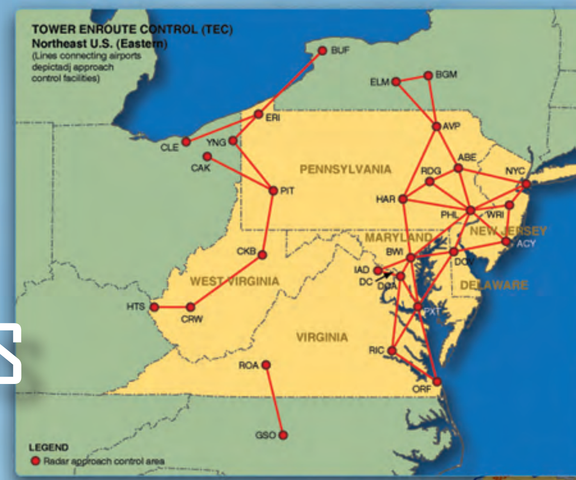
Chapter 2

En Route Operations



Introduction

The en route phase of flight is defined as that segment of flight from the termination point of a departure procedure to the origination point of an arrival procedure. The procedures employed in the en route phase of flight are governed by a set of specific flight standards established by 14 CFR [Figure 2-1], FAA Order 8260.3, and related publications. These standards establish courses to be flown, obstacle clearance criteria, minimum altitudes, navigation performance, and communications requirements.

Figure 2-1. Code of Federal Regulations, Title 14 Aeronautics and Space.

En Route Navigation

En route instrument flight rules (IFR) navigation is evolving from the ground-based navigational aid (NAVAID) airway system to a sophisticated satellite and computer-based system that can generate courses to suit the operational requirements of almost any flight. The FAA Global Navigation Satellite System (GNSS) provides satellite-based positioning, navigation, and timing services in the United States to enable performance-based operations for all phases of flight, to include en route navigation.

14 CFR Part 91, § 91.181, is the basis for the course to be flown. Unless authorized by ATC, to operate an aircraft within controlled airspace under IFR, pilots must either fly along the centerline when on a Federal airway or, on routes other than Federal airways, along the direct course between NAVAIDs or fixes defining the route. The regulation allows maneuvering to pass well clear of other air traffic or, if in visual meteorogical conditions (VMC), to clear the flightpath both before and during climb or descent.

Airways

Airway routing occurs along pre-defined pathways called airways. [Figure 2-2] Airways can be thought of as three-dimensional highways for aircraft. In most land areas of the world, aircraft are required to fly airways between the departure and destination airports. The rules governing airway routing, Standard Instrument Departures (SID) and Standard Terminal Arrival (STAR), are published flight procedures that cover altitude, airspeed, and requirements for entering and leaving the airway. Most airways are eight nautical miles (14 kilometers) wide, and the airway flight levels keep aircraft separated by at least 500 vertical feet from aircraft on the flight level above and below when operating under VFR. When operating under IFR, between the surface and an altitude of Flight Level (FL) 290, no aircraft should come closer vertically than 1,000 feet. Above FL 290, no aircraft should come closer than 2,000 feet except in airspace where Reduced Vertical Separation Minima (RVSM) can be applied in which case the vertical separation is reduced to 1,000 feet. Airways usually intersect at NAVAIDs that designate the allowed points for changing from one airway to another. Airways have names consisting of one or more letters followed by one or more digits (e.g., V484 or UA419).

The en route airspace structure of the National Airspace System (NAS) consists of three strata. The first stratum low

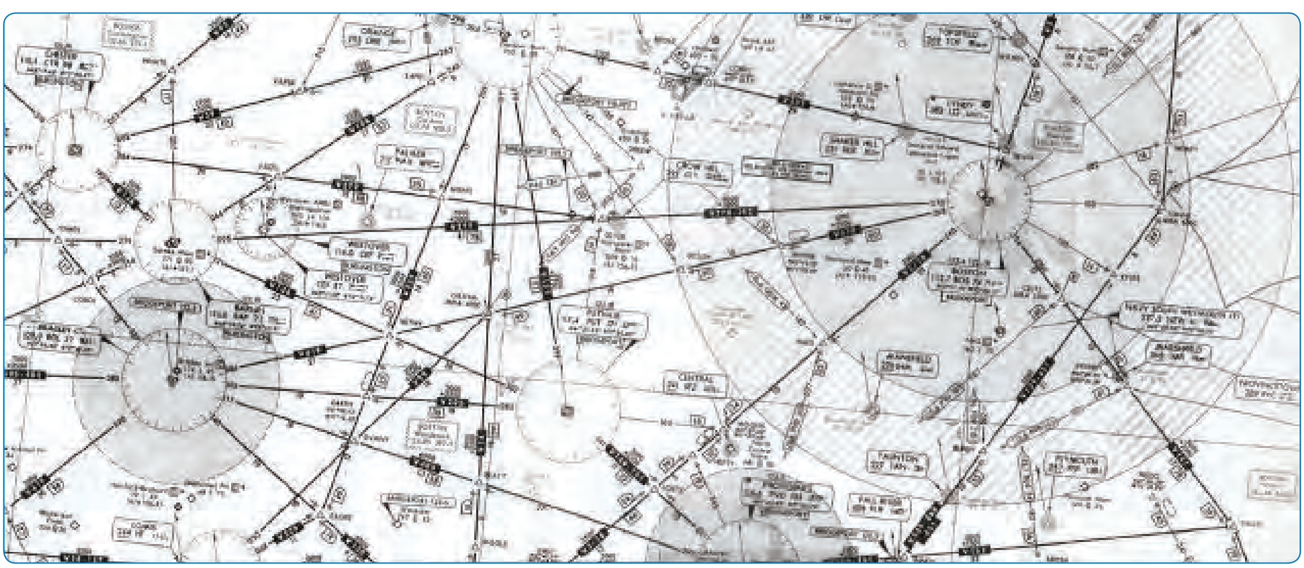


Figure 2-2. Airways depicted on an aeronautical chart.

altitude airways in the United States can be navigated using NAVAIDs, have names that start with the letter V, and are called Victor Airways. [Figure 2-3] They cover altitudes from approximately 1,200 feet above ground level (AGL) up to, but not including 18,000 feet above mean sea level (MSL). The second stratum high altitude airways in the United States all have names that start with the letter J, and are called Jet Routes. [Figure 2-4] These routes run from 18,000 feet to 45,000 feet. The third stratum allows random operations above flight level (FL) 450. The altitude separating the low and high airway structure varies from county to country. For example, in Switzerland it is 19,500 feet and 25,000 feet in Egypt.

Air Route Traffic Control Centers

The FAA defines an Air Route Traffic Control Center (ARTCC) as a facility established to provide air traffic control (ATC) service to aircraft operating on IFR flight plans within controlled airspace, principally during the en route phase of flight. When equipment capabilities and controller workload permit, certain advisory/assistance services may be provided to VFR aircraft.

ARTCCs, usually referred to as Centers, are established primarily to provide air traffic service to aircraft operating on IFR flight plans within the controlled airspace, and principally during the en route phase of flight. There are

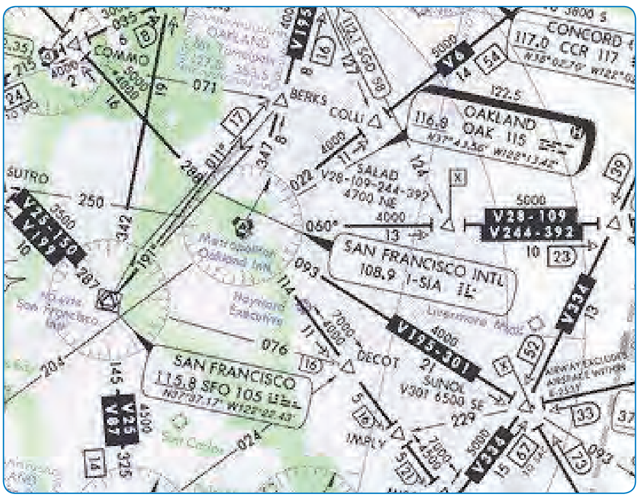


Figure 2-3. Victor airways.

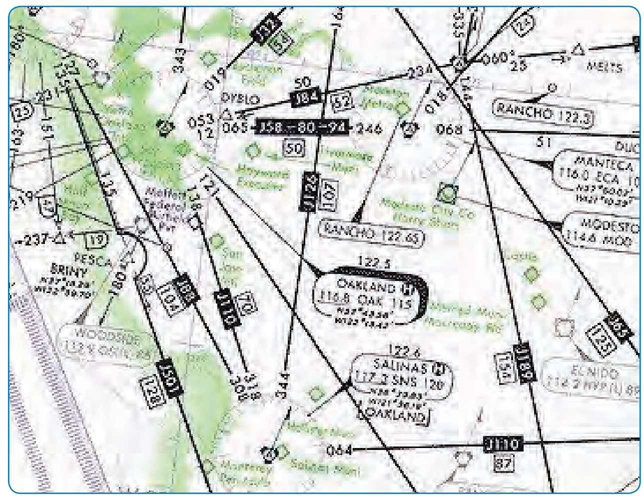


Figure 2-4. Jet routes.

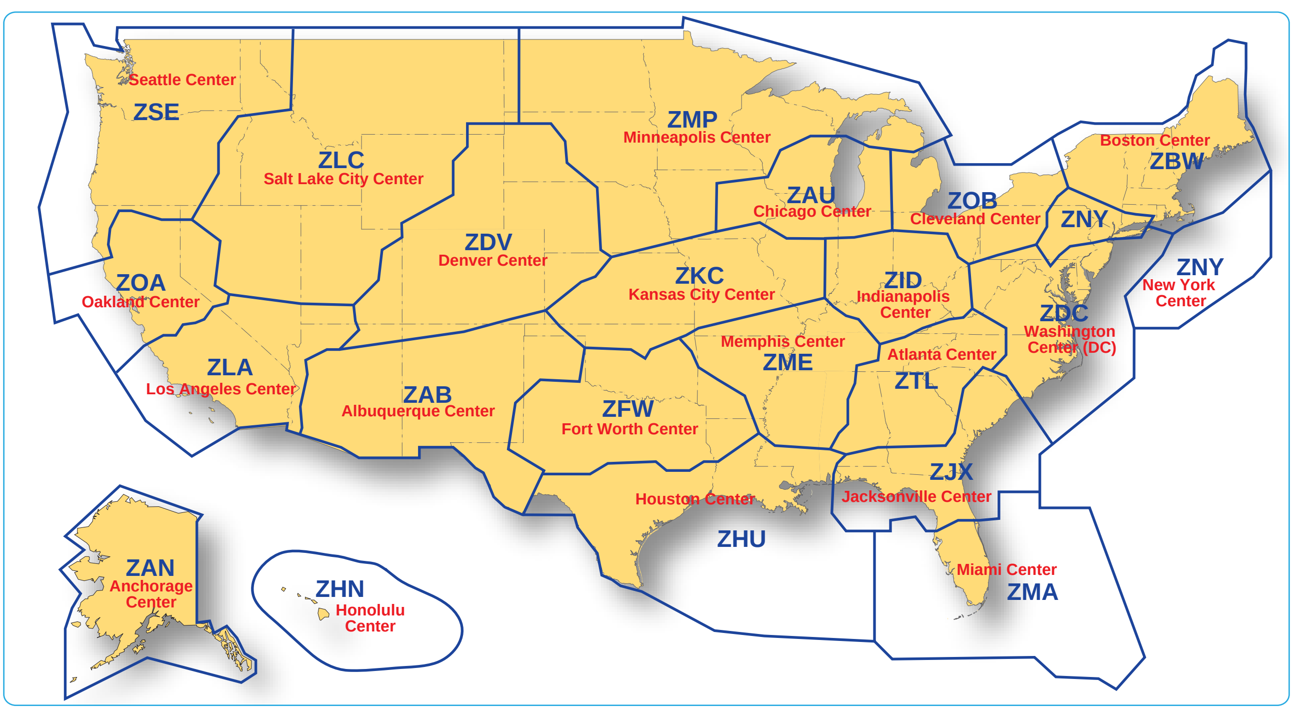


Figure 2-5. Air Route Traffic Control Centers.

21 ARTCC's in the United States. [Figure 2-5] Any aircraft operating under IFR within the confines of an ARTCC's airspace is controlled by air traffic controllers at the Center. This includes all sorts of different types of aircraft: privately owned single engine aircraft, commuter airlines, military jets, and commercial airlines.

The largest component of the NAS is the ARTCC. Each ARTCC covers thousands of square miles encompassing all or part of several states. ARTCCs are built to ensure safe and expeditious air travel. All Centers operate 7-days a week, 24-hours a day, and employ a combination of several hundred ATC specialists, electronic technicians, computer system specialists, environmental support specialists, and administrative staff. Figure 2-6 is an example of the Boston ARTCC. The green lines mark the boundaries of the Boston Center area, and the red lines mark the boundaries of Military Operations Areas (MOAs), Prohibited, Restricted, Alert, and Warning Areas.

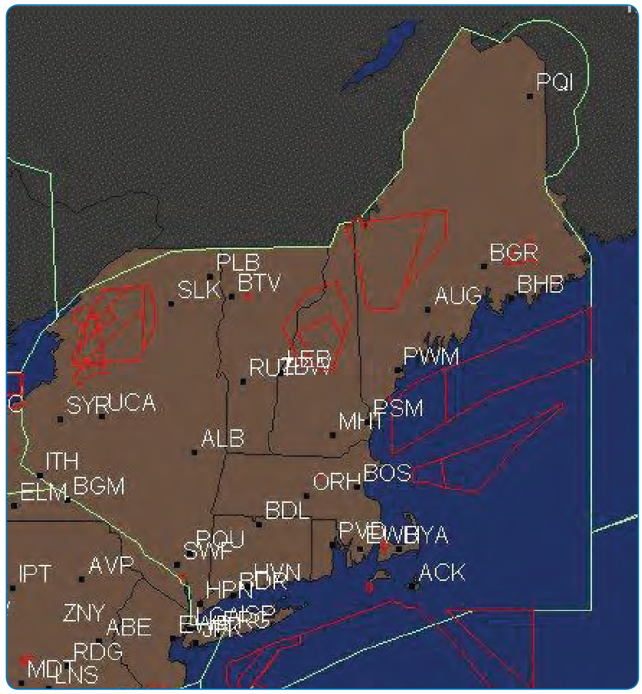


Figure 2-6. Boston Air Route Traffic Control Center.

Safe Separation Standards

The primary means of controlling aircraft is accomplished by using highly sophisticated computerized radar systems. In addition, the controller maintains two-way radio communication with aircraft in his or her sector. In this way, the specialist ensures that the aircraft are separated by the following criteria:

- Laterally—5 miles
- Vertically—
- 1,000 feet (if the aircraft is below FL 290, or between FL 290 and FL 410 for RVSM compliant aircraft)
- 2,000 feet (if the aircraft is at FL 290 or above)

The controllers can accomplish this separation by issuing instructions to the pilots of the aircraft involved. Altitude assignments, speed adjustments, and radar vectors are examples of instructions that might be issued to aircraft.

En route control is handled by pinpointing aircraft positions through the use of flight progress strips. These strips are pieces of printed paper containing pertinent information extracted from the pilot's flight plan. These strips are printed 20 minutes prior to an aircraft reaching each Center's sector. A flight progress strip tells the controller everything needed to direct that aircraft. If the flight progress strips of each aircraft approaching a sector are arranged properly, it is possible to determine potential conflicts long before the aircraft are even visible on the Center controller's display. In areas where radar coverage is not available, this is the sole means of separating aircraft.

The strips, one for each en route point from which the pilot reports his or her position, are posted on a slotted board in front of the air traffic controller. [Figure 2-7] At a glance, he or she is able to see certain vital data: the type of aircraft and who is flying it (airline, business, private, or military pilot), aircraft registration number or flight number, route, speed, altitude, airway designation, and the estimated time of arrival (ETA) at destination. As the pilot calls in the aircraft's position and time at a predetermined location, the strips are removed from their slots and filed. Any change from the original flight plan is noted on the strips as the flight continues. Thus, from a quick study of the flight progress board, a controller can assess the overall traffic situation and can avoid possible conflicts.

Figure 2-7. Flight progress strips.

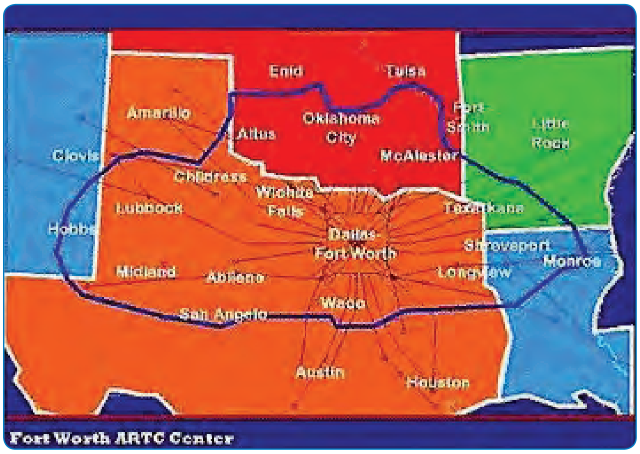


Figure 2-8. Fort Worth Air Route Traffic Control Center.

Figure 2-8 shows the Fort Worth, Texas Air Route Traffic Control Center (ZFW) and the geographical area that it covers. The Center has approximately 350 controllers. Most are certified and some are in on-the-job training.

Sectors

The airspace controlled by a Center may be further administratively subdivided into smaller, manageable pieces of airspace called sectors. A few sectors extend from the ground up, but most areas are stratified into various levels to accommodate a wide variety of traffic. Each sector is staffed by a set of controllers and has a unique radio frequency that the controller uses to communicate with the pilots. As aircraft transition from one sector to another, they are instructed to change to the radio frequency used by the next sector. Each sector also has secure landline communications with adjacent sectors, approach controls, areas, ARTCCs, flight service centers, and military aviation control facilities.

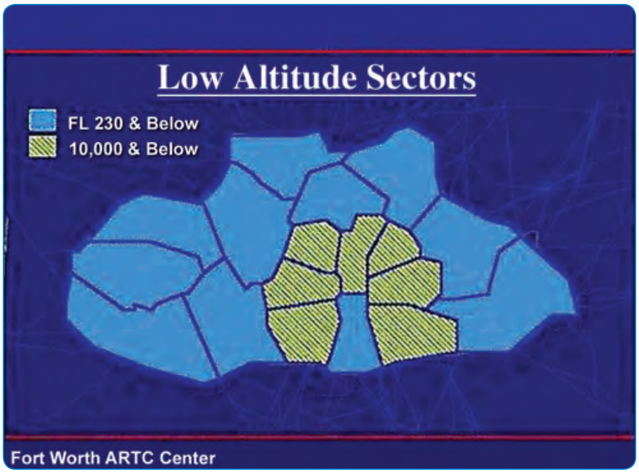


Figure 2-9. Low altitude sectors.

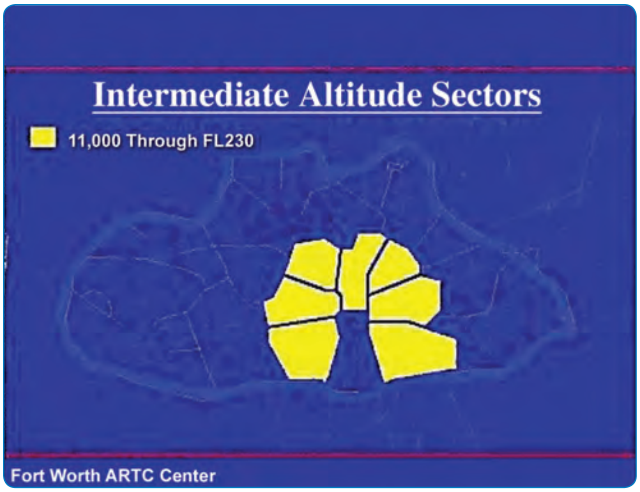


Figure 2-10. Intermediate altitude sectors.

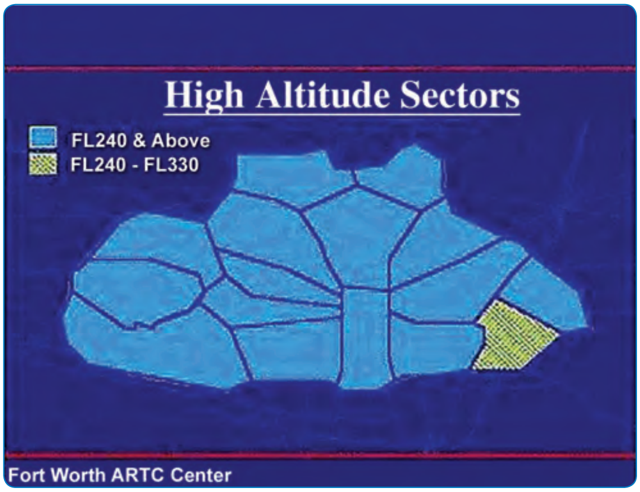


Figure 2-11. High altitude sectors.

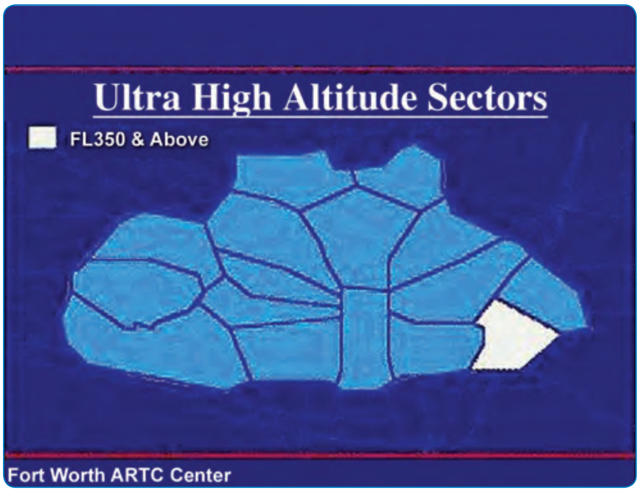


Figure 2-12. Ultra high altitude sectors.

The ARTCC at Fort Worth, Texas is subdivided into sectors that are categorized as follows:

- Eighteen low altitude sectors. [Figure 2-9]
- Seven intermediate altitude sectors. [Figure 2-10]
- Sixteen high altitude sectors. [Figure 2-11]
- One ultra high altitude sector. [Figure 2-12]

From one to three controllers may work a sector, depending upon the amount of air traffic. Each controller is assigned to work the positions within an area of specialization. Controllers have direct communication with pilots, with surrounding sectors and Centers, plus the towers and Flight Service Stations (FSS) under their jurisdiction. Each control position is equipped with computer input and readout devices for aircraft flight plan data.

The Center controllers have many decision support tools (computer software programs) that provide vital information to assist the controllers in maintaining safe separation distances for all aircraft flying through their sector. For example, one tool available allows the controller to display the extended route of any aircraft on the radar screen called a vector line. This line projects where the aircraft will be within a specified number of minutes, assuming the aircraft does not change its course. This is a helpful tool to determine if aircraft flying intersecting routes pass safely within the separation standard, or if they conflict with each other. In addition to vector lines, the controller can also display a route line for any given aircraft on his or her radar screen. This tells the controller where a particular aircraft is in specified number of minutes, as well as the path the aircraft will fly to get there. Decision support tools such as these help each controller look ahead and avoid conflicts.

In-flight Requirements and Instructions

The CFRs require the pilot in command under IFR in controlled airspace to continuously monitor an appropriate Center or control frequency. When climbing after takeoff, an IFR flight is either in contact with a radar-equipped local departure control or, in some areas, an ARTCC facility. As a flight transitions to the en route phase, pilots typically expect a handoff from departure control to a Center frequency if not already in contact with the Center.

The FAA National Aeronautical Information Services publishes en route charts depicting Centers and sector frequencies. [Figure 2-13] During handoff from one Center to another, the previous controller assigns a new frequency. In cases where flights may be out of range, the Center frequencies on the face of the chart are very helpful. In Figure 2-13, notice the boundary between Memphis, Tennessee and Atlanta, Georgia Centers, and the remote sites with discrete very high frequency (VHF) and ultra high frequency (UHF) for communicating with the appropriate

Figure 2-13. Air Route Traffic Control Centers and sector frequencies.

ARTCC. These Center frequency boxes can be used for finding the nearest frequency within the aircraft range. They also can be used for making initial contact with the Center for clearances. The exact location for the Center transmitter is not shown, although the frequency box is placed as close as possible to the known location.

During the en route phase, as a flight transitions from one Center facility to the next, a handoff or transfer of control is required as previously described. The handoff procedure is similar to the handoff between other radar facilities, such as departure or approach control. During the handoff, the controller whose airspace is being vacated issues instructions that include the name of the facility to contact, appropriate frequency, and other pertinent remarks.

Accepting radar vectors from controllers does not relieve pilots of their responsibility for safety of flight. Pilots must maintain a safe altitude and keep track of their position, and it is their obligation to question controllers, request an amended clearance, or, in an emergency, deviate from their instructions if they believe that the safety of flight is in doubt. Keeping track of altitude and position when climbing, and during all other phases of flight, are basic elements of situational awareness (SA). Aircraft equipped with an enhanced ground proximity warning system (EGPWS), terrain awareness and warning system (TAWS), or traffic alert and collision avoidance system (TCAS) help pilots detect and/or correct for potential unsafe proximities to other aircraft and increases pilot(s) situational awareness. Regardless of equipment, pilots must always maintain SA regarding their location and the location of traffic in their vicinity.

High Altitude Area Navigation Routing

Special high altitude routes allow pilots routing options for flight within the initial high altitude routing (HAR) Phase I expansion airspace. Pilots are able to fly user-preferred routes, referred to as non-restrictive routing (NRR), between specific fixes described by pitch (entry into) and catch (exit out of) fixes in the HAR airspace. Pitch points indicate an end of departure procedures, preferred IFR routings, or other established routing programs where a flight can begin a segment of NRR. The catch point indicates where a flight ends a segment of NRR and joins published arrival procedures, preferred IFR routing, or other established routing programs.

The HAR Phase I expansion airspace is defined as that airspace at and above FL 350 in fourteen of the western and southern ARTCCs. The airspace includes Minneapolis (ZMP), Chicago (ZAU), Kansas City (ZKC), Denver (ZDV), Salt Lake City (ZLC), Oakland (ZOA), Seattle Centers (ZSE), Los Angeles (ZLA), Albuquerque (ZAB), Fort Worth (ZFW), Memphis (ZME), and Houston (ZHU). Jacksonville (ZJX) and Miami (ZMA) are included for east-west routes only. To develop a flight plan, select pitch and catch points which can be found in the Chart Supplement (CS) based upon your desired route across the Phase I airspace. Filing requirements to pitch points, and from catch points, remain unchanged from current procedures. For the portion of the route between the pitch and catch points, NRR is permitted. Where pitch points for a specific airport are not identified, aircraft should file an appropriate departure procedure (DP), or any other user preferred routing prior to the NRR portion of their routing. Where catch points for a specific airport are not identified aircraft should file, after the NRR portion of their routing, an appropriate arrival procedure or other user preferred routing to their destination.

Additionally, information concerning the location and schedule of special use airspace (SUA) and Air Traffic Control Assigned Airspace (ATCAA) can be found at http://sua.faa.gov. ATCAA refers to airspace in the high altitude structure supporting military and other special operations. Pilots are encouraged to file around these areas when they are scheduled to be active, thereby avoiding unplanned reroutes around them.

In conjunction with the HAR program, area navigation (RNAV) routes have been established to provide for a systematic flow of air traffic in specific portions of the en route flight environment. The designator for these RNAV routes begin with the letter Q, for example, Q-501. Where those routes aid in the efficient orderly management of air traffic, they are published as preferred IFR routes.

Preferred IFR Routes

Preferred IFR routes are established between busier airports to increase system efficiency and capacity. They normally extend through one or more ARTCC areas and are designed to achieve balanced traffic flows among high density terminals. IFR clearances are issued on the basis of these routes except when severe weather avoidance procedures or other factors dictate otherwise. Preferred IFR routes are listed in the CS and can also be found on www.fly.faa.gov, which requires entering the following data: departure airport designator, destination, route type, area, aircraft types, altitude, route string, direction, departure ARTCC, and arrival ARTCC. [Figure 2-14] If a flight is planned to or from an area having such routes but the departure or arrival point is not listed in the CS, pilots may use that part of a preferred IFR route that is appropriate for the departure or arrival point listed. Preferred IFR routes are correlated with departure procedures (DPs) and STARs and may be defined by airways, jet routes, direct routes between NAVAIDs,

Figure 2-14. Chart Supplement (includes Airport/Facility Directory section).

waypoints, NAVAID radials/ distance measuring equipment (DME), or any combinations thereof.

Preferred IFR routes are published in the CS for the low and high altitude stratum. If they begin or end with an airway number, it indicates that the airway essentially overlies the airport and flights normally are cleared directly on the airway. Preferred IFR routes beginning or ending with a fix indicate that pilots may be routed to or from these fixes via a SID route, radar vectors, or a STAR. Routes for major terminals are listed alphabetically under the name of the departure airport. Where several airports are in proximity, they are listed under the principal airport and categorized as a metropolitan area (e.g., New York Metro Area). One way preferred IFR routes are listed is numerically, showing the segment fixes and the direction and times effective. Where more than one route is listed, the routes have equal priority for use. Official location identifiers are used in the route description for very high frequency omnidirectional ranges (VORs) and very high frequency omnidirectional ranges/ tactical air navigation (VORTACs), and intersection names are spelled out. The route is direct where two NAVAIDs, an intersection and a NAVAID, a NAVAID and a NAVAID radial and distance point, or any navigable combination of these route descriptions follow in succession.

