CHAPTER SEVEN
GLOBAL POSITIONING SYSTEM

700. INTRODUCTION

Prior to conducting any Global Positioning System (GPS) training it is essential the student be thoroughly familiar with the components and operation of the KLN-900 or GTN-650 system, based on their training pipeline. If flying with the KLN-900 (TSO-C129 certified), it is required to have an alternate source of navigation equipment operational in the event of a GPS failure. If flying with the GTN-650 (TSO-C146c certified), an alternate source is not required by the FAA (AIM 1-1-17.b.3). See paragraph 703 for CNAF M-3710.7 restrictions.

Information in this chapter is provided to give the reader a sound understanding of the basics of GPS operations. Essential sections of the AIM and relevant GPS-related websites are referenced here, but it is incumbent on the pilot to be sufficiently familiar with these sources to operate safely and effectively in all phases of flight where GPS will be utilized.

701. LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective

– Upon completion of this chapter, the student will recall elements of the GPS and state techniques and procedures as they apply to the TH-57C. To demonstrate mastery of the subject material, the student should be able to answer a minimum of 80% of the review questions successfully.

Enabling Objectives

1. Describe the GPS.

2. Describe the WAAS.

3. Describe RAIM and state its importance.

4. Describe ADS-B.

5. Describe the “Basic T" Terminal Arrival Area (TAA) configuration and how it is used for GPS approaches.

6. Understand the variations to the “Basic T” configuration.

7. Identify the GPS equipment installed in the TH-57C.

8. Identify the functions of the KLN-900.

9. Identify the functions of the GTN-650.

10. State the procedures for inputting a flight plan.

11. State the procedures for inputting and flying a GPS approach.

12. Describe the sensitivity of the CDI for each step of the approach.

13. Describe the CDI sensitivity and airspeed required for a DP departure.

14. State the procedures for executing a GPS missed approach.

702. GLOBAL POSITIONING SYSTEM (GPS) OVERVIEW

GPS is a United States satellite-based radio navigational, positioning, and time transfer system operated by the Department of Defense (DOD). The 24-satellite constellation is designed to ensure at least five satellites are always visible to a user worldwide in order to provide highly accurate position and velocity information. The system is unaffected by weather and provides a worldwide common grid reference system based on the earth-fixed coordinate system. For its earth model, GPS uses the World Geodetic System of 1984 (WGS-84) datum.

GPS receiver accuracy continues to improve with technological advances. GPS satellites broadcast their signals in space with a certain accuracy, but what you receive depends on additional factors, including satellite geometry, signal blockage, atmospheric conditions, and receiver design features. As of 2017, the government has committed to broadcasting the GPS signal in space with a global average user range error (URE) of 25.6 feet, with 95% probability. Actual performance exceeds the specification, averaging an accuracy of 6.2 feet, 95% of the time.

GPS operation is based on the concept of ranging and triangulation from a group of satellites in space that act as precise reference points. A GPS receiver measures distance from a satellite using the travel time of a low-power radio signal via line of sight. Each satellite transmits a specific code, called a course/acquisition (CA) code, which contains information on the satellite’s position, the GPS system time, and the health and accuracy of the transmitted data. Knowing the speed at which the signal traveled (approximately 186,000 miles per second) and the exact broadcast time, the distance traveled by the signal can be computed from the arrival time.

The GPS receiver matches each satellite’s CA code with an identical copy of the code contained in the receiver’s database. By shifting its copy of the satellite’s code in a matching process, and by comparing this shift with its internal clock, the receiver can calculate how long it took the signal to travel from the satellite to the receiver. The distance derived from this method of computing distance is called a ***pseudo-range*** because it is not a direct measurement of distance, but a measurement based on time. Pseudo-range is subject to several error sources such as ionospheric and tropospheric delays (satellite signals slow as they pass through the atmosphere) and signal multipath (signal may reflect off objects such as tall buildings, which will increase the travel time).

Using the calculated pseudo-range and position information supplied by the satellite, the GPS receiver mathematically determines its position by triangulation. The GPS receiver needs at least four satellites to yield a three-dimensional position (latitude, longitude, and altitude) and time solution. The GPS receiver computes navigational values such as distance and bearing to a waypoint, groundspeed, etc., by using the aircraft's known latitude/longitude and referencing these to a database built into the receiver.

The receiver uses data from a minimum of four satellites above the mask angle (the lowest angle above the horizon at which it can use a satellite).

The GPS receiver verifies the integrity (usability) of the signals received from the GPS constellation through ***receiver autonomous integrity monitoring*** (RAIM) to determine if a satellite is providing corrupted information. RAIM needs a minimum of 5 satellites in view, or 4 satellites and a barometric altimeter (baro-aiding) to detect an integrity anomaly. Some GPS receivers, such as the GTN-650, have a capability called fault detection and exclusion (FDE) that excludes a failed satellite from the position solution. GPS receivers with FDE require 6 satellites in view (or 5 satellites with baro-aiding) to isolate the corrupt satellite signal and remove it from the navigation solution. Baro-aiding is a method of augmenting the GPS integrity solution by using a non-satellite input source. GPS derived altitude should not be relied upon to determine aircraft altitude since the vertical error can be quite large. To ensure baro-aiding is available, the current altimeter setting must be entered into the receiver as described in the operating manual.

Generally, there are two types of RAIM fault messages, although it can vary somewhat between receivers. One type indicates there are not enough satellites available to provide RAIM integrity monitoring and another type indicates the RAIM integrity monitor has detected a potential error exceeding the limit for the current phase of flight. ***Without RAIM capability, the pilot has no assurance of the accuracy of the GPS position*.**

The Department of Defense declared initial operational capability (IOC) of the U.S. GPS on December 8, 1993. The Federal Aviation Administration (FAA) has granted approval for U.S. civil operators to use properly certified GPS equipment as a primary means of navigation in oceanic airspace and certain remote areas. Properly certified GPS equipment may be used as a supplemental means of IFR navigation for domestic enroute, terminal operations, and certain instrument approach procedures (IAP).

