Chapter 3

Arrivals

Introduction

Preparation for the arrival and approach begins long before the descent from the en route phase of flight. Planning early, while there are fewer demands on the pilot's attention, leaves the pilot free to concentrate on precise control of the aircraft and better equipped to deal with problems that might arise during the last segment of the flight.

This chapter focuses on the current procedures pilots and air traffic control (ATC) use for instrument flight rule (IFR) arrivals in the National Airspace System (NAS). The objective is to provide pilots with an understanding of ATC arrival procedures and pilot responsibilities as they relate to the transition between the en route and approach phases of flight. This chapter emphasizes standard terminal arrival routes (STARs), descent clearances, descent planning, and ATC procedures, while the scope of coverage focuses on transitioning from the en route phase of flight, typically the origination point of a STAR to the STAR termination fix.

Optimum IFR arrival options include flying directly from the en route structure to an approach gate or initial approach fix (IAF), a visual arrival, STARs, and radar vectors. Within controlled airspace, ATC routinely uses radar vectors for separation purposes, noise abatement considerations when it is an operational advantage, or when requested by pilots. Vectors outside of controlled airspace are provided only on pilot request. The controller tells the pilot the purpose of the vector when the vector is controller-initiated and takes the aircraft off a previously assigned non-radar route. Typically, when operating on area navigation (RNAV) routes, pilots are allowed to remain on their own navigation.

Navigation in the Arrival Environment

The most significant and demanding navigational requirement is the need to safely separate aircraft. In a non-radar environment, ATC does not have an independent means to separate air traffic and must depend entirely on information relayed from flight crews to determine the actual geographic position and altitude. In this situation, precise navigation is critical to ATC's ability to provide separation.

Even in a radar environment, precise navigation and position reports, when required, are still a primary means of providing separation. In most situations, ATC does not have the capability or the responsibility for navigating an aircraft. Because they rely on precise navigation by the flight crew, flight safety in all IFR operations depends directly on the pilot's ability to achieve and maintain certain levels of navigational performance. ATC uses radar to monitor navigational performance, detect possible navigational errors, and expedite traffic flow. In a non-radar environment, ATC has no independent knowledge of the actual position of the aircraft or its relationship to other aircraft in adjacent airspace. Therefore, ATC's ability to detect a navigational error and resolve collision hazards is seriously degraded when a deviation from a clearance occurs.

The concept of navigation performance, previously discussed in this book, involves the precision that must be maintained for both the assigned route and altitude. Required levels of navigation performance vary from area to area depending on traffic density and complexity of the routes flown. The level of navigation performance must be more precise in domestic airspace than in oceanic and remote land areas since air traffic density in domestic airspace is much greater. For example, there are three million flight operations conducted within Chicago Center's airspace each year. The minimum lateral distance permitted between co-altitude aircraft in Chicago Center's airspace is 8 nautical miles (NM) (3 NM when radar is used). The route ATC assigns an aircraft has protected airspace on both sides of the centerline, equal to one-half of the lateral separation minimum standard. For example, the overall level of lateral navigation performance necessary for flight safety must be better than 4 NM in Center airspace. When STARs are reviewed subsequently in this chapter, it is demonstrated how the navigational requirements become more restrictive in the arrival phase of flight where air traffic density increases and procedural design and obstacle clearance become more limiting.

The concept of navigational performance is fundamental to the code of federal regulations and is best defined in Title 14 of the Code of Federal Regulations (14 CFR) Part 121, sections 121.103 and 121.121, which state that each aircraft must be navigated to the degree of accuracy required for ATC. The requirements of 14 CFR Part 91, section 91.123 related to compliance with ATC clearances and instructions also reflect this fundamental concept. Commercial operators must comply with their Operations Specifications (OpSpecs) and understand the categories of navigational operations and be able to navigate to the degree of accuracy required for the control of air traffic.

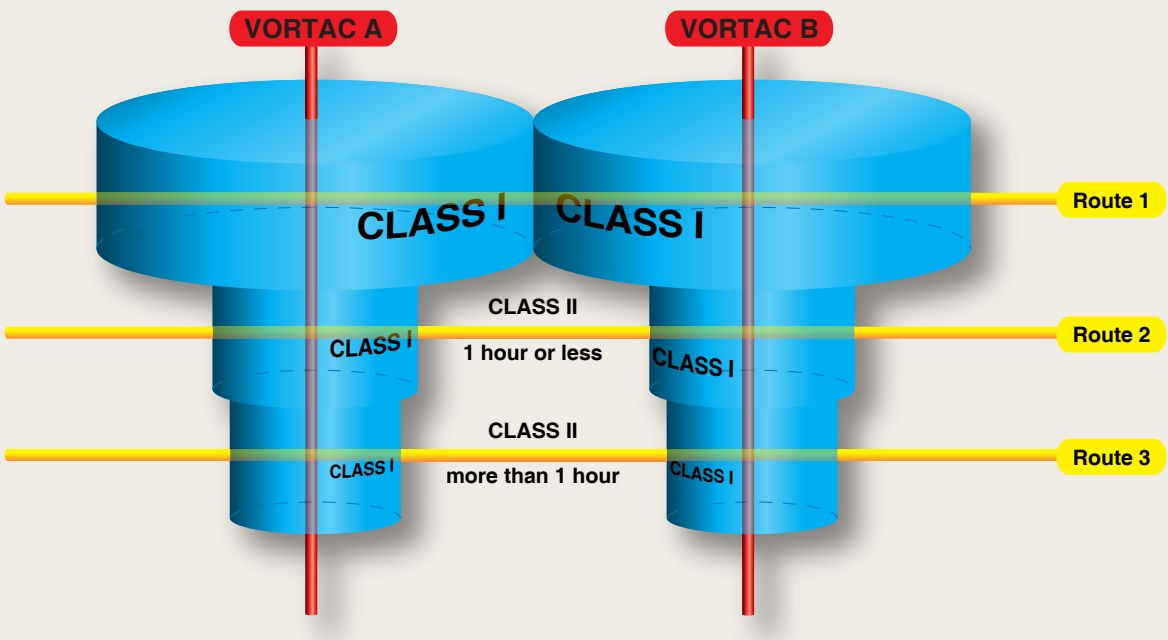
In the broad concept of air navigation, there are two major categories of navigational operations consisting of Class I navigation and Class II navigation. Class I navigation is any en route flight operation conducted in controlled or uncontrolled airspace that is entirely within operational service volumes of International Civil Aviation Organization (ICAO) standard navigational aids (NAVAIDs) (very high frequency (VHF) omnidirectional radio range (VOR), VOR/distance measuring equipment (DME), non-directional beacon (NDB), etc.).

Class II navigation is any en route operation that is not categorized as Class I navigation and includes any operation or portion of an operation that takes place outside the operational service volumes of ICAO standard NAVAIDs. For example, aircraft equipped only with VORs conducts

Class II navigation when the flight operates in an area outside the operational service volumes of federal VORs. Class II navigation does not automatically require the use of long-range, specialized navigational systems if special navigational techniques are used to supplement conventional NAVAIDs. Class II navigation includes transoceanic operations and operations in desolate and remote land areas, such as the Arctic. The primary types of specialized navigational systems approved for Class II operations include inertial navigation system (INS), Doppler, and global positioning system (GPS). Figure 3-1 provides several examples of Class I and II navigation.

Descent Planning

Planning the descent from cruise is important because of the need to dissipate altitude and airspeed in order to arrive at the approach gate properly configured. Descending early results in more flight at low altitudes with increased fuel consumption, and starting down late results in problems controlling both airspeed and descent rates on the approach. Prior to flight, pilots need to calculate the fuel, time, and distance required to descend from the cruising altitude to the approach gate altitude for the specific instrument approach at the destination airport. While in flight prior to the descent, it is important for pilots to verify landing weather to include winds at their intended destination. Inclimate weather at the destination airport can cause slower descents and missed approaches that require a sufficient amount of fuel that should be calculated prior to starting the descent. In order to plan the descent, the pilot needs to know the cruise altitude, approach gate altitude or initial approach fix altitude, descent groundspeed, and



NOTE:

The area encompassed by the cylinders represents the volume of airspace within the operational service volume (OSV) of ICAO standard NAVAIDs. The altitude of your aircraft with respect to the location of the NAVAID is a primary factor in determining OSV range."

Route 1 Your aircraft navigating from A to B is conducting Class I navigation because you remain within the OSV of ICAO standard NAVAIDs during your entire flight.

Route 2 Your aircraft navigating from A to B is conducting Class I navigation while within the OSV of the NAVAIDs. You are conducting Class II navigation during the portion of your route outside the OSV of the NAVAIDs. Because the duration of the Class II navigation is 1 hour or less, long-range navigation equipment or a flight navigator may not be required.

Route 3 Your aircraft navigating from A to B is conducting Class I navigation while within the OSV of the NAVAIDs. You are conducting Class II navigation when outside the OSV of the NAVAIDs. The duration of the Class II navigation is more than 1 hour. Therefore, long-range navigation equipment or a flight navigator is required.

Figure 3-1. Example of Class I and II navigation.

descent rate. This information must be updated while in flight for changes in altitude, weather, and wind. The approach gate is an imaginary point used by ATC to vector aircraft to the final approach course. The approach gate is established along the final approach course 1 NM from the final approach fix (FAF) on the side away from the airport and is located no closer than 5 NM from the landing threshold. Flight manuals or operating handbooks may also contain a fuel, time, and distance to descend chart that contains the same information.

One technique that is often used is the descent rule of thumb, which is used to determine when you need to descend in terms of the number of miles prior to the point at which you desire to arrive at your new altitude. First, divide the altitude needed to be lost by 300. For example, if cruising altitude is 7,000 feet and you want to get down to a pattern altitude of 1,000 feet. The altitude you want to lose is 6,000 feet, which when divided by 300 results in 20. Therefore, you need to start your descent 20 NM out and leave some extra room so that you are at pattern altitude prior to the proper entry. It is also necessary to know what rate-of-descent (ROD) to use.

To determine ROD for a three-degree path, simply multiply your groundspeed by 5. If you are going 120 knots, your ROD to fly the desired path would be 600 feet per minute (120 × 5 = 600). It was determined in the previous example that a descent should be initiated at 20 NM to lose 6,000 feet. If the groundspeed is 120 knots, that means the aircraft is moving along at 2 NM per minute. So to go 20 NM, it takes 10 minutes. Ten minutes at 600 feet per minute means you will lose 6,000 feet.

The calculations should be made before the flight and rules of thumb updates should be applied in flight. For example, from the charted STAR pilots might plan a descent based on an expected clearance to "cross 40 DME West of Brown VOR at 6,000" and then apply rules of thumb for slowing down from 250 knots. These might include planning airspeed at 25 NM from the runway threshold to be 250 knots, 200 knots at 20 NM, and 150 knots at 15 NM until gear and flap speeds are reached, never to fall below approach speed.

Vertical Navigation (VNAV) Planning

Vertical navigation (VNAV) is the vertical component of the flight plan. This approach path is computed from the top-of- descent (TOD) point down to the end-of-descent waypoint (E/D), which is generally the runway or missed approach point, which is slightly different than to the approach gate for non-flight management system (FMS) equipped aircraft. [Figure 3-2] The VNAV path is computed based upon the aircraft performance, approach constraints, weather data (winds, temperature, icing conditions, etc.) and aircraft weight.

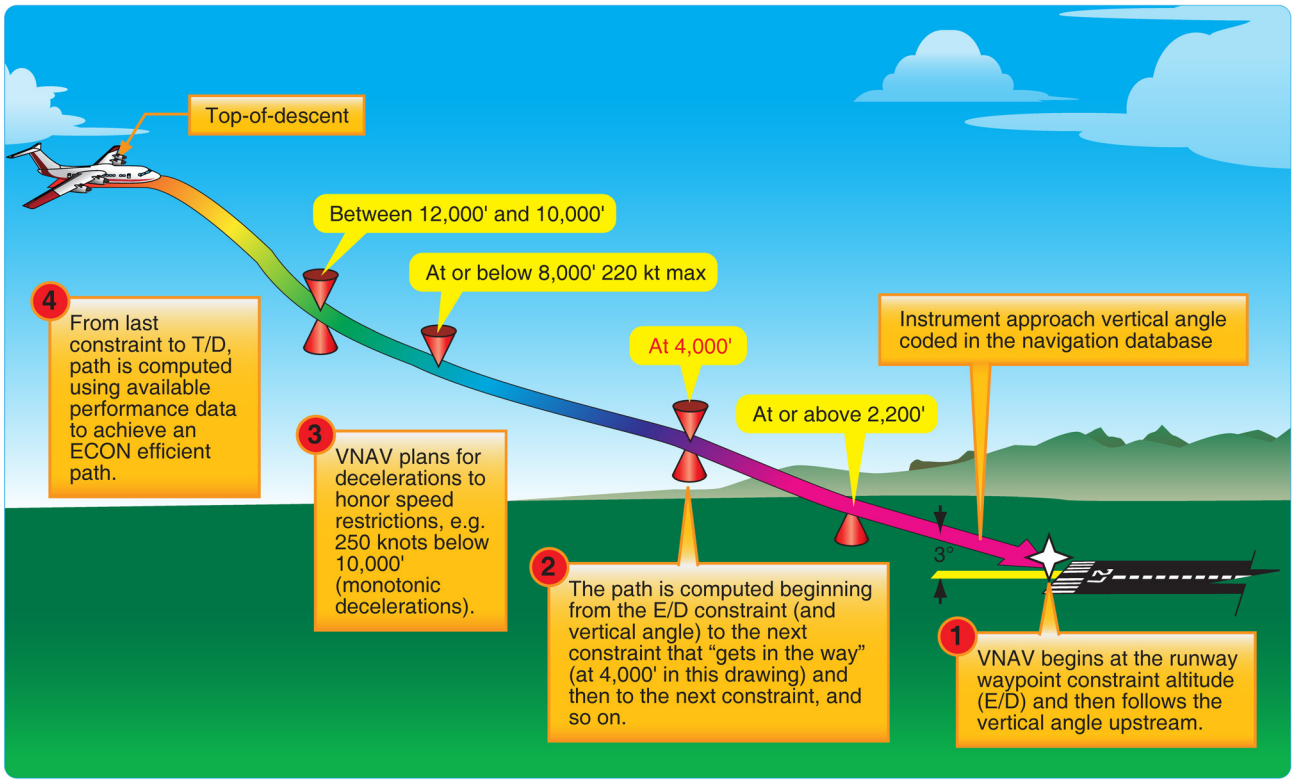


Figure 3-2. VNAV path construction.