A system of preferred IFR routes helps pilots, flight crews, and dispatchers plan a route of flight to minimize route changes, and to aid in the efficient, orderly management of air traffic using Federal airways. Preferred IFR routes are designed to serve the needs of airspace users and to provide for a systematic flow of air traffic in the major terminal and en route flight environments. Cooperation by

PREFERRED IFR ROUTES

Terminals	Route	Effective Times (UTC)
	(60–170 incl 210 kts plus, non–turbojet) V14 CEDOR DNY051 DNY V449 LHY V93 LVZ V613 FJC PTW........	1100–0300
	or	
	(70–170 turbojets only) V14 CEDOR DNY051 DNY SLATT–STAR........	
Trenton (TTN)	(90–170, non–turbojet) V14 CEDOR DNY051 DNY LHY LVZ V613 FJC V149 MAZIE ARD	1100–0300
	or	
	(90–170, turbojet) V14 CEDOR DNY051 DNY LHY LVZ V29 ETX V30 V149 MAZIE ARD	1100–0300
BALTIMORE (BWI)—See Washington/Baltimore Metro		
BOSTON METRO AREA (BOS)		
Cleveland (CLE)	(60–170) MHT V490 UCA V2 SYR V84 GEE V464 V115 TDT V72 V232 CXR	1000–0300
Kennedy (JFK)	(110–170, jets) LUCOS SEY067 SEY PARCH CCC ROBER	1100–0300
	or	
	(110–170, Props) LUCOS SEY067 SEY HTO V46 DPK	
	or	
	(AOB 100) BOSOX V419 V14 ORW V16 DPK	

Figure 2-15 Preferred IFR routes.

all pilots in filing preferred routes results in fewer air traffic delays and better efficiency for departure, en route, and arrival air traffic service. [Figure 2-15]

Substitute Airway or Route Structures

ARTCCs are responsible for specifying essential substitute airway or route segments (sub-routes) and fixes for use during scheduled or unscheduled VOR/VORTAC shutdowns. Scheduled shutdowns of navigational facilities require planning and coordination to ensure an uninterrupted flow of air traffic. Aeronautical Information Services, in coordination with the ARTCCs, determine when the length of outages or other factors require publication of sub-routes and Flight Program Operations (AJW-3) provides flight inspection services, obstacle clearance verification, certification, and final approval of substitute routes.

Substitute Airway En Route Flight Procedures

A schedule of proposed facility shutdowns within the region is maintained and forwarded as far in advance as possible to enable the substitute routes to be published. Substitute routes are normally based on VOR/VORTAC facilities established and published for use in the appropriate altitude strata. In the case of substitute routes in the upper airspace stratum, it may be necessary to establish routes by reference to VOR/VORTAC facilities used in the low altitude system. Non-directional (radio) beacon (NDB) facilities may only be used where VOR/VORTAC coverage is inadequate and ATC requirements necessitate use of such NAVAIDs. Where operational necessity dictates, NAVAIDs may be used beyond their standard service volume (SSV) limits that define the reception limits of unrestricted NAVAIDs, which are usable for random/unpublished route navigation, provided that the routes can be given adequate frequency protection.

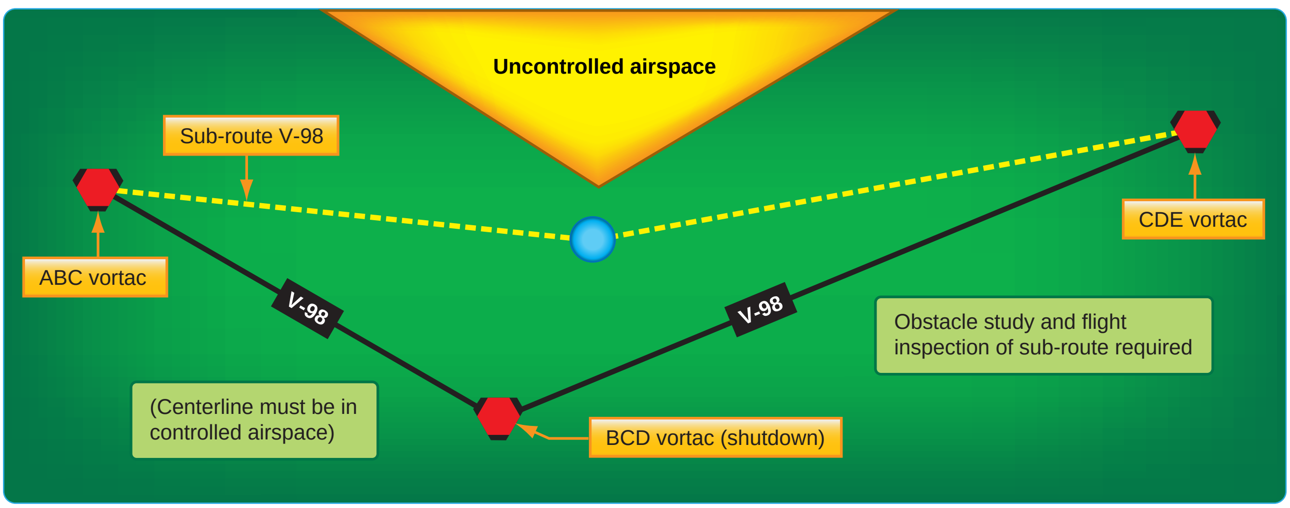


Figure 2-16 14 CFR Part 95 sub-routes.

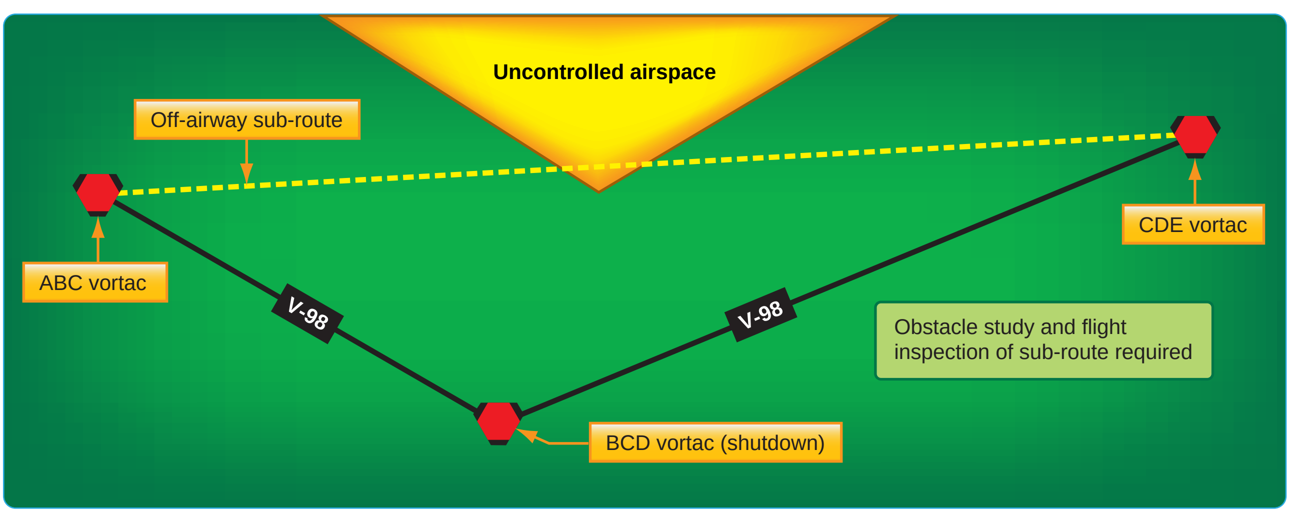


Figure 2-17 Non-Part 95 sub-routes.

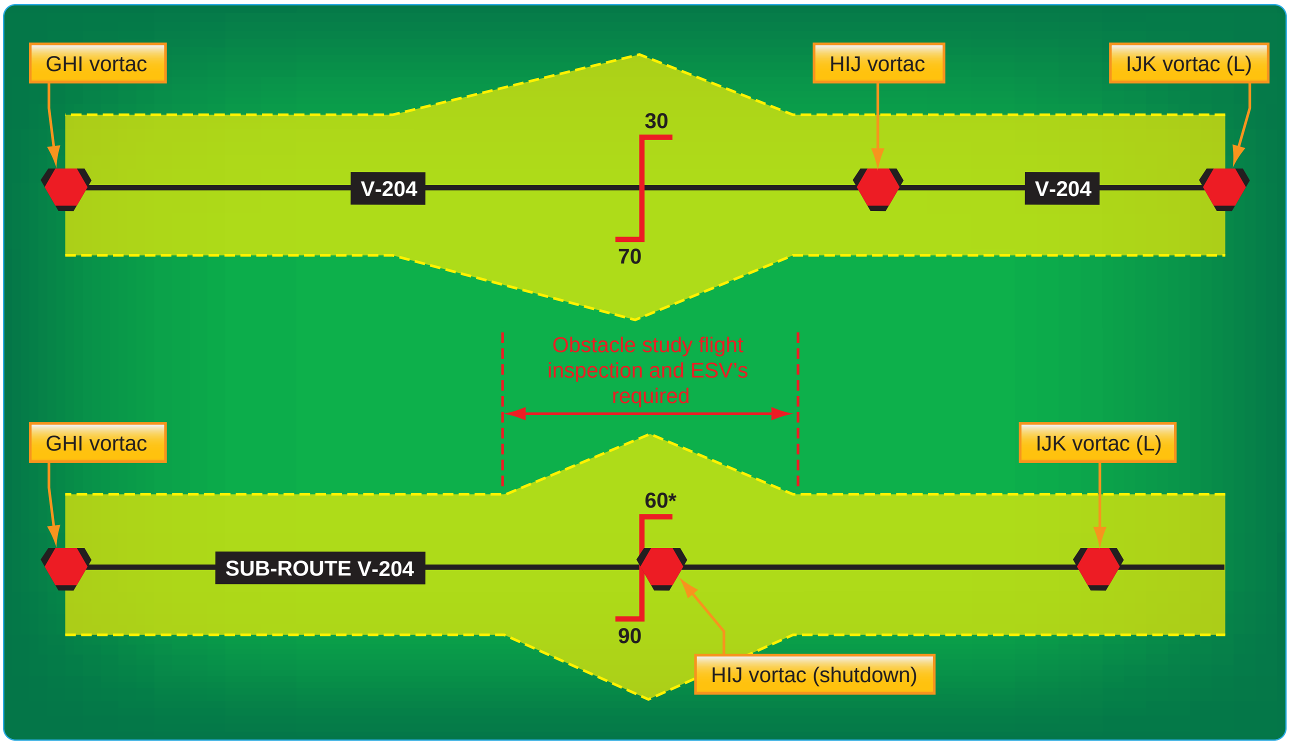


Figure 2-18 Sub-route wider than existing route.

The centerline of substitute routes must be contained within controlled airspace [Figure 2-16], although substitute routes for off-airway routes may not be in controlled airspace. [Figure 2-17] Substitute routes are flight inspected to verify clearance of controlling obstacles and to check for satisfactory facility performance. If substitute routes do not overlie existing routes, or are wider than existing routes, map studies are required to identify controlling obstacles. [Figure 2-18] The format for describing substitute routes is from navigational fix to navigational fix. A minimum en route altitude (MEA) and a maximum authorized altitude (MAA) are provided for each route segment. Temporary reporting points may be substituted for the out-of-service facility and only those other reporting points that are essential for ATC. Normally, temporary reporting points over intersections are not necessary where Center radar coverage exists. A minimum reception altitude (MRA) is established for each temporary reporting point.

Tower En Route Control

Tower en route control (TEC) is an ATC program available to pilots that provides a service to aircraft proceeding to and from metropolitan areas. It links designated approach control areas by a network of identified routes made up of the existing airway structure of the NAS, which makes it possible to fly an IFR flight without leaving approach control airspace. [Figure 2-19] This service is designed to help expedite air traffic and reduces ATC and pilot communication requirements. The program is generally used by non-turbojet aircraft operating at and below 10,000 feet but a few facilities, such as Milwaukee and Chicago, have allowed turbojets to proceed between city pairs. Participating flights are relatively short with a duration of two hours or less.

TEC is referred to as tower en route, or tower-to-tower, and allows flight beneath the en route structure. TEC reallocates airspace both vertically and geographically to allow flight planning between city pairs while remaining with approach control airspace. All users are encouraged to use the TEC route descriptions located in the CS when filing flight plans. [Figure 2-20] All published TEC routes are designed to avoid en route airspace, and the majority is within radar coverage.

Tower En Route Control Route Descriptions

The graphic depiction of TEC routes located in the CS is not to be used for navigation or for detailed flight planning because not all city pairs are depicted. The information is intended to show geographic areas connected by TEC. [Figure 2-19] Pilots should refer to the route descriptions for specific flight planning.

As shown in Figure 2-20, the route description contains four columns of information. The first column is the approach control area within which the departure airport is located, which are listed alphabetically. The second column shows the specific route, airway, or radial that is to be used. The third column shows the highest altitude allowed for

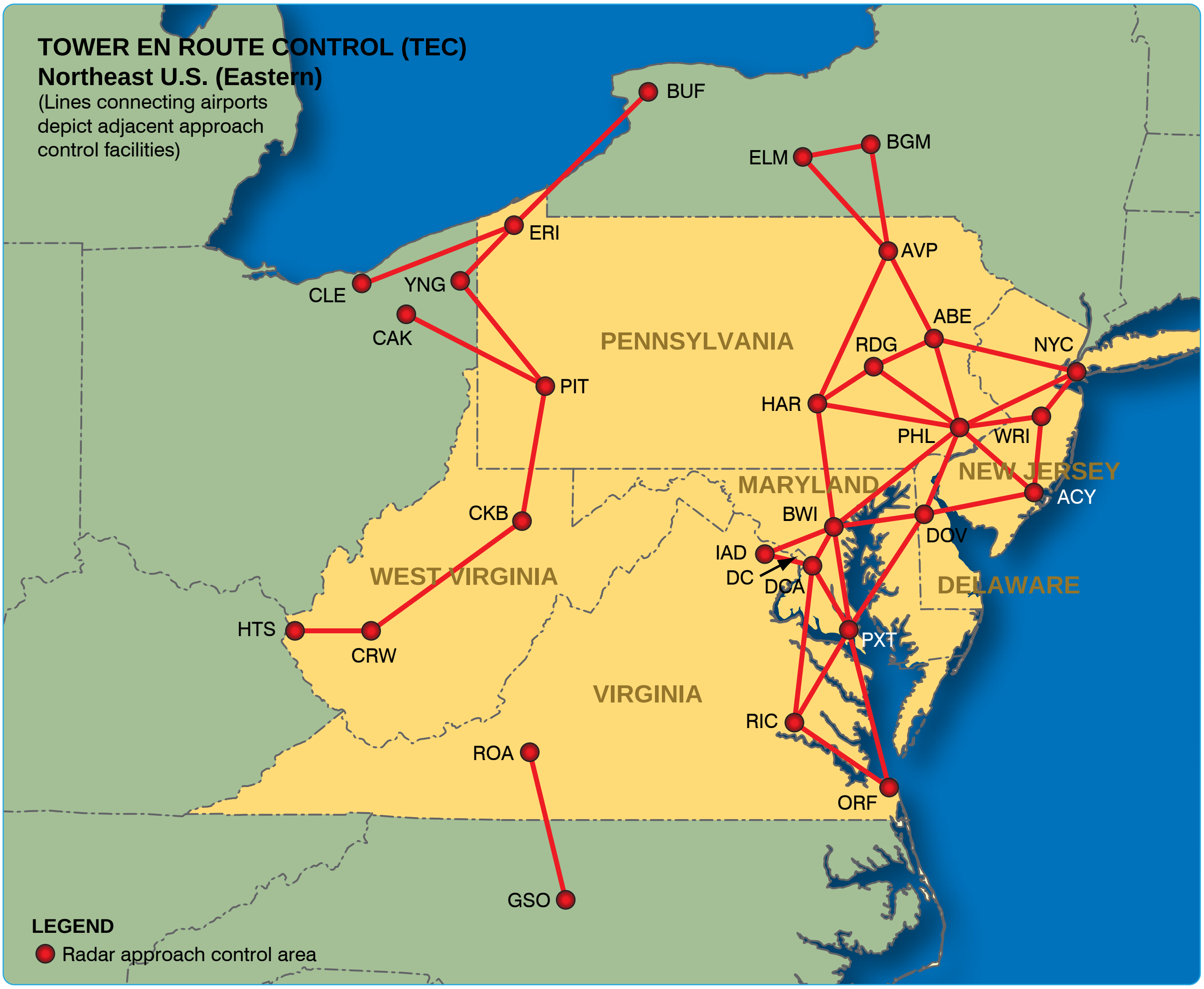
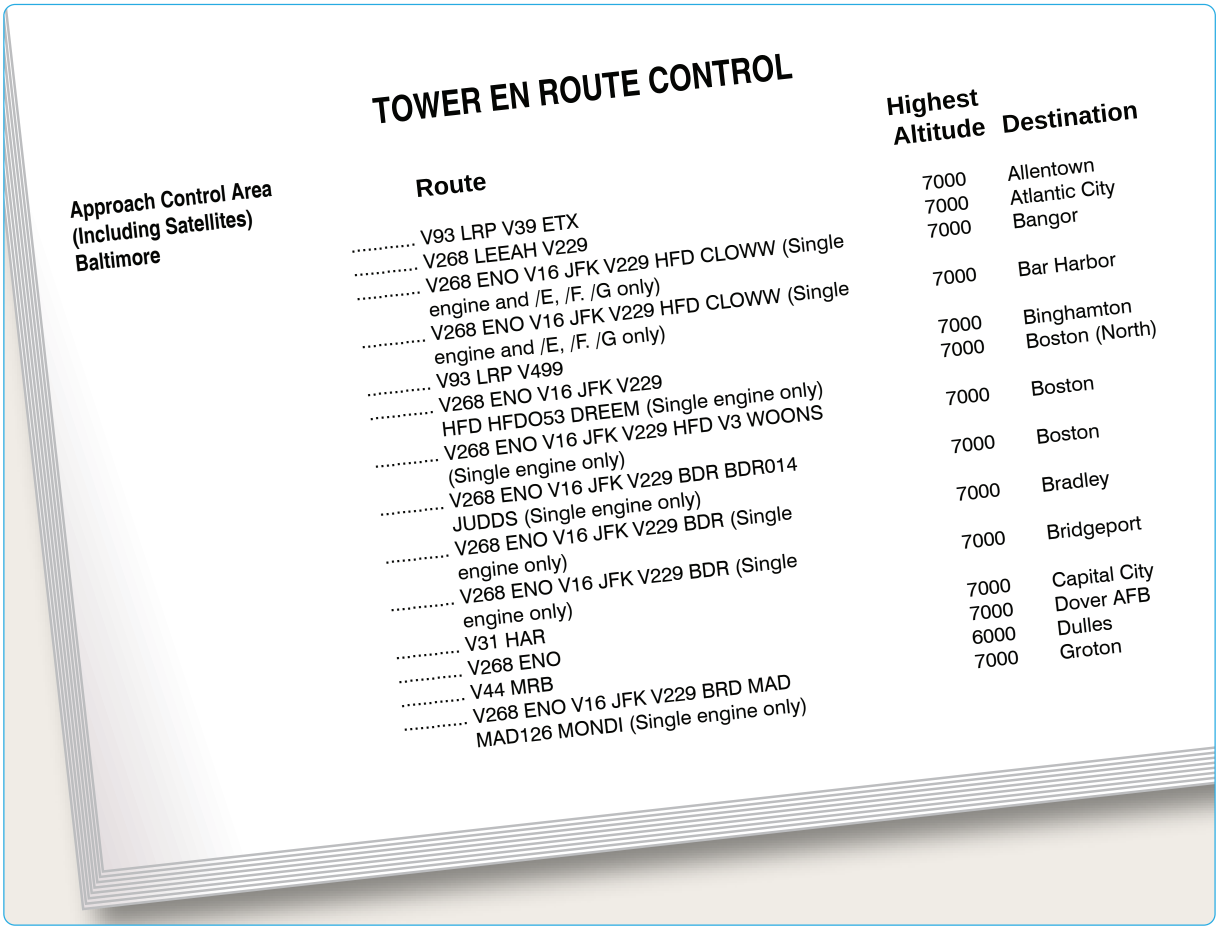


Figure 2-19. Tower En Route Control (TEC) Northeast U.S. (Eastern).

the route, and the fourth shows the destination airport, which are also listed alphabetically. When flight planning, it is important to always check current publications for information about the departure and destination airport. Routes are effective only during each respective terminal facilities normal operating hours. Always check NOTAMs to ensure that appropriate terminal facilities are operating for the planned flight time. Altitudes are always listed in thousands of feet. ATC may request that the pilot changes altitude while in flight in order to maintain the flight within approach control airspace. ATC provides radar monitoring and, if necessary, course guidance if the highest altitude assigned is below the MEA.

Shown in Figure 2-21, under the second column, the word "Direct" appears as the route when radar vectors are used or no airway exists. This also indicates that a SID or STAR may be assigned by ATC. When a NAVAID or intersection identifier appears with no airway immediately preceding or following the identifier, the routing is understood to be direct to or from that point unless otherwise cleared by ATC. Routes beginning and ending with an airway indicate that the airway essentially overflies the airport, or radar vectors are issued. [Figure 2-21] Where more than one route is listed to the same destination, ensure that the correct route for the type of aircraft classification has been filed. These are denoted after the route in the altitude column using J (jet powered), M (turbo props/special, cruise speed 190 knots or greater), P (non-jet, cruise speed 190 knots or greater), or Q (non-jet, cruise speed 189 knots or less). [Figure 2-22] Although all airports are not listed under the destination column, IFR flights may be planned to satellite airports in the proximity of major airports via the same routing. When filing flight plans, the coded route identifier (i.e., BURL 1, VTUL4, or POML3) may be used in lieu of the route of flight.

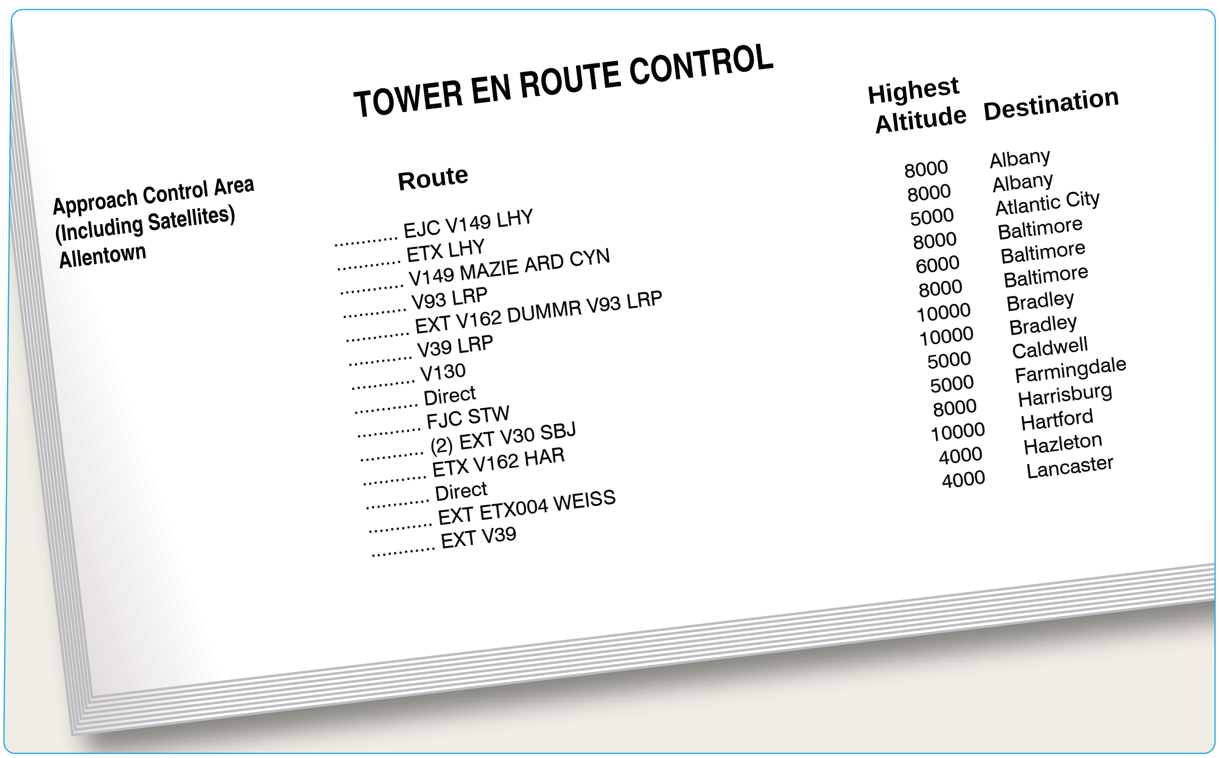


TOWER EN ROUTE CONTROL

Approach Control Area (Including Satellites) Baltimore

Route	Highest Altitude	Destination
V93 LRP V39 ETX	7000	Allentown
V268 LEEAH V229	7000	Atlantic City
V268 ENO V16 JFK V229 HFD CLOWW (Single engine and /E, /F. /G only)	7000	Bangor
V268 ENO V16 JFK V229 HFD CLOWW (Single engine and /E, /F. /G only)	7000	Bar Harbor
V93 LRP V499	7000	Binghamton
V268 ENO V16 JFK V229 HFD HFD053 DREEM (Single engine only)	7000	Boston (North)
V268 ENO V16 JFK V229 HFD V3 WOONS (Single engine only)	7000	Boston
V268 ENO V16 JFK V229 BDR BDR014 JUDDS (Single engine only)	7000	Boston
V268 ENO V16 JFK V229 BDR (Single engine only)	7000	Bradley
V268 ENO V16 JFK V229 BDR (Single engine only)	7000	Bridgeport
V31 HAR	7000	Capital City
V268 ENO	7000	Dover AFB
V44 MRB	6000	Dulles
V268 ENO V16 JFK V229 BRD MAD MAD126 MONDI (Single engine only)	7000	Groton

Figure 2-20. Chart Supplement (NE), Tower En Route Control route descriptions (Baltimore).

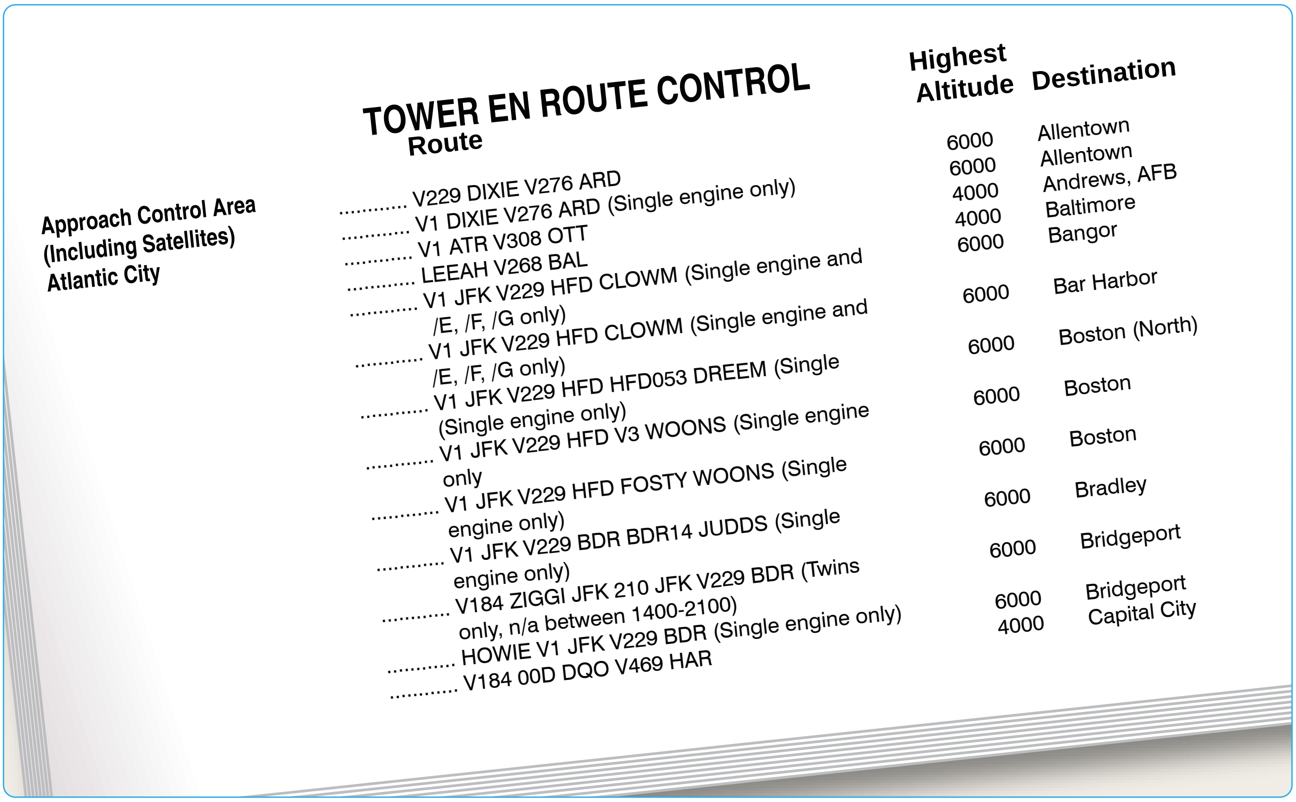


TOWER EN ROUTE CONTROL

Approach Control Area (Including Satellites) Allentown

Route	Highest Altitude	Destination
EJC V149 LHY	8000	Albany
ETX LHY	8000	Albany
V149 MAZIE ARD CYN	5000	Atlantic City
V93 LRP	8000	Baltimore
EXT V162 DUMMR V93 LRP	6000	Baltimore
V39 LRP	8000	Baltimore
V130	10000	Bradley
Direct	10000	Bradley
FJC STW	5000	Caldwell
(2) EXT V30 SBJ	5000	Farmingdale
ETX V162 HAR	8000	Harrisburg
Direct	10000	Hartford
EXT ETX004 WEISS	4000	Hazleton
EXT V39	4000	Lancaster

Figure 2-21. Chart Supplement (NE), Tower En Route Control route descriptions (Allentown).



TOWER EN ROUTE CONTROL

Approach Control Area (Including Satellites)

Atlantic City

Route	Highest Altitude	Destination
V229 DIXIE V276 ARD	6000	Allentown
V1 DIXIE V276 ARD (Single engine only)	6000	Allentown
V1 ATR V308 OTT	4000	Andrews, AFB
LEEAH V268 BAL	4000	Baltimore
V1 JFK V229 HFD CLOWM (Single engine and /E, /F, /G only)	6000	Bangor
V1 JFK V229 HFD CLOWM (Single engine and /E, /F, /G only)	6000	Bar Harbor
V1 JFK V229 HFD HFD053 DREEM (Single (Single engine only)	6000	Boston (North)
V1 JFK V229 HFD V3 WOONS (Single engine only	6000	Boston
V1 JFK V229 HFD FOSTY WOONS (Single engine only)	6000	Boston
V1 JFK V229 BDR BDR14 JUDDS (Single engine only)	6000	Bradley
V184 ZIGGI JFK 210 JFK V229 BDR (Twins only, n/a between 1400-2100)	6000	Bridgeport
HOWIE V1 JFK V229 BDR (Single engine only)	6000	Bridgeport
V184 00D DQO V469 HAR	4000	Capital City

Figure 2-22. Chart Supplement (NE), Tower En Route Control route descriptions (Atlantic City).