703. GPS NAVIGATION PROCEDURES

Authorization to conduct any GPS operation under IFR requires that:

1. Aircraft using GPS navigation equipment under IFR must be equipped with an approved and operational alternate means of navigation appropriate to the flight. Active monitoring of alternative navigation equipment is not required if the GPS receiver uses RAIM for integrity monitoring. Active monitoring of an alternate means of navigation is required when the RAIM capability of the GPS equipment is lost. Although an alternate source of navigation is not required by the FAA for WAAS (TSO-C146) equipped aircraft, CNAF M-3710.7 currently states "During pre-flight planning, when an alternate is required, equipment used to navigate the non-GPS route and non-GPS approach procedure for the

alternate airport shall be installed and operational (5.3.3 RNAV/GPS Navigation 7)."

2. Procedures must be established for use in the event that the loss of RAIM capability is predicted to occur. In situations where this is encountered, the flight must rely on other approved equipment, delay departure, or cancel the flight.

3. The GPS operation must be conducted in accordance with the FAA-approved aircraft flight manual (AFM) or NATOPS flight manual. Pilots must be thoroughly familiar with the particular GPS equipment installed in the aircraft, the receiver operation manual, the AFM or flight manual supplement. Unlike ILS and VOR, the basic operation, cockpit display presentation to the pilot and capabilities of GPS equipment can vary greatly. Due to these differences, operation of different brands, or even models of the same brand, of GPS receiver under IFR should not be attempted without thorough study of the operation of that particular receiver and installation. Most receivers have a built-in simulator mode which will allow the pilot to become familiar with operation prior to attempting operation in the aircraft. Using the equipment in flight under VFR conditions prior to attempting IFR operation will allow further familiarization.

4. Prior to any GPS IFR operation, the pilot must review appropriate NOTAMs and aeronautical information. (See section 705)

5. Aircraft navigating by GPS certified for IFR enroute, terminal, and approach operations can use the G (GPS) code as the TD code under the "No RVSM/GNSS WITH TRANSPONDER AND MODE C" series of GP Chapter 4 on the DD 175 Flight Plan when operating in accordance with GP Chapter 4 and the Aeronautical Information Manual (AIM).

6. If radar contact is lost, RNAV aircraft may be cleared back to the airway because of the inability to maintain radar separation. If an RNAV aircraft is vectored off the planned random RNAV route, it shall be cleared direct to the next flight plan waypoint or issued a revised clearance. If, at any point, GPS avionics become inoperative, the pilot should advise ATC and amend the equipment suffix.

Use of GPS for IFR Domestic Enroute and Terminal Area Operations

Published RNAV routes, (T-Routes (low altitudes) and Q-Routes (high altitude)), are depicted in blue on low and high altitude charts and can be flight planned for use by aircraft with RNAV capability, subject to any limitations or requirements noted on enroute charts or by NOTAM.

The GPS Approach Overlay Program is an authorization for pilots to use GPS avionics under IFR for flying designated existing instrument approach procedures. Overlay procedures are identified by the "name of the procedure" and "or GPS" (e.g., VOR/DME or GPS RWY 15) in the title. Only those approaches included in the receiver database are authorized. Overlay approaches are predicated upon the design criteria of the ground-based NAVAID used as the basis of the approach. As such, they do not adhere to the design criteria described later for the stand-alone GPS approaches (Figure 7-2.)

