the navigation system. This system is required for IFR-certified GPS units.

Recommended altitude. An altitude depicted on an instrument approach chart with the altitude value neither underscored nor overscored. The depicted value is an advisory value.

Receiver-transmitter (RT). A system that receives and transmits a signal and an indicator.

Reduced vertical separation minimum (RVSM). Reduces the vertical separation between flight level (FL) 290–410 from 2,000 feet to 1,000 feet and makes six additional FLs available for operation. Also see DRVSM.

Reference circle (also, distance circle). The circle depicted in the plan view of an IAP chart that typically has a 10 NM radius, within which chart the elements are drawn to scale.

Regions of command. The "regions of normal and reversed command" refers to the relationship between speed and the power required to maintain or change that speed in flight.

REIL. See runway end identifier lights.

Relative bearing (RB). The angular difference between the aircraft heading and the direction to the station, measured clockwise from the nose of the aircraft.

Relative bearing indicator (RBI). Also known as the fixed-card ADF, zero is always indicated at the top of the instrument and the needle indicates the relative bearing to the station.

Relative wind. Direction of the airflow produced by an object moving through the air. The relative wind for an airplane in flight flows in a direction parallel with and opposite to the direction of flight; therefore, the actual flight path of the airplane determines the direction of the relative wind.

Remote communications outlet (RCO). An unmanned communications facility that is remotely controlled by air traffic personnel.

Required navigation performance (RNP). A specified level of accuracy defined by a lateral area of confined airspace in which an RNP-certified aircraft operates.

Restricted area. Airspace designated under 14 CFR part 73 within which the flight of aircraft, while not wholly prohibited, is subject to restriction.

Reverse sensing. The VOR needle appearing to indicate the reverse of normal operation.

RF. Radio frequency.

Rhodopsin. The photosensitive pigments that initiate the visual response in the rods of the eye.

Rigidity. The characteristic of a gyroscope that prevents its axis of rotation tilting as the Earth rotates.

Rime ice. Rough, milky, opaque ice formed by the instantaneous freezing of small supercooled water droplets.

Risk. The future impact of a hazard that is not eliminated or controlled.

RMI. See radio magnetic indicator.

RNAV. See area navigation.

RNP. See required navigation performance.

Runway end identifier lights (REIL). A pair of synchronized flashing lights, located laterally on each side of the runway threshold, providing rapid and positive identification of the approach end of a runway.

Runway visibility value (RVV). The visibility determined for a particular runway by a transmissometer.

Runway visual range (RVR). The instrumentally derived horizontal distance a pilot should be able to see down the runway from the approach end, based on either the sighting of high-intensity runway lights, or the visual contrast of other objects.

RVR. See runway visual range.

RVV. See runway visibility value.

SA. See selective availability.

St. Elmo's Fire. A corona discharge which lights up the aircraft surface areas where maximum static discharge occurs.

Satellite ephemeris data. Data broadcast by the GPS satellite containing very accurate orbital data for that satellite, atmospheric propagation data, and satellite clock error data.

Scan. The first fundamental skill of instrument flight, also known as "cross-check;" the continuous and logical observation of instruments for attitude and performance information.

SDF. See simplified directional facility.

Selective availability (SA). A satellite technology permitting the Department of Defense (DOD) to create, in the interest of national security, a significant clock and ephemeris error in the satellites, resulting in a navigation error.

Semicircular canal. An inner ear organ that detects angular acceleration of the body.

Sensitive altimeter. A form of multipointer pneumatic altimeter with an adjustable barometric scale that allows the reference pressure to be set to any desired level.

SIDS. See standard instrument departure procedures.

SIGMET. The acronym for Significant Meteorological information. A weather advisory issued concerning weather significant to the safety of all aircraft.

Signal-to-noise ratio. An indication of signal strength received compared to background noise, which is a measure of how adequate the received signal is.

Simplex. Transmission and reception on the same frequency.

Simplified directional facility (SDF). A NAVAID used for nonprecision instrument approaches. The final approach course is similar to that of an ILS localizer; however, the SDF course may be offset from the runway, generally not more than 3°, and the course may be wider than the localizer, resulting in a lower degree of accuracy.