Airway and Route System

There are three fixed route systems established for air navigation purposes. They are the Federal airway consisting of VOR (low victor airways, high jet routes), NDB (low or medium frequency) and the RNAV route system. To the extent possible, these route systems are aligned in an overlying manner to facilitate transition between each. The majority of the airways are made up of victor airways, jet routes, and RNAV, but some low/medium frequency (L/MF) airways and routes are still being used in Alaska and one other that is located off the coast of North Carolina and is called Green 13 (G13). [Figure 2-23]

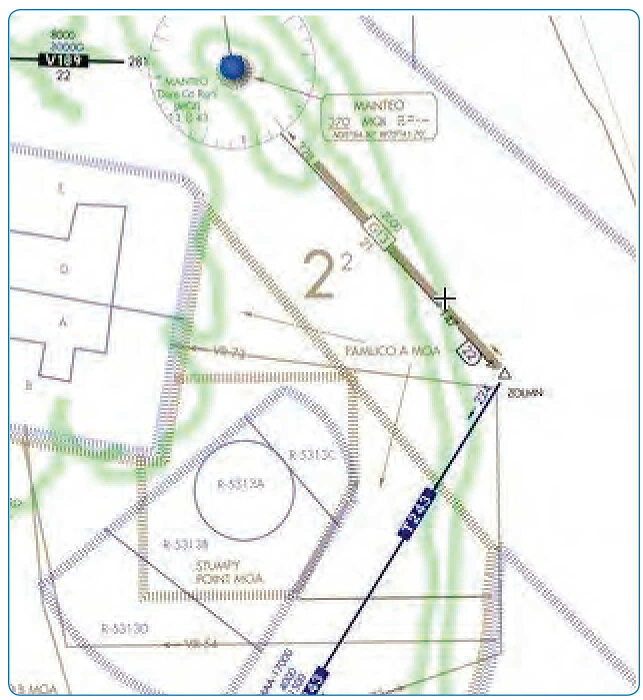


Figure 2-23. Low frequency airway G13.

Airway/Route Depiction

IFR en route charts show all IFR radio NAVAIDs that have been flight-checked by the FAA and are operational. The FAA, Aeronautical Information Services publishes and distributes U.S. Government Civil Aeronautical Charts and flight information publications. IFR en route navigation information is provided on three charts: IFR en route low altitude chart, IFR en route high altitude chart, and Terminal Area Chart (TAC). [Figure 2-24A and B]

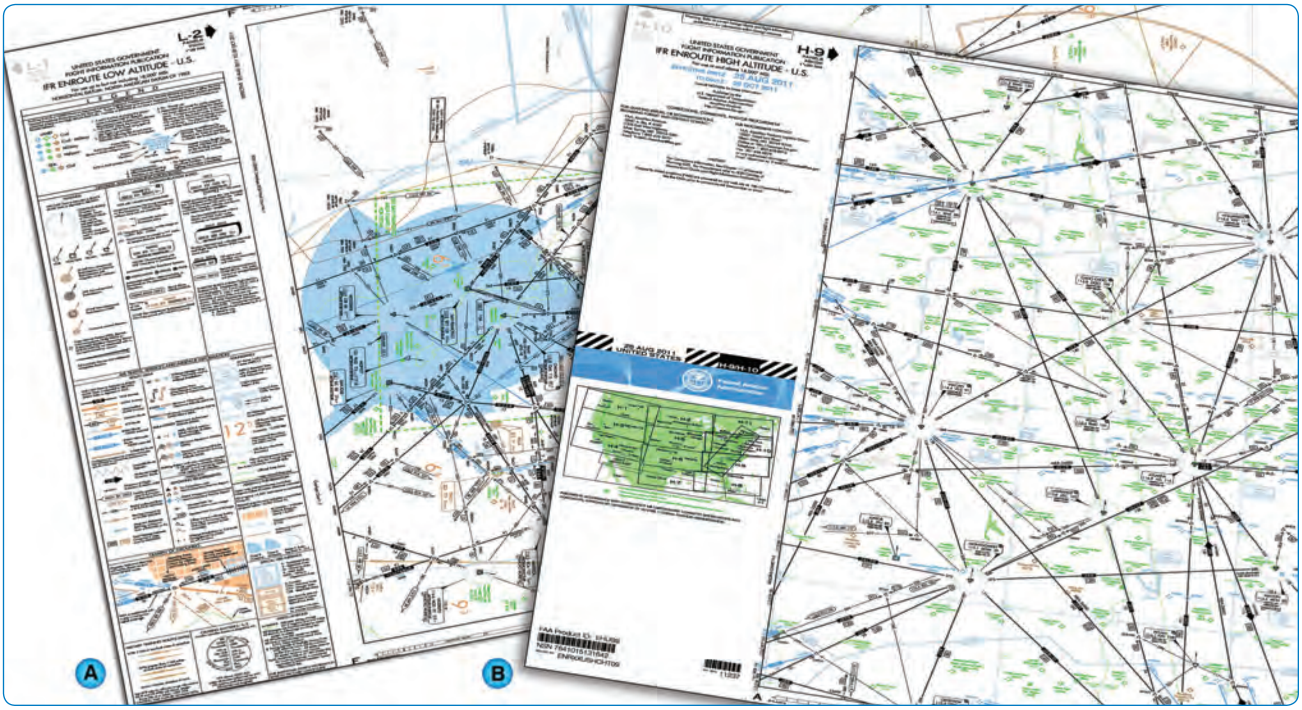


Figure 2-24. IFR en route low altitude (left) and high altitude (right) charts.

IFR En Route Low Altitude Chart

En route low altitude charts provide aeronautical information for navigation under IFR conditions below 18,000 feet MSL. Low altitude charts [Figure 2-25] include the following information:

- Airways[Figure 2-25A]
- RNAV routes [Figure 2-25B]
- Limits of controlled airspace [Figure 2-25C]
- VHF radio aids to navigation (frequency, identification, channel, geographic coordinates) [Figure 2-25D]
- Airports that have an instrument approach procedure or a minimum 3,000 foot hard surface runway [Figure 2-25E]
- Off-route obstruction clearance altitudes (OROCA) [Figure 2-25F]
- Reporting points [Figure 2-25G]
- Special use airspace areas [Figure 2-25H]
- Military training routes [Figure 2-25I]

IFR aeronautical charts depict VOR airways (airways based on VOR or VORTAC NAVAIDs) in black, identified by a "V" (Victor) followed by the route number (e.g., V12). [Figure 2-26] LF/MF airways (airways based on LF/MF NAVAIDs) are sometimes referred to as colored airways because they are identified by color name and number (e.g., Amber One, charted as A1). Green and red airways are plotted east and west, and amber and blue airways are plotted north and south. Regardless of their color identifier, LF/MF airways are depicted in brown. [Figure 2-27]

Airway/route data, such as the airway identifications, bearings or radials, mileages, and altitude (e.g., MEA), minimum obstacle clearance altitude (MOCA), and MAA, are shown aligned with the airway and in the same color as the airway. [Figure 2-26]

All airways/routes that are predicated on VOR or VORTAC NAVAIDs are defined by the outbound radial from the NAVAID. Airways/routes that are predicated on LF/MF NAVAIDs are defined by the inbound bearing.

New low altitude RNAV routes have been created by the FAA. RNAV routes provide more direct routing for IFR aircraft and enhance the safety and efficiency of the NAS. In order to utilize these routes, aircraft must be equipped with IFR approved GNSS. In Alaska, when using RNAV routes, the aircraft must be equipped with Technical Standing Order (TSO)-145a and 146a equipment.

Low altitude RNAV only routes are identified by the letter "T" prefix, followed by a three digit number (T-200 to T-500). RNAV routes are depicted in aeronautical blue, as well as the RNAV route data, which includes the following [Figure 2-28]:

- Route line
- Identification boxes

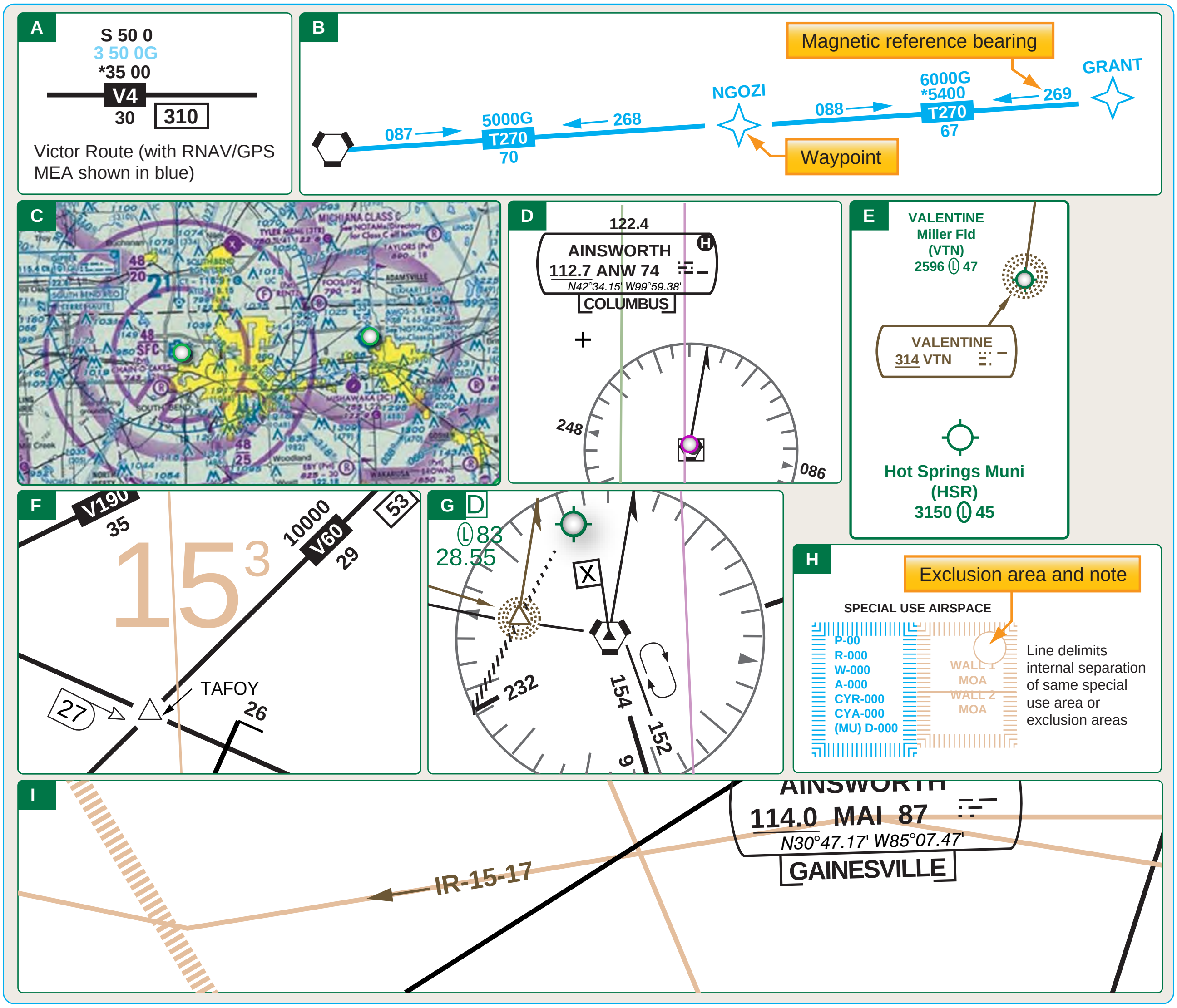


Figure 2-25. Information found on en route low altitude charts.

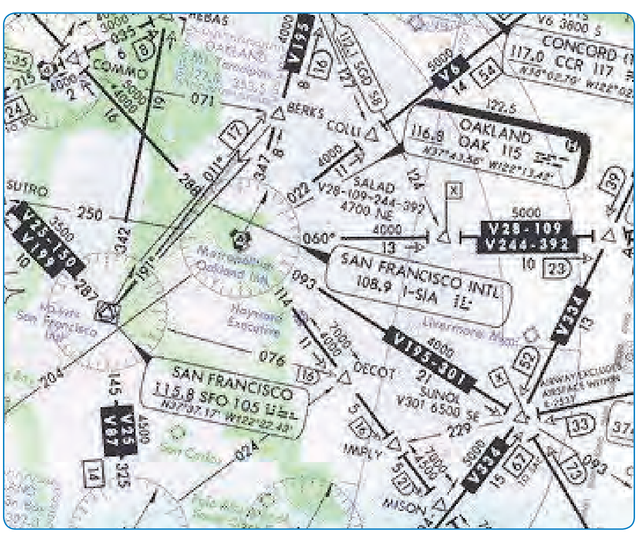


Figure 2-26. Victor airways.

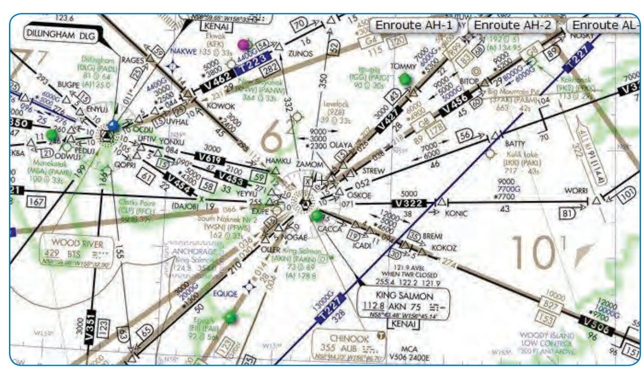


Figure 2-27. LF/MF airways.

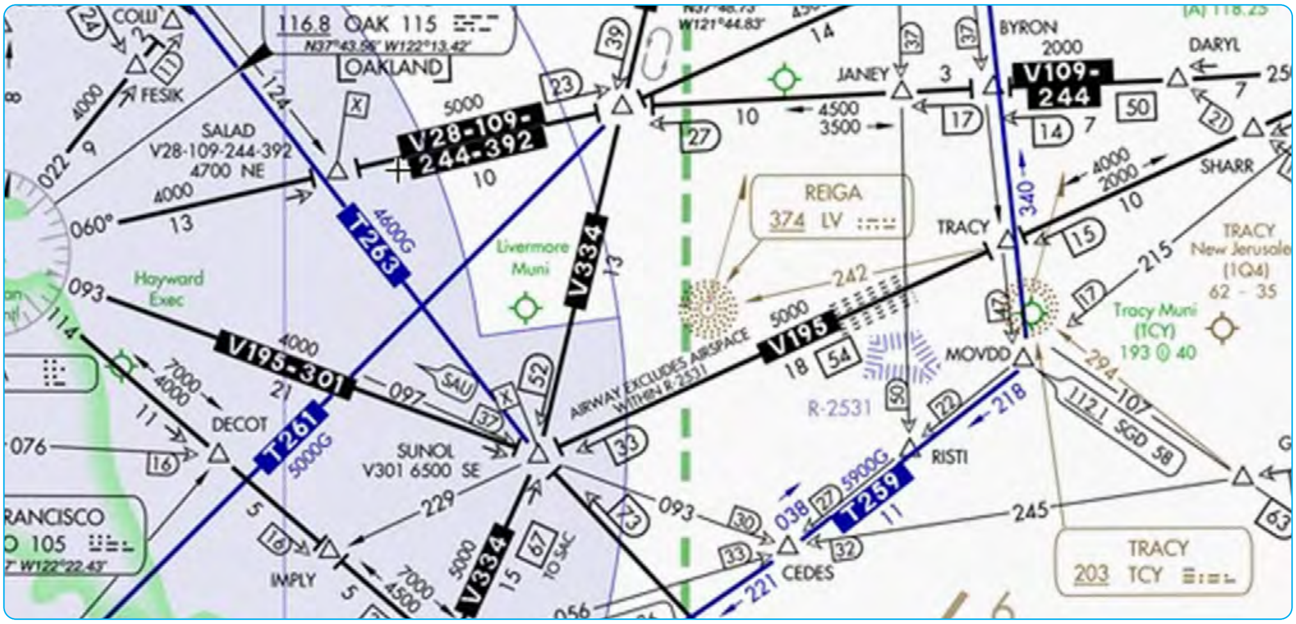


Figure 2-28. Low altitude RNAV routes.

- Mileages
- Waypoints
- Waypoint names
- Magnetic reference bearings
- MEAs

Magnetic reference bearings are shown originating from a waypoint, fix/reporting point, or NAVAID. A GNSS MEA for each segment is established to ensure obstacle clearance and communications reception. All MEAs are identified with a "G" suffix. [Figure 2-29]

Joint Victor/RNAV routes are depicted using black for the victor airways and blue for the RNAV routes, and the identification boxes for each are shown adjacent to one another. Magnetic reference bearings are not shown. MEAs are stacked in pairs or in two separate columns, GNSS and Victor. On joint routes, or victor routes, RNAV specific information is printed in blue. [Figure 2-30]

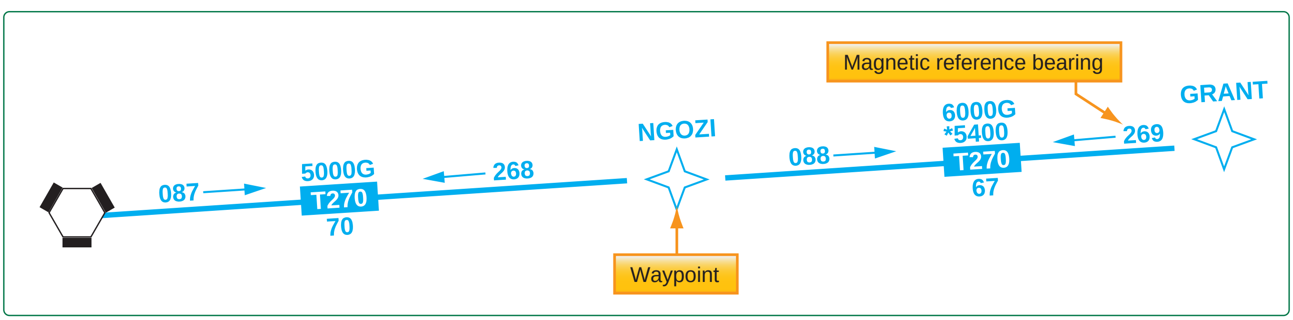


Figure 2-29. Low altitude RNAV route data.

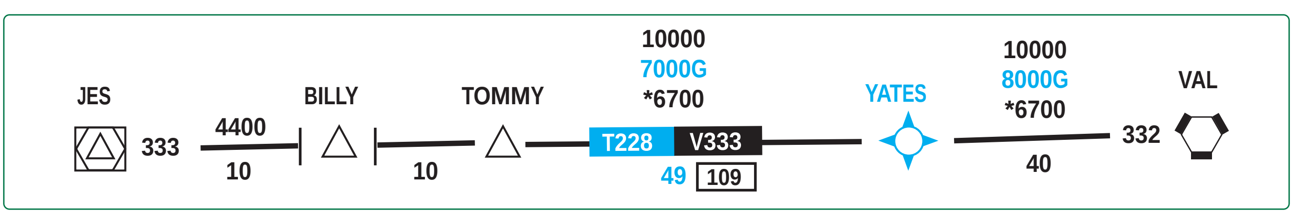


Figure 2-30. Joint Victor/RNAV airway.

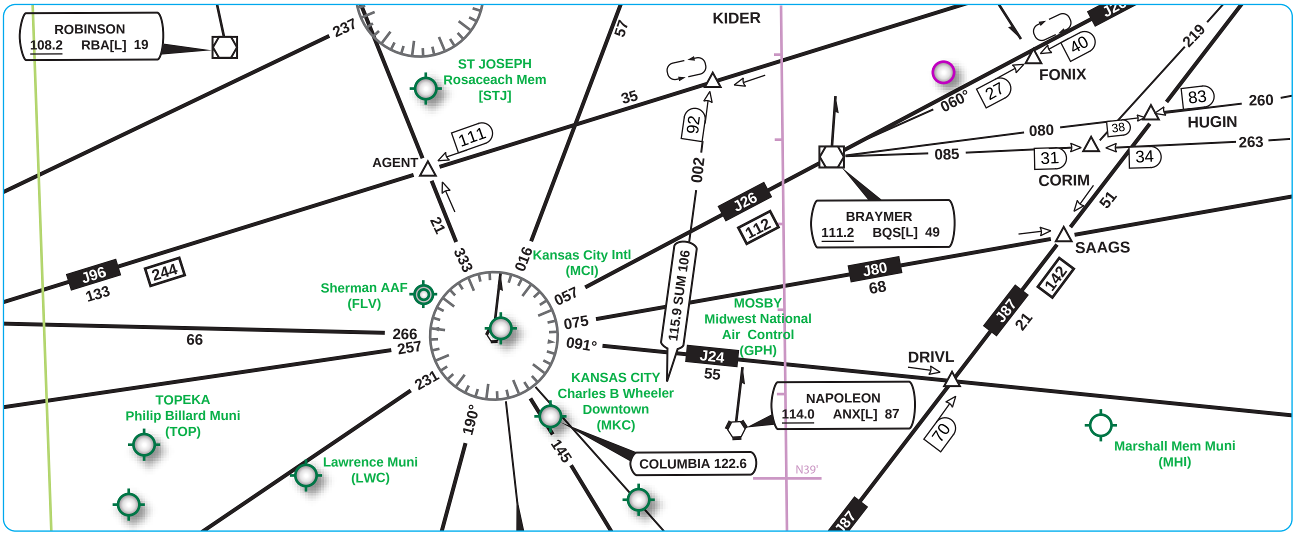


Figure 2-31. IFR en route high altitude chart.

IFR En Route High Altitude Chart

En route high altitude charts provide aeronautical information for navigation under IFR conditions at and above FL 180. [Figure 2-31] High altitude charts include the following information:

- Jet route structure
- RNAV Q-routes
- VHF radio aids to navigation (frequency, ID, channel, geographic coordinates)
- Selected airports
- Reporting points
- Navigation reference system (NRS) waypoints [Figure 2-32]

Jet routes are depicted in black with a "J" identifier followed by the route number (e.g., "J12") and are based on VOR or

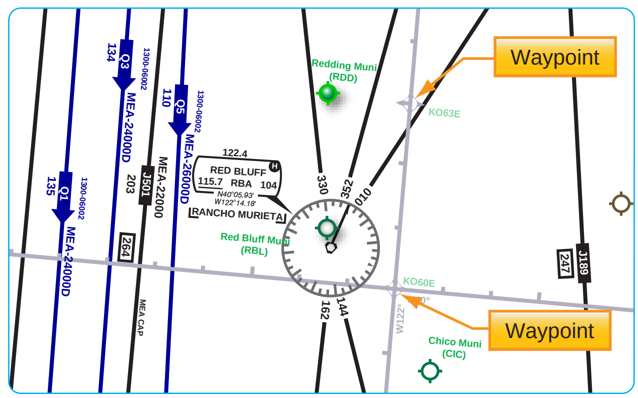


Figure 2-32. Navigation reference system (NRS) waypoints.

VORTAC NAVAIDs. [Figure 2-33] RNAV "Q" Route MEAs are shown when other than 18,000 feet. [Figure 2-34] MEAs for GNSS RNAV aircraft are identified with a "G" suffix. MEAs for DME/DME/IRU RNAV aircraft do not have a "G" suffix. All RNAV routes and associated data is charted in aeronautical blue and magnetic reference bearings are

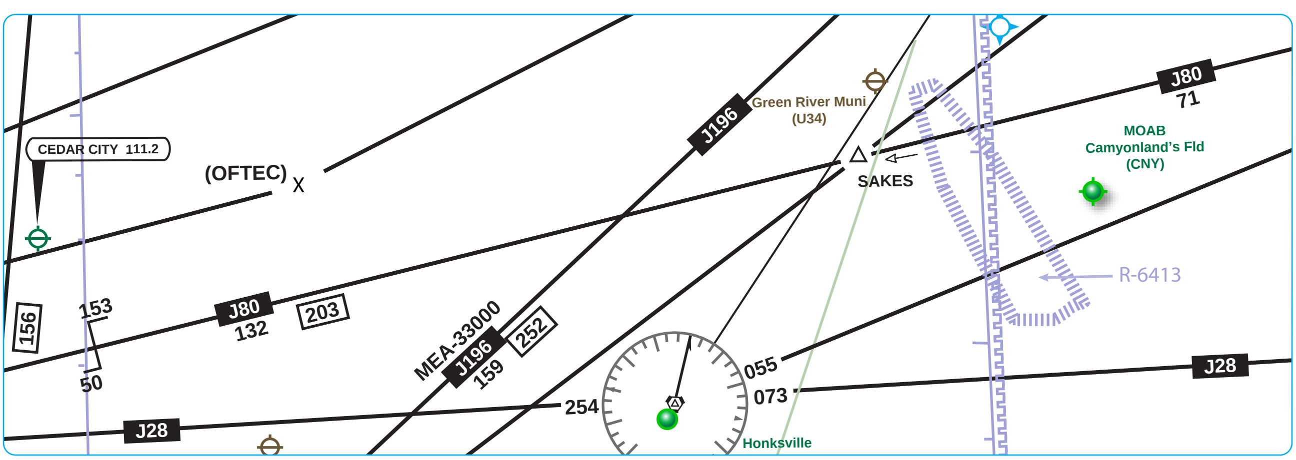


Figure 2-33. High altitude jet routes.

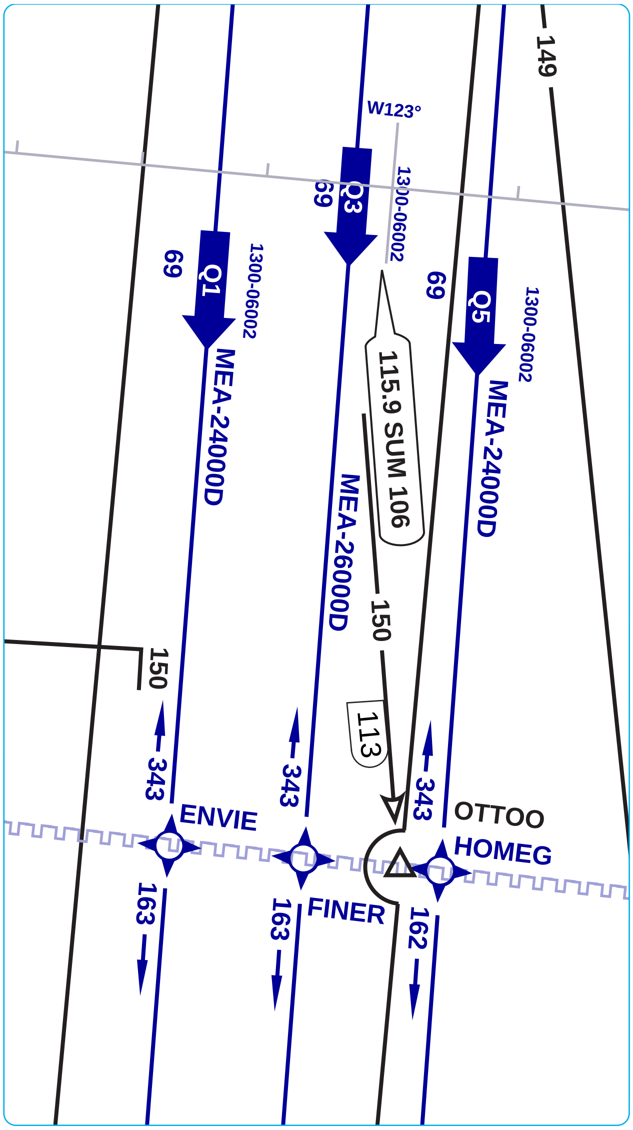


Figure 2-34. MEAs on RNAV (Q) routes.

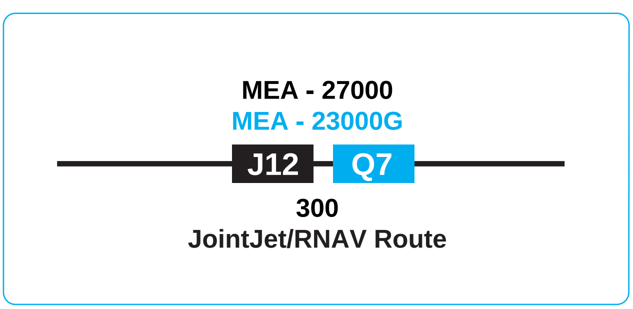


Figure 2-35. Joint jet/RNAV routes.

shown originating from a waypoint, fix/reporting point, or NAVAID. When joint Jet/RNAV routes are depicted, the route identification boxes are located adjacent to each other with the route charted in black. [Figure 2-35] With the exception of "Q" routes in the Gulf of Mexico, GNSS or DME/DME/IRU RNAV equipment is required along with radar monitoring capabilities. For aircraft that have DME/DME/IRU RNAV equipment, refer to the CS for specific DME information.

VHF Airways

Victor airways are a system of established routes that run along specified VOR radials, from one VOR station to another. The purpose is to make flight planning easier and they help ATC to organize and regulate the air traffic flow. Almost all commercial flights are routed along these airways but they are available for use by any pilot provided that the proper altitudes are employed.

Victor Airway Navigation Procedures

The procedure for getting established on a victor airway is to either fly directly to a nearby VOR or to intercept an airway radial along the route of flight. Once the pilot is established on an airway, it is important to follow the procedures and guidelines put in place to ensure air traffic separation and optimal safety on the airway. When using victor airways for navigation, procedures do not allow the pilot to jump from one VOR to another, but must navigate from one to the next by using the alternating outbound/inbound procedure of linking VORs. For example, when departing from Zanesville VOR on V-214, the pilot selects the 090° radial with a FROM indication on the course deviation indicator (CDI) and should correct as necessary to continuously maintain track on the centerline of the airway. [Figure 2-36] The pilot should continue on this course until it is time to change over to the inbound course to the Bellaire VOR.

LF/MF Airways

The basic LF/MF airway width is 4.34 nautical miles (NM) on each side of the centerline; the width expands by five degrees when the distance from the facility providing course guidance is greater than 49.66 NM. [Figure 2-37]

En Route Obstacle Clearance Areas

All published routes in the NAS are based on specific obstacle clearance criteria. An understanding of en route obstacle clearance areas helps with SA and may help avoid controlled flight into terrain (CFIT). Obstacle clearance areas for the en route phase of flight are identified as primary, secondary, and turning areas.