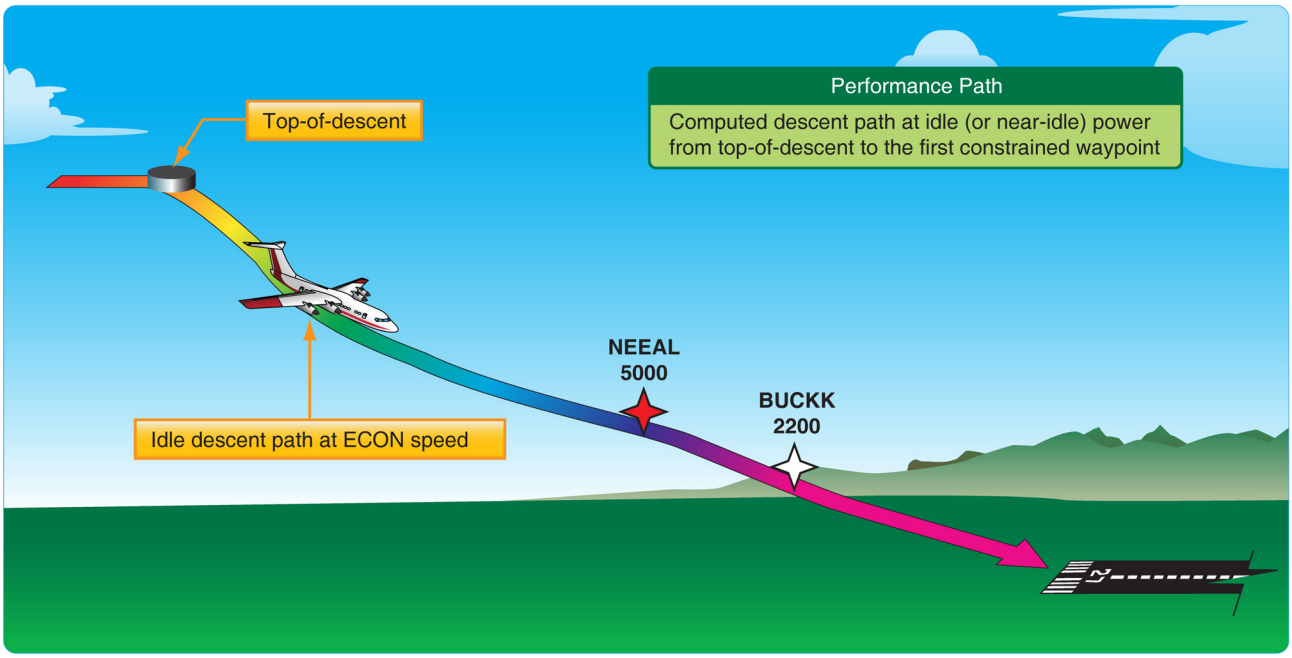


Figure 3-3. VNAV performance path.

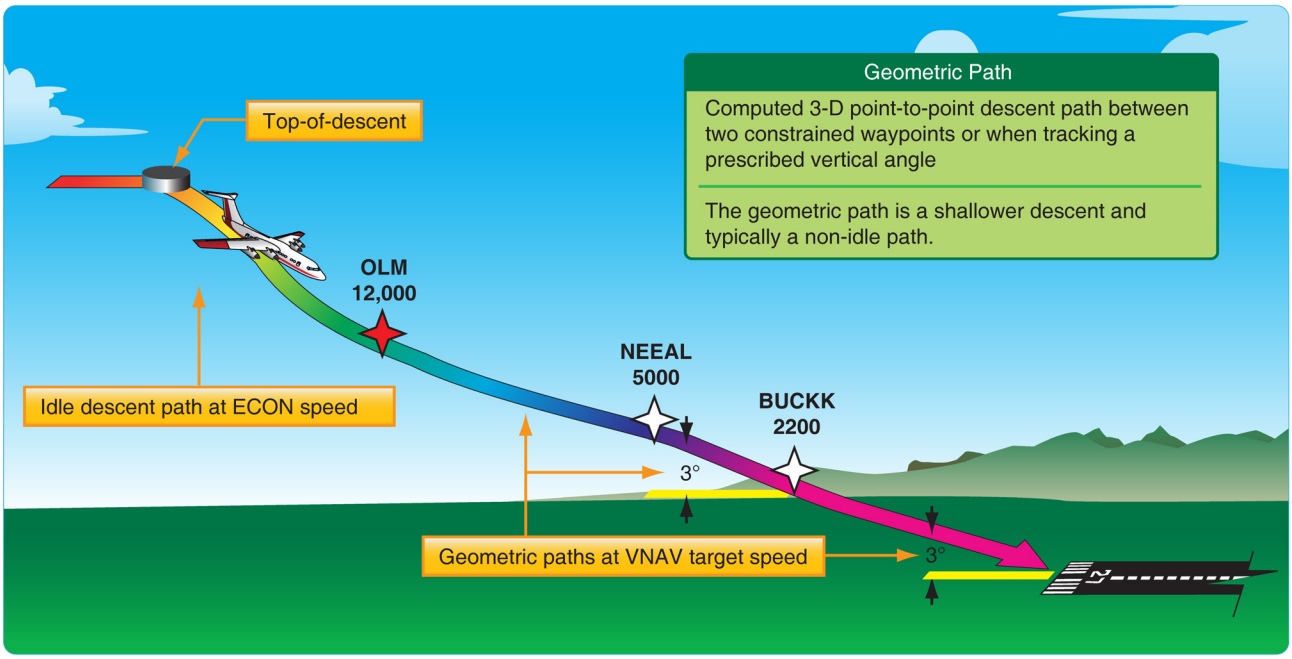


Figure 3-4. VNAV geometric path.

The two types of VNAV paths that the FMS use is either a performance path or a geometric path. The performance path is computed using at idle or near idle power from the TOD to the first constrained waypoint. [Figure 3-3] The geometric path is computed from point to point between two constrained waypoints or when on an assigned vertical angle. The geometric path is shallower than the performance path and is typically a non-idle path. [Figure 3-4]

LNAV/VNAV Equipment

Lateral navigation/vertical navigation (LNAV/VNAV) equipment is similar to an instrument landing system (ILS) in that it provides both lateral and vertical approach course guidance. Since precise vertical position information is beyond the current capabilities of the GPS, approaches with LNAV/VNAV minimums make use of certified barometric VNAV (baro-VNAV) systems for vertical guidance and/or the wide area augmentation system (WAAS) to improve GPS accuracy for this purpose.

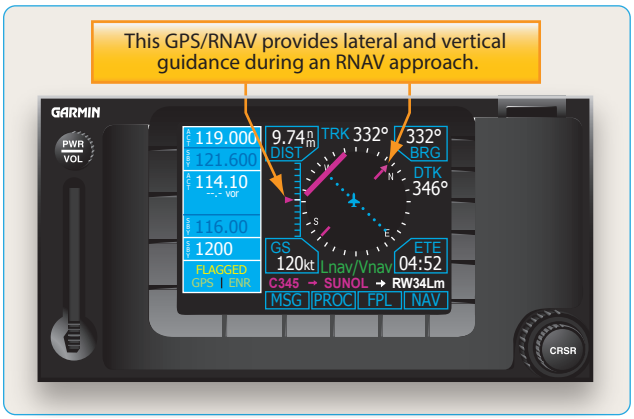


Figure 3-5. WAAS data provide lateral and vertical guidance.

NOTE: WAAS makes use of a collection of ground stations that are used to detect and correct inaccuracies in the position information derived from the GPS. Using WAAS, the accuracy of vertical position information is increased to within three meters.

To make use of WAAS, however, the aircraft must be equipped with an IFR-approved GPS receiver with WAAS signal reception that integrates WAAS error correction signals into its position determining processing. The WAAS enabled GPS receiver [Figure 3-5] allows the pilot to load an RNAV approach and receive guidance along the lateral and vertical profile shown on the approach chart. [Figure 3-6] It is very important to know what kind of equipment is installed in an aircraft, and what it is approved to do. It is also important to understand that the VNAV function of non-WAAS capable or non-WAAS equipped IFR-approved GPS receivers does not make the aircraft capable of flying approaches to LNAV/VNAV minimums.

FMS are the primary tool for most modern aircraft, air carriers, and any operators requiring performance based navigation. Most of the modern FMS are fully equipped with LNAV/VNAV and WAAS. The FMS provides flight control steering and thrust guidance along the VNAV path. Some less integrated systems may only advise the flight crew of the VNAV path but have no auto-throttle capability. These less integrated systems require an increase in pilot workload during the arrival/approach phase in order to maintain the descent path.

Descent Planning for High Performance Aircraft

The need to plan the IFR descent into the approach gate and airport environment during the preflight planning stage of flight is particularly important for turbojet powered airplanes. TOD from the en route phase of flight for high performance airplanes is often used in this process and is calculated manually or automatically through a FMS based upon the altitude of the approach gate. A general rule of thumb for initial IFR descent planning in jets is the 3 to 1 formula. This means that it takes 3 nautical miles (NM) to descend 1,000 feet. If an airplane is at flight level (FL) 310 and the approach gate or initial approach fix is at 6,000 feet, the initial descent requirement equals 25,000 feet (31,000–6,000). Multiplying 25 times 3 equals 75; therefore begin descent 75 NM from the approach gate, based on a normal jet airplane, idle thrust, speed Mach 0.74 to 0.78, and vertical speed of 1,800–2,200 feet per minute (fpm). For a tailwind adjustment, add 2 NM for each 10 knots of tailwind. For a headwind adjustment, subtract 2 NM for each 10 knots of headwind. During the descent planning stage, try to determine which runway is in use at the destination airport, either by reading the latest aviation routine weather report (METAR) or checking the automatic terminal information service (ATIS) information. There can be big differences in distances depending on the active runway and STAR. The objective is to determine the most economical point for descent.

An example of a typical jet descent-planning chart is depicted in Figure 3-7. Item 1 is the pressure altitude from which the descent begins; item 2 is the time required for the descent in minutes; item 3 is the amount of fuel consumed in pounds during descent to sea level; and item 4 is the distance covered in NM. Item 5 shows that the chart is based on a Mach .80 airspeed until 280 knots

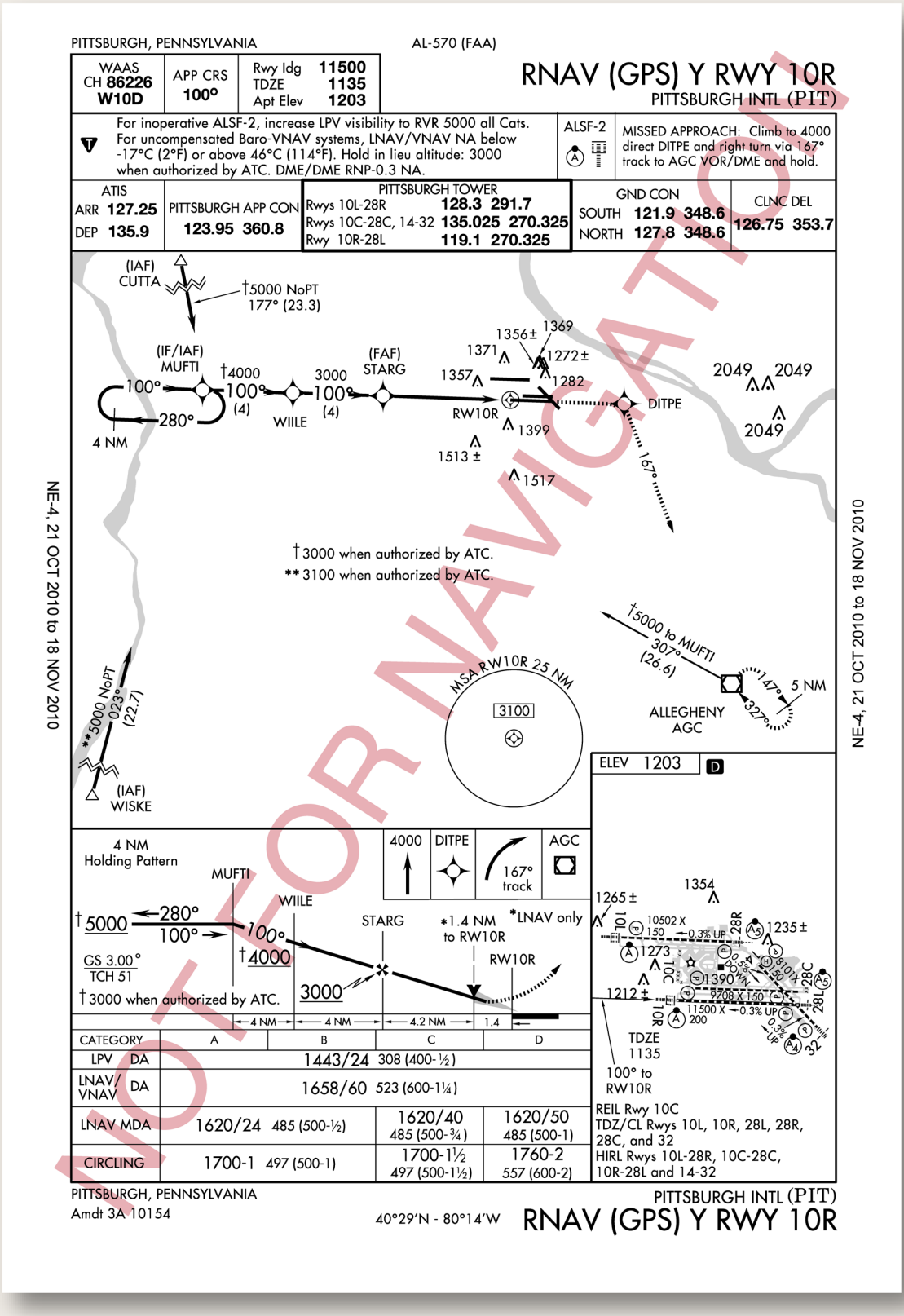


Figure 3-6. RNAV (GPS) approach.