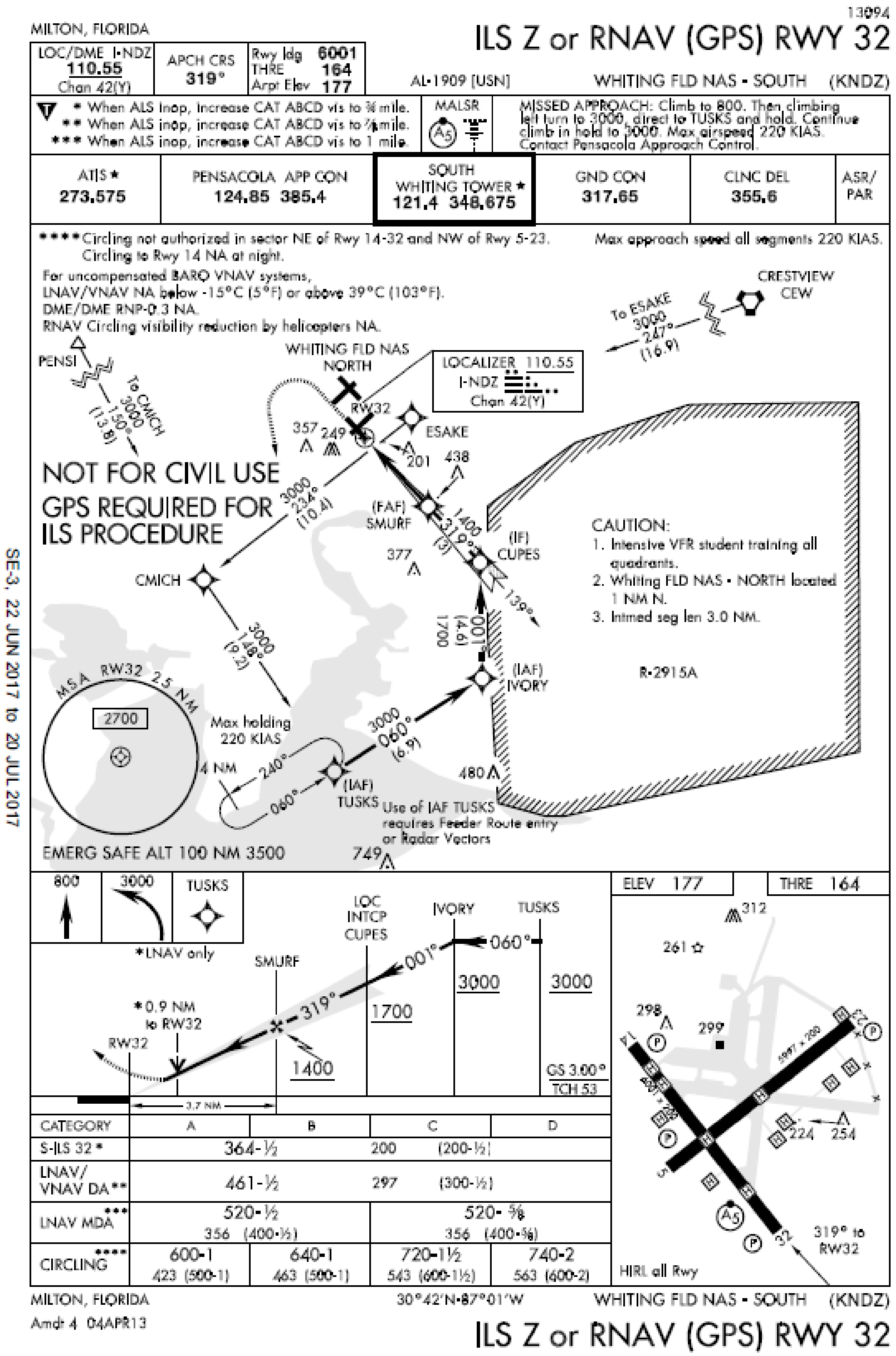
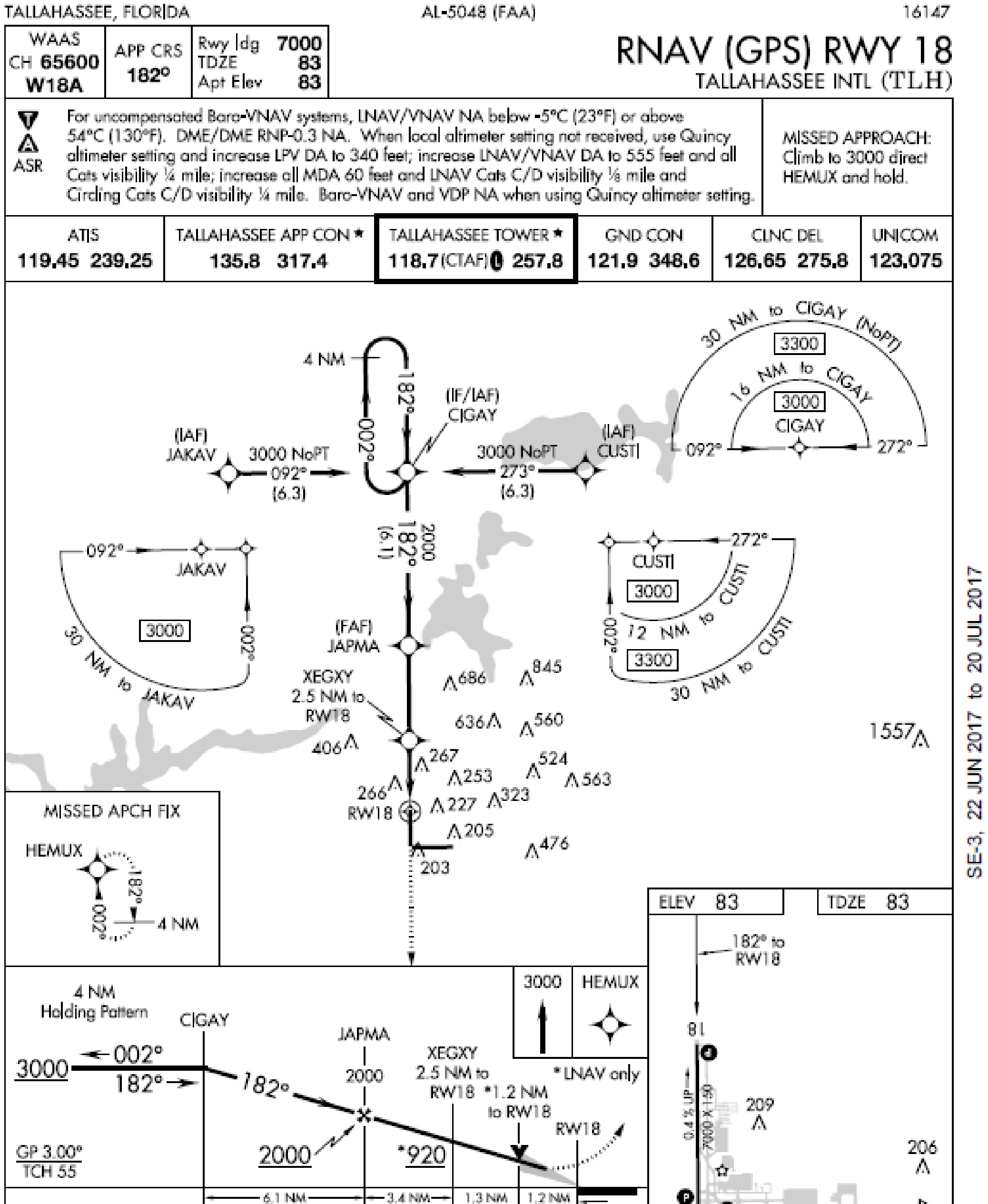


Figure 7-1 ILS Z or RNAV (GPS) RWY 32 as Whiting Field NAS-South



CATEGORY	A	B	C	D
LPV DA	283-¾ 200 (200-¾)			
LNAV/VNAV DA	498-1⅜ 415 (500-1⅜)			
LNAV MDA	520-1 437 (500-1)		520-1¼ 437 (500-1¼)	
CIRCLING	580-1 497 (500-1)		640-1½ 557 (600-1½)	780-2¼ 697 (700-2¼)

Figure 7-2 RNAV (GPS) RWY 17

GPS may be used in lieu of NAVAIDs on conventional procedures and routes in the following ways (ref: AIM 1-2-3):

1. Determine aircraft position relative to, or distance from a VOR, TACAN, NDB, compass locator, DME fix, or a named fix defined by a VOR radial, TACAN course, NDB bearing, or compass locator bearing intersecting a VOR or localizer course.

2. Navigate to or from a VOR, TACAN, NDB, or compass locator.

3. Hold over a VOR, TACAN, NDB, compass locator, or DME Fix.

4. Fly an arc based upon DME.

NOTE

GPS may not be utilized for lateral guidance for the final approach segment unless one of the following conditions are satisfied:

1. The IAP includes "or GPS" in the title and the pilot is using GPS.

2. For IAPs based on VOR, TACAN, or NDB, the underlying NAVAID must be operational and monitored for the final segment course alignment.

NOTE

GPS may be substituted for NAVAIDs as described above even when a facility is identified as required on a procedure (example: "Note ADF required").