The primary and secondary area obstacle clearance criteria, airway and route widths, and the ATC separation procedures for en route segments are a function of safety and practicality in flight procedures. These flight procedures are dependent upon the pilot, the aircraft, and the navigation system being used, resulting in a total VOR system accuracy factor along with an associated probability

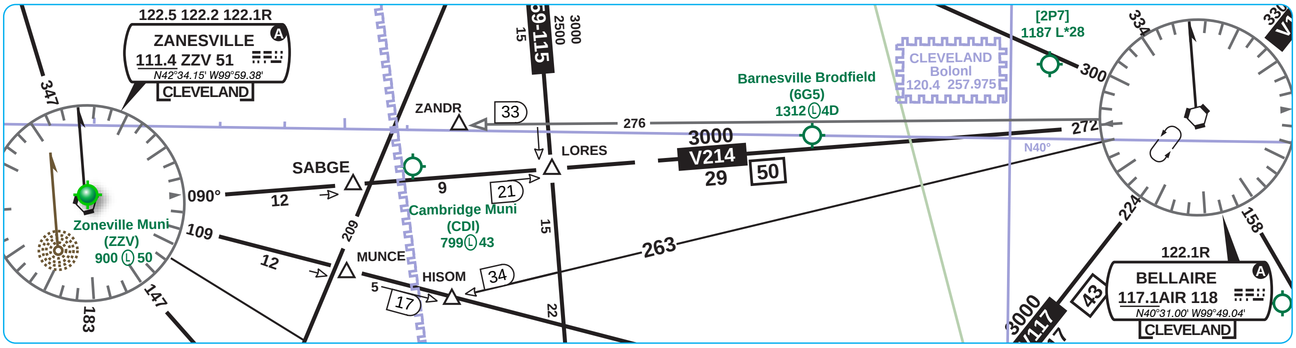


Figure 2-36. Zanesville VOR/Victor Airway 214.

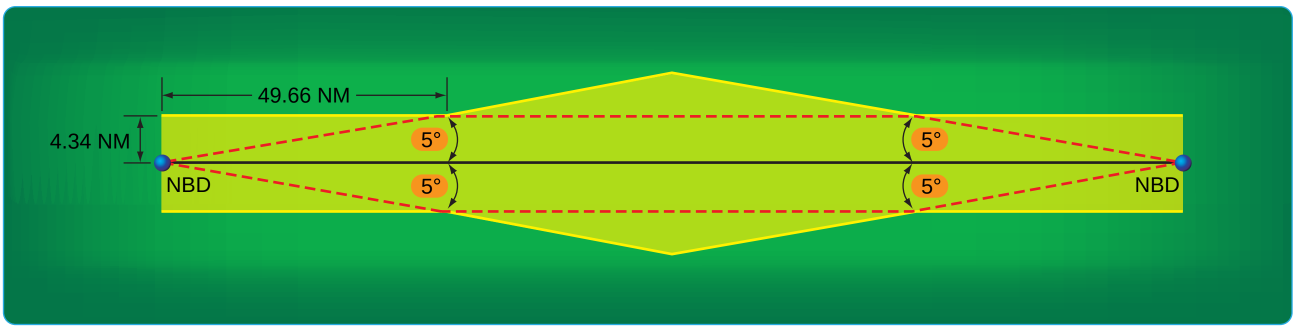


Figure 2-37. LF/MR airway width.

factor. The pilot/aircraft information component of these criteria includes pilot ability to track the radial and the flight track resulting from turns at various speeds and altitudes under different wind conditions. The navigation system information includes navigation facility radial alignment displacement, transmitter monitor tolerance, and receiver accuracy. All of these factors were considered during development of en route criteria. From this analysis, the computations resulted in a total system accuracy of ±4.5° 95 percent of the time and ±6.7° 99 percent of the time. The 4.5° value became the basis for primary area obstacle clearance criteria, airway and route widths, and the ATC separation procedures. The 6.7° value provides secondary obstacle clearance area dimensions.

Primary and Secondary En Route Obstacle Clearance Areas

The primary obstacle clearance area has a protected width of 8 NM with 4 NM on each side of the centerline. The primary area has widths of route protection based upon system accuracy of a ±4.5° angle from the NAVAID. These 4.5° lines extend out from the NAVAID and intersect the boundaries of the primary area at a point approximately 51 NM from the NAVAID. Ideally, the 51 NM point is where pilots would change over from navigating away from the facility, to navigating toward the next facility, although this ideal is rarely achieved. [Figure 2-38]

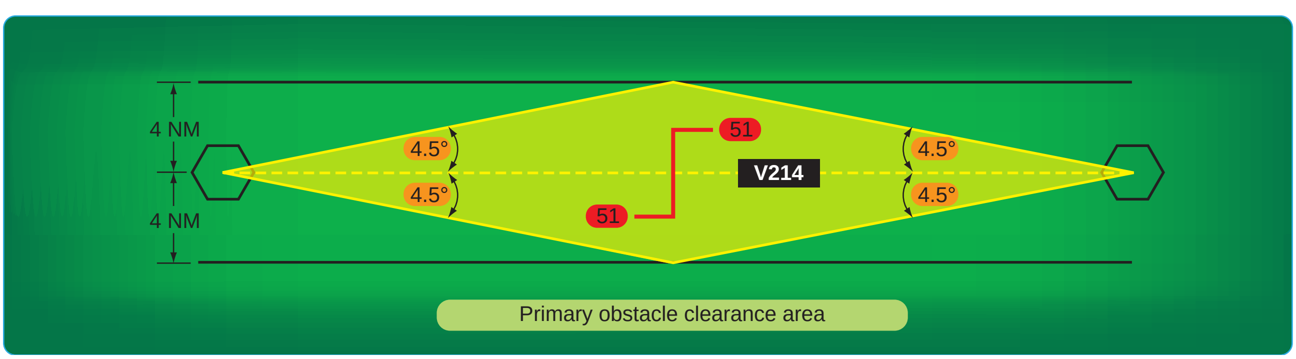


Figure 2-38. Primary obstacle clearance area.

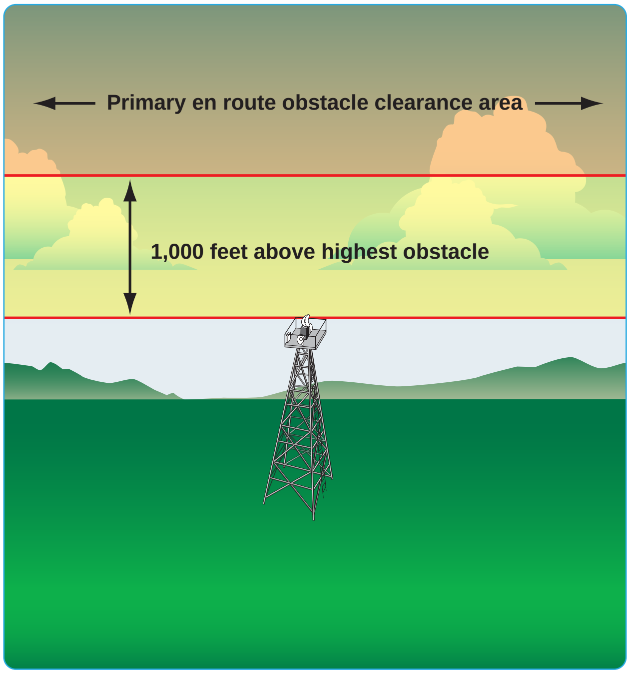


Figure 2-39. Non-mountainous obstacle clearance in the primary area.

If the distance from the NAVAID to the change-over point (COP) is more than 51 NM, the outer boundary of the primary area extends beyond the 4 NM width along the 4.5° line when the COP is at midpoint. This means the primary area, along with its obstacle clearance criteria, is extended out into what would have been the secondary area. Additional differences in the obstacle clearance area result in the case of the effect of an offset COP or dogleg segment. For protected en route areas, the minimum obstacle clearance in the primary area, not designated as mountainous under 14 CFR Part 95—IFR altitude, is 1,000 feet over the highest obstacle. [Figure 2-39] The secondary obstacle clearance area extends along a line 2 NM on each side of the primary area. Navigation system accuracy in the secondary area has widths of route protection of a

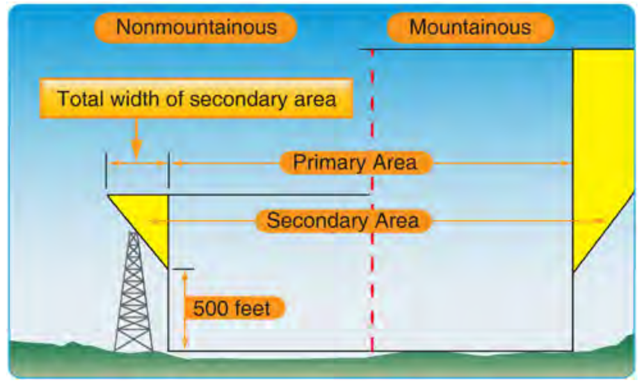


Figure 2-41. Primary and secondary obstacle clearance area.

±6.7° angle from the NAVAID. These 6.7° lines intersect the outer boundaries of the secondary areas at the same point as primary lines, 51 NM from the NAVAID. If the distance from the NAVAID to the COP is more than 51 NM, the secondary area extends along the 6.7° line when the COP is at mid-point. [Figure 2-40] In all areas, mountainous and non-mountainous, obstacles that are located in secondary areas are considered as obstacles to air navigation if they extend above the secondary obstacle clearance plane. This plane begins at a point 500 feet above the obstacles (natural or man-made) upon which the primary obstacle clearance area is based, and slants upward at an angle that causes it to intersect the outer edge of the secondary area at a point 500 feet higher. [Figure 2-41]

Changeover Points

When flying airways, pilots normally change frequencies midway between NAVAIDs, although there are times when this is not practical. If the navigation signals cannot be received from the second VOR at the midpoint of the route, a COP is depicted and shows the distance in NM to each NAVAID. [Figure 2-42] COPs indicate the point where a frequency change is necessary to receive course guidance from the facility ahead of the aircraft instead of the one

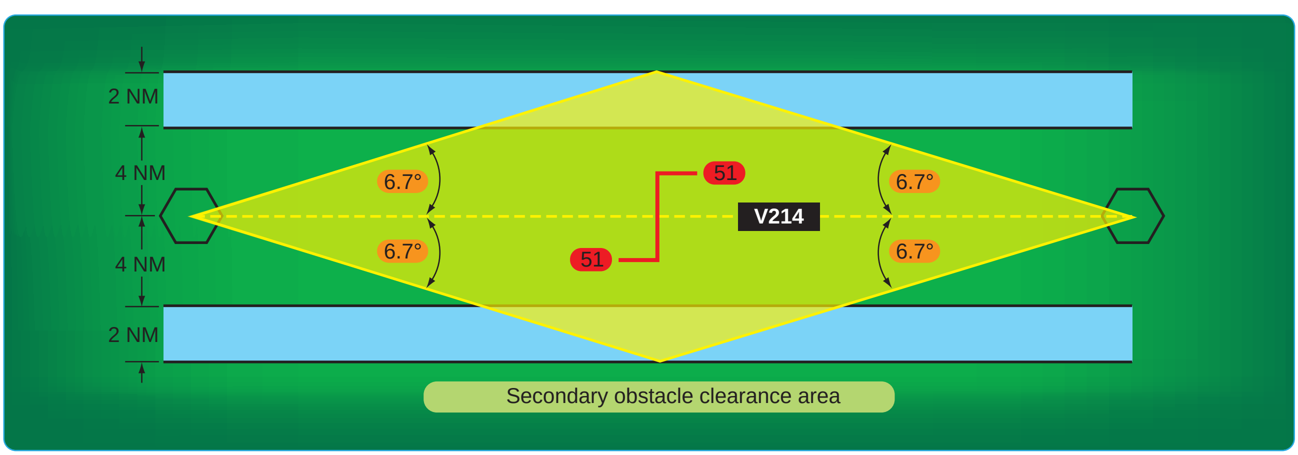


Figure 2-40. Secondary obstacle clearance area.

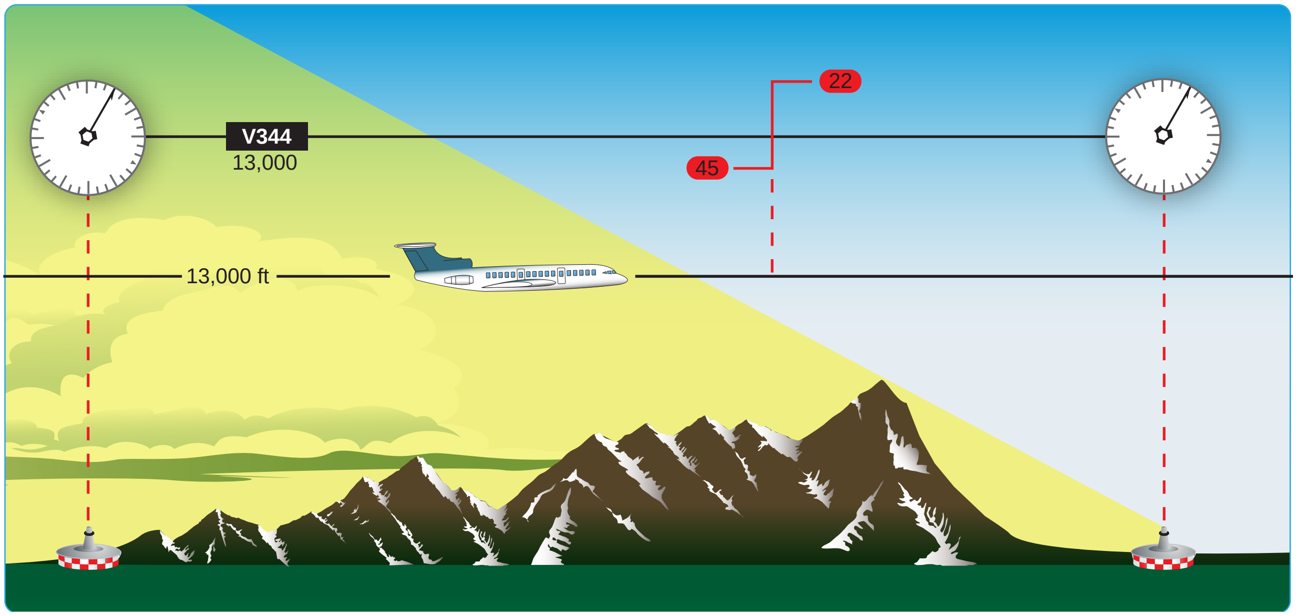


Figure 2-42. Changeover points.

behind. These COPs divide an airway or route segment and ensure continuous reception of navigation signals at the prescribed minimum en route IFR altitude. They also ensure that other aircraft operating within the same portion of an airway or route segment receive consistent azimuth signals from the same navigation facilities regardless of the direction of flight.

Where signal coverage from two VORs overlaps at the MEA, the COP normally is designated at the midpoint. Where radio frequency interference or other navigation signal problems exist, the COP is placed at the optimum location, taking into consideration the signal strength, alignment error, or any other known condition that affects reception. The COP has an effect on the primary and secondary obstacle clearance areas. On long airway or route segments, if the distance between two facilities is over 102 NM and the COP is placed at the midpoint, the system accuracy lines extend beyond the minimum widths of 8 and 12 NM, and a flare or spreading outward results at the COP. [Figure 2-43] Offset COP and dogleg segments on airways or routes can also result in a flare at the COP.

Direct Route Flights

Direct route flights are flights that are not flown on the radials or courses of established airways or routes. Direct route flights must be defined by indicating the radio fixes over which the flight passes. Fixes selected to define the route should be those over which the position of the aircraft can be accurately determined. Such fixes automatically become compulsory reporting points for the flight, unless advised otherwise by ATC. Only those NAVAIDs established

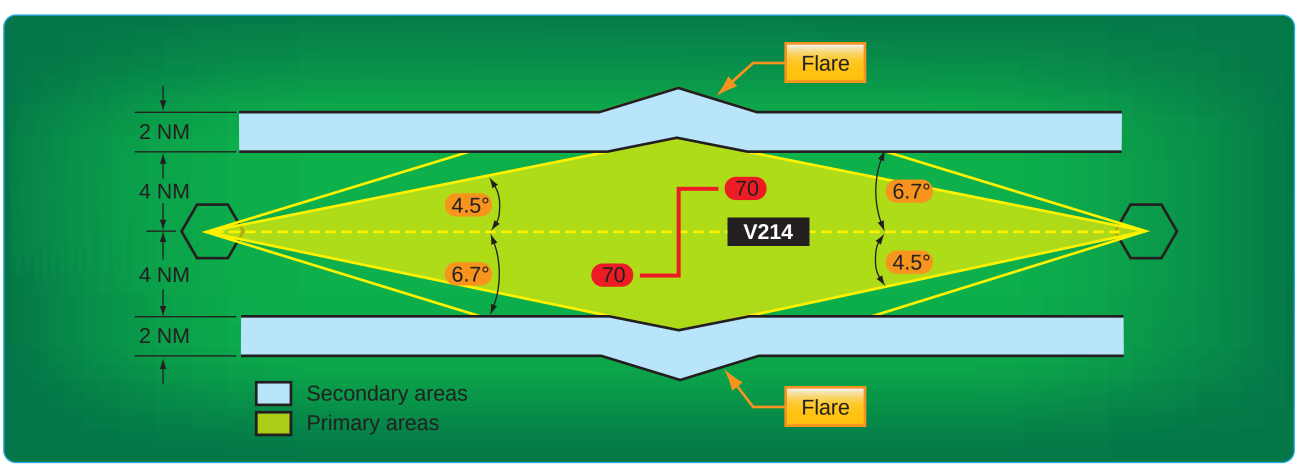


Figure 2-43. Changeover point effect on long airway or route segment.

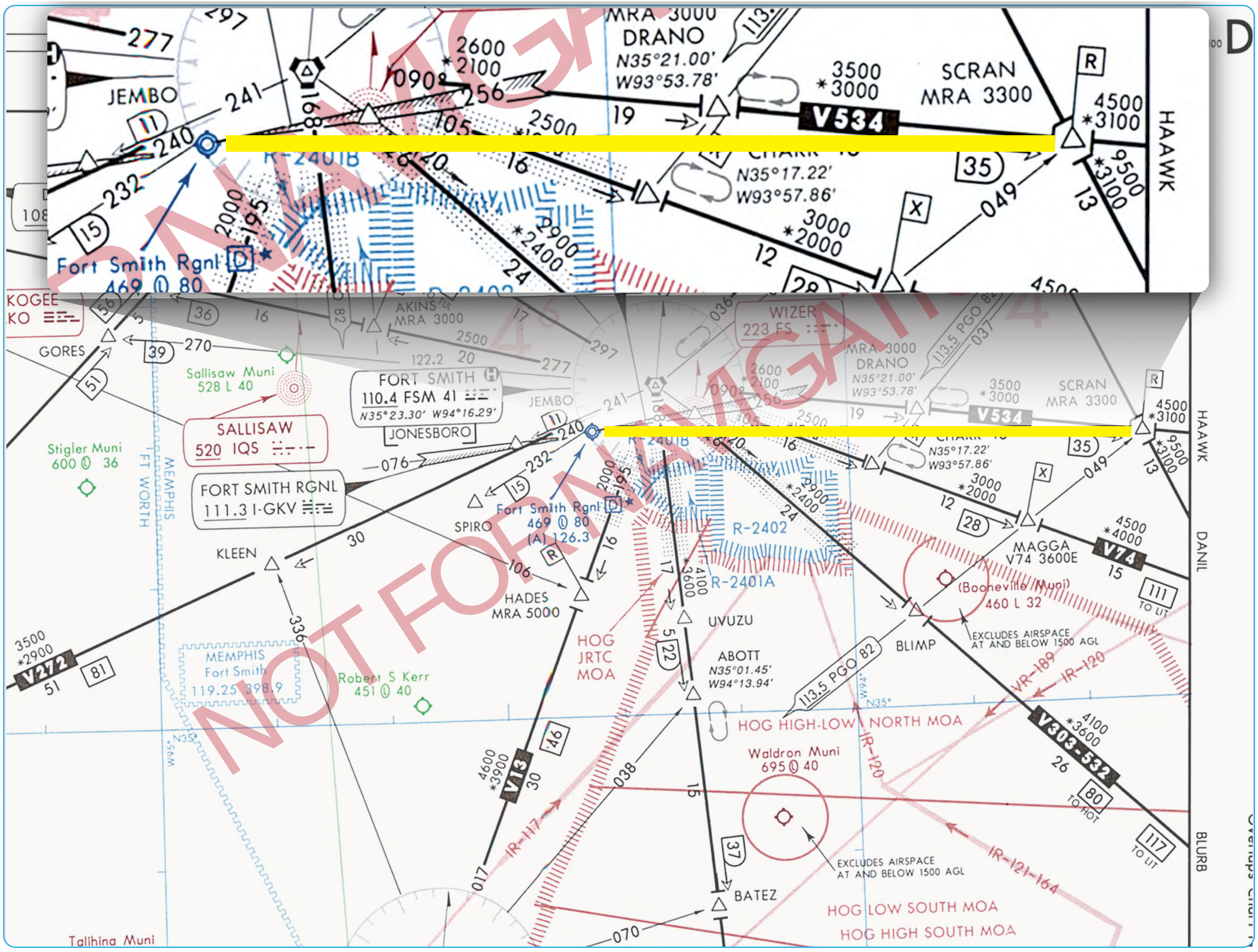


Figure 2-44. Direct route navigation.

for use in a particular structure (i.e., in the low or high structures) may be used to define the en route phase of a direct flight within that altitude structure.

Figure 2-44 shows a straight line on a magnetic course from SCRAN intersection of 270° direct to the Fort Smith Regional Airport in Arkansas that passes just north of restricted areas R-2401A and B and R-2402. Since the airport and the restricted areas are precisely plotted, there is an assurance that you will stay north of the restricted areas. From a practical standpoint, it might be better to fly direct to the Wizer NDB. This route goes even further north of the restricted areas and places you over the final approach fix to Runway 25 at Fort Smith.

The azimuth feature of VOR aids and the azimuth and distance (DME) features of VORTAC and TACAN aids are assigned certain frequency protected areas of airspace that are intended for application to established airway and route use and to provide guidance for planning flights outside of established airways or routes. These areas of airspace are expressed in terms of cylindrical service volumes of specified dimensions called class limits or categories.

An operational service volume has been established for each class in which adequate signal coverage and frequency protection can be assured. To facilitate use of VOR, VORTAC, or TACAN aids, consistent with their operational service volume limits, pilot use of such aids for defining a direct route of flight in controlled airspace should not exceed the following:

1. Operations above FL 450—use NAVAIDs not more than 200 NM apart. These aids are depicted on en route high altitude charts.
2. Operation off established routes from 18,000 feet MSL to FL 450—use NAVAIDs not more than 260 NM apart. These aids are depicted on en route high altitude charts.
3. Operation off established airways below 18,000 feet MSL—use NAVAIDs not more than 80 NM apart. These aids are depicted on en route low altitude charts.
4. Operation off established airways between 14,500

feet MSL and 17,999 feet MSL in the conterminous United States—(H) facilities not more than 200 NM apart may be used.

Increasing use of self-contained airborne navigational systems that do not rely on the VOR/VORTAC/TACAN system has resulted in pilot requests for direct routes that exceed NAVAID service volume limits. These direct route requests are approved only in a radar environment with approval based on pilot responsibility for navigation on the authorized direct route. Radar flight following is provided by ATC for ATC purposes. At times, ATC initiates a direct route in a radar environment that exceeds NAVAID service volume limits. In such cases, ATC provides radar monitoring and navigational assistance as necessary.

When filing for a direct route flight, airway or jet route numbers, appropriate to the stratum in which operation is conducted, may also be included to describe portions of the route to be flown. The following is an example of how a direct route flight would be written.

MDW V262 BDF V10 BRL STJ SLN GCK

Spelled out: from Chicago Midway Airport via Victor 262 to Bradford, Victor 10 to Burlington, Iowa, direct St. Joseph, Missouri, direct Salina, Kansas, direct Garden City, Kansas.

Note: When route of flight is described by radio fixes, the pilot is expected to fly a direct course between the points named.

Pilots should keep in mind that they are responsible for adhering to obstruction clearance requirements on those segments of direct routes that are outside of controlled airspace. The MEAs and other altitudes shown on low altitude IFR en route charts pertain to those route segments within controlled airspace, and those altitudes may not meet obstruction clearance criteria when operating off those routes.

Published RNAV Routes

Published RNAV routes are fixed, permanent routes that can be flight planned and flown by aircraft with RNAV capability. These are being expanded worldwide as new RNAV routes are developed, and existing charted, conventional routes are being designated for RNAV use. It is important to be alert to the rapidly changing application of RNAV techniques being applied to conventional en route airways. Published RNAV routes may potentially be found on any en route chart. The published RNAV route designation may be obvious, or, on the other hand, RNAV route designations may be less obvious, as in the case where a published route shares a common flight track with a conventional airway.

Note: The use of RNAV is dynamic and rapidly changing; therefore, en route charts are continuously being updated for information changes, and you may find some differences between charts.

Basic designators for air traffic service (ATS) routes and their use in voice communications have been established. One of the main purposes of a system of route designators is to allow both pilots and ATC to make unambiguous reference to RNAV airways and routes. Basic designators for ATS routes consist of a maximum of five, and in no case to exceed six, alpha/numeric characters in order to be usable by both ground and airborne automation systems. The designator indicates the type of the route, such as high/low altitude, specific airborne navigation equipment requirements, such as RNAV, and the aircraft type using the route primarily and exclusively. The basic route designator consists of one or two letter(s) followed by a number from 1 to 999.

Composition of Designators

The prefix letters that pertain specifically to RNAV designations are included in the following list:

1. The basic designator consists of one letter of the alphabet followed by a number from 1 to 999. The letters may be:
    a. A, B, G, R—for routes that form part of the regional networks of ATS route and are not RNAV routes;
    b. L, M, N, P—for RNAV routes that form part of the regional networks of ATS routes;
    c. H, J, V, W—for routes that do not form part of the regional networks of ATS routes and are not RNAV routes;
    d. Q, T, Y, Z—for RNAV routes that do not form part of the regional networks of ATS routes.
2. Where applicable, one supplementary letter must be added as a prefix to the basic designator as follows:
    a. K—to indicate a low level route established for use primarily by helicopters;
    b. U—to indicate that the route or portion thereof is established in the upper airspace;
    c. S—to indicate a route established exclusively for use by supersonic aircraft during acceleration/deceleration and while in supersonic flight.
3. Where applicable, a supplementary letter may be added after the basic designator of the ATS route as a suffix as follows:

a. F—to indicate that on the route or portion thereof advisory service only is provided;

b. G—to indicate that on the route or portion thereof flight information services only is provided;

c. Y—for RNP 1 routes at and above FL 200 to indicate that all turns on the route between 30° and 90° must be made within the tolerance of a tangential arc between the straight leg segments defined with a radius of 22.5 NM;

d. Z—for RNP 1 routes at and below FL 190 to indicate that all turns on the route between 30° and 90° should be made within the tolerance of a tangential arc between the straight leg segments defined with a radius of 15 NM.

Note: RNAV Q-routes require en route RNAV 2, corresponding NAV/E2 code and PBN/C1-C4 based on navigation system update source.

Use of Designators in Communications

In voice communications, the basic letter of a designator should be spoken in accordance with the International Civil Aviation Organization (ICAO) spelling alphabet. Where the prefixes K, U, or S, previously mentioned, are used in voice communications, they should be pronounced as:

K—Kopter

U—Upper, as in the English language

S—Supersonic

Where suffixes F, G, Y or Z specified in above, are used, the flight crew should not be required to use them in voice communications. Below is an example of how the letters and numbers are spoken.

A11—Alpha Eleven

UR5—Upper Romeo Five

KB34—Kopter Bravo Thirty Four

UW456—Upper Whiskey Four Fifty Six

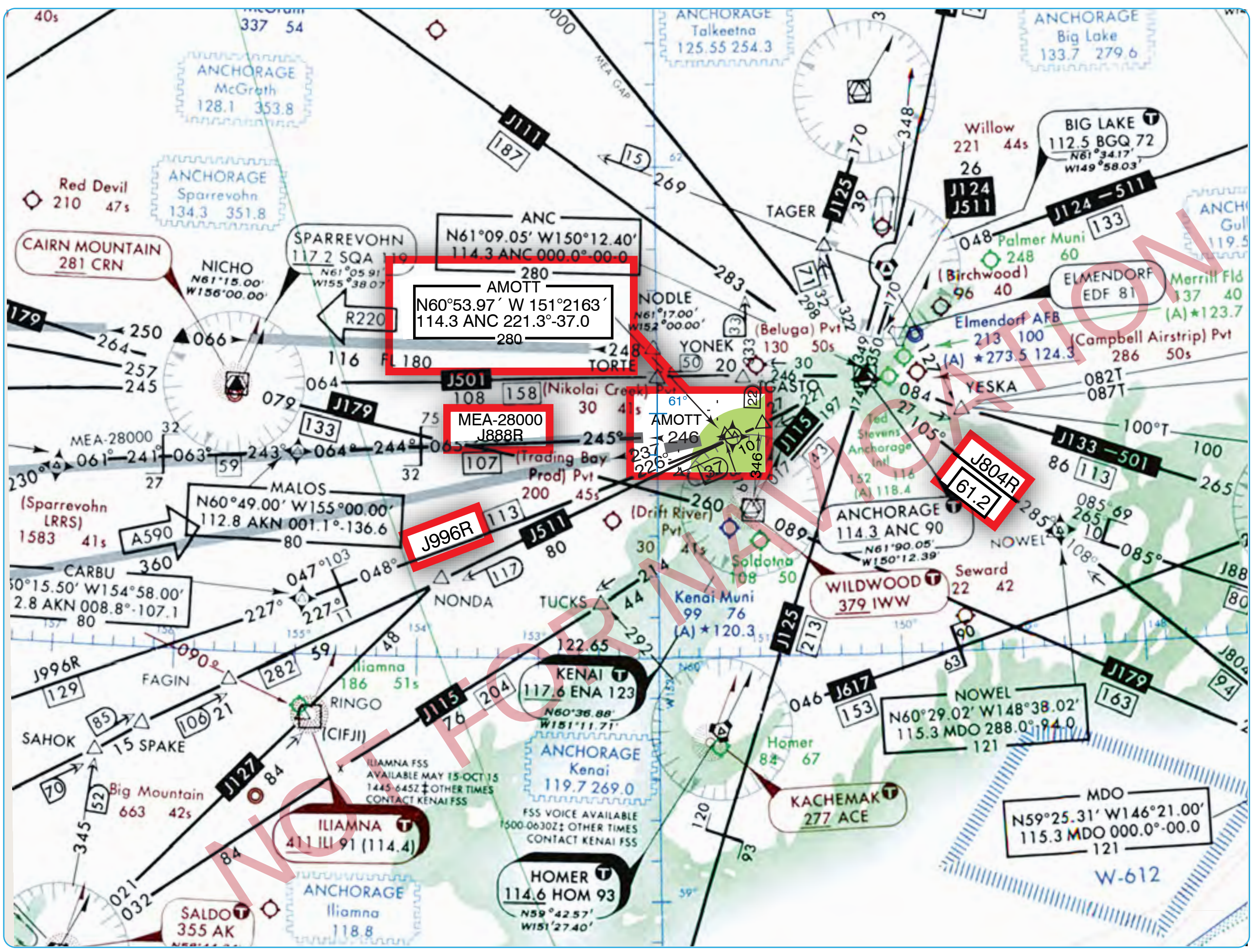


Figure 2-45. Published RNAV jet routes.