Pressure Altitude (1,000 feet)	Time (minutes)	Fuel (pounds)	Distance (NM)
39	20	850	124
37	19	800	112
35	18	700	101
33	17	650	92
31	16	600	86
29	15	600	80
27	14	550	74
25	13	550	68
23	12	500	63
21	11	500	58
19	10	450	52
17	10	450	46
15	9	400	41
10	6	300	26
5	3	150	13

1 5 2 3 4

.80/280

NOTE:

Note: Subtract 30 lb of fuel and 36 seconds for each 1,000 feet that the destination airport is above sea level

SAMPLE NOT FOR ACTUAL USE

Figure 3-7. Jet descent task.

indicated airspeed (KIAS) is obtained. The 250 knot airspeed limitation below 10,000 feet mean sea level (MSL) is not included on the chart, since its effect is minimal. Also, the effect of temperature or weight variation is negligible and is therefore omitted.

Due to the increased flight deck workload, pilots should get as much done ahead of time as possible. As with the climb and cruise phases of flight, aircrews should consult the proper performance charts to compute their fuel requirements, as well as the time and distance needed for their descent.

During the cruise and descent phases of flight, pilots need to monitor and manage the airplane according to the appropriate manufacturer's recommendations. Flight manuals and operating handbooks contain cruise and descent checklists, performance charts for specific cruise configurations, and descent charts that provide information regarding the fuel, time, and distance required to descend. Aircrews should review this information prior to the departure of every flight so they have an understanding of how the airplane is supposed to perform at cruise and during descent. A stabilized descent constitutes a preplanned maneuver in which the power is properly set, and minimum control input is required to maintain the appropriate descent path. Excessive corrections or control inputs indicate the descent was improperly planned. Plan the IFR descent from cruising altitude so that the aircraft arrives at the approach gate altitude or initial approach fix altitude prior to beginning the instrument approach. For example, suppose you are asked to descend from 11,000 feet to meet a crossing restriction at 3,000 feet. [Figure 3-8] Since there is a 200 knot speed restriction while approaching the destination airport, you choose a descent speed of 190 knots and a descent rate of 1,000 fpm. Assuming a 10 knot headwind component, groundspeed in the descent is 180 knots.

Descending From the En Route Altitude

Making the transition from cruise flight to the beginning of an instrument approach procedure sometimes requires arriving at a given waypoint at an assigned altitude. When this requirement is prescribed by a published arrival

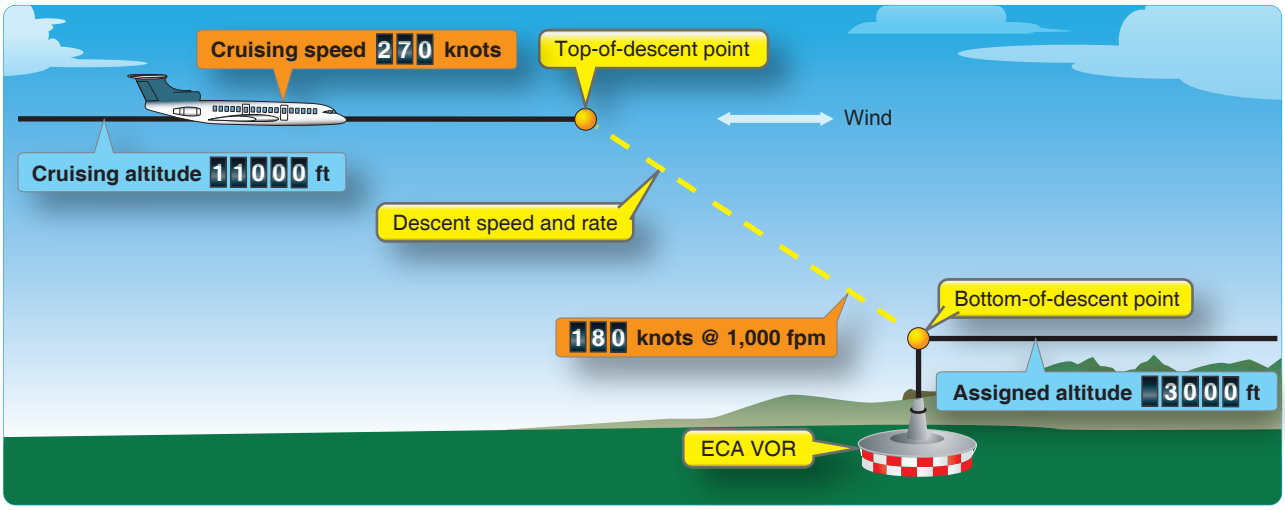


Figure 3-8. The descent planning task.

procedure or issued by ATC, it is called a crossing restriction. Even when ATC allows a descent at the pilot's discretion, aircrews need to choose a waypoint and altitude for positioning convenient to start the approach. In either case, descending from a cruising altitude to a given waypoint or altitude requires both planning and precise flying.

ATC may ask the pilot to descend to and maintain a specific altitude. Generally, this clearance is for en route traffic separation purposes, and pilots need to respond to it promptly. Descend at the optimum rate for the aircraft being flown until 1,000 feet above the assigned altitude, then descend at a rate between 500 and 1,500 fpm to the assigned altitude. If at any time, other than when slowing to 250 KIAS at 10,000 feet MSL, the pilot cannot descend at a rate of at least 500 fpm, advise ATC.

The second type of clearance allows the pilot to descend "… at pilot's discretion." When ATC issues a clearance to descend at pilot's discretion, pilots may begin the descent whenever they choose and at any rate of their choosing. Pilots are also authorized to level off, temporarily, at any intermediate altitude during the descent. However, once the aircraft leaves an altitude, it may not return to that altitude.

A descent clearance may also include a segment where the descent is at the pilots' discretion—such as "cross the Joliet VOR at or above 12,000, descend and maintain 5,000." This clearance authorizes pilots to descend from their current altitude whenever they choose, as long as they cross the Joliet VOR at or above 12,000 feet MSL. After that, they are expected to descend at a normal rate until they reach the assigned altitude of 5,000 feet MSL.

Clearances to descend at pilots' discretion are not just an option for ATC. Pilots may also request this type of clearance so that they can operate more efficiently. For example, if a pilot was en route above an overcast layer, he or she might ask for a descent at his or her discretion to allow the aircraft to remain above the clouds for as long as possible. This might be particularly important if the atmosphere is conducive to icing and the aircraft's icing protection is limited. The pilot's request permits the aircraft to stay at its cruising altitude longer to conserve fuel or to avoid prolonged IFR flight in icing conditions. This type of descent can also help to minimize the time spent in turbulence by allowing pilots to level off at an altitude where the air is smoother.

Controlled Flight Into Terrain (CFIT)

Inappropriate descent planning and execution during arrivals has been a contributing factor to many fatal aircraft accidents. Since the beginning of commercial jet operations, more than 9,000 people have died worldwide because of controlled flight into terrain (CFIT). CFIT is described as an event in which a normally functioning aircraft is inadvertently flown into the ground, water, or an obstacle. Of all CFIT accidents, 7.2 percent occurred during the descent phase of flight.

The basic causes of CFIT accidents involve poor flight crew situational awareness, or SA. One definition of SA is an accurate perception by pilots of the factors and conditions currently affecting the safe operation of the aircraft and the crew. The causes of CFIT are the flight crews' lack of vertical position awareness or their lack of horizontal position awareness in relation to the ground, water, or an obstacle. More than two-thirds of all CFIT accidents are the result of an altitude error or lack of vertical SA. CFIT accidents most often occur during reduced visibility associated with instrument meteorological conditions (IMC), darkness, or a combination of both.

The inability of controllers and pilots to properly communicate has been a factor in many CFIT accidents. Heavy workloads can lead to hurried communication and the use of abbreviated or non-standard phraseology. The importance of good communication during the arrival phase of flight was made evident in a report by an air traffic controller and the flight crew of an MD-80.

The controller reported that he was scanning his radarscope for traffic and noticed that the MD-80 was descending through 6,400 feet. He immediately instructed a climb to at least 6,500 feet. The pilot returned to 6,500 feet, but responded to ATC that he had been cleared to 5,000 feet. When he had read back 5,000 feet to the controller, he received no correction from the controller. After almost simultaneous ground proximity warning system (GPWS) and controller warnings, the pilot climbed and avoided the terrain. The recording of the radio transmissions confirmed that the airplane was cleared to 7,000 feet and the pilot mistakenly read back 5,000 feet then attempted to descend to 5,000 feet. The pilot stated in the report: "I don't know how much clearance from the mountains we had, but it certainly makes clear the importance of good communications between the controller and pilot."

ATC is not always responsible for safe terrain clearance for the aircraft under its jurisdiction. Many times ATC issue en route clearances for pilots to proceed off airway direct to a point. Pilots who accept this type of clearance also are accepting the shared responsibility for maintaining safe terrain clearance. Know the height of the highest terrain and obstacles in the operating area and your position in relation to the surrounding high terrain.

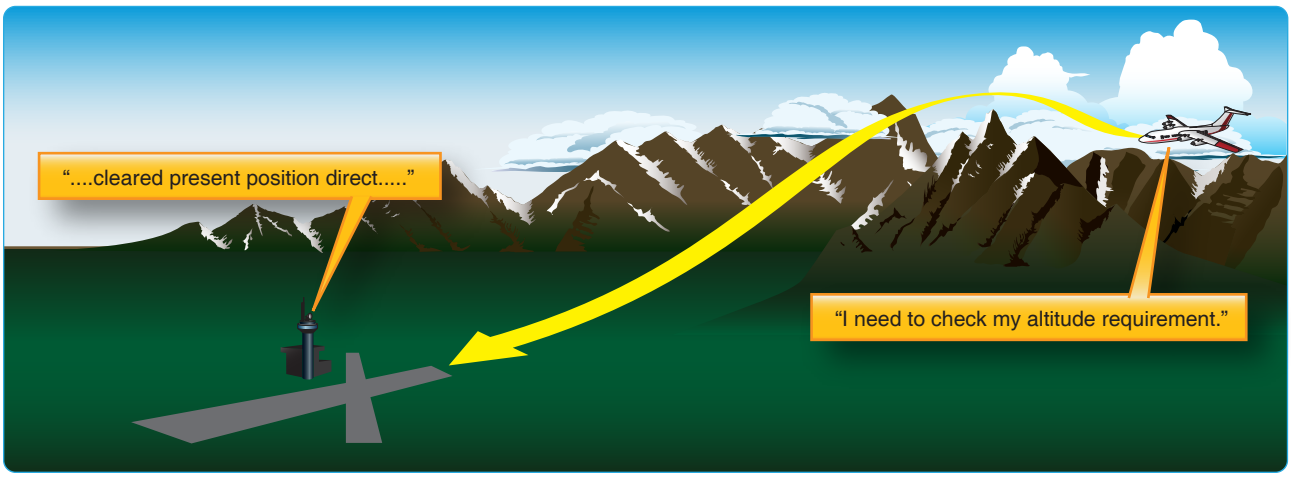


Figure 3-9. Altitude management when cleared direct.

The following are excerpts from CFIT accidents related to descending on arrival: "…delayed the initiation of the descent…"; "Aircraft prematurely descended too early…"; "…late getting down…"; "During a descent…incorrectly cleared down…"; "…aircraft prematurely let down…"; "…lost situational awareness…"; "Premature descent clearance…"; "Prematurely descended…"; "Premature descent clearance while on vector…"; "During initial descent…" [Figure 3-9]

Practicing good communication skills is not limited to just pilots and controllers. In its findings from a 1974 air carrier accident, the National Transportation Safety Board (NTSB) wrote, "…the extraneous conversation conducted by the flight crew during the descent was symptomatic of a lax atmosphere in the flight deck that continued throughout the approach." The NTSB listed the probable cause as "… the flight crew's lack of altitude awareness at critical points during the approach due to poor flight deck discipline in that the crew did not follow prescribed procedures."

In 1981, the FAA issued 14 CFR Part 121, section 121.542 and Part 135, section 135.100, Flight Crewmember Duties, commonly referred to as "sterile flight deck rules." The provisions in this rule can help pilots, operating under any regulations, to avoid altitude and course deviations during arrival. In part, it states: (a) No certificate holder should require, nor may any flight crewmember perform, any duties during a critical phase of flight except those duties required for the safe operation of the aircraft. Duties such as company required calls made for such purposes as ordering galley supplies and confirming passenger connections, announcements made to passengers promoting the air carrier or pointing out sights of interest, and filling out company payroll and related records are not required for the safe operation of the aircraft. (b) No flight crewmember may engage in, nor may any pilot in command permit, any activity during a critical phase of flight that could distract any flight crewmember from the performance of his or her duties or which could interfere in any way with the proper conduct of those duties. Activities such as eating meals, engaging in nonessential conversations within the flight deck and nonessential communications between the cabin and flight deck crews, and reading publications not related to the proper conduct of the flight are not required for the safe operation of the aircraft. (c) Critical phases of flight include all ground operations involving taxi, takeoff and landing, and all other flight operations conducted below 10,000 feet, except cruise flight.

Standard Terminal Arrival Routes (STARs)

A STAR is an ATC-coded IFR route established for application to arriving IFR aircraft destined for certain airports. A STAR provides a critical form of communication between pilots and ATC. Once a flight crew has accepted a clearance for a STAR, they have communicated with the controller what route, and in some cases what altitude and airspeed, they fly during the arrival, depending on the type of clearance. The STAR provides a common method for leaving the en route structure and navigating to your destination. It is a preplanned instrument flight rule ATC arrival procedure published for pilot use in graphic and textual form that simplifies clearance delivery procedures.