Single-pilot resource management (SRM). The ability for crew or pilot to manage all resources effectively to ensure the outcome of the flight is successful.

Situational awareness. Pilot knowledge of where the aircraft is in regard to location, air traffic control, weather, regulations, aircraft status, and other factors that may affect flight.

Skidding turn. An uncoordinated turn in which the rate of turn is too great for the angle of bank, pulling the aircraft to the outside of the turn.

Skin friction drag. Drag generated between air molecules and the solid surface of the aircraft.

Slant range. The horizontal distance from the aircraft antenna to the ground station, due to line-of-sight transmission of the DME signal.

Slaved compass. A system whereby the heading gyro is "slaved to," or continuously corrected to bring its direction readings into agreement with a remotely located magnetic direction sensing device (usually this is a flux valve or flux gate compass).

Slipping turn. An uncoordinated turn in which the aircraft is banked too much for the rate of turn, so the horizontal lift component is greater than the centrifugal force, pulling the aircraft toward the inside of the turn.

Small airplane. An airplane of 12,500 pounds or less maximum certificated takeoff weight.

Somatogravic illusion. The misperception of being in a nose-up or nose-down attitude, caused by a rapid acceleration or deceleration while in flight situations that lack visual reference.

Spatial disorientation. The state of confusion due to misleading information being sent to the brain from various sensory organs, resulting in a lack of awareness of the aircraft position in relation to a specific reference point.

Special use airspace. Airspace in which flight activities are subject to restrictions that can create limitations on the mixed use of airspace. Consists of prohibited, restricted, warning, military operations, and alert areas.

SRM. See single-pilot resource management.

SSR. See secondary surveillance radar.

SSV. See standard service volume.

Standard holding pattern. A holding pattern in which all turns are made to the right.

Standard instrument departure procedures (SIDS). Published procedures to expedite clearance delivery and to facilitate transition between takeoff and en route operations.

Standard rate turn. A turn in which an aircraft changes its direction at a rate of 3° per second (360° in 2 minutes) for low- or medium-speed aircraft. For high-speed aircraft, the standard rate turn is 1-1/2° per second (360° in 4 minutes).

Standard service volume (SSV). Defines the limits of the volume of airspace which the VOR serves.

Standard terminal arrival route (STAR). A preplanned IFR ATC arrival procedure published for pilot use in graphic and/or textual form.

STAR. See standard terminal arrival route.

Static longitudinal stability. The aerodynamic pitching moments required to return the aircraft to the equilibrium angle of attack.

Static pressure. Pressure of air that is still, or not moving, measured perpendicular to the surface of the aircraft.

Steep turns. In instrument flight, any turn greater than standard rate; in visual flight, anything greater than a 45° bank.

Stepdown fix. The point after which additional descent is permitted within a segment of an IAP.

Strapdown system. An INS in which the accelerometers and gyros are permanently "strapped down" or aligned with the three axes of the aircraft.

Stress. The body's response to demands placed upon it.

Structural icing. The accumulation of ice on the exterior of the aircraft.

Suction relief valve. A relief valve in an instrument vacuum system required to maintain the correct low pressure inside the instrument case for the proper operation of the gyros.

Synchro. A device used to transmit indications of angular movement or position from one location to another.

Synthetic vision. A realistic display depiction of the aircraft in relation to terrain and flight path.

TAA. See terminal arrival area.

TACAN. See tactical air navigation.

Tactical air navigation (TACAN). An electronic navigation system used by military aircraft, providing both distance and direction information.

TAWS. See terrain awareness and warning system.

TCAS. See traffic alert collision avoidance system.

TCH. See threshold crossing height.

TDZE. See touchdown zone elevation.

TEC. See Tower En Route Control.

Technique. The manner in which procedures are executed.

Temporary flight restriction (TFR). Restriction to flight imposed in order to:

1. Protect persons and property in the air or on the surface from an existing or imminent flight associated hazard;
2. Provide a safe environment for the operation of disaster relief aircraft;
3. Prevent an unsafe congestion of sightseeing aircraft above an incident;
4. Protect the President, Vice President, or other public figures; and,
5. Provide a safe environment for space agency operations.