The en route chart excerpt depicts three published RNAV jet routes: J804R, J888R, and J996R. [Figure 2-45] The R suffix is a supplementary route designator denoting an RNAV route. The overlapping symbols for the AMOTT intersection and waypoint indicate that AMOTT can be identified by conventional navigation or by latitude and longitude coordinates. Although coordinates were originally included for aircraft equipped with an inertial navigation system (INS), they are now a good way to cross check between the coordinates on the chart and in the flight management system (FMS) or global positioning system (GPS) databases to ensure you are tracking on your intended en route course. The AMOTT RNAV waypoint includes bearing and distance from the Anchorage VORTAC.

Random RNAV Routes

Random RNAV routes are direct routes that are based on RNAV capability between waypoints defined in terms of latitude or longitude coordinates, degree-distance fixes, or offsets from established routes or airways at a specified distance and direction. Radar monitoring by ATC is required on all random RNAV routes. Random RNAV routes can only be approved in a radar environment. Factors that are considered by ATC when approving random RNAV routes include the capability to provide radar monitoring and compatibility with traffic volume and flow. ATC radar monitor each flight; however, navigation on the random RNAV route is the responsibility of the pilot.

Pilots flying aircraft that are equipped with approved area navigation equipment may file for RNAV routes throughout the NAS and may be filed for in accordance with the following procedures:

1. File airport-to-airport flight plans.
2. File the appropriate RNAV capability certification suffix in the flight plan.
3. Plan the random route portion of the flight plan to begin and end over appropriate arrival and departure transition fixes or appropriate NAVAIDs for the altitude stratum within which the flight is conducted. The use of normal preferred DPs and STAR, where established, is recommended.
4. File route structure transitions to and from the random route portion of the flight.
5. Define the random route by waypoints. File route description waypoints by using degree distance fixes based on navigational aids that are appropriate for the altitude stratum.
6. File a minimum of one route description waypoint for each ARTCC through whose area the random route is flown. These waypoints must be located within 200 NM of the preceding center's boundary.
7. File an additional route description waypoint for each turnpoint in the route.
8. Plan additional route description waypoints as required to ensure accurate navigation via the filed route of flight. Navigation is the pilot's responsibility unless ATC assistance is requested.
9. Plan the route of flight so as to avoid prohibited and restricted airspace by 3 NM unless permission has been obtained to operate in that airspace and the appropriate ATC facilities are advised.

Note: To be approved for use in the NAS, RNAV equipment must meet the appropriate system availability, accuracy, and airworthiness standards. For additional guidance on equipment requirements, see Advisory Circular (AC) 20-138C, Airworthiness Approval of Positioning and Navigation Systems. For airborne navigation database, see AC 90-105, Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System.

Pilots flying aircraft that are equipped with latitude/longitude coordinate navigation capability, independent of VOR/TACAN references, may file for random RNAV routes at and above FL 390 within the conterminous United States using the following procedures:

1. File airport-to-airport flight plans prior to departure.
2. File the appropriate RNAV capability certification suffix in the flight plan.
3. Plan the random route portion of the flight to begin and end over published departure/arrival transition fixes or appropriate NAVAIDs for airports without published transition procedures. The use of preferred departure and arrival routes, such as DP and STAR where established, is recommended.
4. Plan the route of flight so as to avoid prohibited and restricted airspace by 3 NM unless permission has been obtained to operate in that airspace and the appropriate ATC facility is advised.
5. Define the route of flight after the departure fix, including each intermediate fix (turnpoint) and the arrival fix for the destination airport in terms of latitude/longitude coordinates plotted to the nearest minute or in terms of Navigation Reference System (NRS) waypoints. For latitude/longitude filing, the arrival fix must be identified by both the latitude/ longitude coordinates and a fix identifier as shown in the example below.

MIA[1] SRQ[2] 3407/10615[3] 3407/11546 TNP[4] LAX[5]

[1]Departure airport

[2]Departure fix

[3]Intermediate fix (turning point)

[4]Arrival fix

[5]Destination airport

Or:

ORD[1] IOW[2] KP49G[3] KD34U[4] KL16O[5] OAL[6] MOD2[7] SFO[8]

[1]Departure airport

[2]Transition fix (pitch point)

[3]Minneapolis ARTCC waypoint

[4]Denver ARTCC waypoint

[5]Los Angeles ARTCC waypoint (catch point)

[6]Transition fix

[7]Arrival

[8]Destination airport

6. Record latitude/longitude coordinates by four figures describing latitude in degrees and minutes followed by a solidus and five figures describing longitude in degrees and minutes.
7. File at FL 390 or above for the random RNAV portion of the flight.
8. Fly all routes/route segments on Great Circle tracks.
9. Make any in-flight requests for random RNAV clearances or route amendments to an en route ATC facility.

Authorized areas of en route operation	Limitations, provisions, and reference paragraphs
The 48 contiguous United States and the District of Columbia	Note 1
Canada, excluding Canadian MNPS airspace and the areas of magnetic unreliability as established in the Canadian AIP	Note 3
SPECIAL REQUIREMENTS: Note 1 - B-737 Class II navigation operations with a single long-range system is authorized only within this area of en route operation. Note 3 - Only B-747 and DC-10 operations authorized in these areas.	

Figure 2-46. Excerpt of authorized areas of en route operation.

Off-Airway Routes

14 CFR Part 95 prescribes altitudes governing the operation of aircraft under IFR on Federal airways, jet routes, RNAV low or high altitude routes, and other direct routes for which a MEA is designated. In addition, it designates mountainous areas and COPs. Off-airway routes are established in the same manner and in accordance with the same criteria as airways and jet routes. If a pilot flies for a scheduled air carrier or operator for compensation or hire, any requests for the establishment of off-airway routes are initiated by the company through the principal operations inspector (POI) who works directly with the company and coordinates FAA approval. Air carrier authorized routes should be contained in the company's Operations Specifications (OpSpecs) under the auspices of the air carrier operating certificate. [Figure 2-46]

Off-airway routes predicated on public navigation facilities and wholly contained within controlled airspace are published as direct Part 95 routes. Off-airway routes predicated on privately owned navigation facilities or not contained wholly within controlled airspace are published as off-airway non-Part 95 routes. In evaluating the adequacy of off-airway routes, the following items are considered: the type of aircraft and navigation systems used; proximity to military bases, training areas, low level military routes; and the adequacy of communications along the route.

Commercial operators planning to fly off-airway routes should have specific instructions in the company's OpSpecs that address en route limitations and provisions regarding en route authorizations to use the GPS or other RNAV systems in the NAS. The company's manuals and checklists should include practices and procedures for long-range navigation and training on the use of long range navigation equipment. Minimum equipment lists (MELs) and maintenance programs must address the long range navigation equipment. Examples of other selected areas requiring specialized en route authorization include the following:

- Class I navigation in the United States Class A airspace using area of long range navigation system.
- Class II navigation using multiple long range navigation systems.
- Operations in central East Pacific airspace.
- North Pacific operations.
- Operations within North Atlantic (NAT) minimum navigation performance specifications (MNPS) airspace.

- Operations in areas of magnetic unreliability.
- North Atlantic operation (NAT/OPS) with two engine aircraft under 14 CFR Part 121.
- Extended range operations (ER-OPS) with two engine aircraft under 14 CFR Part 121.
- Special fuel reserves in international operations.
- Planned in-flight re-dispatch or re-release en route.
- Extended over water operations using a single long-range communication system.
- Operations in reduced vertical separation minimum (RVSM) airspace.

Off-Route Obstruction Clearance Altitude

An off-route obstruction clearance altitude (OROCA) is an off-route altitude that provides obstruction clearance with a 1,000-foot buffer in non-mountainous terrain areas and a 2,000-foot buffer in designated mountainous areas within the United States. This altitude may not provide signal coverage from ground-based NAVAIDs, ATC radar, or communications coverage. OROCAs are intended primarily as a pilot tool for emergencies and SA. OROCAs depicted on en route charts do not provide the pilot with an acceptable altitude for terrain and obstruction clearance for the purposes of off-route, random RNAV direct flights in either controlled or uncontrolled airspace. OROCAs are not subject to the same scrutiny as MEAs, minimum vectoring altitude (MVAs), MOCAs, and other minimum IFR altitudes. Since they do not undergo the same obstruction evaluation, airport airspace analysis procedures, or flight inspection, they cannot provide the same level of confidence as the other minimum IFR altitudes.

When departing an airport VFR intending to or needing to obtain an IFR clearance en route, you must be aware of the position of your aircraft relative to terrain and obstructions. When accepting a clearance below the MEA, MIA, MVA, or the OROCA, you are responsible for your own terrain/obstruction clearance until reaching the MEA, MIA, or MVA. If unable to visually maintain terrain/obstruction clearance, pilots should advise ATC and state intentions of the flight. [Figure 2-47]

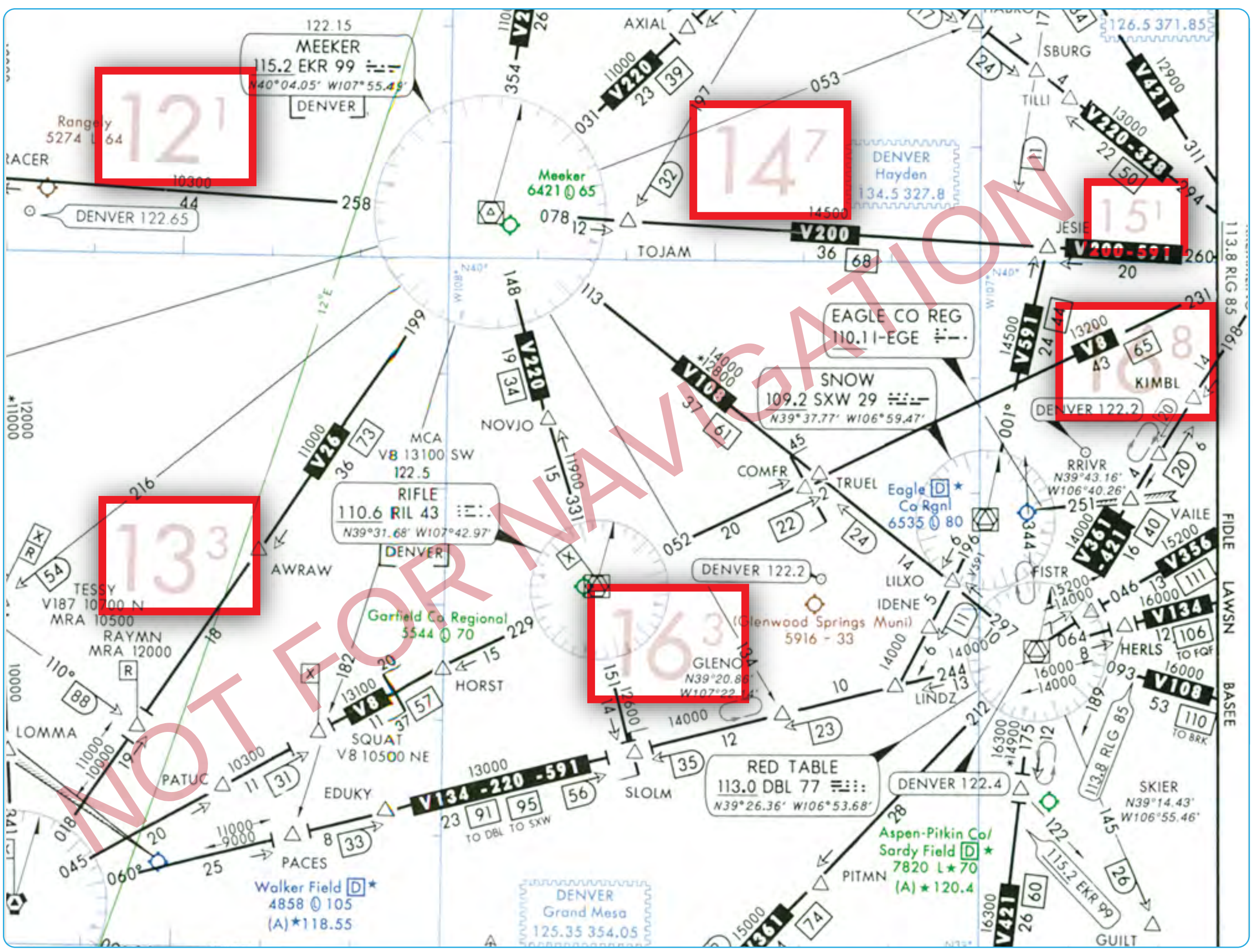


Figure 2-47. Off-route obstacle clearance altitude.

Figure 2-48. Random RNAV route.

For all random RNAV flights, there needs to be at least one waypoint in each ARTCC area through which you intend to fly. One of the biggest problems in creating an RNAV direct route is determining if the route goes through special use airspace. For most direct routes, the chances of going through prohibited, restricted, or special use airspace are good. In the United States, all direct routes should be planned to avoid prohibited or restricted airspace by at least 3 NM. If a bend in a direct route is required to avoid special use airspace, the turning point needs to be part of the flight plan. Two of the most prominent long range navigation systems today include FMS with integrated GPS and stand-alone GPS. The following example is a simplified overview showing how the RNAV systems might be used to fly a random RNAV route.

Shown in Figure 2-48, the aircraft is northeast of Tuba City VORTAC at FL 200 using RNAV (showing both GPS and FMS), RNAV direct on a southwesterly heading to Lindbergh Regional Airport in Winslow. As the pilot is monitoring his or her position and cross-checking the avionics against the high altitude en route chart, he or she receives a company message instructing to divert to Las Vegas, requiring a change in the flight plan as highlighted on the depicted chart excerpt.

During the flight deck review of the high and low altitude en route charts, the pilot determines that the best course of action is to fly direct to the MIRAJ waypoint, 28 DME northeast of the Las Vegas VORTAC on the 045° radial. This places the aircraft 193 NM out on a 259° magnetic course inbound, and may help to avoid diverting north, allowing to bypass the more distant originating and intermediate fixes feeding into Las Vegas. The pilot requests an RNAV random route clearance direct MIRAJ to expedite the flight. Denver Center comes back with the following amended flight plan and initial clearance into Las Vegas:

"Marathon five sixty four, turn right heading two six zero, descend and maintain one six thousand, cleared present position direct MIRAJ."

The latitude and longitude coordinates of the aircraft's present position on the high altitude chart is N36 19.10 and W110 40.24 as the course is changed. Notice the GPS moving map (upper left), the FMS control display unit (below the GPS), and FMS map mode navigation displays (to the right of the GPS) as the flight is rerouted to Las Vegas. For SA, the pilot makes note that the altitude is well above any of the OROCAs on the direct route as the flight arrives in the Las Vegas area using the low altitude chart.

Monitoring of Navigation Facilities

VOR, VORTAC, and instrument landing system (ILS) facilities, as well as most NDBs and marker beacons installed by the FAA, are provided with an internal monitoring feature. Internal monitoring is provided at the facility through the use of equipment that causes a facility shutdown if performance deteriorates below established tolerances. A remote status indicator also may be provided through the use of a signal-sampling receiver, microwave link, or telephone circuit. Older FAA NDBs and some non-Federal NDBs do not have the internal feature, and monitoring is accomplished by manually checking the operation at least once each hour. FAA facilities, such as automated flight service stations (AFSSs) and ARTCCs/sectors, are usually the control point for NAVAID facility status. Pilots can query the appropriate FAA facility if they have questions in flight regarding NAVAID status, in addition to checking NOTAMs prior to flight, since NAVAIDs and associated monitoring equipment are continuously changing.

Navigational Gaps

A navigational course guidance gap, referred to as an MEA gap, describes a distance along an airway or route segment where a gap in navigational signal coverage exists. The navigational gap may not exceed a specific distance that varies directly with altitude, from 0 NM at sea level to 65 NM at 45,000 feet MSL and not more than one gap may exist in the airspace structure for the airway or route segment. Additionally, a gap usually does not occur at any airway or route turning point. To help ensure the maximum amount of continuous positive course guidance available when flying, there are established en route criteria for both straight and turning segments. Where large gaps exist that require altitude changes, MEA "steps" may be established at increments of not less than 2,000 feet below 18,000 feet MSL, or not less than 4,000 feet at 18,000 MSL and above, provided that a total gap does not exist for the entire segment within the airspace structure. MEA steps are limited to one step between any two facilities to eliminate continuous or repeated changes of altitude in problem areas. The allowable navigational gaps pilots can expect to see are determined, in part, by reference to the graph depicted in Figure 2-49. Notice the en route chart excerpt depicting that the MEA is established with a gap in navigation signal coverage northwest of the Carbon VOR/DME on V134. At the MEA of 13,000, the allowable navigation course guidance gap is approximately 18.5 NM, as depicted in Figure 2-49. The navigation gap area is not identified on the chart by distances from the navigation facilities. Proper flight planning will help pilots prepare for MEA gaps by insuring that appropriate maps are available as they may need to dead reckon through the gap. Calculating the ground track (with adjustments for winds) before and after the gap will also help to stay on course when navigational course guidance is not available.

NAVAID Accuracy Check

The CFRs and good judgment dictate that the equipment of aircraft flying under IFR be within a specified tolerance before taking off. When approved procedures are available, they should be used for all equipment inspections.

VOR Accuracy

VOR accuracy can be checked by using any of the following methods: VOR test facility signal (VOT), VOR checkpoint signs, dual VOR check, or airborne VOR check.

VOT

The VOT is an approved test signal and is located on an airport. This enables the pilot to check the VOR accuracy from the flight deck before takeoff. Listed below are the steps used for a VOT:

1. Tune the VOR receiver to the VOT frequency. VOT frequencies can be found in the CS. [Figure 2-50] These frequencies are coded with a series of Morse code dots or a continuous 1020-cycle tone.

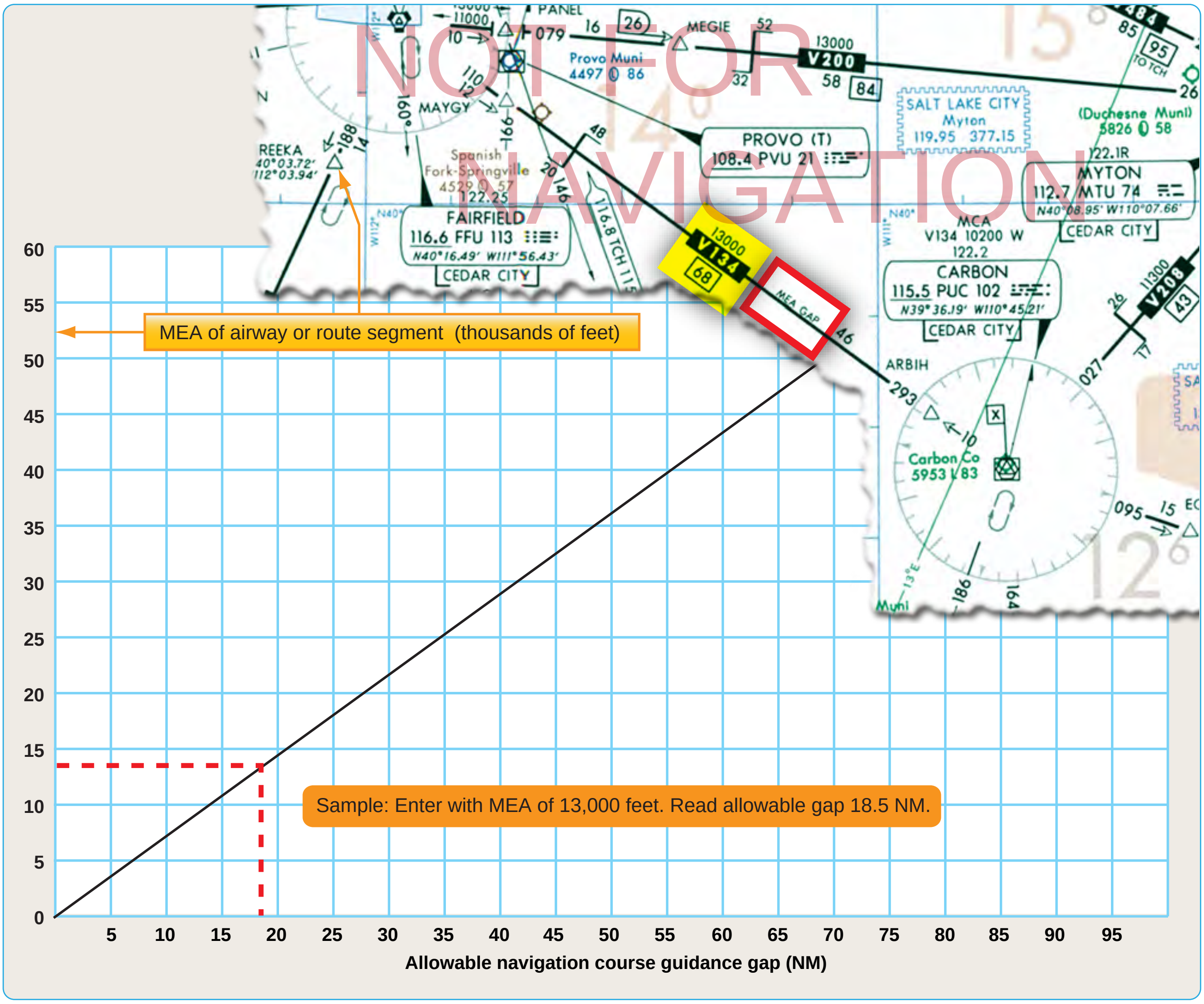


Figure 2-49. Navigational course guidance gaps.

VOR test facilities (VOT)

Facility Name (Airport Name)	Frequency	Type VOT Facility	Remarks
Bradlay Intl	111.40	G	
Bridgeport	109.25	G	
Groton	110.25	G	
Hartford	108.20	G	

Figure 2-50. VOR test facilities (VOT) frequencies.

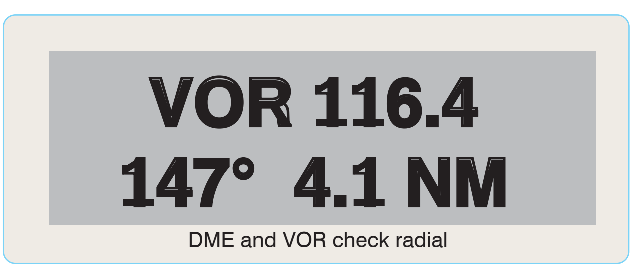


Figure 2-51. VOR checkpoint signs.

2. On the VOR, set the course selector to 0° and the track bar (TB) indicator should read center. The TO-FROM indicator should read FROM.
3. Set the course selector to 180° and the TO-FROM indicator should read TO and the TB should then be centered.

Note: Determining the exact error in the receiver is done by turning the track selector until the TB is centered and noting the degrees difference between 180° or 0°. The maximum bearing error with the VOT system check is plus or minus 4° and apparent errors greater than 4° indicate that the VOR receiver is beyond acceptable tolerance.

VOR Checkpoint Signs

Many aerodromes have VOR checkpoint signs that are located beside the taxiways. [Figure 2-51] These signs indicate the exact point on the aerodrome that there is sufficient signal strength from a VOR to check the aircraft's

VOR receiver against the radial designated on the sign. Listed below are the steps to use at a VOR checkpoint:

1. Tune the proper VOR frequency.
2. Identify the VOR frequency.
3. Set the published radial on the course deviation indicator (CDI).
4. Confirm that the TB is centered.
5. Check the needle sensitivity by changing the omnibearing select (OBS) 10° each way.
6. Set the reciprocal of the radial and check the TO-FROM flag change.
7. The maximum permissible difference between aircraft equipment and the designated radial is 4° and 0.5 NM of the posted distance.

Dual VOR Check

If a VOT or VOR checkpoint is not available and the aircraft is equipped with dual VORs, the equipment may be checked against one another by tuning both sets to the VOR facility at the same time and noting the indicated bearings to that station. [Figure 2-52] A difference greater than 4° between the two VORs indicates that one of the receivers may be out of tolerance.

Airborne VOR Check

VOR equipment can also be checked for accuracy while in flight by flying over a fix or landmark located on a published radial and noting the indicated radial. Variances of more than 6° from the published radial should be considered out of tolerance and not be used for IFR navigation.

NDB Accuracy Check

The pilot must identify an NDB before using it for navigation, and continuously monitor it while using it for an instrument approach. The lack of an IDENT may indicate that the NDB is out of service, even though it may still be transmitting (for instance for maintenance or test purposes). If an incorrect IDENT is heard, then the NDB should not be used.

RNAV Accuracy Check

RNAV accuracy checks may differ depending on the different type of equipment and manufacturer. When available, all written procedures should be followed.

Figure 2-52. Instrument panel with dual VORs.

Below is a list of generic checks that should be used when checking the accuracy of the system prior to flight.

1. System initialization—pilots should confirm that the navigation database is current and verify that the aircrafts present position has been entered correctly.
2. Active flight plan check—the active flight plan should be checked by comparing the aeronautical charts, departure and arrival procedures, and other applicable documents with the map display.

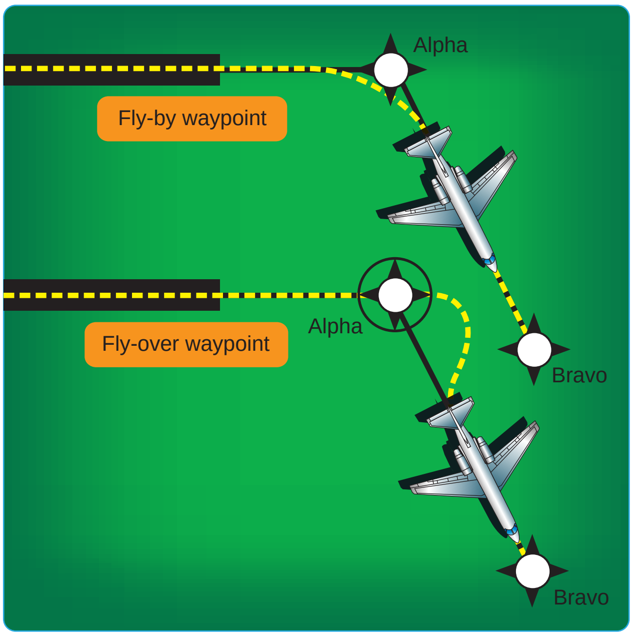


Figure 2-53. Fly-by and fly-over waypoints.

3. Prior to takeoff—ensure that the RNAV system is available. If possible, check to see that the system is updating when aircraft position is changing.

Note: While in flight, continue to verify system accuracy by displaying bearing/range to a VOR/DME on the RNAV system and compare it to the actual RMI reading of that particular NAVAID.

Waypoints

Waypoints are predetermined geographical locations that are defined in terms of latitude/longitude coordinates or fixes, used to define an RNAV route or the flight path of an aircraft employing RNAV. Waypoints may be a simple named point in space or may be associated with existing NAVAIDs, intersections, or fixes. A waypoint is most often used to indicate a change in direction, speed, or altitude along the desired path. Aviation RNAV procedures make use of both fly-over and fly-by waypoints. A fly-over waypoint is a waypoint that must be crossed vertically by an aircraft. A fly-by waypoint is a waypoint that marks the intersection of two straight paths, with the transition from one path to another being made by the aircraft using a precisely calculated turn that flies by but does not vertically cross the waypoint. [Figure 2-53]

User-Defined Waypoints

Pilots typically create user-defined waypoints for use in their own random RNAV direct navigation. They are newly established, unpublished airspace fixes that are designated geographic locations/positions that help provide positive course guidance for navigation and a means of checking progress on a flight. They may or may not be actually plotted by the pilot on en route charts, but would normally be communicated to ATC in terms of bearing and distance or latitude/longitude. An example of user-defined waypoints typically includes those generated by various means including keyboard input, and even electronic map mode functions used to establish waypoints with a cursor on the display.

Another example is an offset phantom waypoint, which is a point-in-space formed by a bearing and distance from NAVAIDs, such as VORTACs and tactical air navigation (TACAN) stations, using a variety of navigation systems. When specifying unpublished waypoints in a flight plan, they can be communicated using the frequency/bearing/distance format or latitude and longitude, and they automatically become compulsory reporting points unless otherwise advised by ATC. All aircraft with latitude and longitude navigation systems flying above FL 390 must use latitude and longitude to define turning points.