The principal difference between standard instrument departure (SID) or departure procedures (DPs) and STARs is that the DPs start at the airport pavement and connect to the en route structure. STARs on the other hand, start at the en route structure but do not make it down to the pavement; they end at a fix or NAVAID designated by ATC, where radar vectors commonly take over. This is primarily

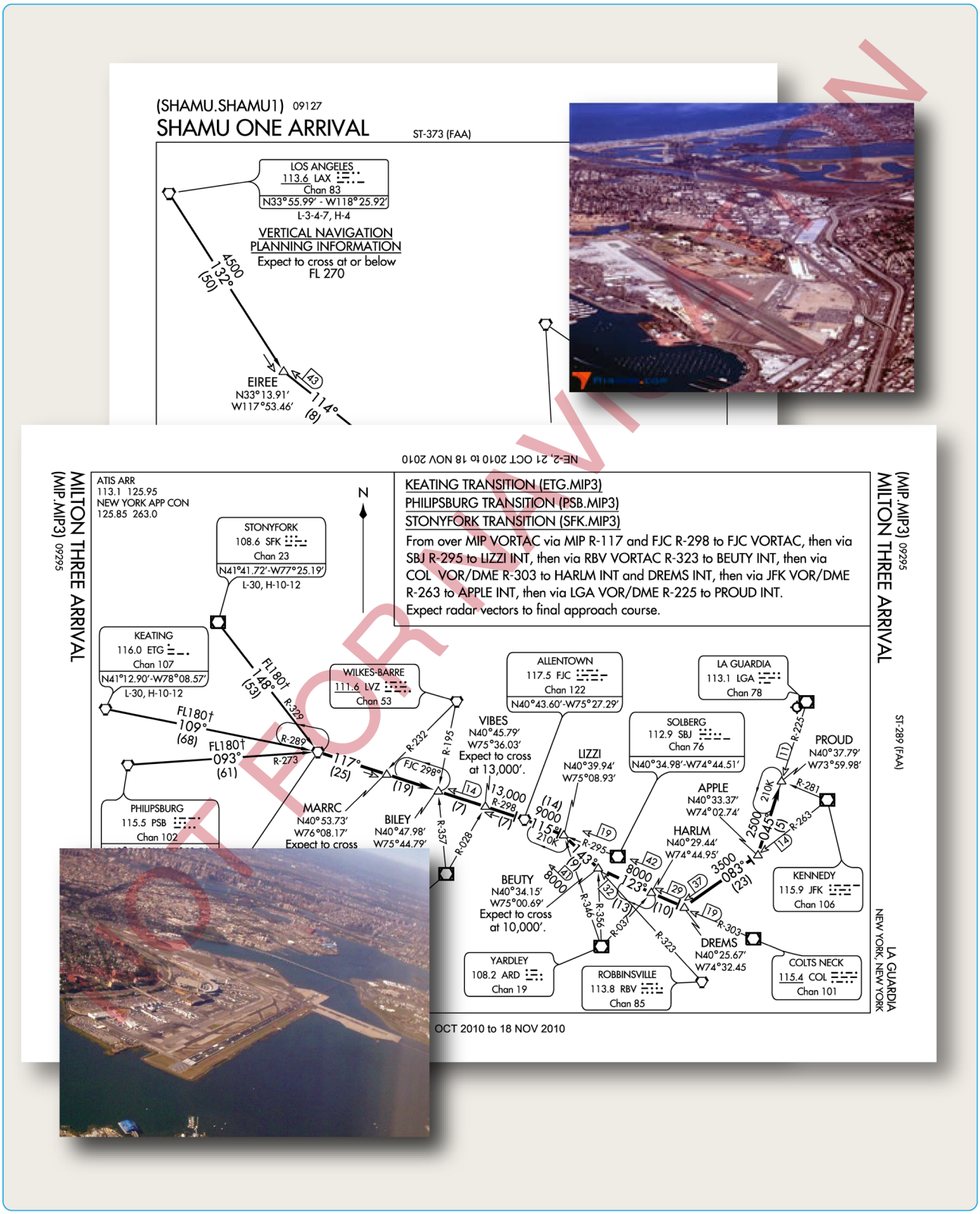


Figure 3-10. Arrival charts.

because STARs serve multiple airports. STARs greatly help to facilitate the transition between the en route and approach phases of flight. The objective when connecting a STAR to an instrument approach procedure is to ensure a seamless lateral and vertical transition. The STAR and approach procedure should connect to one another in such a way as to maintain the overall descent and deceleration profiles. This often results in a seamless transition between the en route, arrival, and approach phases of flight, and serves as a preferred route into high volume terminal areas. [Figure 3-10]

STARs provide a transition from the en route structure to an approach gate, outer fix, instrument approach fix, or arrival waypoint in the terminal area, and they usually terminate with an instrument or visual approach procedure. STARs are included at the front of each Terminal Procedures Publication (TPP) regional booklet.

For STARs based on conventional NAVAIDs, the procedure design and obstacle clearance criteria are essentially the same as that for en route criteria, covered in Chapter 2, En Route Operations. STAR procedures typically include a standardized descent gradient at and above 10,000 feet MSL of 318 feet per nautical mile (FPNM), or 3 degrees. Below 10,000 feet MSL, the maximum descent rate is 330 FPNM, or approximately 3.1 degrees. In addition to standardized descent gradients, STARs allow for deceleration segments at any waypoint that has a speed restriction. As a general guideline, deceleration considerations typically add 1 NM of distance for each 10 knots of speed reduction required.

RNAV STARs or STAR Transitions

STARs designated RNAV serve the same purpose as conventional STARs, but are only used by aircraft equipped with FMS or GPS. An RNAV STAR or STAR transition typically includes flyby waypoints, with fly over waypoints used only when operationally required. These waypoints may be assigned crossing altitudes and speeds to optimize the descent and deceleration profiles. RNAV STARs often are designed, coordinated, and approved by a joint effort between air carriers, commercial operators, and the ATC facilities that have jurisdiction for the affected airspace.

RNAV STAR procedure design, such as minimum leg length, maximum turn angles, obstacle assessment criteria, including widths of the primary and secondary areas, use the same design criteria as RNAV DPs. Likewise, RNAV STAR procedures are designated as either RNAV 1 or RNAV 2, based on the aircraft navigation equipment required, flight crew procedures, and the process and criteria used to develop the STAR. The RNAV 1 or RNAV 2 designation appears in the notes on the chart. RNAV 1 STARs have higher equipment requirements and, often, tighter required navigation performance (RNP) tolerances than RNAV 2. For RNAV 1 STARS, pilots are required to use a course deviation indicator (CDI)/flight director, and/or autopilot in LNAV mode while operating on RNAV courses. (These requirements are detailed in Chapter 1 of this book, under RNAV Departures.) RNAV 1 STARs are generally designated for high-traffic areas. Controllers may clear a pilot to use an RNAV STAR in various ways.

If the pilots clearance simply states, "cleared Hadly One arrival," the pilot is to use the arrival for lateral routing only.

- A clearance such as "cleared Hadly One arrival, descend and maintain flight level two four zero," clears the pilot to descend only to the assigned altitude, and then should maintain that altitude until cleared for further VNAV.
- If the pilot is cleared using the phrase "descend via," the controller expects the pilot to use the equipment for both lateral and VNAV, as published on the chart.
- The controller may also clear the pilot to use the arrival with specific exceptions—for example, "Descend via the Haris One arrival, except cross Bruno at one three thousand then maintain one zero thousand." In this case, the pilot should track the arrival both laterally and vertically, descending so as to comply with all altitude and airspeed restrictions until reaching Bruno, and then maintain 10,000 feet until cleared by ATC to continue to descend.
- Pilots might also be given direct routing to intercept a STAR and then use it for VNAV. For example, "Proceed direct Mahem, descend via the Mahem Two arrival."

Interpreting the STAR

STARs use much of the same symbology as departure and approach charts. In fact, a STAR may at first appear identical to a similar graphic DP, except the direction of flight is reversed and the procedure ends at an approach fix. The STAR officially begins at the common NAVAID, intersection, or fix where all the various transitions to the arrival come together. A STAR transition is a published segment used to connect one or more en route airways, jet routes, or RNAV routes to the basic STAR procedure. It is one of several routes that bring traffic from different directions into one STAR. This way, arrivals from several directions can be accommodated on the same chart, and traffic flow is routed appropriately within the congested airspace.

To illustrate how STARs can be used to simplify a complex clearance and reduce frequency congestion, consider

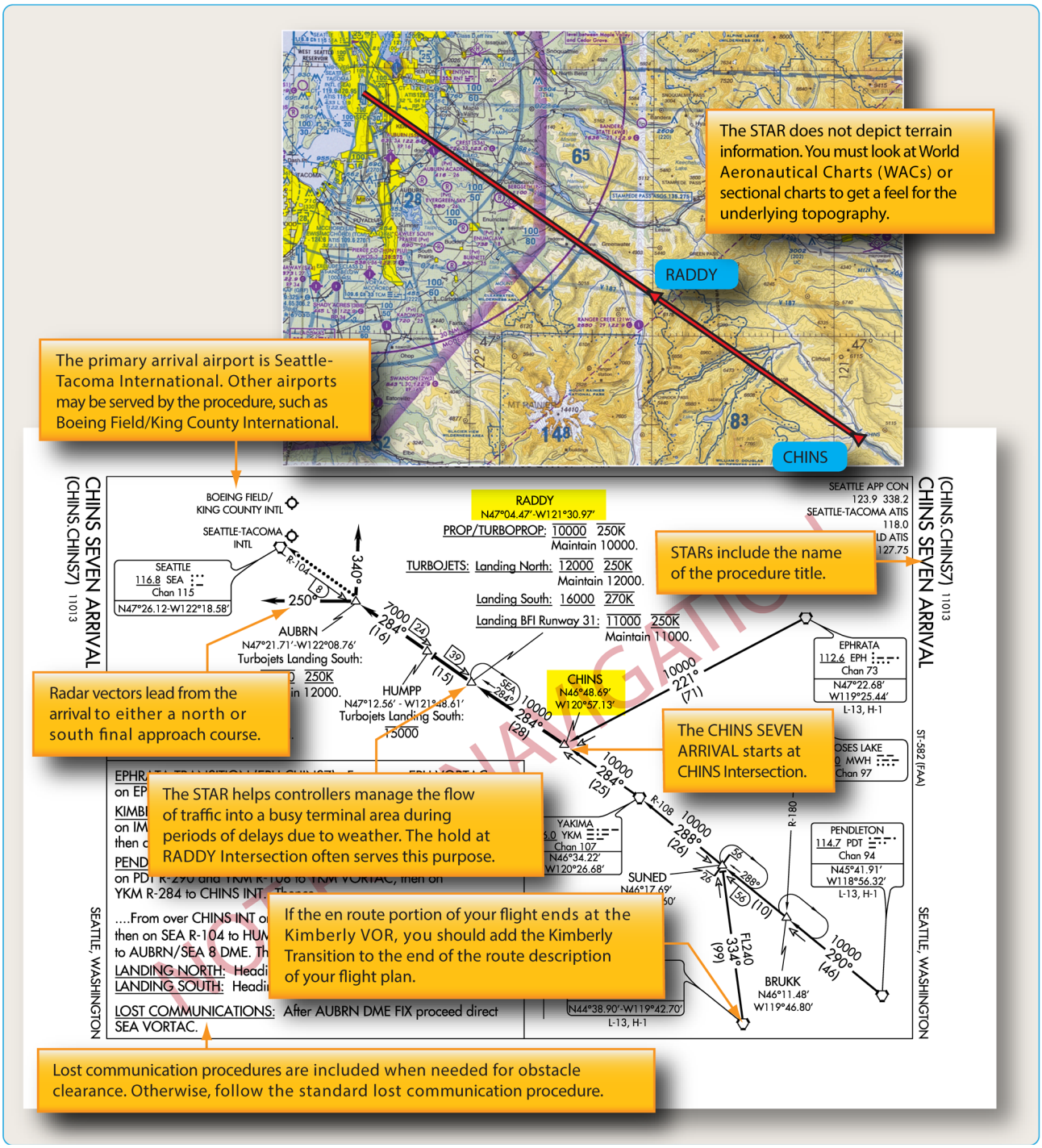


Figure 3-11. STAR interpretation.

the following arrival clearance issued to a pilot flying to Seattle, Washington, depicted in Figure 3-11: "Cessna 32G, cleared to the Seattle/Tacoma International Airport as filed. Maintain 12,000. At the Ephrata VOR, intercept the 221° radial to CHINS Intersection. Intercept the 284° radial of the Yakima VOR to RADDY Intersection. Cross RADDY at 10,000. Continue via the Yakima 284° radial to AUBRN Intersection. Expect radar vectors to the final approach course."

Now consider how this same clearance is issued when a STAR exists for this terminal area. "Cessna 32G, cleared to Seattle/Tacoma International Airport as filed, then CHINS EIGHT ARRIVAL, Ephrata Transition. Maintain 10,000 feet." A shorter transmission conveys the same information.

Safety is enhanced when both pilots and controllers know what to expect. Effective communication increases with the

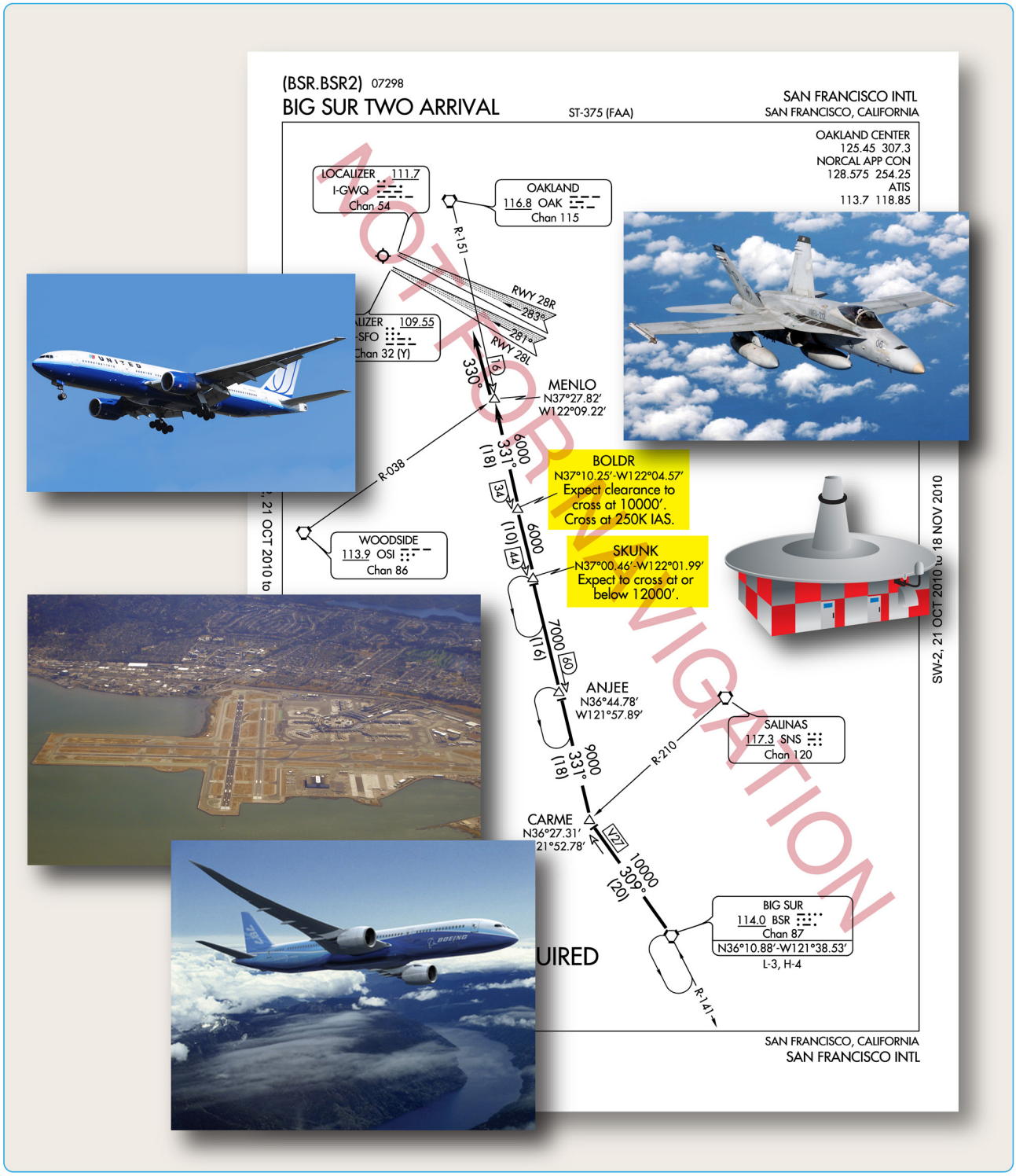


Figure 3-12. Reducing pilot/controlling workload.