NOTE

GPS may not be utilized as substitution for lateral navigation on localizer-based courses (including back-course guidance) without reference to raw localizer data.

NOTE

Unless otherwise specified, a suitable RNAV system cannot be used for navigation procedures that are identified as "not authorized" ("NA") without exception by a NOTAM.

704. WIDE AREA AUGMENTATION SYSTEM (WAAS)

The FAA developed the WAAS to improve the accuracy, integrity, and availability of GPS signals. WAAS corrects for GPS signal errors caused by ionospheric disturbances, timing, and satellite orbit errors, and it provides vital information regarding the health of each GPS satellite. The GTN-650 uses WAAS in addition to GPS signals to provide navigational information. The KLN-900 does not have WAAS functionality.

WAAS consists of multiple precisely surveyed wide-area ground reference stations (WRS) positioned across the United States that monitor GPS satellite data, with one master station on each coast. The WRS network monitors and collects satellite clock and ephemeris correction data that is then relayed to the master station where correction information is computed. A correction message is prepared and uplinked to a geostationary satellite, a satellite with a fixed position over the equator, via a GEO uplink station. The message is then broadcast on the same frequency as GPS to WAAS receivers within the broadcast coverage area, which means any WAAS-enabled GPS receiver can read the signal. The correction signal provided by the WAAS thus improves the real-time monitoring and accuracy of GPS by providing corrections to reduce errors. GPS position accuracy with WAAS is less than 3 meters as compared to GPS-only position accuracy of about 15 meters.

Instrument Approach Capability with the WAAS

A class of procedures with vertical guidance, which do not meet precision approach requirements as described in ICAO Annex 10, have been developed to support satellite navigation use for aviation applications worldwide. These procedures do not meet the stringent standards of precision approaches and are referred to as an Approach with Vertical Guidance (APV), which includes Localizer Performance with Vertical Guidance (LPV) and Lateral Navigation and Vertical Navigation (LNAV/VNAV). Aircraft with properly certified WAAS receivers will be able to fly to LPV minima and LNAV/VNAV minima, using an approved electronic glidepath, which eliminates errors that can be introduced by using barometric altimetry. LPV approaches take advantage of the refined accuracy of WAAS lateral and vertical guidance to provide an approach very similar to a Category I ILS. Like an ILS, an LPV has vertical guidance and is flown to a Decision Altitude (DA). LPV minima have Decision Altitudes (DA) as low as 200 feet height above touchdown with visibility minimums as low as ½ mile. An LNAV/VNAV approach also incorporates approved vertical guidance but at a less accurate sensitivity than LPV. Despite the presence of electronic vertical guidance, these APV approaches are still considered non-precision approaches. Localizer Performance (LP) approaches also take advantage of the improved accuracy of WAAS. LPs are non-precision approaches with WAAS lateral guidance. They are added in locations where terrain or obstructions do not allow publication of vertically guided LPV procedures. Lateral sensitivity increases as an aircraft gets closer to the runway (or PinS type approaches for helicopters). LP is not a fail-down mode for an LPV. LP and LPV are independent. LP minimums will not be published with lines of minima that contain approved vertical guidance (LNAV/VNAV or LPV). LP approaches are flown to an MDA rather than a DA. LP approaches are not common, but do exist throughout the U.S. LPV, LNAV/VNAV, and LP minima are published on the RNAV (GPS) approach charts (see Figure 7-3 and figure 7-4 fore examples). Pilots with WAAS receivers may plan flights to use any instrument approach procedure authorized for use with their WAAS avionics.

Pilots with WAAS receivers may also plan flights to use any instrument approach procedure authorized for use with their WAAS avionics as the planned approach at a required alternate, with the following restrictions. When using WAAS at an alternate airport, flight planning must be based on flying the RNAV (GPS) LNAV or circling minima line, or minima on a GPS approach procedure, or conventional approach procedure with "or GPS" in the title. Upon arrival at an alternate, when the WAAS navigation system indicates that LNAV/VNAV or LPV service is available, then vertical guidance may be used to complete the approach using the displayed level of service (see AIM 1-1-18).

CATEGORY	A	B	C	D
LPV DA	314-¾ 200 (200-¾)			
LNAV/ VNAV DA	364-¾ 250 (300-¾)			
LNAV MDA	440-1 326 (400-1)			
CIRCLING	560-1 439 (500-1)	720-1 599 (600-1)	720-1½ 599 (600-1½)	720-2 599 (600-2)

PENSACOLA INTL (PNS)

30°28′N-87°11′W RNAV (GPS) RWY 26

Figure 7-3 RNAV Minimums example with LPV, LNAV/VNA, and LNAV minima

CATEGORY	A	B	C	D
LP MDA	1640-1 361 (400-1)			
LNAV MDA	1700-1 421 (500-1)		1700-1¼ 421 (500-1¼)	
C CIRCLING	1740-1 444 (500-1)	1760-1 464 (500-1)	1960-1¾ 664 (700-1¾)	2000-2¼ 704 (800-2¼)

OKLAHOMA CITY, OKLAHOMA

Figure 7-4 RNAV Minimums example with LP minima

705. RECEIVER AUTONOMOUS INTEGRITY MONITORING (RAIM)

RAIM outages may occur due to an insufficient number of satellites or due to unsuitable satellite geometry which causes the error in the position solution to become too large. Loss of satellite reception and RAIM warnings may occur due to aircraft dynamics (changes in pitch or bank angle). Antenna location on the aircraft, satellite position relative to the horizon, and aircraft attitude may affect reception of one or more satellites. Since the relative positions of the satellites are constantly changing, prior experience with the airport does not guarantee reception at all times, and RAIM availability should always be checked.

If RAIM is not available, another type of navigation and approach system must be used, another destination selected, or the trip delayed until RAIM is predicted to be available on arrival. On longer flights, pilots should consider rechecking the RAIM prediction for the destination during the flight. This may provide early indications that an unscheduled satellite outage has occurred since takeoff.