Floating Waypoints

Floating waypoints, or reporting points, represent airspace fixes at a point in space not directly associated with a conventional airway. In many cases, they may be established for such purposes as ATC metering fixes, holding points, RNAV-direct routing, gateway waypoints, STAR origination points leaving the en route structure, and SID terminating points joining the en route structure. In the top example of Figure 2-54, a low altitude en route chart depicts three floating waypoints that have been highlighted: SCORR, FILUP, and CHOOT. Notice that waypoints are named with five-letter identifiers that are unique and pronounceable. Pilots must be careful of similar waypoint names. Notice on the high altitude en route chart excerpt in the bottom example, the similar sounding and spelled floating waypoint named SCOOR, rather than SCORR. This emphasizes the importance of correctly entering waypoints into database-driven navigation systems. One waypoint character incorrectly entered into your navigation system could adversely affect your flight. The SCOOR floating reporting point also is

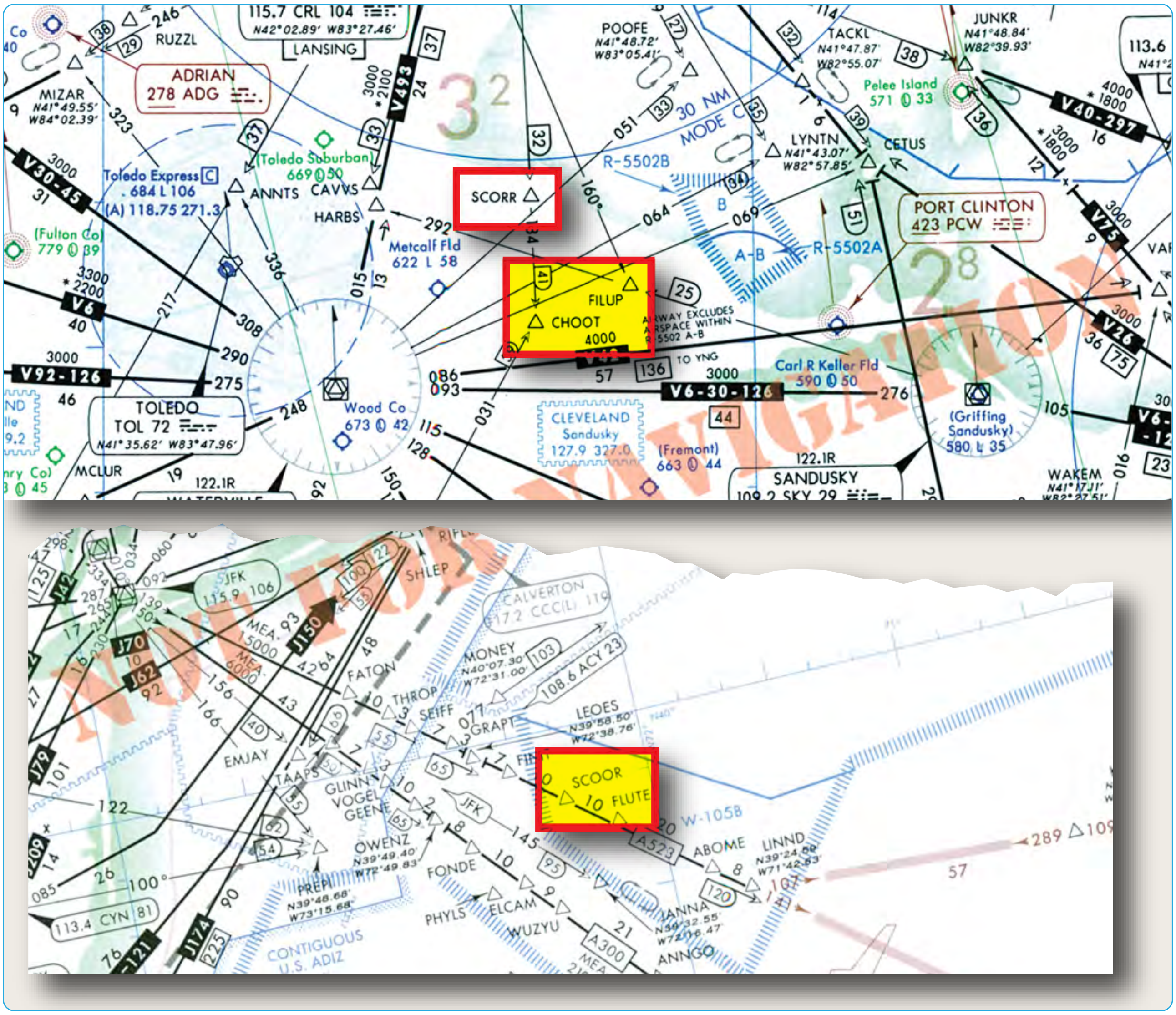


Figure 2-54. Floating waypoints.

depicted on a Severe Weather Avoidance Plan (SWAP) en route chart. These waypoints and SWAP routes assist pilots and controllers when severe weather affects the East Coast.

Computer Navigation Performance

An integral part of RNAV using en route charts typically involves the use of airborne navigation databases. Because GPS receivers are basically "to-to" navigators, they must always be navigating to a defined point. On overlay approaches, if no pronounceable five-character name is published for an approach waypoint or fix, it has been given a database identifier consisting of letters and numbers. These points appear in the list of waypoints in the approach procedure database, but may not appear on the approach chart. A point used for the purpose of defining the navigation track for an airborne computer system (i.e., GPS or FMS) is called a Computer Navigation Fix (CNF). CNFs include unnamed DME fixes, beginning and ending points of DME arcs, and sensor final approach fixes (FAFs) on some GPS overlay approaches.

To aid in the approach chart/database correlation process, the FAA has begun a program to assign five-letter names to CNFs and to chart CNFs on various National Oceanic Service aeronautical products. [Figure 2-55] These CNFs are not to be used for any ATC application, such as holding for which the fix has not already been assessed. CNFs are charted to distinguish them from conventional reporting points, fixes, intersections, and waypoints. A CNF name is enclosed in parenthesis, e.g., (MABEE) and is placed next to the CNF it defines. If the CNF is not at an existing point defined by means such as crossing radials or radial/DME, the point is indicated by an X. The CNF name is not used in filing a flight plan or in aircraft/ATC communications. Use current phraseology (e.g., facility name, radial, distance) to describe these fixes.

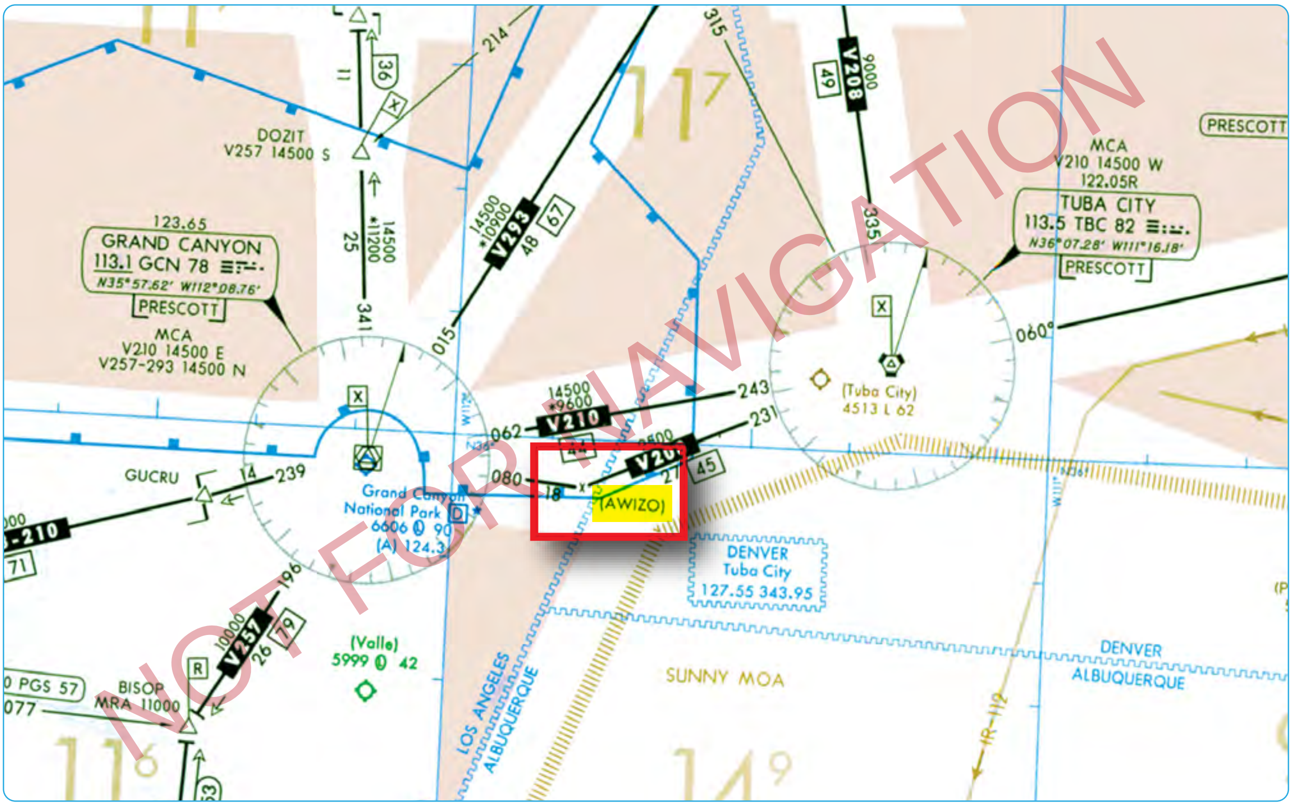


Figure 2-55. Computer navigation fix.

Many of the RNAV systems available today make it all too easy to forget that en route charts are still required and necessary for flight. As important as databases are, they really are onboard the aircraft to provide navigation guidance and situational awareness (SA); they are not intended as a substitute for paper charts. When flying with GPS, FMS, or planning a flight with a computer, it is critical to understand the limitations of the system you are using, for example, incomplete information, unloadable procedures, complex procedures, and database storage limitations.

Required Navigation Performance

Required navigation performance (RNP) is RNAV with onboard navigation monitoring and alerting. RNP is also a statement of navigation performance necessary for operation within a defined airspace. A critical component of RNP is the ability of the aircraft navigation system to monitor its achieved navigation performance, and to identify for the pilot whether the operational requirement is, or is not being met during an operation. This onboard performance monitoring and alerting capability; therefore, allows a lessened reliance on ATC intervention (via radar monitoring, automatic dependent surveillance-broadcast (ADS-B), multilateration, communications), and/or route separation to achieve the overall safety of the operation. RNP capability of the aircraft is a major component in determining the separation criteria to ensure that the overall containment of the operation is met.

The RNP capability of an aircraft varies depending upon the aircraft equipment and the navigation infrastructure. For example, an aircraft may be equipped and certified for RNP 1.0, but may not be capable of RNP 1.0 operations due to limited NAVAID coverage.

RNP Level	Typical Application	Primary Route Width (NM) - Centerline to Boundary
0.1 to 1.0	RNP AR Approach Segments	0.1 to 1.0
0.3 to 1.0	RNP Approach Segments	0.3 to 1.0
1	Terminal and En Route	1.0
2	En Route	2.0

Figure 2-56. U.S. standard RNP levels.

RNP Levels

An RNP level or type is applicable to a selected airspace, route, or procedure. As defined in the Pilot/Controller Glossary, the RNP level or type is a value typically expressed as a distance in nautical miles from the intended centerline of a procedure, route, or path. RNP applications also account for potential errors at some multiple of RNP level (e.g., twice the RNP level).

Standard RNP Levels

United States standard values supporting typical RNP airspace are shown in Figure 2-56. Other RNP levels as identified by ICAO, other states, and the FAA may also be used.

Application of Standard RNP Levels

United States standard levels of RNP typically used for various routes and procedures supporting RNAV operations may be based on use of a specific navigational system or sensor, such as GPS, or on multi-sensor RNAV systems having suitable performance.

Note: The performance of navigation in RNP refers not only to the level of accuracy of a particular sensor or aircraft navigation system, but also to the degree of precision with which the aircraft is flown. Specific required flight procedures may vary for different RNP levels.

IFR En Route Altitudes

Minimum En Route Altitudes (MEAs), Minimum Reception Altitudes (MRAs), Maximum Authorized Altitudes (MAAs), Minimum Obstacle Clearance Altitudes (MOCAs), Minimum Turning Altitudes (MTAs) and Minimum Crossing Altitudes (MCAs) are established by the FAA for instrument flight along Federal airways, as well as some off-airway routes. The altitudes are established after it has been determined that the NAVAIDs to be used are adequate and so oriented on the airways or routes that signal coverage is acceptable, and that flight can be maintained within prescribed route widths.

For IFR operations, regulations require that pilots operate their aircraft at or above minimum altitudes. Except when necessary for takeoff or landing, pilots may not operate an aircraft under IFR below applicable minimum altitudes, or if no applicable minimum altitude is prescribed, in the case of operations over an area designated as mountainous, an altitude of 2,000 feet above the highest obstacle within a horizontal distance of 4 NM from the course to be flown. In any other case, an altitude of 1,000 feet above the highest obstacle within a horizontal distance of 4 NM from the course to be flown must be maintained as a minimum altitude. If both a MEA and a MOCA are prescribed for a particular route or route segment, pilots may operate an aircraft below the MEA down to, but not below, the MOCA, only when within 22 NM of the VOR. When climbing to a higher minimum IFR altitude (MIA), pilots must begin climbing immediately after passing the point beyond which that minimum altitude applies, except when ground obstructions intervene, the point beyond which that higher minimum altitude applies must be crossed at or above the applicable MCA for the VOR.

If on an IFR flight plan, but cleared by ATC to maintain VFR conditions on top, pilots may not fly below minimum en route IFR altitudes. Minimum altitude rules are designed to ensure safe vertical separation between the aircraft and the terrain. These minimum altitude rules apply to all IFR flights, whether in IFR or VFR weather conditions, and whether assigned a specific altitude or VFR conditions on top.

Minimum En Route Altitude (MEA)

The MEA is the lowest published altitude between radio fixes that assures acceptable navigational signal coverage and meets obstacle clearance requirements between those fixes. The MEA prescribed for a Federal airway or segment, RNAV low or high route, or other direct route applies to the entire width of the airway, segment, or route between the radio fixes defining the airway, segment, or route. MEAs for routes wholly contained within controlled airspace normally provide a buffer above the floor of controlled airspace consisting of at least 300 feet within transition areas and 500 feet within control areas. MEAs are established based upon obstacle clearance over terrain and manmade objects, adequacy of navigation facility performance, and communications requirements.

RNAV Minimum En Route Altitude

RNAV MEAs are depicted on some IFR en route low altitude charts, allowing both RNAV and non-RNAV pilots to use the same chart for instrument navigation.

Minimum Reception Altitude (MRA)

MRAs are determined by FAA flight inspection traversing an entire route of flight to establish the minimum altitude the navigation signal can be received for the route and for off-course NAVAID facilities that determine a fix. When the MRA at the fix is higher than the MEA, an MRA is established for the fix and is the lowest altitude at which an intersection can be determined.

Maximum Authorized Altitude (MAA)

An MAA is a published altitude representing the maximum usable altitude or flight level for an airspace structure

Figure 2-57. Maximum authorized altitude (MAA).

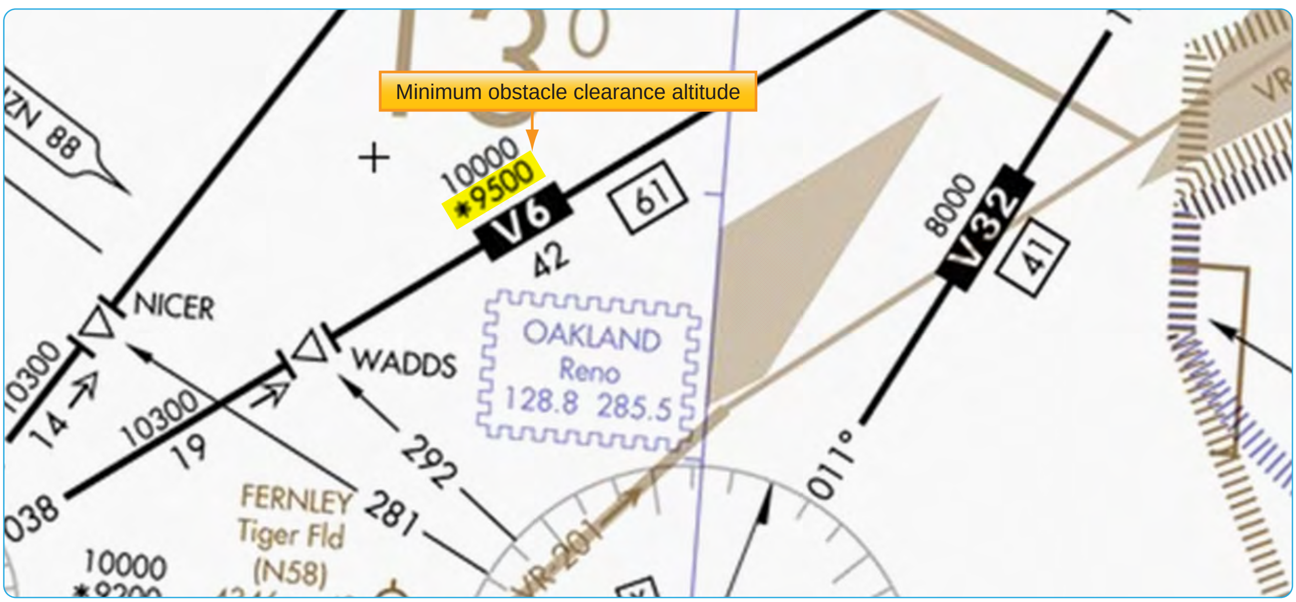


Figure 2-58. Minimum obstacle clearance altitude (MOCA).

or route segment. [Figure 2-57] It is the highest altitude on a Federal airway, jet route, RNAV low or high route, or other direct route for which an MEA is designated at which adequate reception of navigation signals is assured. MAAs represent procedural limits determined by technical limitations or other factors, such as limited airspace or frequency interference of ground-based facilities.

Minimum Obstruction Clearance Altitude (MOCA)

The MOCA is the lowest published altitude in effect between fixes on VOR airways, off-airway routes, or route segments that meets obstacle clearance requirements for the entire route segment. [Figure 2-58] This altitude also assures acceptable navigational signal coverage only within 22 NM of a VOR. The MOCA seen on the en route chart may have been computed by adding the required obstacle clearance (ROC) to the controlling obstacle in the primary area or computed by using a TERPS chart if the controlling obstacle is located in the secondary area. This figure is then rounded to the nearest 100 foot increment (i.e., 2,049 feet becomes 2,000, and 2,050 feet becomes 2,100 feet). An extra 1,000

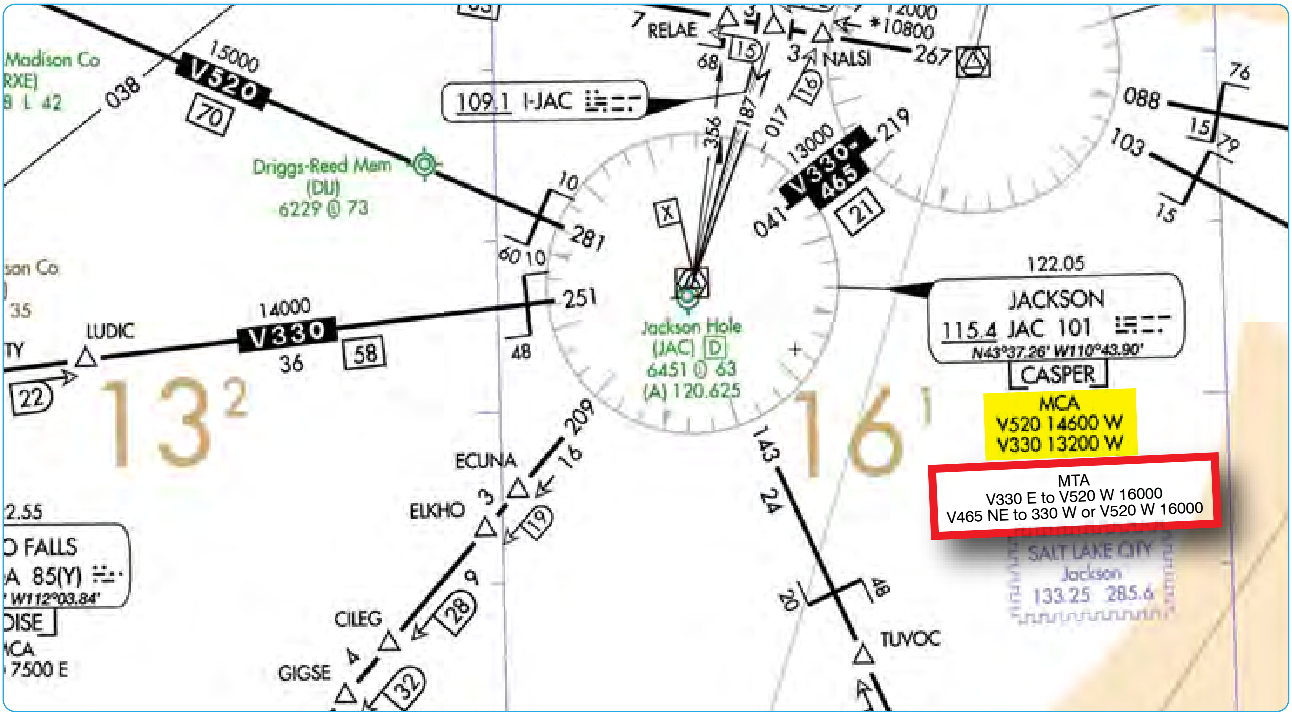


Figure 2-59. Minimum turning altitude (MTA).

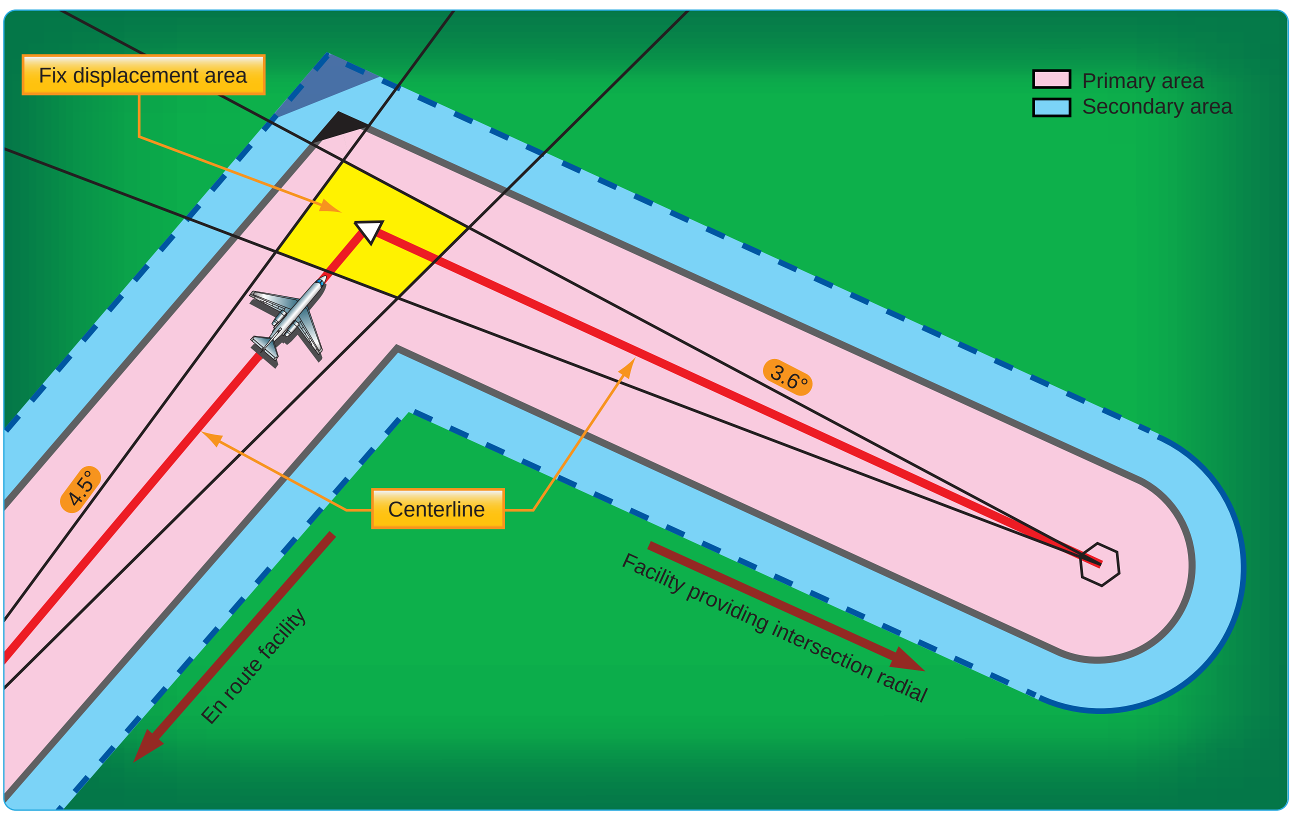


Figure 2-60. Turning area at the intersection fix with NAVAID distance less than 51 NM.

feet is added in mountainous areas, in most cases.

ATC controllers have an important role in helping pilots remain clear of obstructions. Controllers are instructed to issue a safety alert if the aircraft is in a position that, in their judgment, places the pilot in unsafe proximity to terrain, obstructions, or other aircraft. Once pilots inform ATC of action being taken to resolve the situation, the controller may discontinue the issuance of further alerts. A typical terrain/obstruction alert may sound like this: "(Aircraft call sign), Low altitude alert. Check your altitude immediately. The MOCA in your area is 12,000."

Minimum Turning Altitude (MTA)

Minimum turning altitude (MTA) is a charted altitude providing vertical and lateral obstruction clearance based on turn criteria over certain fixes, NAVAIDs, waypoints, and on charted route segments. [Figure 2-59] When a VHF airway or route terminates at a NAVAID or fix, the primary area extends beyond that termination point. When a change of course on VHF airways and routes is necessary, the en route obstacle clearance turning area extends the primary and secondary obstacle clearance areas to accommodate the turn radius of the aircraft. Since turns at or after fix passage may exceed airway and route boundaries, pilots are expected to adhere to airway and route protected airspace by leading turns early before a fix. The turn area provides obstacle clearance for both turn anticipation (turning prior to the fix) and flyover protection (turning after crossing the fix). This does not violate the requirement to fly the centerline of the airway. Many factors enter into the construction and application of the turning area to provide pilots with adequate obstacle clearance protection. These may include aircraft speed, the amount of turn versus NAVAID distance, flight track, curve radii, MEAs, and MTA. [Figure 2-60]

Due to increased airspeeds at 10,000 feet MSL or above, an expanded area in the vicinity of the turning fix is examined to ensure the published MEA is sufficient for obstacle clearance. In some locations (normally mountainous), terrain/obstacles in the expanded search area may obviate the published MEA and necessitate a higher minimum altitude while conducting the turning maneuver. Turning fixes requiring a higher MTA are charted with a flag along with accompanying text describing the MTA restriction. [Figure 2-59]

An MTA restriction normally consists of the ATS route leading to the turning fix, the ATS route leading from the turning fix, and an altitude (e.g., MTA V330 E TO V520 W 16000). When an MTA is applicable for the intended route of flight, pilots must ensure they are at or above the charted MTA prior to beginning the turn and maintain at

Transmittal of Airways/Route Data

Airway number or route	From / To	Routine or docket number	Controlling @ terrain/Obstruction and coordinates	MRA / MOCA	MAA / MEA	GNSS MEA	Change over point	Fix MRA/MCA	Remarks	Flight inspection dates
V330	Idaho Falls, ID VOR/DME *Osity, ID		Tree 6177 @ 432912.00N/1114118.00W Terrain 6077 432912.00N/1114118.00W	8000 --7900--	17500 8000			*9500E	300 MTN ROC RED DEL MCA ATIDA COME ADD MCA AT OSITY DEC MOCA	
									DEL directional MEA MEA CARONIAL ALT	
V330	Osity, ID # Jackson, WY VOR/DME		AAO 12138 (SEC) @ 434118.30N/1104858.30W Terrain 11132 433900.00N/1105057.00W	14000 --13600--	17500 14000		JAC 10	# MTA * 13400W	INC MCA PRECIP TER DEC MOCA MEA CARDINAL ALT	
									JAC R-251 UNUSABLE BYD 10 # CHART: MTA V330 E TO VS20W 16000	

Date	Office	Title	Signature
	AJW-3773	Manager	Ray Nussear

Figure 2-61. Minimum turning altitude information located in the remarks section of FAA Form 8260-16 Transmittal of Airways/Route Data.

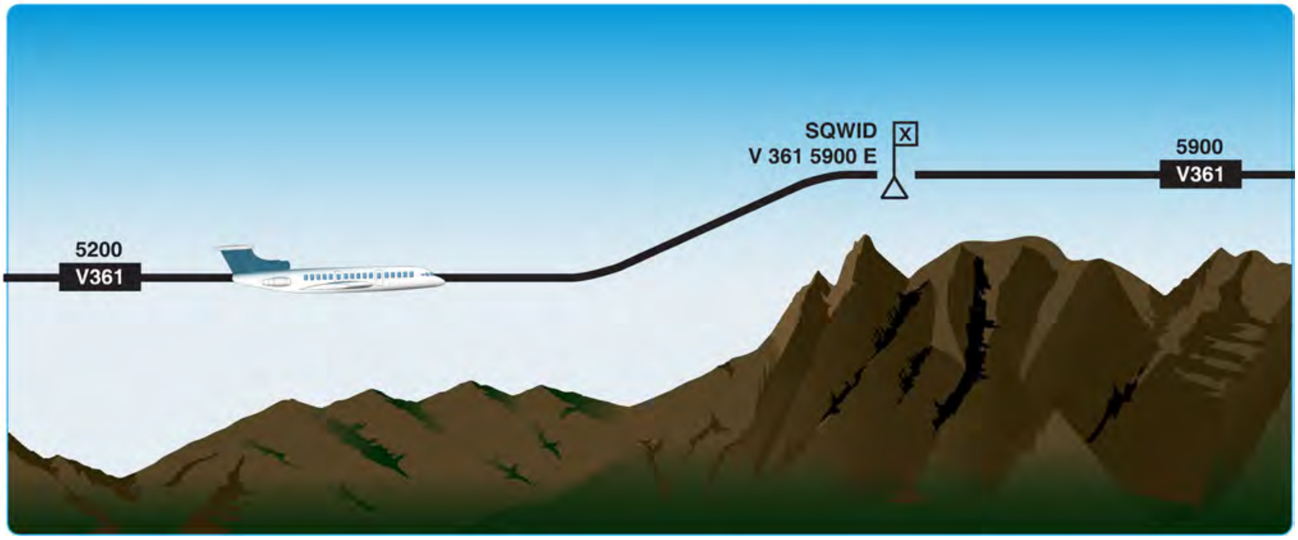


Figure 2-62. Minimum crossing altitude (MCA).

or above the MTA until joining the centerline of the ATS route following the turn. Once established on the centerline following the turning fix, the MEA/MOCA determines the minimum altitude available for assignment.

An MTA may also preclude the use of a specific altitude or a range of altitudes during a turn. For example, the MTA may restrict the use of 10,000 through 11,000 feet MSL. In this case, any altitude greater than 11,000 feet MSL is unrestricted, as are altitudes less than 10,000 feet MSL provided MEA/MOCA requirements are satisfied.