reduction of repetitive clearances, decreasing congestion on control frequencies. To accomplish this, STARs are developed according to the following criteria:

- STARs must be simple, easily understood and, if possible, limited to one page.
- A STAR transition should be able to accommodate as many different types of aircraft as possible.
- VHF Omnidirectional Range/Tactical Aircraft Control (VORTACs) are used wherever possible, with some exceptions on RNAV STARs, so that military and civilian aircraft can use the same arrival.
- DME arcs within a STAR should be avoided since not all aircraft operating under IFR are equipped to navigate them.
- Altitude crossing and airspeed restrictions are included when they are assigned by ATC a majority of the time. [Figure 3-12]

STARs usually are named according to the point at which the procedure begins. In the United States, typically there are en route transitions before the STAR itself. So the STAR name is usually the same as the last fix on the en route transitions where they come together to begin the basic STAR procedure. A STAR that commences at the CHINS Intersection becomes the CHINS SEVEN ARRIVAL. When a

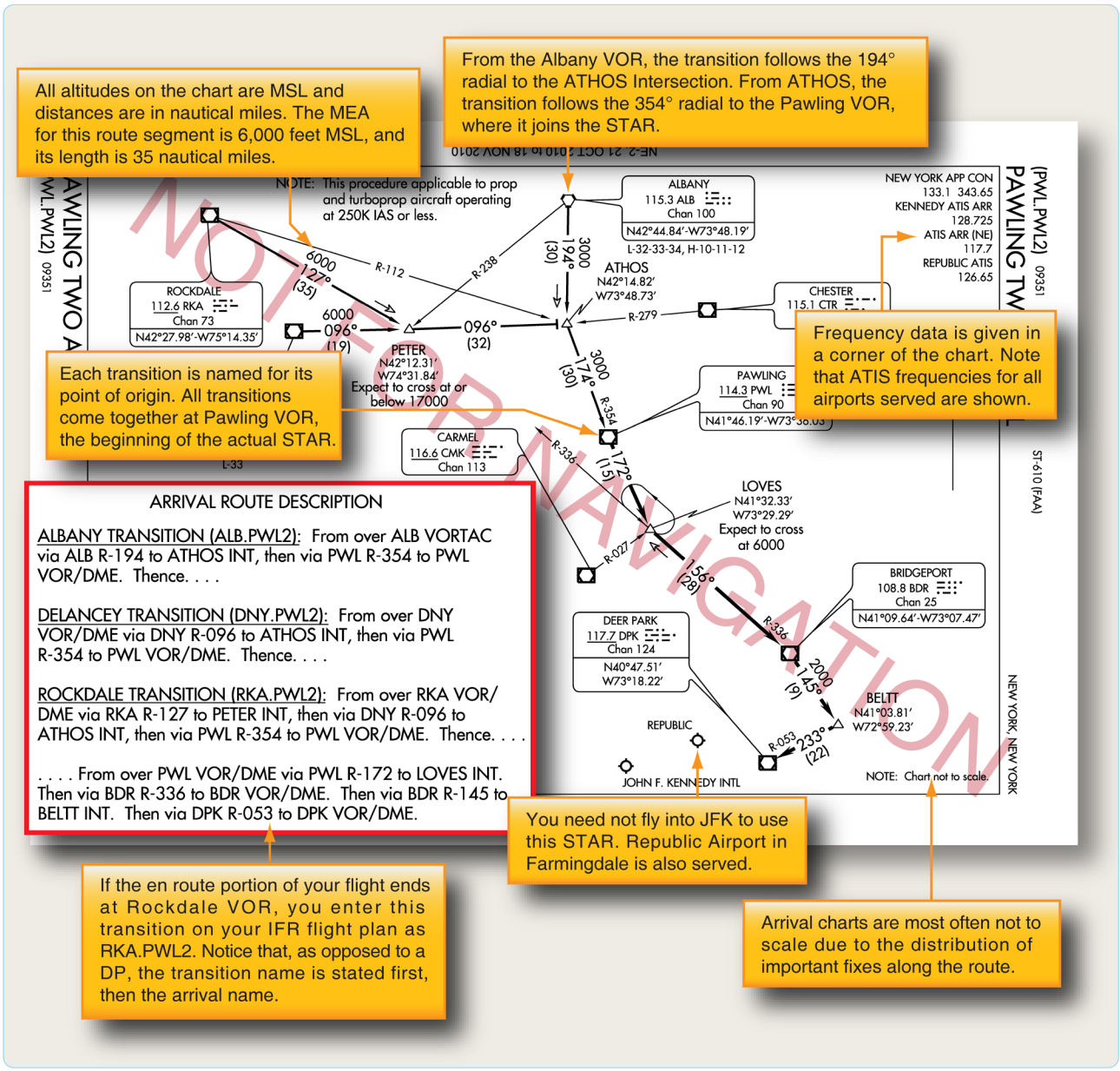


Figure 3-13. STAR symbology.

significant portion of the arrival is revised, such as an altitude, a route, or data concerning the NAVAID, the number of the arrival changes. For example, the CHINS SEVEN ARRIVAL is now the CHINS EIGHT ARRIVAL due to modifications in the procedure.

Studying the STARs for an airport may allow pilots to perceive the specific topography of the area. Note the initial fixes and where they correspond to fixes on the Aeronautical Information Systems (AIS) en route or area chart. Arrivals may incorporate step-down fixes when necessary to keep aircraft within airspace boundaries or for obstacle clearance. Routes between fixes contain courses, distances, and minimum altitudes, alerting aircrews to possible obstructions or terrain under their arrival path. Airspeed restrictions also appear where they aid in managing the traffic flow. In addition, some STARs require that pilots use DME and/or ATC radar. Aircrews can decode the symbology on the PAWLING TWO ARRIVAL by referring to the legend at the beginning of the TPP. [Figure 3-13]

STAR Procedures

Pilots may accept a STAR within a clearance or they may file for one in their flight plan. As the aircraft nears its destination airport, ATC may add a STAR procedure to its original clearance. Keep in mind that ATC can assign a STAR even if the aircrew has not requested one. Use of a STAR requires pilot possession of at least the approved chart. RNAV STARs must be retrievable by the procedure name from the aircraft database and conform to charted procedure. If an aircrew does not want to use a STAR, they must specify "No STAR" in the remarks section of their flight plan. Pilots may also refuse the STAR when it is given to them verbally by ATC, but the system works better if the aircrew advises ATC ahead of time.

Preparing for the Arrival

As mentioned before, STARs include navigation fixes that are used to provide transition and arrival routes from the en route structure to the final approach course. They also may lead to a fix where radar vectors are provided to intercept the final approach course. Pilots may have noticed that minimum crossing altitudes and airspeed restrictions appear on some STARs. These expected altitudes and airspeeds are not part of the clearance until ATC includes them verbally. A STAR is simply a published routing; it does not have the force of a clearance until issued specifically by ATC. For example, minimum en route altitude (MEAs) printed on STARs are not valid unless stated within an ATC clearance or in cases of lost communication. After receiving the arrival clearance, the aircrew should review the assigned STAR procedure and ensure the FMS has the appropriate procedure loaded (if so equipped).
Obtain the airport and weather information as early as practical. It is recommended that pilots have this information prior to flying the STAR. If you are landing at an airport with approach control services that has two or more published instrument approach procedures, you will receive advance notice of which instrument approaches to expect. This information is broadcast either by ATIS or by a controller. [Figure 3-14] It may not be provided when the visibility is 3 statute miles (SM) or better and the ceiling is at or above the highest initial approach altitude established for any instrument approach procedure for the airport.

For STAR procedures charted with radar vectors to the final approach, look for routes from the STAR terminating fixes to the IAF. If no route is depicted, you should have a predetermined plan of action to fly from the STAR terminating fix to the IAF in the event of a communication failure.

Reviewing the Approach

Once the aircrew has determined which approach to expect, review the approach chart thoroughly before entering the terminal area. Aircrews should check fuel level and make sure a prolonged hold or increased headwinds have not cut into the aircraft's fuel reserves because there is always a chance the pilot has to make a missed approach or go to an alternate. By completing landing checklists early, aircrews can concentrate on the approach.

In setting up for the expected approach procedure when using an RNAV, GPS, or FMS system, it is important to understand how multiple approaches to the same runway are coded in the database. When more than one RNAV procedure is issued for the same runway, there must be a way to differentiate between them within the equipment's database, as well as to select which procedure is to be used. (Multiple procedures may exist to accommodate GPS receivers and FMS, both with and without VNAV capability.) Each procedure name incorporates a letter of the alphabet, starting with Z and working backward through Y, X, W, and so on. (Naming conventions for approaches are covered in more depth in the next chapter). [Figure 3-15]

Altitude

Upon arrival in the terminal area, ATC either clears the aircraft to a specific altitude, or they give it a "descend via" clearance that instructs the pilot to follow the altitudes published on the STAR. [Figure 3-16] Pilots are not authorized to leave their last assigned altitude unless specifically cleared to do so. If ATC amends the altitude or route to one that is different from the published procedure, the rest of the charted descent procedure is cancelled. ATC assigns any further route, altitude, or airspeed clearances, as necessary. Notice the JANESVILLE FOUR ARRIVAL depicts only one published arrival route, with no named transition

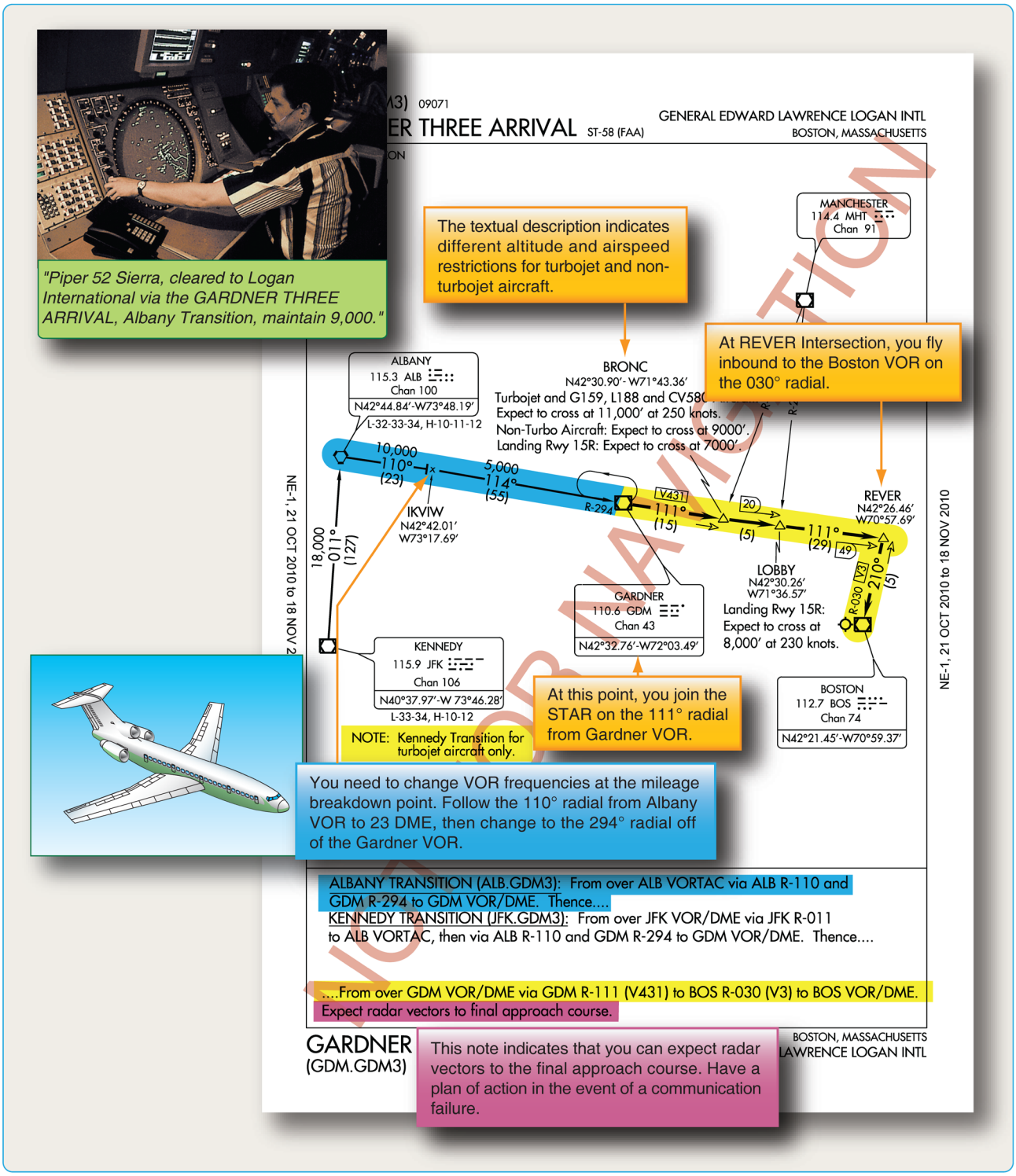


Figure 3-14. Arrival clearance.