If a RAIM failure/status annunciation occurs prior to the final approach waypoint (FAWP), the approach should not be completed since GPS may no longer provide the required accuracy. For GTN-650 crews, reference appropriate Message and take the appropriate actions. The receiver performs a RAIM prediction by 2 NM prior to the FAWP to ensure RAIM is available at the FAWP as a condition for entering the approach mode. If flying with the KLN-900, the pilot should ensure the receiver has sequenced from "Armed" to "Approach" prior to the FAWP (normally occurs 2 NM prior). Failure to sequence may be an indication of the detection of a satellite anomaly, failure to arm the receiver (if required), or other problems, which preclude completing the approach. If flying with the GTN-650, the avionics unit continually monitors RAIM and will provide an indication of a fault by flashing the Message key on the screen.

If the receiver does not sequence into the approach mode or a RAIM failure/status annunciation occurs prior to the FAWP, the pilot should not descend to MDA, but should proceed to the missed approach waypoint (MAWP) via the FAWP, perform a missed approach, and contact ATC as soon as practical. Refer to the receiver operating manual for specific indications and instructions associated with loss of RAIM prior to the FAF.

A GPS integrity warning occurring after the FAWP is a serious situation and pilots must be prepared to take immediate action. Transition to your backup approach (if available) or proceed to the MAP along the final approach course and execute the missed approach via the route and altitudes specified in the published missed approach procedure or comply with ATC instructions (NATOPS IFM).

706. GPS AND WAAS NOTAMS/AERONAUTICAL INFORMATION

GPS satellite or WAAS asset outages are issued as GPS/WAAS NOTAMs both domestically and internationally. However, the effect of an outage on the intended operation cannot be determined unless the pilot has a RAIM availability prediction program which allows excluding a satellite which is predicted to be out of service based on the NOTAM information.

Civilian pilots may obtain GPS RAIM availability information for non-precision approach procedures by specifically requesting GPS aeronautical information from a Flight Service Station during preflight briefings. GPS RAIM aeronautical information can be obtained for a period of 3 hours (ETA hour and 1 hour before to 1 hour after the ETA hour) or a 24-hour time frame at a particular airport. FAA briefers will provide RAIM information for a period of 1 hour before to 1 hour after the ETA, unless a specific time frame is requested by the pilot. If flying a published GPS departure, a RAIM prediction should also be requested for the departure airport.

The military provides airfield specific GPS RAIM NOTAMs for non-precision approach procedures at military airfields. The RAIM outages are issued as M-series NOTAMs and may be obtained for up to 24 hours from the time of request.

GPS and WAAS NOTAMS may be viewed on the Defense Internet NOTAM Service (DINS) website: https://www.notams.jcs.mil/dinsQueryWeb/. GPS/WAAS NOTAMs can be found here for applicable notices along the route of intended flight (Figure 7-5). The DINS website also provides a tool which can be used to graphically view RAIM outage predictions for specific equipment configurations (Figure 7-5).

Figure 7-5 DINS Website

In addition to this GPS/WAAS NOTAMS and RAIM prediction information, database suppliers supply their own database alerts. These alerts are available for aircrew to check as part of preflight planning. The Jeppesen alerts can be found on the DINS website (Figure 7-5) and the Garmin alerts can be found at www.flygarmin.com (Figure 7-6).

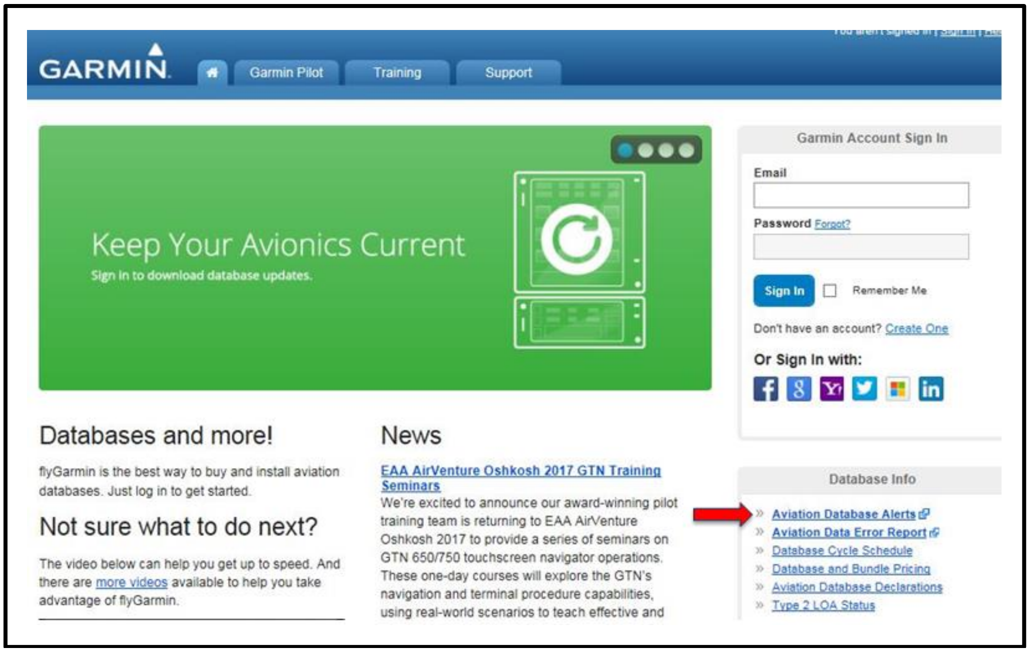


Figure 7-6 Garmin Website

In addition to the DINS website, pilots may also call the Flight Service Station for WAAS status and levels of service available. In flight, Air Traffic Control will not advise pilots of “WAAS MAY NOT BE AVBL” NOTAMs which indicate a loss or malfunction of the WAAS system.

“WAAS MAY NOT BE AVBL” NOTAMs are predictive in nature and published for flight planning purposes. Upon commencing an approach at locations NOTAMed WAAS MAY NOT BE AVBL, if the WAAS avionics indicate LNAV/VNAV or LPV service is available, then vertical guidance may be used to complete the approach using the displayed level of service. Should an outage occur during the approach, reversion to LNAV minima or an alternate instrument approach procedure may be required. When GPS testing NOTAMS are published and testing is actually occurring, Air Traffic Control will advise pilots requesting or cleared for a GPS or RNAV (GPS) approach that GPS may not be available and request intentions. If pilots have reported GPS anomalies, Air Traffic Control will request the pilot’s intentions and/or clear the pilot for an alternate approach, if available and operational.