Pilots are expected to check appropriate NOTAMs during flight planning when conducting flight in an area where a temporary flight restriction is in effect.

Tension. Maintaining an excessively strong grip on the control column, usually resulting in an overcontrolled situation.

Terminal Instrument Approach Procedure (TERP). Prescribes standardized methods for use in designing instrument flight procedures.

Terminal arrival area (TAA). A procedure to provide a new transition method for arriving aircraft equipped with FMS and/or GPS navigational equipment. The TAA contains a "T" structure that normally provides a NoPT for aircraft using the approach.

TERP. See terminal instrument approach procedure.

Terrain Awareness and Warning System (TAWS). A timed-based system that provides information concerning potential hazards with fixed objects by using GPS positioning and a database of terrain and obstructions to provide true predictability of the upcoming terrain and obstacles.

TFR. See temporary flight restriction.

Threshold crossing height (TCH). The theoretical height above the runway threshold at which the aircraft's glide slope antenna would be if the aircraft maintains the trajectory established by the mean ILS glide slope or MLS glide path.

Thrust (aerodynamic force). The forward aerodynamic force produced by a propeller, fan, or turbojet engine as it forces a mass of air to the rear, behind the aircraft.

Time and speed table. A table depicted on an instrument approach procedure chart that identifies the distance from the FAF to the MAP, and provides the time required to transit that distance based on various groundspeeds.

Timed turn. A turn in which the clock and the turn coordinator are used to change heading a definite number of degrees in a given time.

TIS. See traffic information service.

Title 14 of the Code of Federal Regulations (14 CFR). The federal aviation regulations governing the operation of aircraft, airways, and airmen.

Touchdown zone elevation (TDZE). The highest elevation in the first 3,000 feet of the landing surface, TDZE is indicated on the instrument approach procedure chart when straight-in landing minimums are authorized.

Tower En Route Control (TEC). The control of IFR en route traffic within delegated airspace between two or more adjacent approach control facilities, designed to expedite traffic and reduce control and pilot communication requirements.

TPP. See United States Terminal Procedures Publication.

Tracking. Flying a heading that will maintain the desired track to or from the station regardless of crosswind conditions.

Traffic Alert Collision Avoidance System (TCAS). An airborne system developed by the FAA that operates independently from the ground-based Air Traffic Control system. Designed to increase flight deck awareness of proximate aircraft and to serve as a "last line of defense" for the prevention of mid-air collisions.

Traffic information service (TIS). A ground-based service providing information to the flight deck via data link using the S-mode transponder and altitude encoder to improve the safety and efficiency of "see and avoid" flight through an automatic display that informs the pilot of nearby traffic.

Transcribed Weather Broadcast (TWEB). Meteorological and aeronautical data recorded on tapes and broadcast over selected NAVAIDs. Generally, the broadcast contains route-oriented data with specially prepared NWS forecasts, inflight advisories, and winds aloft. It also includes selected current information such as weather reports (METAR/SPECI), NOTAMs, and special notices.

Transponder. The airborne portion of the ATC radar beacon system.

Transponder code. One of 4,096 four-digit discrete codes ATC assigns to distinguish between aircraft.

Trend. Immediate indication of the direction of aircraft movement, as shown on instruments.

Trim. Adjusting the aerodynamic forces on the control surfaces so that the aircraft maintains the set attitude without any control input.

TWEB. See Transcribed Weather Broadcast.

True airspeed. Actual airspeed, determined by applying a correction for pressure altitude and temperature to the CAS.

UHF. See ultra-high frequency.

Ultra-high frequency (UHF). The range of electromagnetic frequencies between 962 MHz and 1213 MHz.

Uncaging. Unlocking the gimbals of a gyroscopic instrument, making it susceptible to damage by abrupt flight maneuvers or rough handling.

Underpower. Using less power than required for the purpose of achieving a faster rate of airspeed change.