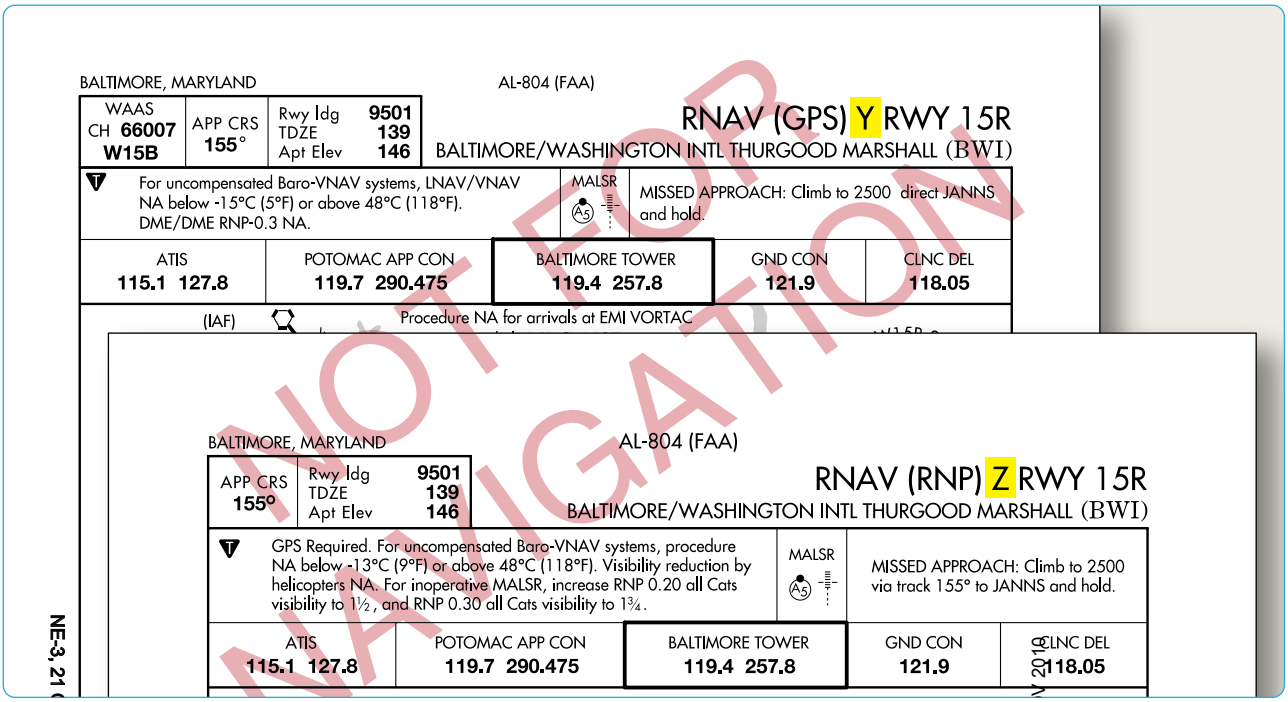


Figure 3-15. Two RNAV (GPS) approaches to Runway 15R at Baltimore. A controller issuing a clearance for one of these approaches would speak the identifying letter—for example, "...cleared for the RNAV (GPS) Yankee approach, Runway 15R..."

routes leading to the basic STAR procedure beginning at the Janesville VOR/DME. VNAV planning information is included for turbojet and turboprop airplanes at the bottom of the chart. Additionally, note that there are several ways to identify the BRIBE reporting point using alternate formation radials, some of which are from off- chart NAVAIDs. ATC may issue a descent clearance that includes a crossing altitude restriction. In the PENNS ONE ARRIVAL, the ATC clearance authorizes aircraft to descend at the pilots' discretion, as long as the pilot crosses the PENNS Intersection at 6,000 feet MSL. [Figure 3-17]

In the United States, Canada, and many other countries, the common altitude for changing to the standard altimeter setting of 29.92 inches of mercury ("Hg) (or 1013.2 hectopascals or millibars) when climbing to the high altitude structure is 18,000 feet. When descending from high altitude, the altimeter should be changed to the local altimeter setting when passing through FL 180, although in most countries throughout the world the change to or from the standard altimeter setting is not done at the same altitude for each instance.

For example, the flight level where aircrews change their altimeter setting to the local altimeter setting is specified by ATC each time they arrive at a specific airport. This information is shown on STAR charts outside the United States with the words: TRANS LEVEL: BY ATC. When departing from that same airport (also depicted typically on the STAR chart), the altimeter should be set to the standard setting when passing through 5,000 feet, as an example. This means that altimeter readings when flying above 5,000 feet are actual flight levels, not feet. This is common for Europe, but very different for pilots experienced with flying in the United States and Canada.

Although standardization of these procedures for terminal locations is subject to local considerations, specific criteria apply in developing new or revised arrival procedures. Normally, high performance airplanes enter the terminal area at or above 10,000 feet above the airport elevation and begin their descent 30 to 40 NM from touchdown on the landing runway. Unless pilots indicate an operational need for a lower altitude, descent below 5,000 feet above the airport elevation is typically limited to an altitude where final descent and glideslope/glidepath intercept can be made without exceeding specific obstacle clearance and other related arrival, approach, and landing criteria.

Arrival delays typically are absorbed at a metering fix. This fix is established on a route prior to the terminal airspace, 10,000 feet or more above the airport elevation. The metering fix facilitates profile descents, rather than controllers using delaying vectors or a holding pattern at low altitudes. Descent restrictions normally are applied prior to reaching the final approach phase to preclude relatively high descent rates close in to the destination airport. At least 10 NM from initial descent from 10,000

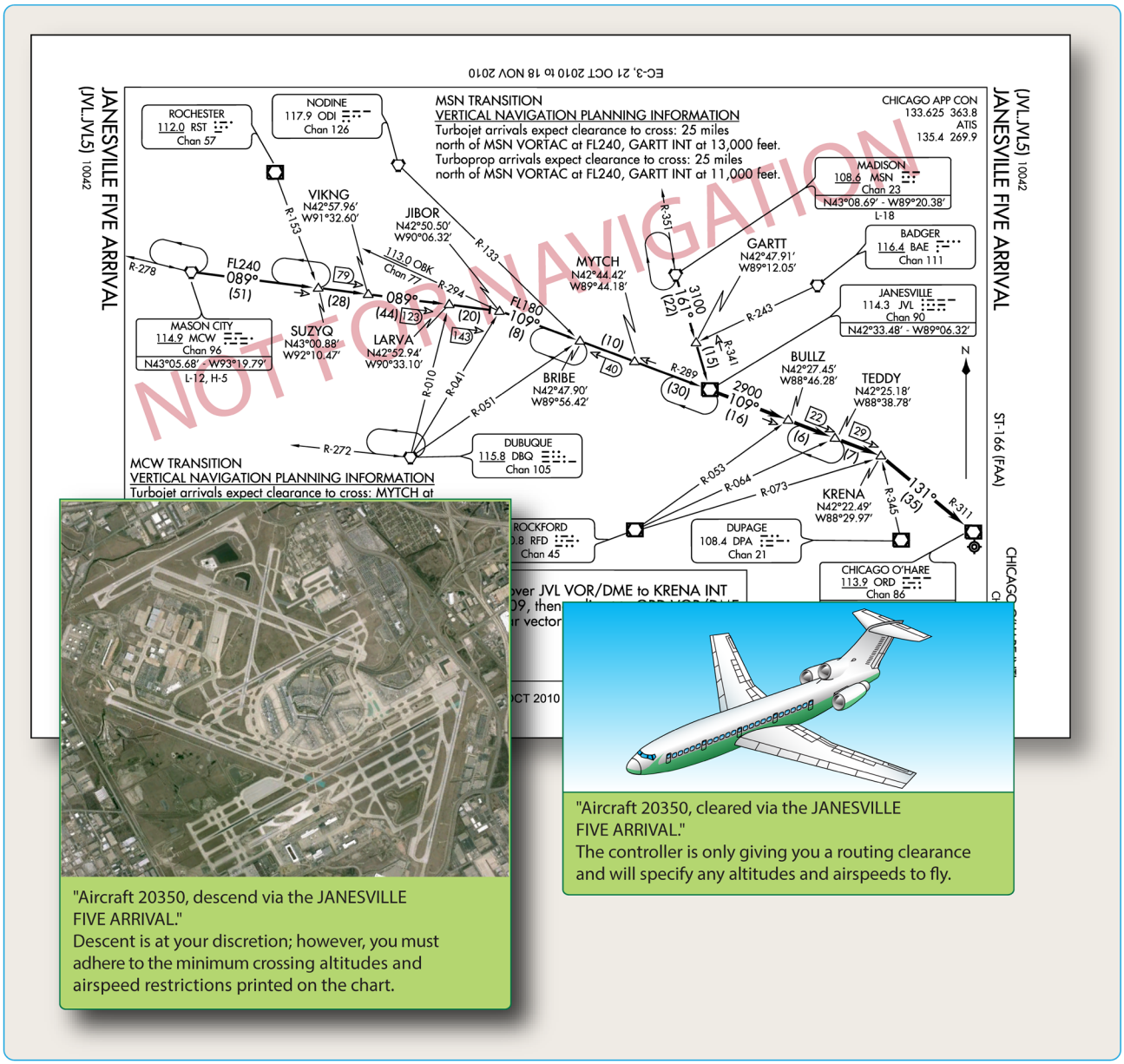


Figure 3-16. Assigned altitudes.

feet above the airport elevation, the controller issues an advisory that details when to expect to commence the descent. ATC typically uses the phraseology, "Expect descent in (number) miles." Standard ATC phraseology is, "Maintain (altitude) until specified point (e.g., abeam landing runway end), cleared for visual approach or expect visual or contact approach clearance in (number of miles, minutes, or specified point)."

Once the determination is made regarding the instrument approach and landing runway pilots use, ATC will not permit a change to another NAVAID that is not aligned with the landing runway. When altitude restrictions are required for separation purposes, ATC avoids assigning an altitude below 5,000 feet above the airport elevation.

There are numerous exceptions to the high performance airplane arrival procedures previously outlined. For example, in a non-radar environment, the controller may clear the flight to use an approach based on a NAVAID other than the one aligned with the landing runway, such as a circling approach. In this case, the descent to a lower altitude usually is limited to the circling approach area with the circle-to-land maneuver confined to the traffic pattern.

IFR en route descent procedures should include a review

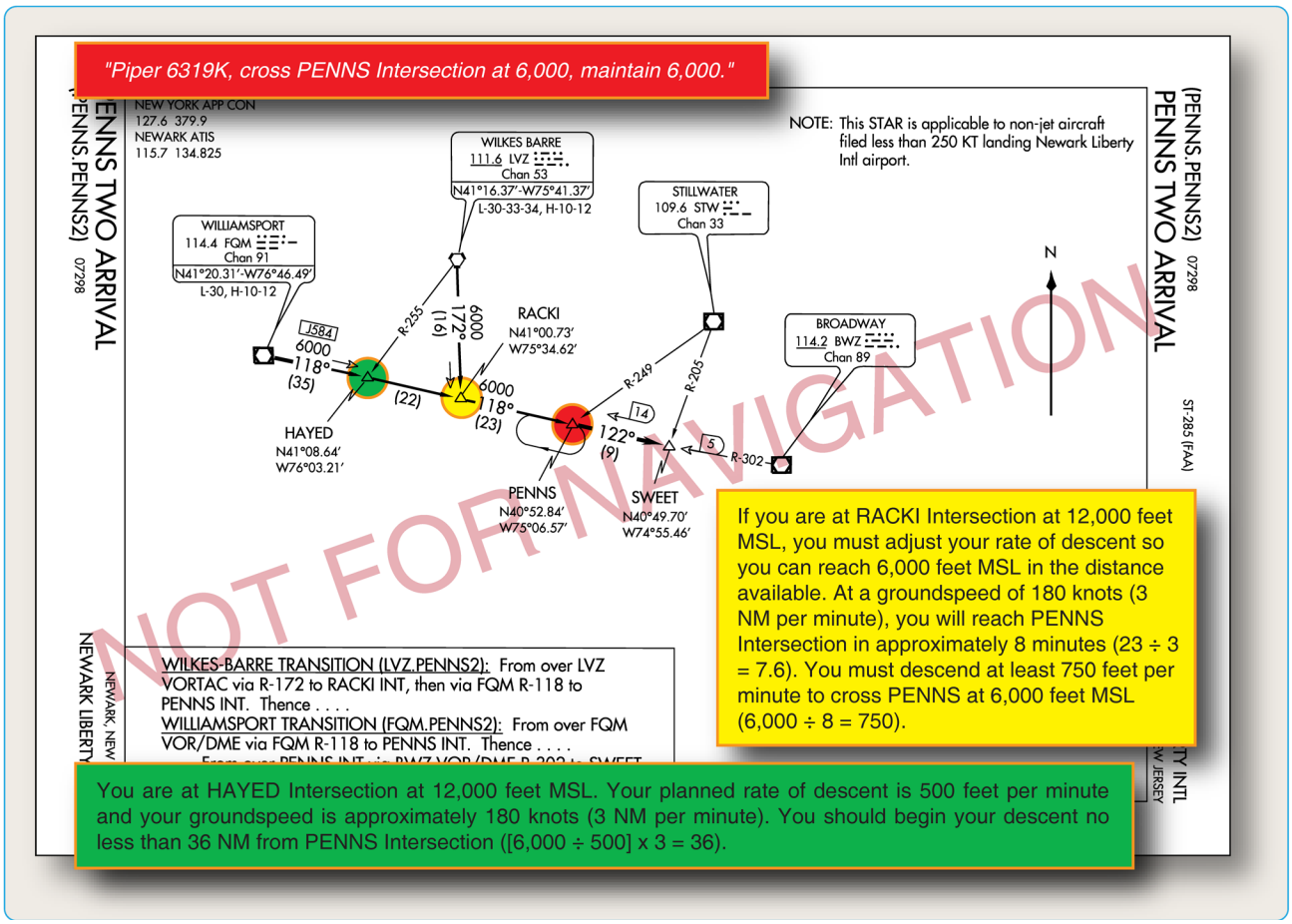


Figure 3-17. Altitude restrictions.

of minimum, maximum, mandatory, and recommended altitudes that normally precede the fix or NAVAID facility to which they apply. The initial descent gradient for a low altitude instrument approach procedure does not exceed 500 FPNM (approximately 5°), and for a high altitude approach, the maximum allowable initial gradient is 1,000 FPNM (approximately 10°).

Remember during arrivals, when cleared for an instrument approach, maintain the last assigned altitude until established on a published segment of the approach or on a segment of a published route. If no altitude is assigned with the approach clearance and the aircraft is already on a published segment, the pilot can descend to its minimum altitude for that segment of the approach.