When the approach chart is annotated with the W symbol in the notes section, site–specific WAAS MAY NOT BE AVBL NOTAMs or Air Traffic advisories ***are not provided*** for outages in WAAS LNAV/VNAV and LPV vertical service. Vertical outages may occur daily at these locations due to being close to the edge of WAAS system coverage. Use LNAV or circling minima for flight planning at these locations, whether as a destination or alternate. For flight operations at these locations, when the WAAS avionics indicate that LNAV/VNAV or LPV service is available, then the vertical guidance may be used to complete the approach using the displayed level of service. Should an outage occur during the procedure, reversion to LNAV minima may be required. (AIM 1-1-18)

707. GPS STANDARD INSTRUMENT APPROACH PROCEDURE (SAIP) DESIGN CONCEPTS & TERMINAL ARRIVAL AREAS (TAA)

The objective of the TAA design is to provide a transition from the enroute structure to the terminal environment with little required pilot/ATC interface for arriving aircraft equipped with Area Navigation (RNAV) equipment. The TAA contains within it a "T" structure that normally provides an arrival without a procedure turn (NoPT) for aircraft using the approach.

The basic "T" contained in the TAA is based on the civilian box pattern. It normally aligns the procedure with runway centerline. The “T” design incorporates two IAFs plus a dual purpose IF/IAF that functions as both an intermediate fix and an initial approach fix. The T configuration continues from the IF/IAF to the final approach fix (FAF) and then to the missed approach point (MAP), where the MAP is located at the runway threshold. A Hold-in-Lieu-of-PT is often anchored at the IF/IAF and depicted on approach procedure publications. The two base leg IAFs are typically aligned in a straight-line perpendicular to the intermediate course connecting at the IF/IAF. The missed approach segment is ideally aligned with the final approach course and terminates in a direct entry into a holding pattern. Conditions may require a different routing (ex: turn left and proceed direct to the IAF for the “left base” segment). (See Figures 7-7 and 7-8.)

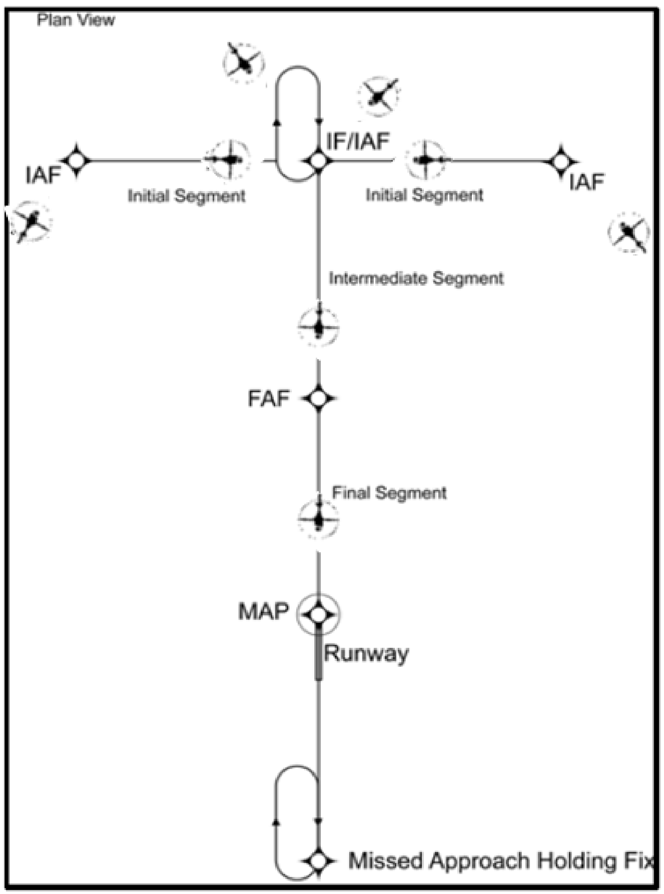


Figure 7-7 Basic "T" Design #1

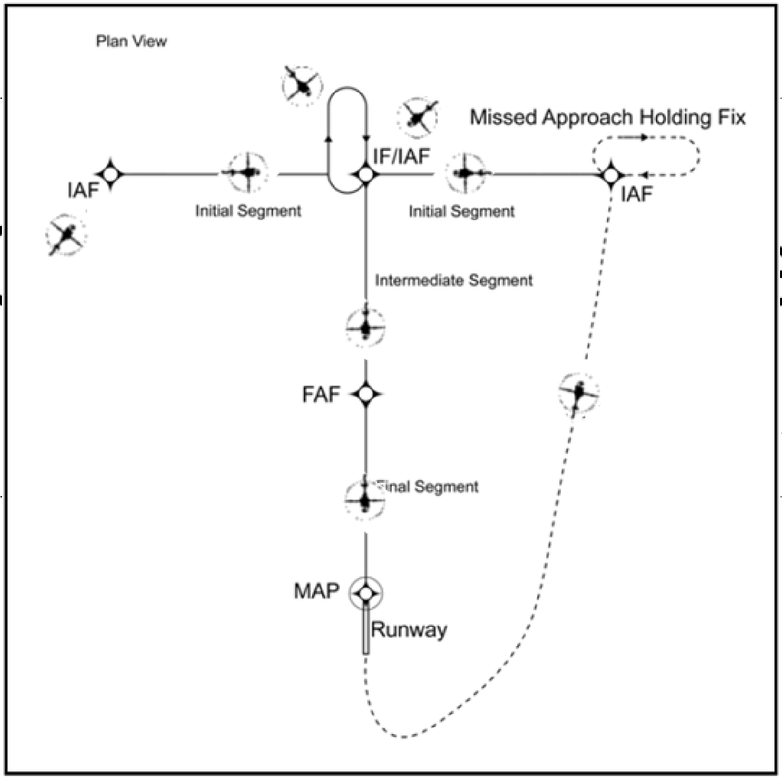


Figure 7-8 Basic "T" Design #2

In order to accommodate descent from a high enroute altitude to the initial segment altitude, the basic "T" configuration may be modified. When this occurs, a PT holding pattern provides aircraft an extended distance for the necessary descent gradient. The holding pattern constructed for this purpose is always established on the IF (IAF) waypoint (Figure 7-7/8).