All MTA information associated with the airway/route inbound to the turn fix/facility is put in the remarks section of FAA Form 8260-16, Transmittal of Airways/Route Data, using the following format [Figure 2-61]:

#CHART: MTA V330 E TO V520 W 16000
(Document on V330 FAA Form 8260-16)

#CHART: MTA V465 NE TO V330 W OR V520 W 16000
(Document on V465 FAA Form 8260-16)

When an MTA is required by FAA Order 8260.3, paragraph 15-1-5c, enter the MTA information in the REMARKS section of FAA Form 8260-2, Radio Fix and Holding Data Record, as specified on the appropriate FAA Form 8260-16, Transmittal of Airways/Route Data, using the following format:

MTA: V330 E TO V520 W 16000

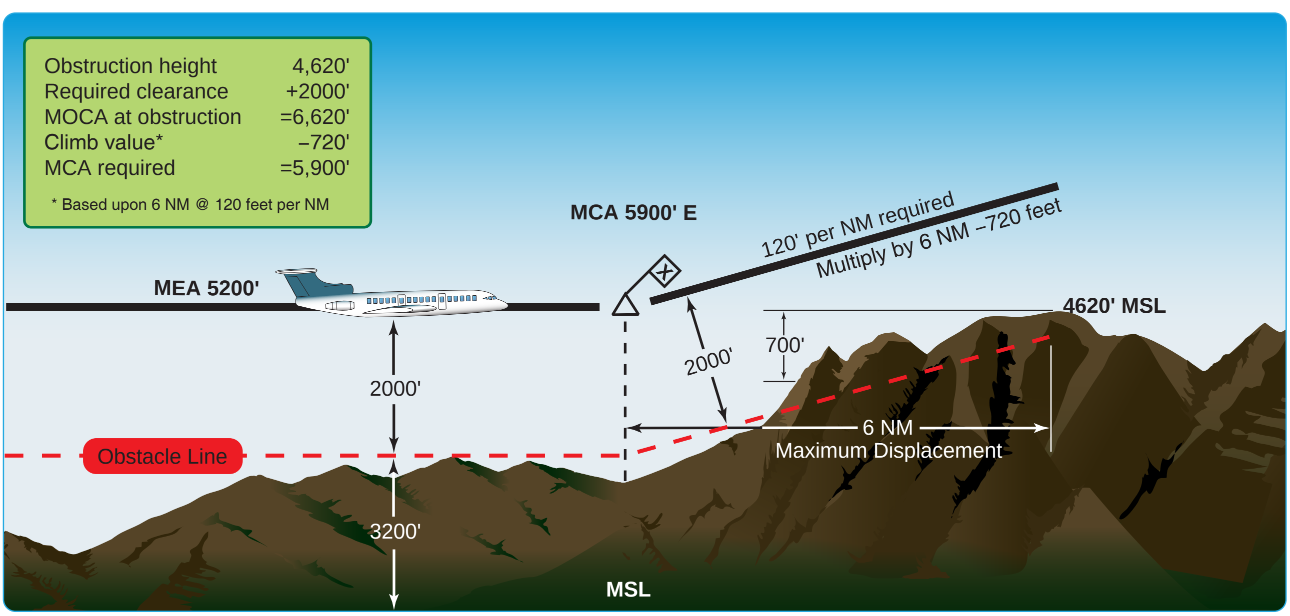


Figure 2-63. Minimum crossing altitude (MCA) determination point.

MTA: V465 NE TO V330 W OR V520 W 16000

Minimum Crossing Altitude (MCA)

An MCA is the lowest altitude at certain fixes at which the aircraft must cross when proceeding in the direction of a higher minimum en route IFR altitude. [Figure 2-62] When applicable, MCAs are depicted on the en route chart. [Figure 2-59] MCAs are established in all cases where obstacles intervene to prevent pilots from maintaining obstacle clearance during a normal climb to a higher MEA after passing a point beyond which the higher MEA applies. The same protected en route area vertical obstacle clearance requirements for the primary and secondary areas are considered in the determination of the MCA. The standard for determining the MCA is based upon the following climb gradients and is computed from the flight altitude:

- Sea level through 5,000 feet MSL—150 feet per NM
- 5000 feet through 10,000 feet MSL—120 feet per NM
- 10,000 feet MSL and over—100 feet per NM

To determine the MCA seen on an en route chart, the distance from the obstacle to the fix is computed from the point where the centerline of the en route course in the direction of flight intersects the farthest displacement from the fix. [Figure 2-63] When a change of altitude is involved with a course change, course guidance must be provided if the change of altitude is more than 1,500 feet and/or if the course change is more than 45°, although there is an exception to this rule. In some cases, course changes of up to 90° may be approved without course guidance provided that no obstacles penetrate the established MEA requirement of the previous airway or route segment. Outside United States airspace, pilots may encounter different flight procedures regarding MCA and transitioning from one MEA to a higher MEA. In this case, pilots are expected to be at the higher MEA crossing the fix, similar to an MCA. Pilots must thoroughly review flight procedure differences when flying outside United States airspace. On IFR en route low altitude charts, routes and associated data outside the conterminous United States are shown for transitional purposes only and are not part of the high altitude jet route and RNAV route systems. [Figure 2-64]

Minimum IFR Altitude (MIA)

The MIA for operations is prescribed in 14 CFR Part 91. These MIAs are published on aeronautical charts and prescribed in 14 CFR Part 95 for airways and routes, and in 14 CFR Part 97 for standard instrument approach procedures. If no applicable minimum altitude is prescribed

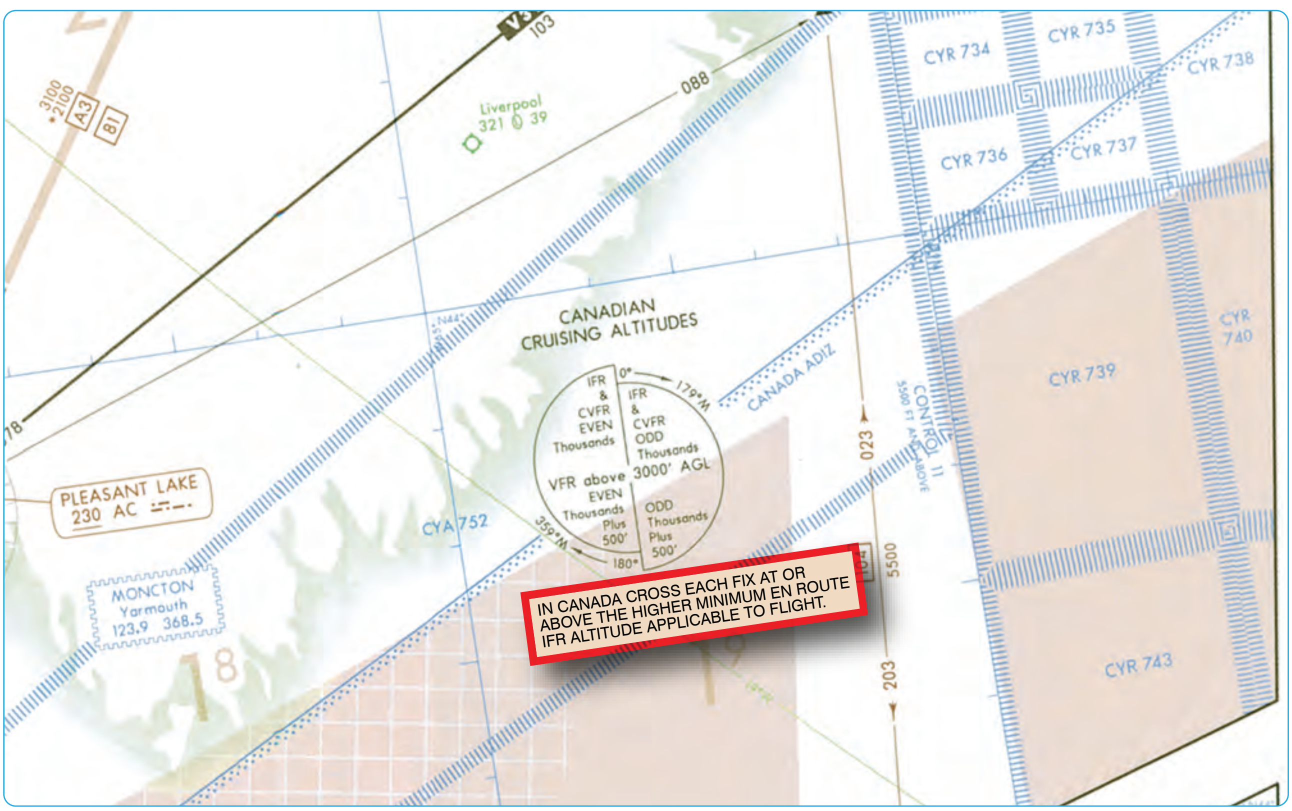


Figure 2-64. En route chart minimum crossing altitude data (outside of the U.S.).

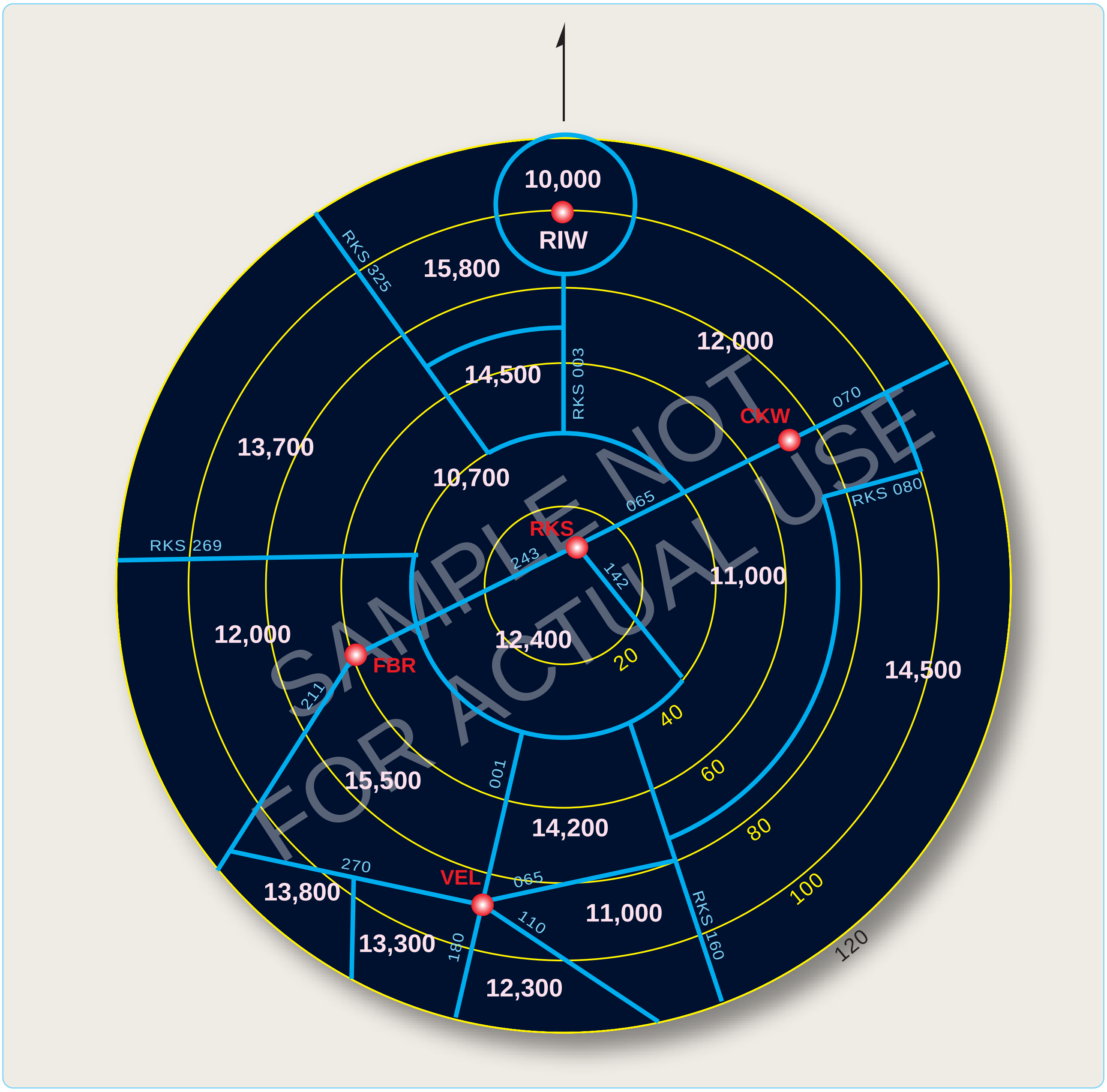


Figure 2-65. MVA chart.

in 14 CFR Parts 95 or 97, the following MIA applies: In designated mountainous areas, 2,000 feet above the highest obstacle within a horizontal distance of 4 NM from the course to be flown; or other than mountainous areas, 1,000 feet above the highest obstacle within a horizontal distance of 4 NM from the course to be flown; or as otherwise authorized by the Administrator or assigned by ATC. MIAs are not flight checked for communication.

Minimum Vectoring Altitudes (MVA)

MVAs are established for use by ATC when radar ATC is exercised. The MVA provides 1,000 feet of clearance above the highest obstacle in non-mountainous areas and 2,000 feet above the highest obstacle in designated mountainous areas. Because of the ability to isolate specific obstacles, some MVAs may be lower than MEAs, MOCAs, or other minimum altitudes depicted on charts for a given location. While being radar vectored, IFR altitude assignments by ATC are normally at or above the MVA.

Air traffic controllers use MVAs only when they are assured an adequate radar return is being received from the aircraft. Charts depicting MVAs are available to controllers and have recently become available to pilots. They can be found at http://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/mva_mia/ Situational Awareness is

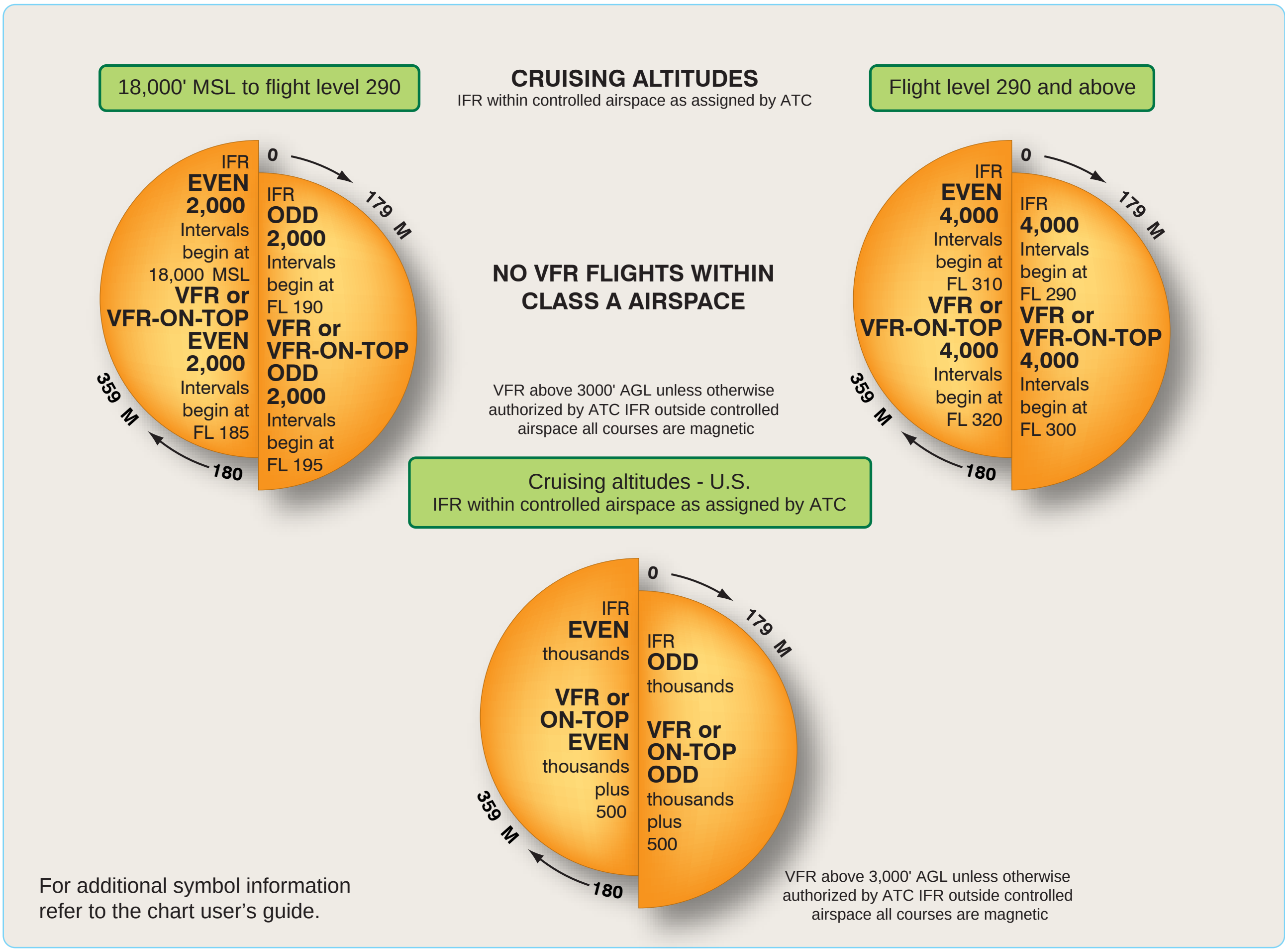


Figure 2-66. Cruising altitude or flight level.

always important, especially when being radar vectored during a climb into an area with progressively higher MVA sectors, similar to the concept of MCA. Except where diverse vector areas have been established, when climbing, pilots should not be vectored into a sector with a higher MVA unless at or above the next sector's MVA. Where lower MVAs are required in designated mountainous areas to achieve compatibility with terminal routes or to permit vectoring to an instrument approach procedure, 1,000 feet of obstacle clearance may be authorized with the use of Airport Surveillance Radar (ASR). The MVA provides at least 300 feet above the floor of controlled airspace. The MVA charts are developed to the maximum radar range. Sectors provide separation from terrain and obstructions. Each MVA chart has sectors large enough to accommodate vectoring of aircraft within the sector at the MVA. [Figure 2-65]

IFR Cruising Altitude or Flight Level

In controlled airspace, pilots must maintain the altitude or flight level assigned by ATC, although if the ATC clearance assigns "VFR conditions on-top," an altitude or flight level as prescribed by 14 CFR Part 91, § 91.159 must be maintained. In uncontrolled airspace (except while in a holding pattern of two minutes or less or while turning) if operating an aircraft under IFR in level cruising flight, an appropriate altitude as depicted in the legend of IFR en route high and low altitude charts must be maintained. [Figure 2-66]

When operating on an IFR flight plan below 18,000 feet MSL in accordance with a VFR-on-top clearance, any VFR cruising altitude appropriate to the direction of flight between the MEA and 18,000 feet MSL may be selected that allows the flight to remain in VFR conditions. Any change in altitude must be reported to ATC, and pilots must comply with all other IFR reporting procedures. VFR-on-top is not authorized in Class A airspace. When cruising below 18,000 feet MSL, the altimeter must be adjusted to the current setting, as reported by a station within 100 NM of your position. In areas where weather-reporting stations are more than 100 NM from the route, the altimeter setting of a station that is closest may be used.

During IFR flight, ATC advises flights periodically of the current altimeter setting, but it remains the responsibility of the pilot or flight crew to update altimeter settings in a timely manner. Altimeter settings and weather information are available from weather reporting facilities operated or approved by the U.S. National Weather Service, or a source approved by the FAA. Some commercial operators have the authority to act as a government-approved source of weather information, including altimeter settings, through certification under the FAA's Enhanced Weather Information System.

Flight level operations at or above 18,000 feet MSL require the altimeter to be set to 29.92 inches of mercury (" Hg). A flight level (FL) is defined as a level of constant atmospheric pressure related to a reference datum of 29.92 " Hg. Each flight level is stated in three digits that represent hundreds of feet. For example, FL 250 represents an altimeter indication of 25,000 feet. Conflicts with traffic operating below 18,000 feet MSL may arise when actual altimeter settings along the route of flight are lower than 29.92 " Hg. Therefore, 14 CFR Part 91, § 91.121 specifies the lowest usable flight levels for a given altimeter setting range.

Reduced Vertical Separation Minimums (RSVM)

Reduced vertical separation minimums (RVSM) is a term used to describe the reduction of the standard vertical separation required between aircraft flying at levels between FL 290 (29,000 feet) and FL 410 (41,000 feet) from 2,000 feet to 1,000 feet. The purpose; therefore, increases the number of aircraft that can safely fly in a particular volume of airspace. Historically, standard vertical separation was 1,000 feet from the surface to FL 290, 2,000 feet from FL 290 to FL 410 and 4,000 feet above this. This was because the accuracy of the pressure altimeter (used to determine altitude) decreases with height. Over time, air data computers (ADCs) combined with altimeters have become more accurate and autopilots more adept at maintaining a set level; therefore, it became apparent that for many modern aircraft, the 2,000-foot separation was not required . It was, therefore, proposed by ICAO that this be reduced to 1,000 feet.

Between 1997 and 2005, RVSM was implemented in all of Europe, North Africa, Southeast Asia, North America, South America, and over the North Atlantic, South Atlantic, and Pacific Oceans. The North Atlantic implemented initially in March 1997, at FL 330 through FL 370. The entire western hemisphere implemented RVSM FL 290–FL 410 on January 20, 2005.

Only aircraft with specially certified altimeters and autopilots may fly in RVSM airspace, otherwise the aircraft must fly lower or higher than the airspace, or seek special exemption from the requirements. Additionally, aircraft operators (airlines or corporate operators) must receive specific approval from the aircraft's state of registry in order to conduct operations in RVSM airspace. Non-RVSM approved aircraft may transit through RVSM airspace provided they are given continuous climb throughout the designated airspace, and 2,000 feet vertical separation is provided at all times between the non-RVSM flight and all others for the duration of the climb/descent.

Critics of the change were concerned that by reducing the space between aircraft, RVSM may increase the number of mid-air collisions and conflicts. In the ten years since RVSM was first implemented, not one collision has been attributed to RVSM. In the United States, this program was known as the Domestic Reduced Vertical Separation Minimum (DRVSM).

Cruise Clearance

The term "cruise" may be used instead of "maintain" to assign a block of airspace to an aircraft. The block extends from the minimum IFR altitude up to and including the altitude that is specified in the cruise clearance. On a cruise clearance, you may level off at any intermediate altitude within this block of airspace. You are allowed to climb or descend within the block at your own discretion. However, once you start descent and verbally report leaving an altitude in the block to ATC, you may not return to that altitude without an additional ATC clearance. A cruise clearance also authorizes you to execute an approach at the destination airport.

Lowest Usable Flight Level

When the barometric pressure is 31.00 " Hg or less and pilots are flying below 18,000 feet MSL, use the current reported altimeter setting. When an aircraft is en route on an instrument flight plan, air traffic controllers furnish this information at least once while the aircraft is in the controller's area of jurisdiction. When the barometric pressure exceeds 31.00 " Hg, the following procedures are placed in effect by NOTAM defining the geographic area affected: Set 31.00 " Hg for en route operations below 18,000 feet MSL and maintain this setting until beyond the affected area. ATC issues actual altimeter settings and advises pilots to set 31.00 " Hg in their altimeter, for en route operations below 18,000 feet MSL in affected areas. If an aircraft has the capability of setting the current altimeter setting and operating into airports with the capability of measuring the current altimeter setting, no additional restrictions apply. At or above 18,000 feet MSL, altimeters should be set to 29.92 " Hg (standard setting). Additional procedures exist beyond the en route phase of flight.

The lowest usable flight level is determined by the atmospheric pressure in the area of operation. As local altimeter settings fall below 29.92 " Hg, pilots operating in Class A airspace must cruise at progressively higher indicated altitudes to ensure separation from aircraft

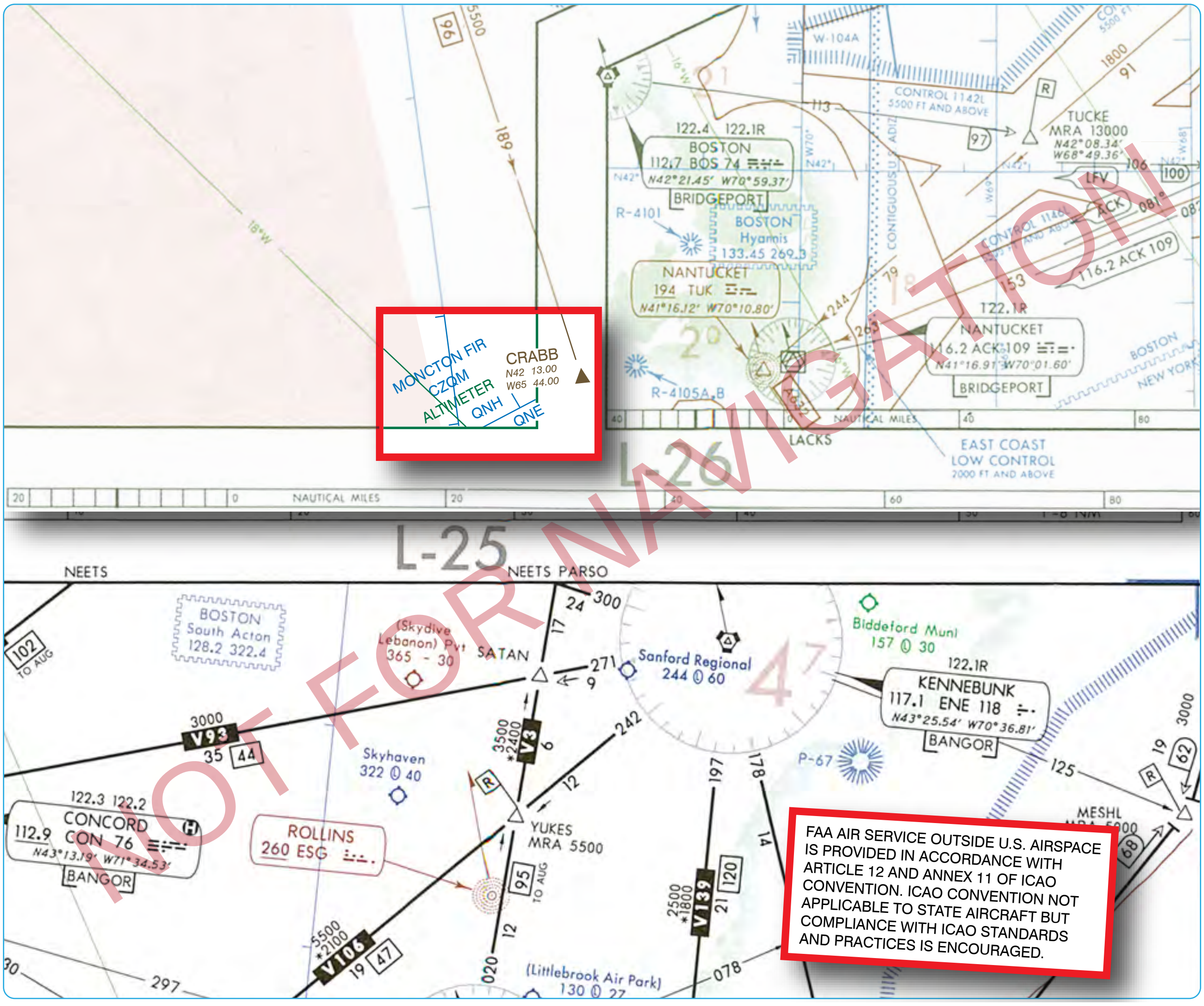


Figure 2-67. Altimeter setting changes.

operating in the low altitude structure as follows:

Current Altimeter Setting	Lowest Usable Flight Level
29.92 or higher	180
29.91 to 29.42	185
29.41 to 28.92	190
28.91 to 28.42	195
28.41 to 27.91	200

When the minimum altitude, as prescribed in 14 CFR Part 91, § 91.159 and 91.177, is above 18,000 feet MSL, the lowest usable flight level is the flight level equivalent of the minimum altitude plus the number of feet specified according to the lowest flight level correction factor as follows:

Altimeter Setting	Correction Factor
29.92 or higher	—
29.91 to 29.42	500 feet
29.41 to 28.92	1,000 feet
28.91 to 28.42	1,500 feet
28.41 to 27.91	2,000 feet
27.91 to 27.42	2,500 feet

Operations in Other Countries

When flight crews transition from the U.S. NAS to another country's airspace, they should be aware of differences not only in procedures but also airspace. For example, when flying into Canada as depicted in Figure 2-67, notice the change from transition level (QNE) to transition altitude (QNH) when flying north-bound into the Moncton flight information region (FIR).

Operations in international airspace demand that pilots are aware of, and understand the use of, the three types of altimeter settings. *Most overseas airports give altimeter*

RADAR/NON-RADAR REPORTS These reports should be made at all times without a specific ATC request.	
REPORTS	**EXAMPLE**
Leaving one assigned flight altitude or flight level for another	"Marathon 564, leaving 8,000, climb to 10,000."
VFR-on-top change in altitude	"Marathon 564, VFR-on-top, climbing to 10,500."
Leaving any assigned holding fix or point	"Marathon 564, leaving FARGO Intersection."
Missed approach	"Marathon 564, missed approach, request clearance to Chicago."
Unable to climb or descend at least 500 fpm	"Marathon 564, maximum climb rate 400 feet per minute."
TAS variation from filed speed of 5% or 10 knots, whichever is greater	"Marathon 564, advises TAS decrease to140 knots."
Time and altitude or flight level upon reaching a holding fix or clearance limit	"Marathon 564, FARGO Intersection at 05, 10,000, holding east."
Loss of Nav/Comm capability (required by Part 91.187)	"Marathon 564, ILS receiver inoperative."
Unforecast weather conditions or other information relating to the safety of flight (required by Part 91.183)	"Marathon 564, experiencing moderate turbulence at 10,000."
NON-RADAR REPORTS When you are not in radar contact, these reports should be made without a specific request from ATC.	
REPORTS	**EXAMPLE**
Leaving FAF or OM inbound on final approach	"Marathon 564, outer marker inbound, leaving 2,000."
Revised ETA of more than three minutes	"Marathon 564, revising SCURRY estimate to 55."

Figure 2-68. ATC reporting procedures.

settings in hectopascals (hPa) (millibars). Therefore, it is imperative that pilots or on-board equipment are able to accurately convert inches of mercury to hPa, or hPa to inches of mercury.