Airspeed

During the arrival, expect to make adjustments in speed at the controller's request. When pilots fly a high-performance aircraft on an IFR flight plan, ATC may ask them to adjust their airspeed to achieve proper traffic sequencing and separation. This also reduces the amount of radar vectoring required in the terminal area. When operating a reciprocating engine or turboprop airplane within 20 NM from the destination airport, 150 knots is usually the slowest airspeed that is assigned. If the aircraft cannot maintain the assigned airspeed, the pilot must advise ATC. Controllers may ask pilots to maintain the same speed as the aircraft ahead of or behind them on the approach. Pilots are expected to maintain the specified airspeed ±10 knots. At other times, ATC may ask pilots to increase or decrease airspeed by 10 knots, or multiples thereof. When the speed adjustment is no longer needed, ATC advises the pilot to "… resume normal speed."

Keep in mind that the maximum speeds specified in 14 CFR Part 91, section 91.117 still apply during speed adjustments. It is the pilot's responsibility to advise ATC if an assigned speed adjustment would cause an exceedence of these limits. For operations in Class C or D airspace at or below 2,500 feet above ground level (AGL), within 4 NM of the primary airport, ATC has the authority to approve a faster speed than those prescribed in 14 CFR Part 91, section 91.117.

Pilots operating at or above 10,000 feet MSL on an assigned speed adjustment that is greater than 250 KIAS are expected

to reduce speed to 250 KIAS to comply with 14 CFR Part 91, section 91.117(a) when cleared below 10,000 feet MSL, within domestic airspace. This speed adjustment is made without notifying ATC. Pilots are expected to comply with the other provisions of 14 CFR Part 91, section 91.117 without notifying ATC. For example, it is normal for faster aircraft to level off at 10,000 feet MSL while slowing to the 250 KIAS limit that applies below that altitude, and to level off at 2,500 feet above airport elevation to slow to the 200 KIAS limit that applies within the surface limits of Class C or D airspace. Controllers anticipate this action and plan accordingly.

Speed restrictions of 250 knots do not apply to aircraft operating beyond 12 NM from the coastline within the United States Flight Information Region in offshore Class E airspace below 10,000 feet MSL. In airspace underlying a Class B airspace area designated for an airport, pilots are expected to comply with the 200 KIAS limit specified in 14 CFR Part 91, section 91.117(c). (See 14 CFR Part 91, sections 91.117(c) and 91.703.) Approach clearances cancel any previously assigned speed adjustment.

Holding Patterns

If aircraft reach a clearance limit before receiving a further clearance from ATC, a holding pattern is required at the last assigned altitude. Controllers assign holds for a variety of reasons, including deteriorating weather or high traffic volume. Holding might also be required following a missed approach. Since flying outside the area set aside for a holding pattern could lead to an encounter with terrain or other aircraft, aircrews need to understand the size of the protected airspace that a holding pattern provides.

Each holding pattern has a fix, a direction to hold from the fix, and an airway, bearing, course, radial, or route on which the aircraft is to hold. These elements, along with the direction of the turns, define the holding pattern.

Since the speed of the aircraft affects the size of a holding pattern, maximum holding airspeeds have been designated to limit the amount of airspace that must be protected. The three airspeed limits are shown in Figure 2-73 in Chapter 2, En Route Operations, of this book. Some holding patterns have additional airspeed restrictions to keep faster airplanes from flying out of the protected area. These are depicted on charts by using an icon and the limiting airspeed.

DME and IFR-certified GPS equipment offer some additional options for holding. Rather than being based on time, the leg lengths for DME/GPS holding patterns are based on distances in nautical miles. These patterns use the same entry and holding procedures as conventional holding patterns. The controller or the instrument approach procedure chart specifies the length of the outbound leg. The end of the outbound leg is determined by the DME or the along track distance (ATD) readout. The holding fix on conventional procedures, or controller-defined holding based on a conventional navigation aid with DME, is a specified course or radial and distances are from the DME station for both the inbound and outbound ends of the holding pattern. When flying published GPS overlay or standalone procedures with distance specified, the holding fix is a waypoint in the database and the end of the outbound leg is determined by the ATD. Instead of using the end of the outbound leg, some FMS are programmed

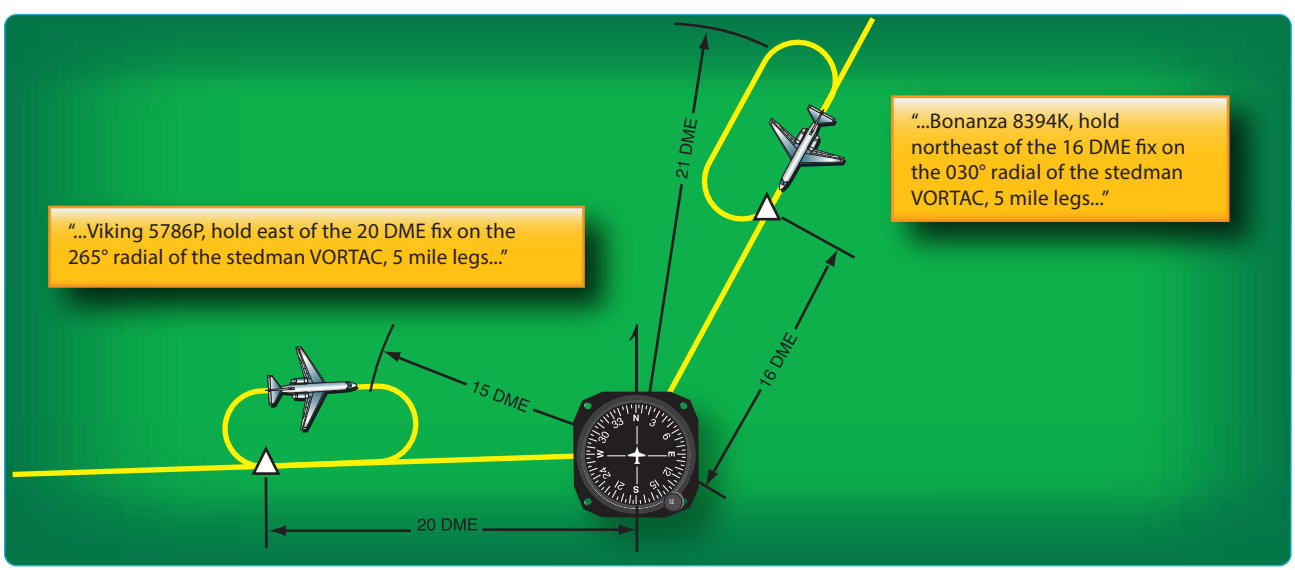


Figure 3-18. Instead of flying for a specific time after passing the holding fix, these holding patterns use distances to mark where the turns are made. The distances come from DME or IFR-certified GPS equipment.

to cue the inbound turn so that the inbound leg length matches the charted outbound leg length.

Normally, the difference is negligible, but in high winds, this can enlarge the size of the holding pattern. Aircrews need to understand their aircraft's FMS holding program to ensure that the holding entry procedures and leg lengths match the holding pattern. Some situations may require pilot intervention in order to stay within protected airspace. [Figure 3-18]

Approach Clearance

The approach clearance provides guidance to a position from where the pilot can execute the approach. It is also a clearance to fly that approach. If only one approach procedure exists, or if ATC authorizes the aircrew to execute the approach procedure of their choice, the clearance may be worded as simply as "… cleared for approach." If ATC wants to restrict the pilot to a specific approach, the controller names the approach in the clearance. For example, "…cleared ILS Runway 35 Right approach."

When the landing is to be made on a runway that is not aligned with the approach being flown, the controller may issue a circling approach clearance, such as "…cleared for VOR Runway 17 approach, circle to land Runway 23." Approaches whose final approach segment is more than 30 degrees different from the landing runway alignment are always designated as circling approaches. Unless a specific landing runway is specified in the approach clearance, the pilot may land on any runway. Pilots landing at non-towered airports are reminded of the importance of making radio calls as set forth in the AIM.

When cleared for an approach prior to reaching a holding fix, ATC expects the pilot to continue to the holding fix, along the feeder route associated with the fix, and then to the IAF. If a feeder route to an IAF begins at a fix located

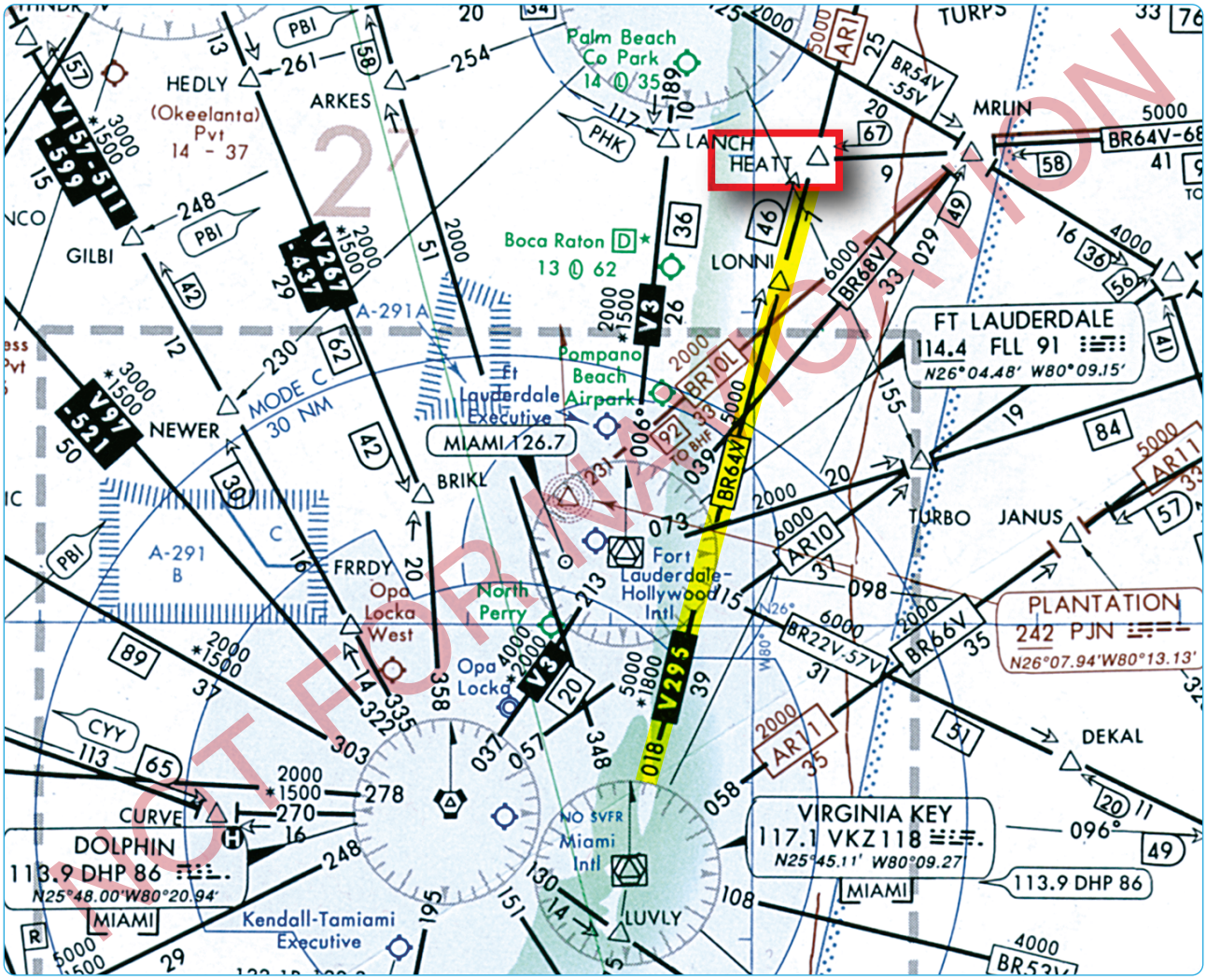


Figure 3-19. Cleared present position direct from V295.

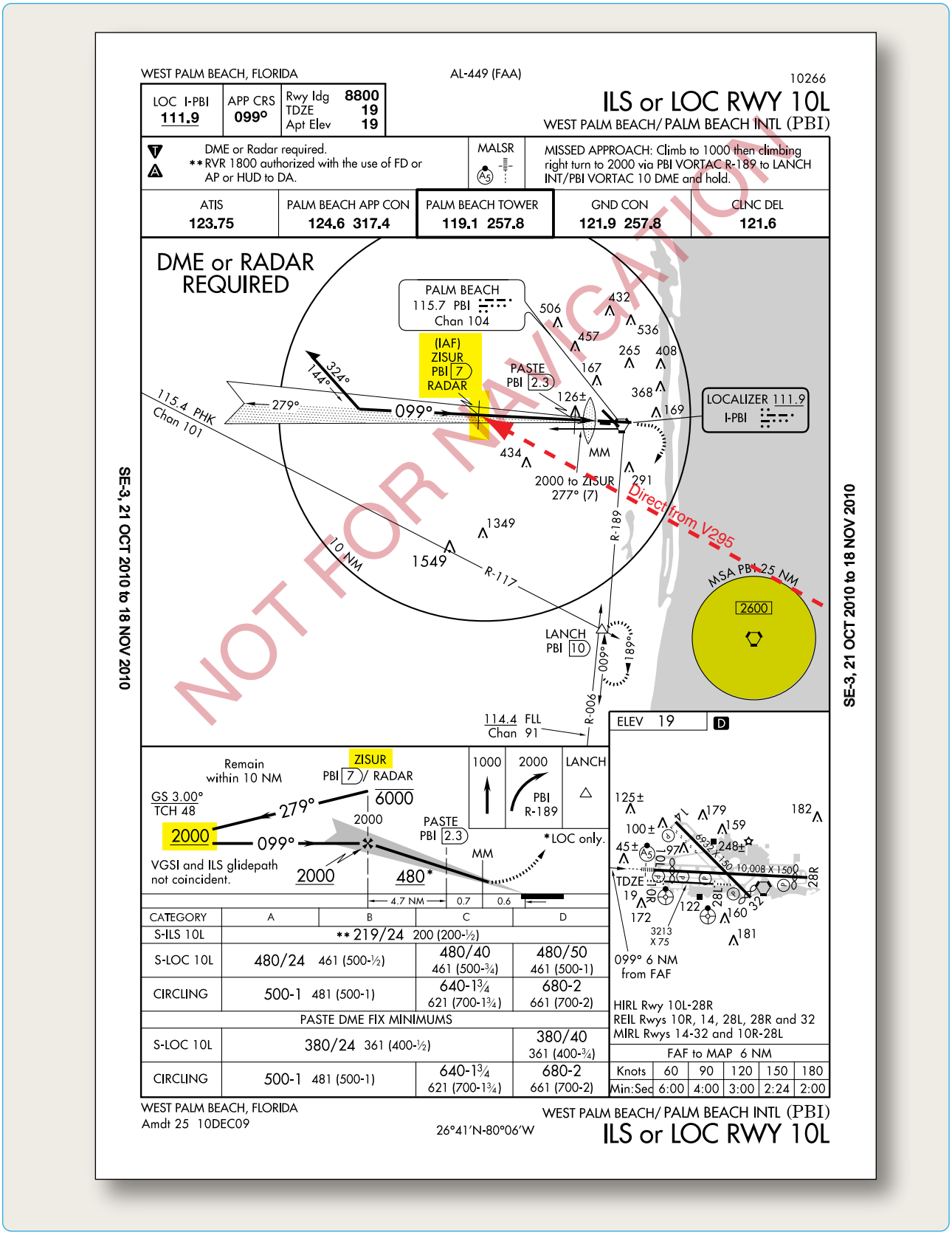


Figure 3-20. Cleared for the Palm Beach ILS approach.

along the route of flight prior to reaching the holding fix, and clearance for an approach is issued, the pilot should commence the approach via the published feeder route. The pilot is expected to commence the approach in a similar manner at the IAF, if the IAF is located along the route to the holding fix.