The standard TAA consists of 3 areas established by the extension of the legs of the basic "T." These areas are the straight-in, left base, and right base. The 30-nautical-mile arc boundary of each area is equivalent to a feeder fix. When crossing the boundary of each of these areas or when released by ATC, within the area, the pilot is expected to proceed direct to the appropriate waypoint IAF for the approach area being flown via NoPT routing or a course reversal. The published procedure will be annotated to indicate when the course reversal is not necessary when flying within a particular TAA area (labeled "NoPT"). Otherwise, the pilot is expected to execute the course reversal under the provisions of the 14 CFR Section 91.175. The pilot may elect to use the course reversal pattern when it is not required by the procedures, but must inform air traffic control and receive clearance to do so (AIM 5-4-5d4). Area boundaries are magnetic course lines to the IF/IAF. The charted altitudes within the TAA are maintained by aircraft that traverse these areas (see Figure 7-9) unless cleared otherwise by ATC.

ATC should not clear an aircraft to the left or right base leg IAF with an intercept angle greater than 90 degrees. Do not execute a HILPT course reversal in a sector labeled "NoPT." ATC may clear aircraft direct to the fix labeled IF/IAF if it is a straight-in approach and the intercept angle does not exceed 90 degrees.

Altitudes published within the TAA replace Minimum Safe/Sector Altitudes (MSA); however, unlike MSA altitudes, the TAA altitudes are operationally usable altitudes, providing at least 1,000 feet of obstacle clearance, more in mountainous areas. ***An ATC clearance direct to an IAF without approach clearance does not authorize a pilot to descend to a lower TAA altitude. A pilot must request the lower TAA altitude from ATC or wait for approach clearance.***

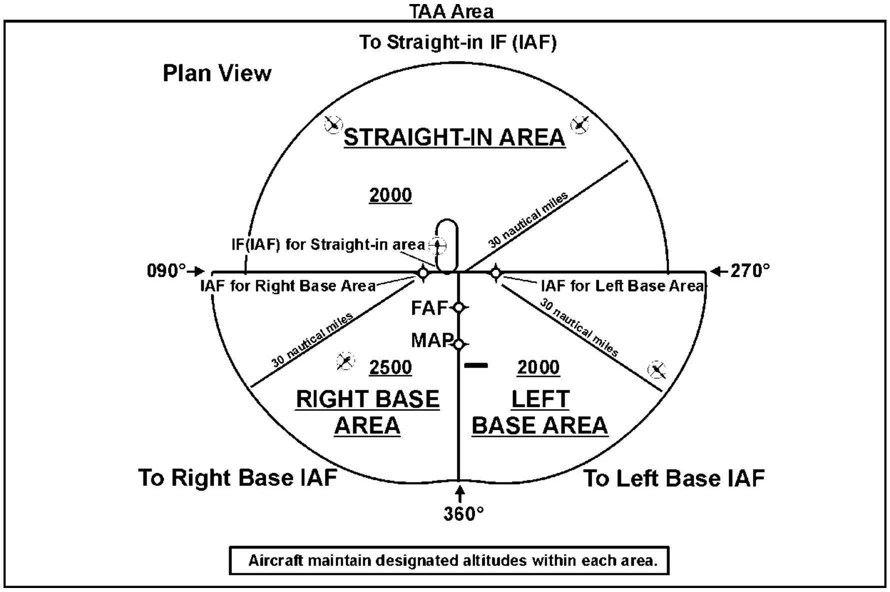


Figure 7-9 TAA Area

Normally, the minimum altitudes specified in the TAA and PT holding pattern are the same. However, there may be locations where terrain or operational situations require minimum altitudes to maintain within a sector of an area. In Figure 7-10, pilots flying into the right or left base areas are expected to maintain a minimum altitude of 6000 feet MSL until within 17 NM of the appropriate IAF and then descend to the lower charted altitudes. Pilots approaching from the northwest are expected to maintain a minimum altitude of 6000 feet MSL until within 22 nautical miles of the IF (IAF) then descend to an altitude not lower than 2000 feet MSL until reaching the IF (IAF).