United States Terminal Procedures Publication (TPP). Booklets published in regional format by the NACO that include DPs, STARs, IAPs, and other information pertinent to IFR flight.

Unusual attitude. An unintentional, unanticipated, or extreme aircraft attitude.

User-defined waypoints. Waypoint location and other data which may be input by the user, this is the only GPS database information that may be altered (edited) by the user.

Variation. Compass error caused by the difference in the physical locations of the magnetic north pole and the geographic north pole.

VASI. See visual approach slope indicator.

VDP. See visual descent point.

Vectoring. Navigational guidance by assigning headings.

Venturi tube. A specially shaped tube attached to the outside of an aircraft to produce suction to allow proper operation of gyro instruments.

Vertical speed indicator (VSI). A rate-of-pressure change instrument that gives an indication of any deviation from a constant pressure level.

Very-high frequency (VHF). A band of radio frequencies falling between 30 and 300 MHz.

Very-high frequency omnidirectional range (VOR). Electronic navigation equipment in which the flight deck instrument identifies the radial or line from the VOR station, measured in degrees clockwise from magnetic north, along which the aircraft is located.

Vestibule. The central cavity of the bony labyrinth of the ear, or the parts of the membranous labyrinth that it contains.

VFR. See visual flight rules.

VFR-on-top. ATC authorization for an IFR aircraft to operate in VFR conditions at any appropriate VFR altitude.

VFR over-the-top. A VFR operation in which an aircraft operates in VFR conditions on top of an undercast.

Victor airways. Airways based on a centerline that extends from one VOR or VORTAC navigation aid or intersection, to another navigation aid (or through several navigation aids or intersections); used to establish a known route for en route procedures between terminal areas.

Visual approach slope indicator (VASI). A visual aid of lights arranged to provide descent guidance information during the approach to the runway. A pilot on the correct glide slope will see red lights over white lights.

Visual descent point (VDP). A defined point on the final approach course of a nonprecision straight-in approach procedure from which normal descent from the MDA to the runway touchdown point may be commenced, provided the runway environment is clearly visible to the pilot.

Visual flight rules (VFR). Flight rules adopted by the FAA governing aircraft flight using visual references. VFR operations specify the amount of ceiling and the visibility the pilot must have in order to operate according to these rules. When the weather conditions are such that the pilot can not operate according to VFR, he or she must use instrument flight rules (IFR).

Visual meteorological conditions (VMC). Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling meeting or exceeding the minimums specified for VFR.

VMC. See visual meteorological conditions.

VOR. See very-high frequency omnidirectional range.

VORTAC. A facility consisting of two components, VOR and TACAN, which provides three individual services: VOR azimuth, TACAN azimuth, and TACAN distance (DME) at one site.

VOR test facility (VOT). A ground facility which emits a test signal to check VOR receiver accuracy. Some VOTs are available to the user while airborne, while others are limited to ground use only.

VOT. See VOR test facility.

VSI. See vertical speed indicator.

WAAS. See wide area augmentation system.

Warning area. An area containing hazards to any aircraft not participating in the activities being conducted in the area. Warning areas may contain intensive military training, gunnery exercises, or special weapons testing.

Waypoint. A designated geographical location used for route definition or progress-reporting purposes and is defined in terms of latitude/longitude coordinates.

WCA. See wind correction angle.

Weather and radar processor (WARP). A device that provides real-time, accurate, predictive and strategic weather information presented in an integrated manner in the National Airspace System (NAS).

Weight. The force exerted by an aircraft from the pull of gravity.

Wide area augmentation system (WAAS). A differential global positioning system (DGPS) that improves the accuracy of the system by determining position error from the GPS satellites, then transmitting the error, or corrective factors, to the airborne GPS receiver.

Wind correction angle (WCA). The angle between the desired track and the heading of the aircraft necessary to keep the aircraft tracking over the desired track.

Work. A measurement of force used to produce movement.

Zone of confusion. Volume of space above the station where a lack of adequate navigation signal directly above the VOR station causes the needle to deviate.

Index

A

M

N

O

P

R

S

T

U

V

W

Z