Altitude Above Ground (QFE)

A local altimeter setting equivalent to the barometric pressure measured at an airport altimeter datum, usually signifying the approach end of the runway is in use. At the airport altimeter datum, an altimeter set to QFE indicates zero altitude. If required to use QFE altimetry, altimeters are set to QFE while operating at or below the transition altitude and below the transition level. On the airport, the altimeter will read "0" feet.

Barometric Pressure for Standard Altimeter Setting (QNE)

Use the altimeter setting (en route) at or above the transition altitude (FL 180 in the United States). The altimeter setting is always 29.92 inches of mercury/1013.2 hPa for a QNE altitude. *Transition levels differ from country to country and pilots should be particularly alert when making a climb or descent in a foreign area.*

Barometric Pressure for Local Altimeter Setting (QNH)

A local altimeter setting equivalent to the barometric pressure measured at an airport altimeter datum and corrected to sea level pressure. At the airport altimeter datum, an altimeter set to QNH indicates airport elevation above mean sea level (MSL). Altimeters are set to QNH while operating at and below the transition altitude and below the transition level.

For flights in the vicinity of airports, express the vertical position of aircraft in terms of QNH or QFE at or below the transition altitude and in terms of QNE at or above the transition level. While passing through the transition layer, express vertical position in terms of FLs when ascending and in terms of altitudes when descending.

When an aircraft that receives a clearance as number one to land completes its approach using QFE, express the vertical position of the aircraft in terms of height above the airport elevation during that portion of its flight for which you may use QFE.

It is important to remember that most pressure altimeters are subject to mechanical, elastic, temperature, and installation errors. In addition, extremely cold temperature differences may also require altimeter correction factors as appropriate.

En Route Reporting Procedures

In addition to acknowledging a handoff to another Center en route controller, there are reports that should be made without a specific request from ATC. Certain reports should be made at all times regardless of whether a flight is in radar contact with ATC, while others are necessary only if radar contact has been lost or terminated. [Figure 2-68]

Non-Radar Position Reports

If radar contact has been lost or radar service terminated, the CFRs require pilots to provide ATC with position reports over designated VORs and intersections along their route of flight. These compulsory reporting points are depicted on IFR en route charts by solid triangles. Position reports over fixes indicated by open triangles are noncompulsory reporting points and are only necessary when requested by ATC. If on a direct course that is not on an established airway, report over the fixes used in the flight plan that define the route, since they automatically become compulsory reporting points. Compulsory reporting points also apply when conducting an IFR flight in accordance with a VFR-on-top clearance.

Whether a route is on an airway or direct, position reports are mandatory in a non-radar environment, and they must include specific information. A typical position report includes information pertaining to aircraft position, expected route, and ETA. When a position report is to be made passing a VOR radio facility, the time reported should be the time at which the first complete reversal of the TO/FROM indicator is accomplished. When a position report is made passing a facility by means of an airborne ADF, the time reported should be the time at which the indicator makes a complete reversal. When an aural or a light panel indication is used to determine the time passing a reporting point, such as a fan marker, Z marker, cone of silence or intersection of range courses, the time should be noted when the signal is first received and again when it ceases. The mean of these two times should then be taken as the actual time over the fix. If a position is given with respect to distance and direction from a reporting point, the distance and direction should be computed as accurately as possible. Except for terminal area transition purposes, position reports or navigation with reference to aids not established for use in the structure in which flight is being conducted are not normally required by ATC.

Flights in a Radar Environment

When informed by ATC that their aircraft are in "Radar Contact," pilots should discontinue position reports over designated reporting points. They should resume normal position reporting when ATC advises "radar contact lost" or "radar service terminated." ATC informs pilots that they are in radar contact:

1. When their aircraft is initially identified in the ATC system; and
2. When radar identification is reestablished after radar service has been terminated or radar contact lost.

Subsequent to being advised that the controller has established radar contact, this fact is not repeated to the pilot when handed off to another controller. At times, the aircraft identity is confirmed by the receiving controller; however, this should not be construed to mean that radar contact has been lost. The identity of transponder equipped aircraft is confirmed by asking the pilot to "ident," "squawk standby," or to change codes. Aircraft without transponders are advised of their position to confirm identity. In this case, the pilot is expected to advise the controller if in disagreement with the position given. Any pilot who cannot confirm the accuracy of the position given because of not being tuned to the NAVAID referenced by the controller should ask for another radar position relative to the tuned in NAVAID.

Position Report Items

Position reports should include the following items:

1. Aircraft 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

Additional Reports

The following reports should be made at all times to ATC or Flight Service facilities without a specific ATC request:

1. When vacating any previously assigned altitude or flight level for a newly assigned altitude or flight level.
2. When an altitude change is made if operating on a clearance specifying VFR-on-top.

3. When unable to climb/descend at a rate of a least 500 feet per minute (fpm).
4. When approach has been missed. (Request clearance for specific action (i.e., to alternative airport, another approach).
5. Change in the average true airspeed (at cruising altitude) when it varies by 5 percent or 10 knots (whichever is greater) from that filed in the flight plan.
6. The time and altitude or flight level upon reaching a holding fix or point to which cleared.
7. When leaving any assigned holding fix or point.

   Note: The reports stated in subparagraphs 6 and 7 may be omitted by pilots of aircraft involved in instrument training at military terminal area facilities when radar service is being provided.
8. 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.
9. Any information relating to the safety of flight.

Other equipment installed in an aircraft may impair your ability to safely operate under IFR. If a malfunction of such equipment (e.g., weather radar) affects any safety or IFR capability, reports should be made as stated above. When reporting GPS anomalies, be very specific and include the location, altitude, and duration of the anomaly. Deliberate GPS interference or outage areas resulting from pre-approved government tests will be disseminated in NOTAMs. These outages should not be reported to ATC, as this condition is known and not an anomaly. See also AIM 1-1-13.

Communication Failure

Two-way radio communication failure procedures for IFR operations are outlined in 14 CFR Part 91, § 91.185. Unless otherwise authorized by ATC, pilots operating under IFR are expected to comply with this regulation. Expanded procedures for communication failures are found in the Aeronautical Information Manual (AIM). Pilots can use the transponder to alert ATC to a radio communication failure by squawking code 7600. [Figure 2-69] If only the transmitter is inoperative, listen for ATC instructions on any operational receiver, including the navigation receivers. It is possible ATC may try to make contact with pilots over a VOR, VORTAC, NDB, or localizer frequency. In addition to monitoring NAVAID receivers, attempt to reestablish communications by contacting ATC on a previously assigned frequency or calling an FSS.

The primary objective of the regulations governing communication failures is to preclude extended IFR no-radio operations within the ATC system since these operations may adversely affect other users of the airspace. If the radio fails while operating on an IFR clearance, but in VFR conditions, or if encountering VFR conditions at any time after the failure, continue the flight under VFR conditions, if possible, and land as soon as practicable. The requirement to land as soon as practicable should not be construed to mean as soon as possible. Pilots retain the prerogative of exercising their best judgment and are not required to land at an unauthorized airport, at an airport unsuitable for the type of aircraft flown, or to land only minutes short of their intended destination. However, if IFR conditions prevail, pilots must comply with procedures designated in the CFRs to ensure aircraft separation.

When an aircraft squawks code 7600 during a two-way radio communication failure, the information block on the radar screen flashes RDOF (radio failure) to alert the controller.

Figure 2-69. Two-way radio communications failure transponder code.

If pilots must continue their flight under IFR after experiencing two-way radio communication failure, they should fly one of the following routes:

- The route assigned by ATC in the last clearance received.
- If being radar vectored, the direct route from the point of radio failure to the fix, route, or airway specified in the radar vector clearance.
- In the absence of an assigned route, the route ATC has advised to expect in a further clearance.
- In the absence of an assigned or expected route, the route filed in the flight plan.

It is also important to fly a specific altitude should two-way radio communications be lost. The altitude to fly after a communication failure can be found in 14 CFR Part 91, § 91.185 and must be the highest of the following altitudes for each route segment flown.

- The altitude or flight level assigned in the last ATC clearance.
- The minimum altitude or flight level for IFR operations.
- The altitude or flight level ATC has advised to expect in a further clearance.

In some cases, the assigned or expected altitude may not be as high as the MEA on the next route segment. In this situation, pilots normally begin a climb to the higher MEA when they reach the fix where the MEA rises. If the fix also has a published MCA, they start the climb so they are at or above the MCA when reaching the fix. If the next succeeding route segment has a lower MEA, descend to the applicable altitude either the last assigned altitude or the altitude expected in a further clearance—when reaching the fix where the MEA decreases.

ARTCC Radio Frequency Outage

ARTCCs normally have at least one back-up radio receiver and transmitter system for each frequency that can usually be placed into service quickly with little or no disruption of ATC service. Occasionally, technical problems may cause a delay but switchover seldom takes more than 60 seconds. When it appears that the outage is not quickly remedied, the ARTCC usually requests a nearby aircraft, if there is one, to switch to the affected frequency to broadcast communications instructions. It is important that the pilot wait at least one minute before deciding that the ARTCC has actually experienced a radio frequency failure. When such an outage does occur, the pilot should, if workload and equipment capability permit, maintain a listening watch on the affected frequency while attempting to comply with the following recommended communications procedures:

1. If two-way communications cannot be established with the ARTCC after changing frequencies, a pilot should attempt to re-contact the transferring controller for the assignment of an alternative frequency or other instructions.
2. When an ARTCC radio frequency failure occurs after two-way communications have been established, the pilot should attempt to reestablish contact with the center on any other known ARTCC frequency, preferably that of the next responsible sector when practicable, and ask for instructions. However, when the next normal frequency change along the route is known to involve another ATC facility, the pilot should contact that facility, if feasible, for instructions. If communications cannot be reestablished by either method, the pilot is expected to request communication instructions from the FSS appropriate to the route of flight.

Note: The exchange of information between an aircraft and an ARTCC through an FSS is quicker than relay via company radio because the FSS has direct interphone lines to the responsible ARTCC sector. Accordingly, when circumstances dictate a choice between the two during an ARTCC frequency outage relay via FSS radio is recommended.

Climbing and Descending En Route

When ATC issues a clearance or instruction, pilots are expected to execute its provisions upon receipt. In some cases, ATC includes words that modify their expectation. For example, the word "immediately" in a clearance or instruction is used to impress urgency to avoid an imminent situation, and expeditious compliance is expected and necessary for safety. The addition of a climb point or time restriction, for example, does not authorize pilots to deviate from the route of flight or any other provision of the ATC clearance. If the pilot receives the term "climb at pilot's discretion" in the altitude information of an ATC clearance, it means that the pilot has the option to start a climb when they desire and are authorized to climb at any rate, and to temporarily level off at any intermediate altitude as desired, although once you vacate an altitude, you may not return to that altitude. When ATC has not used the term nor imposed any climb restrictions, pilots should climb promptly on acknowledgment of the clearance. Climb at an optimum rate consistent with the operating characteristics of the aircraft to 1,000 feet below the assigned altitude, and then attempt to climb at a rate of between 500 and 1,500 fpm until the assigned altitude is reached. If at any time the pilot is unable to climb at a rate of at least 500 fpm, advise ATC. If it is necessary to level off at an intermediate altitude during climb, advise ATC.

When ATC issues the instruction, "Expedite climb," this normally indicates that the pilot should use the approximate best rate of climb without an exceptional change in aircraft handling characteristics. Normally controllers inform pilots of the reason for an instruction to expedite. If flying a turbojet aircraft equipped with afterburner engines, such as a military aircraft, pilots should advise ATC prior to takeoff if intending to use afterburning during the climb to the en route altitude. Often, the controller may be able to plan traffic to accommodate a high performance climb and allow the pilot to climb to the planned altitude without "expedite" clearance from restriction. If you receive an ATC instruction, and your altitude to maintain is subsequently changed or restated without an expedite instruction, the expedite instruction is canceled.

During en route climb, as in any other phase of flight, it is essential that you clearly communicate with ATC regarding clearances. In the following example, a flight crew experienced an apparent clearance readback/hearback error, that resulted in confusion about the clearance and, ultimately, to inadequate separation from another aircraft. "Departing IFR, clearance was to maintain 5,000 feet, expect 12,000 in 10 minutes." After handoff to Center, the pilot understood and read back, "Leaving 5,000 turn left heading 240° for vector on course." The pilot turned to the assigned heading climbing through 5,000 feet. At 5,300 feet, Center advised assigned altitude was 5,000 feet. The pilot immediately descended to 5,000. Center then informed the pilot that there was traffic at 12 o'clock and a mile at 6,000. After passing traffic, a higher altitude was assigned and climb resumed. The pilot then believed the clearance was probably "reaching" 5,000, etc. Even the readback to the controller with "leaving" did not catch the different wording. "Reaching" and "leaving" are commonly used ATC terms having different usages. They may be used in clearances involving climbs, descents, turns, or speed changes. In the flight deck, the words "reaching" and "leaving" sound much alike.

For altitude awareness during climb, pilots often call out altitudes on the flight deck. The pilot monitoring may call 2,000 and 1,000 feet prior to reaching an assigned altitude. The callout may be, "two" climbing through the transit to go altitude (QNH), both pilots set their altimeters to 29.92 inches of mercury and announce "2992 inches" (or 'standard,' on some aircraft) and the flight level passing. For example, "2992 inches" (standard), flight level one eight zero. The second officer on three pilot crews may ensure that both pilots have inserted the proper altimeter setting. On international flights, pilots must be prepared to differentiate, if necessary, between barometric pressure equivalents with inches of mercury, and millibars or hectopascals, to eliminate any potential for error. For example, 996 millibars erroneously being set as 2996.

For a typical IFR flight, the majority of in-flight time often is flown in level flight at cruising altitude from top of climb (TOC) to top of descent (TOD). Generally, TOD is used in airplanes with a FMS and represents the point at which descent is first initiated from cruise altitude. FMS also assist in level flight by cruising at the most fuel saving speed, providing continuing guidance along the flight plan route including great circle direct routes, and continuous evaluation and prediction of fuel consumption along with changing clearance data.

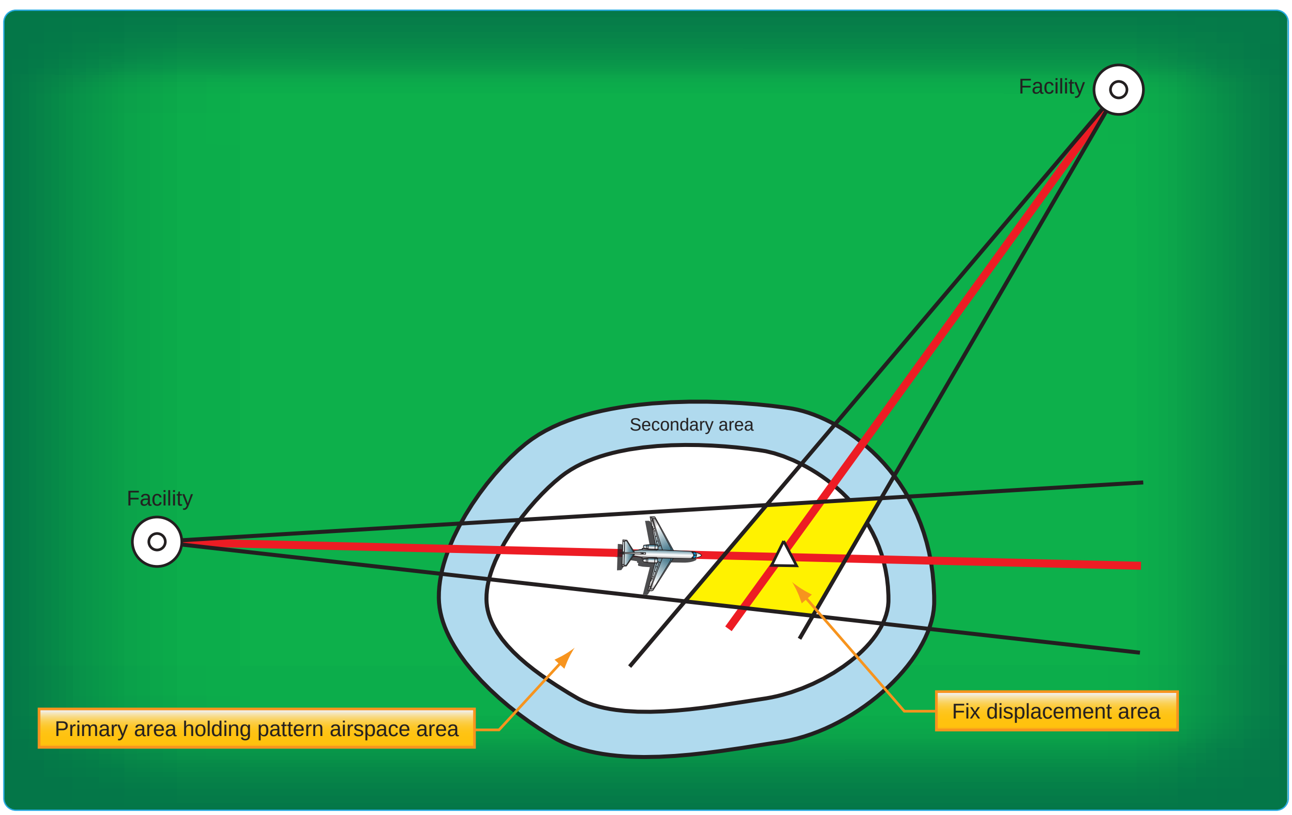


Figure 2-70. Holding pattern design criteria template.

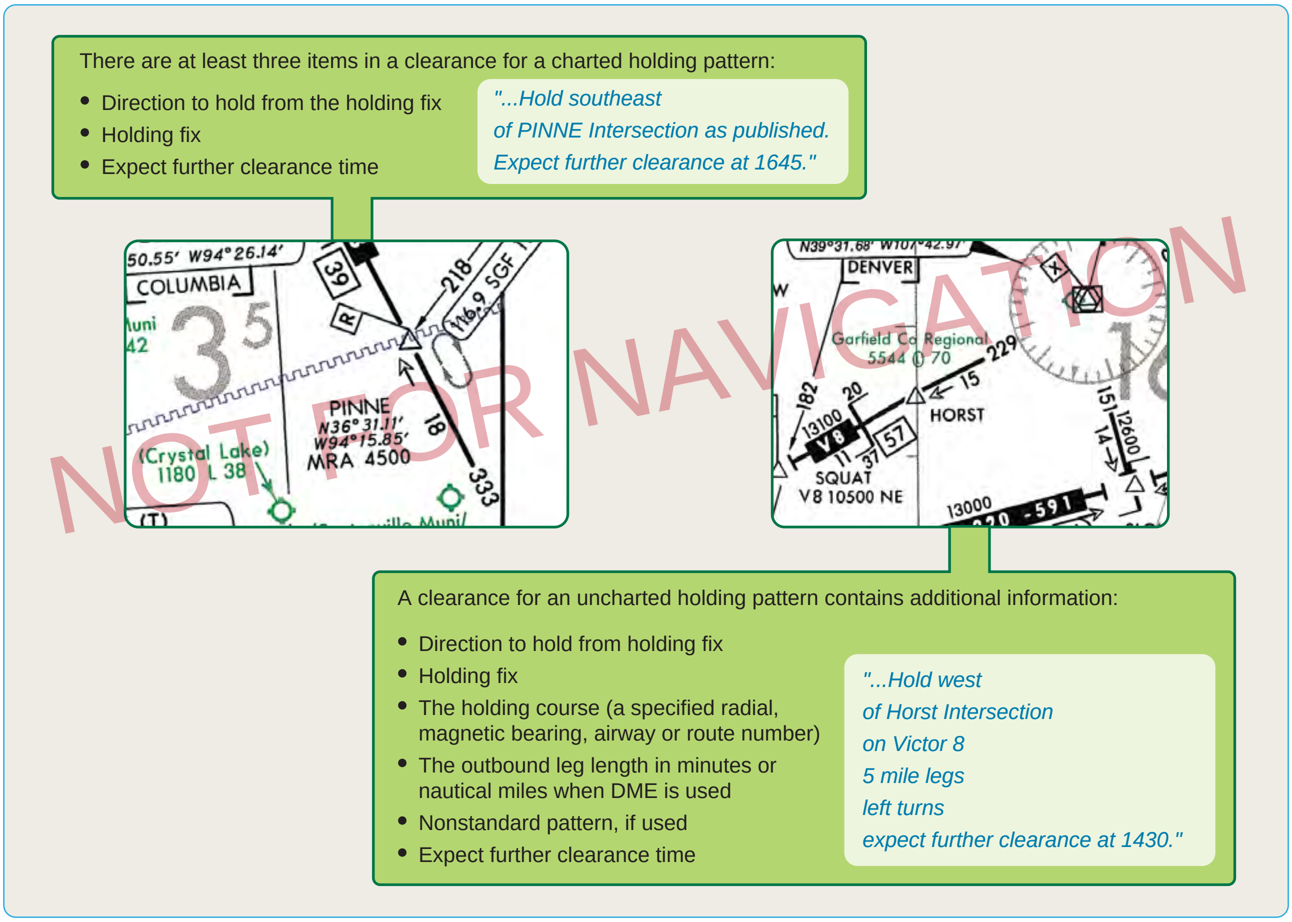


Figure 2-71. ATC holding instructions.

Aircraft Speed and Altitude

During the en route descent phase of flight, an additional benefit a FMS is that it provides fuel saving idle thrust descent to your destination airport. This allows an uninterrupted profile descent from level cruising altitude to an appropriate MIA, except where level flight is required for speed adjustment. Controllers anticipate and plan that

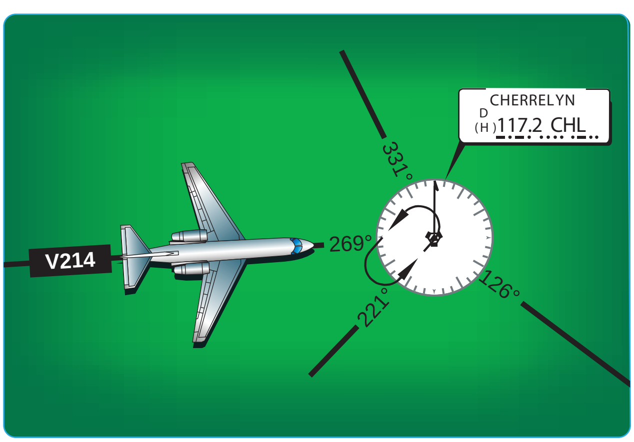


Figure 2-72. Clearance limit holding.

the pilot may level off at 10,000 feet MSL on descent to comply with the 14 CFR Part 91 indicated airspeed limit of 250 knots. Leveling off at any other time on descent may seriously affect air traffic handling by ATC. It is imperative that pilots make every effort to fulfill ATC expected actions on descent to aid in safely handling and expediting air traffic.

ATC issues speed adjustments if the flight is being radar controlled to achieve or maintain required or desired spacing. They express speed adjustments in terms of knots based on indicated airspeed in 10 knot increments except that at or above FL 240 speeds may be expressed in terms of Mach numbers in 0.01 increments. The use of Mach numbers by ATC is restricted to turbojets. If complying with speed adjustments, pilots are expected to maintain that speed within plus or minus 10 knots or 0.02 Mach.

Speed and altitude restrictions in clearances are subject to misinterpretation, as evidenced in this case where a corporate flight crew treated instructions in a published procedure as a clearance. The aircraft was at FL 310 and had already programmed the 'expect-crossing altitude' of

Figure 2-73. Maximum holding speeds for different altitudes.

17,000 feet at the VOR. When the altitude alerter sounded, the pilot advised Center that we were leaving FL 310. ATC acknowledged with a "Roger." At FL 270, Center questioned the pilot about the aircrafts descent. The pilot told the controller that the reason for the descent was to cross the VOR at 17,000 feet. ATC advised the pilot that he did not have clearance to descend. What the pilot thought was a clearance was in fact an "expect" clearance. Whenever pilots are in doubt about a clearance it is imperative they request clarity from ATC. Also, the term "Roger" only means that ATC received the transmission, not that they understood the transmission. "Expect" altitudes are published for planning purposes and are not considered crossing restrictions until verbally issued by ATC.

En Route Holding Procedures

The criteria for holding pattern airspace is developed both to provide separation of aircraft, as well as obstacle clearance. The alignment of holding patterns typically coincides with the flight course you fly after leaving the holding fix. For level holding, a minimum of 1,000 feet obstacle clearance is provided throughout the primary area. In the secondary area, 500 feet of obstacle clearance is provided at the inner edge, tapering to zero feet at the outer edge. Allowance for precipitous terrain is considered, and the altitudes selected for obstacle clearance may be rounded to the nearest 100 feet. When criteria for a climb in hold are applied, no obstacle penetrates the holding surface. [Figure 2-70]

There are many factors that affect aircraft during holding maneuvers, including navigational aid ground and airborne tolerance, effect of wind, flight procedures, application of ATC, outbound leg length, maximum holding airspeeds, fix to NAVAID distance, DME slant range effect, holding airspace size, and altitude holding levels.

ATC Holding Instructions

When controllers anticipate a delay at a clearance limit or fix, pilots are usually issued a holding clearance at least five minutes before the ETA at the clearance limit or fix. If the holding pattern assigned by ATC is depicted on the appropriate aeronautical chart, pilots are expected to hold as charted. In the following example, the controller issues a holding clearance that includes the name of the fix, directs the pilot to hold as charted, and includes an expect further clearance (EFC) time. "Marathon five sixty four, hold east of MIKEY Intersection as published, expect further clearance at 1521."

When ATC issues a clearance requiring you to hold at a fix where a holding pattern is not charted, pilots are issued complete holding instructions. The holding instructions include the direction from the fix, name of the fix, course, leg length, if appropriate, direction of turns (if left turns are required), and the EFC time. Pilots are required to maintain the last assigned altitude unless a new altitude is specifically included in the holding clearance and should fly right turns unless left turns are assigned. Note that all holding instructions should include an EFC time. In the event that two-way radio communication is lost, the EFC allows the pilot to depart the holding fix at a definite time. Pilots should plan the last lap of the holding pattern to leave the fix as close as possible to the exact time. [Figure 2-71]

When approaching the clearance limit and you have not received holding instructions from ATC, pilots are expected to follow certain procedures. First, call ATC and request further clearance before reaching the fix. If further clearance cannot be obtained, pilots are expected to hold at the fix in compliance with the charted holding pattern. If a holding pattern is not charted at the fix, pilots are expected to hold on the inbound course using right turns. This procedure ensures that ATC provides adequate separation. [Figure 2-72] For example, the aircraft is heading eastbound on V214 and the Cherrelyn VORTAC is the clearance limit and the pilot has not been able to obtain further clearance and has not received holding instructions, plan to hold southwest on the 221° radial using left-hand turns, as depicted. If this holding pattern is not charted, hold west of the VOR on V214 using right-hand turns.

Where required for aircraft separation, ATC may request that the pilot hold at any designated reporting point in a standard holding pattern at the MEA or the MRA, whichever altitude is the higher at locations where a minimum holding altitude has not been established. Unplanned holding at en route fixes may be expected on airway or route radials, bearings, or courses. If the fix is a facility, unplanned holding could be on any radial or bearing and there may be holding limitations required if standard holding cannot be accomplished at the MEA or MRA.

Maximum Holding Speed

The size of the holding pattern is directly proportional to the speed of the aircraft. In order to limit the amount of airspace that must be protected by ATC, maximum holding speeds in knots indicated airspeed (KIAS) have been designated for specific altitude ranges. [Figure 2-73] Even so, some holding patterns may have additional speed restrictions to keep faster aircraft from flying out of the protected area. If a holding pattern has a nonstandard speed restriction, it is depicted by an icon with the limiting airspeed. If the holding speed limit is less than the pilot feels necessary, advise ATC of the revised holding speed. Also, if the indicated airspeed exceeds the applicable maximum holding speed, ATC expects the pilot to slow to the speed limit within three minutes of the ETA at the holding fix. Often pilots can avoid flying a holding pattern, or reduce the length of time spent in the holding pattern, by slowing down on the way to the holding fix.

High Performance Holding

When operating at higher airspeeds, there are certain limitations that must be adhered to. For example, aircraft do not make standard rate turns in holding patterns if the bank angle exceeds 30°. If your aircraft is using a flight director system, the bank angle is limited to 25°. The aircraft must be traveling over 210 knots true airspeed (TAS) for the bank angle in a standard rate turn to exceed 30°; therefore, this limit applies to relatively fast aircraft. An aircraft using a flight director would have to be holding at more than 170 knots TAS to come up against the 25° limit. These true airspeeds correspond to indicated airspeeds of about 183 and 156 knots, respectively, at 6,000 feet in a standard atmosphere.

En Route Safety Considerations

Fuel State Awareness

In order to increase fuel state awareness, pilots are required to monitor the time and fuel remaining during an IFR flight. For example, on a flight scheduled for one hour or less, the flight crew may record the time and fuel remaining at the top of climb (TOC) and at one additional waypoint listed in the flight plan. Generally, TOC is used in aircraft with an FMS, and represents the point at which cruise altitude is first reached. TOC is calculated based on current altitude, climb speed, and cruise altitude. The pilot may elect to delete the additional waypoint recording requirement if the flight is so short that the record will not assist in the management of the flight. For flights scheduled for more than one hour, the pilot may record the time and fuel remaining shortly after TOC and at selected waypoints listed in the flight plan, conveniently spaced approximately one hour apart. The actual fuel burn is then compared to the planned fuel burn. Each fuel tank must be monitored to verify proper burn off and appropriate fuel remaining. For two-pilot aircraft, the pilot monitoring (PM) keeps the flight plan record. On three-pilot aircraft, the second officer and PM coordinate recording and keeping the flight plan record. In all cases, the crew member(s) making the recording communicates the information to the pilot flying.

Diversion Procedures

OpSpecs for commercial operators include provisions for en route emergency diversion airport requirements. Operators are expected to develop a sufficient set of emergency diversion airports, so that one or more can be reasonably expected to be available in varying weather conditions. The flight must be able to make a safe landing, and the airplane maneuvered off of the runway at the selected diversion airport. In the event of a disabled airplane following landing, the capability to move the disabled airplane must exist so as not to block the operation of any recovery aircraft. In addition, those airports designated for use must be capable of protecting the safety of all personnel by being able to:

- Offload the passengers and flight crew in a safe manner during possible adverse weather conditions.
- Provide for the physiological needs of the passengers and flight crew for the duration until safe evacuation.
- Be able to safely extract passengers and flight crew as soon as possible. Execution and completion of the recovery is expected within 12 to 48 hours following diversion.

Part 91 operators also need to be prepared for a diversion. Designation of an alternate on the IFR flight plan is a good first step; but changing weather conditions or equipment issues may require pilots to consider other options.