ATC also may clear an aircraft directly to the IAF by using language such as "direct" or "proceed direct." Controllers normally identify an approach by its published name, even if some component of the approach aid (such as the glideslope of an ILS) is inoperative or unreliable. The controller uses the name of the approach as published but advises the aircraft when issuing the approach clearance that the component is unusable.

Present Position Direct

In addition to using high and low altitude en route charts as resources for arrivals, area charts can be helpful as a planning aid for SA. Many pilots find the area chart helpful in locating a depicted fix after ATC clears them to proceed to a fix and hold, especially at unfamiliar airports.

Looking at Figures 3-19 and 3-20 assume the pilot is on V295 northbound en route to Palm Beach International Airport. The pilot is en route on the airway when the controller clears him present position direct to the ZISUR (IAF) and for the ILS approach. There is no transition authorized or charted between his present position and the approach facility. There is no minimum altitude published for the route the pilot is about to travel.

In Figure 3-20, the pilot is just north of HEATT Intersection at 5,000 feet when the approach controller states, "Citation 9724J, 2 miles from HEATT, cleared present position direct ZISUR, cleared for the Palm Beach ILS Runway 10L Approach, contact Palm Beach Tower on 119.1 established inbound." With no minimum altitude published from that point to the ZISUR intersection, the pilot should maintain the last assigned altitude until he reaches the IAF. In Figure 3-19, after passing ZISUR intersection outbound, commence the descent to 2,000 feet for the course reversal.

The ILS procedure relies heavily on the controller's recognition of the restriction upon the pilot to maintain the last assigned altitude until "established" on a published segment of the approach. Prior to issuing a clearance for the approach, the controller usually assigns the pilot an altitude to maintain until established on the final approach course , compatible with glideslope intercept.

Radar Vectors to Final Approach Course

Arriving aircraft usually are vectored to intercept the final approach course, except with vectors for a visual approach, at least 2 NM outside the approach gate unless one of the following exists:

1. When the reported ceiling is at least 500 feet above the minimum vectoring altitude or minimum IFR altitude and the visibility is at least 3 NM (report may be a pilot report if no weather is reported for the airport), aircraft may be vectored to intercept the final approach course closer than 2 NM outside the approach gate but no closer than the approach gate.

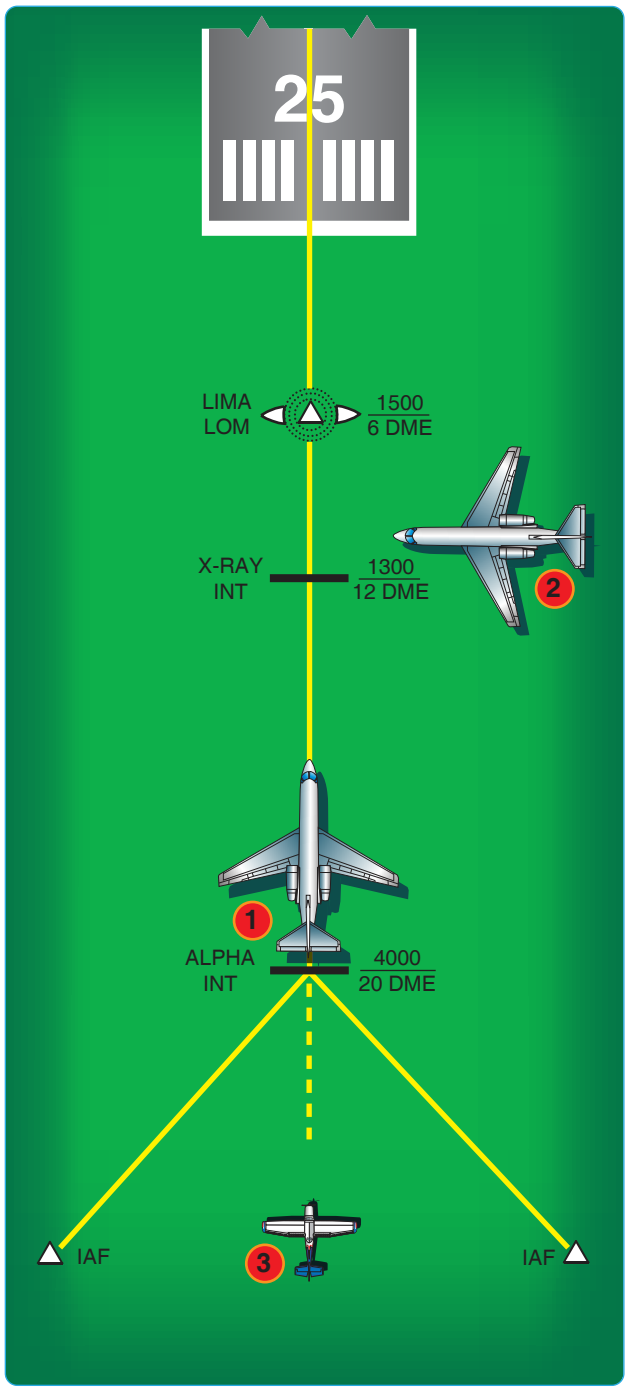


Figure 3-21. Arrival instructions when established.

2. If specifically requested by a pilot, ATC may vector aircraft to intercept the final approach course inside the approach gate but no closer than the final approach fix (FAF).

For a precision approach, aircraft are vectored at an altitude that is not above the glideslope/glidepath or below the minimum glideslope/glidepath intercept altitude specified on the approach procedure chart. For a non-precision approach, aircraft are vectored at an altitude that allows descent in accordance with the published procedure.

When a vector takes the aircraft across the final approach course, pilots are informed by ATC and the reason for the action is stated. In the event that ATC is not able to inform the aircraft, the pilot is not expected to turn inbound on the final approach course unless an approach clearance has been issued. An example of ATC phraseology in this case is, "… expect vectors across final for spacing."

The following ATC arrival instructions are issued to an IFR aircraft before it reaches the approach gate:

1. Position relative to a fix on the final approach course. If none is portrayed on the controller's radar display or if none is prescribed in the instrument approach procedure, ATC issues position information relative to the airport or relative to the NAVAID that provides final approach guidance.
2. Vector to intercept the final approach course if required.
3. Approach clearance except when conducting a radar approach. ATC issues the approach clearance only after the aircraft is established on a segment of a published route or instrument approach procedure, or in the following examples as depicted in Figure 3-21.

Aircraft 1 was vectored to the final approach course but clearance was withheld. It is now at 4,000 feet and established on a segment of the instrument approach procedure. "Seven miles from X-RAY. Cleared ILS runway three six approach."

Aircraft 2 is being vectored to a published segment of the final approach course, 4 NM from LIMA at 2,000 feet. The minimum vectoring altitude for this area is 2,000 feet. "Four miles from LIMA. Turn right heading three four zero. Maintain two thousand until established on the localizer. Cleared ILS runway three six approach."
Aircraft 3: There are many times when it is desirable to position an aircraft onto the final approach course prior to a published, charted segment of an instrument approach procedure (IAP).

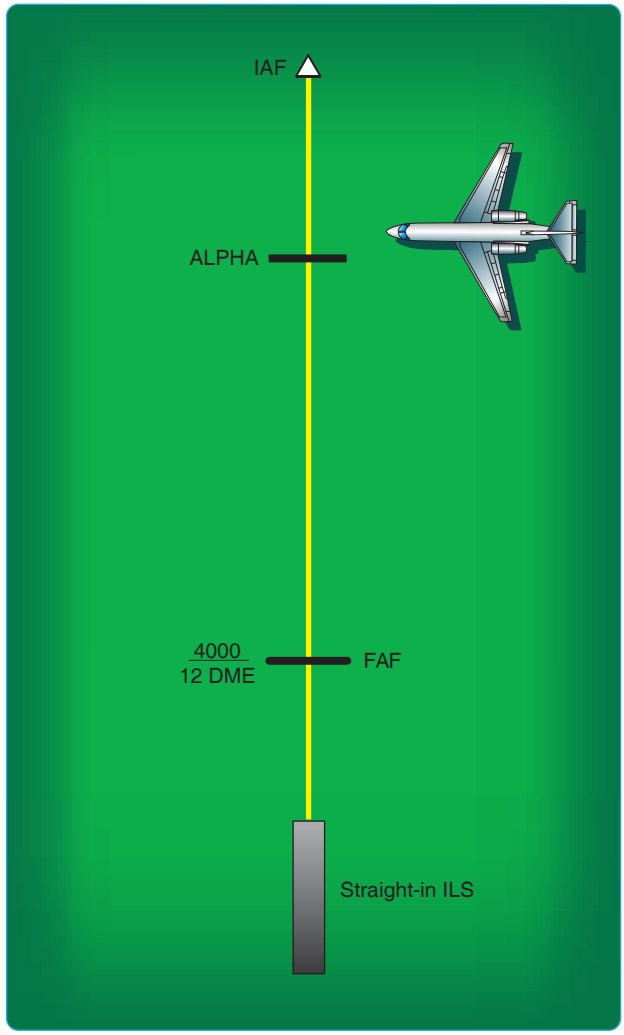


Figure 3-22. Arrival instructions when not established.

Sometimes IAPs have no initial segment and require vectors. "RADAR REQUIRED" is charted in the plan view. Sometimes a route intersects an extended final approach course making a long intercept desirable.

When ATC issues a vector or clearance to the final approach course beyond the published segment, controllers assign an altitude to maintain until the aircraft is established on a segment of a published route or IAP. This ensures that both the pilot and controller know precisely what altitude is to be flown and precisely where descent to appropriate minimum altitudes or step-down altitudes can begin.

Most aircraft are vectored onto a localizer or final approach course between an intermediate fix and the approach gate. These aircraft normally are told to maintain an altitude until established on a segment of the approach.

When an aircraft is assigned a route that is not a published segment of an approach, the controller must issue an

altitude to maintain until the aircraft is established on a published segment of the approach. [Figure 3-21] Assume the aircraft is established on the final approach course beyond the approach segments, 8 NM from Alpha at 6,000 feet. The minimum vectoring altitude for this area is 4,000 feet. "Eight miles from Alpha. Cross Alpha at or above four thousand. Cleared ILS runway three six approach."

If an aircraft is not established on a segment of a published approach and is not conducting a radar approach, ATC assigns an altitude to maintain until the aircraft is established on a segment of a published route or instrument approach procedure. [Figure 3-22]

The aircraft is being vectored to a published segment of the ILS final approach course, 3 NM from Alpha at 4,000 feet. The minimum vectoring altitude for this area is 4,000 feet. "Three miles from Alpha. Turn left heading two one zero. Maintain four thousand until established on the localizer. Cleared ILS runway one eight approach."

The ATC assigned altitude ensures IFR obstruction clearance from the point at which the approach clearance is issued until established on a segment of a published route or instrument approach procedure.
ATC tries to make frequency changes prior to passing the FAF, although when radar is used to establish the FAF, ATC informs the pilot to contact the tower on the local control frequency after being advised that the aircraft is over the fix. For example, "Three miles from final approach fix. Turn left heading zero one zero. Maintain two thousand until established on the localizer. Cleared ILS runway three six approach. I will advise when over the fix."

"Over final approach fix. Contact tower one-one eight point one."

Special Airport Qualification

It is important to note an example of additional resources that are helpful for arrivals, especially into unfamiliar airports requiring special pilot or navigation qualifications. The operating rules governing domestic and flag air carriers require pilots in command to be qualified over the routes and into airports where scheduled operations are conducted, including areas, routes, and airports in which special pilot qualifications or special navigation qualifications are needed. For Part 119 certificate holders who conduct operations under 14 CFR Part 121, section 121.443, there are provisions in OpSpecs under which operators can comply with this regulation. Figure 3-27 provides some examples of special airports in the United States along with associated comments.

Special Airports	Comments
Kodiak, AK	Airport is surrounded by mountainous terrain. Any go-around beyond ILS or GCA MAP will not provide obstruction clearance.
Petersburg, AK	Mountainous terrain in immediate vicinity of airport, all quadrants.
Cape Newenham AFS, AK	Runway located on mountain slope with high gradient factor; nonstandard instrument approach.
Washington, DC (National)	Special arrival/departure procedures.
Shenandoah Valley, VA (Stanton-Waynesboro-Harrisonburg)	Mountainous terrain.
Aspen, CO	High terrain; special procedures.
Gunnison, CO	VOR only; uncontrolled; numerous obstructions in airport area; complete departure procedures.
Missoula, MT	Mountainous terrain; special procedures.
Jackson Hole, WY	Mountainous terrain; all quadrants; complex departure procedures.
Hailey, ID (Friedman Memorial)	Mountainous terrain; special arrival/departure procedures.
Hayden, Yampa Valley, CO	Mountainous terrain; no control tower; special engine-out procedures for certain large airplanes.
Lihue, Kauai, HI	High terrain; mountainous to 2,300 feet within 3 miles of the localizer.
Ontario, CA	Mountainous terrain and extremely limited visibility in haze conditions.

Figure 3-27. Special airports and comments.