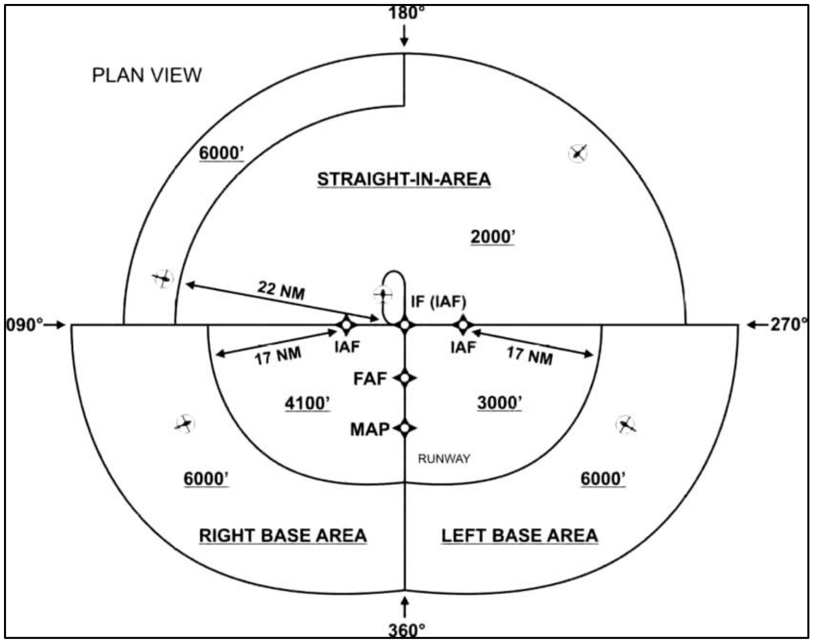


Figure 7-10 Sectored TAA Areas

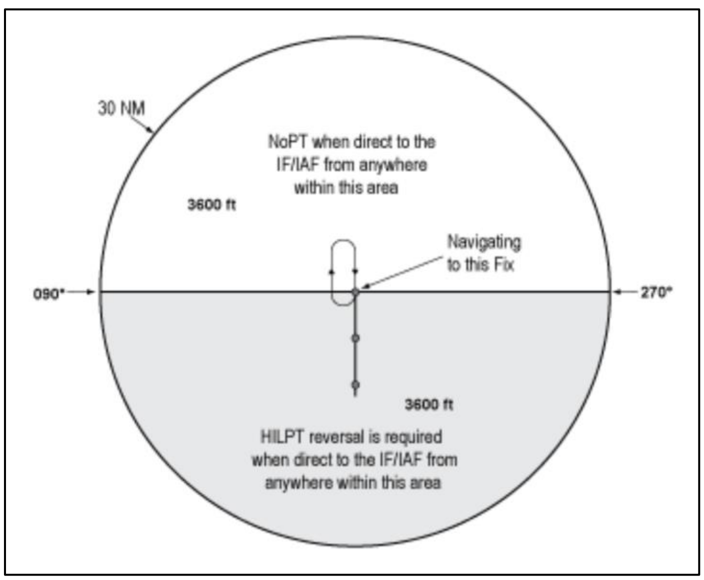


Figure 7-11 TAA with Left and Right Base Areas Eliminated

There may be modifications to the area of the standard TAA because of operational or ATC requirements. For example, the right or left base areas may be modified or eliminated. For example, Figure 7-11 shows a TAA where there are no left or right base legs so any approach from 271 to 089 degrees will be a straight-in while any approach from 270 to 090 will require a course reversal. In these cases, it is common to see a conventional MSA circle vice TAA segments.

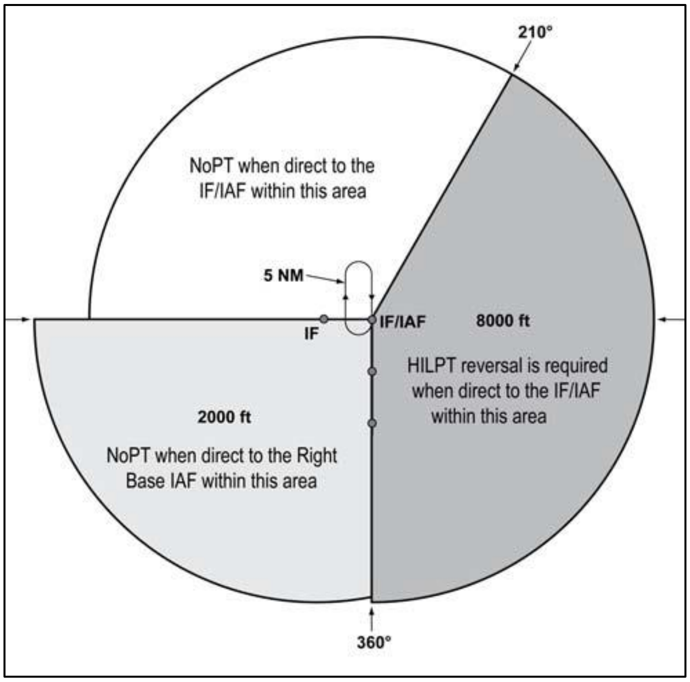


Figure 7-12 TAA with Right Base Eliminated

Figure 7-12 shows a TAA with no right base leg. Any approach from a heading of 360 to 210 degrees will require a HILPT to safely navigate to the final approach course.

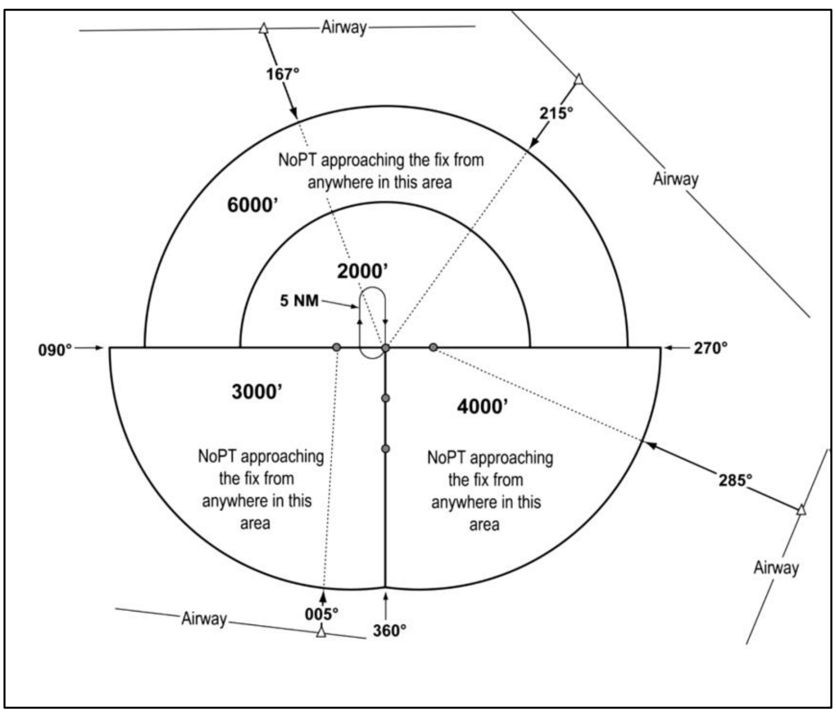


Figure 7-13 TAA with Feeders from an Airway

When an airway does not cross a lateral boundary of the TAA, a feeder route will be established from an airway fix or NAVAID to the TAA. This provides a transition from the enroute structure to the appropriate IAF. The feeder will terminate at the TAA boundary, aligned with the associated IAF. Figure 7-13 shows several examples of feeder routes and their intended transition to the TAA. The airway to the northwest requires a 167 degree heading to intercept the IF/IAF with NoPT.

708. GPS APPROACHES

Determining which area of the TAA the aircraft will enter when flying a "T" with a TAA must be accomplished using the bearing and distance to the IF /IAF. This is most critical when entering the TAA in the vicinity of the extended runway centerline and determining whether you will be entering the right or left base area. Once inside the TAA, all sectors and stepdowns are based on the bearing and distance to the IAF for that area, which the aircraft should be proceeding direct to at that time, unless on vectors (see Figures 7-14).

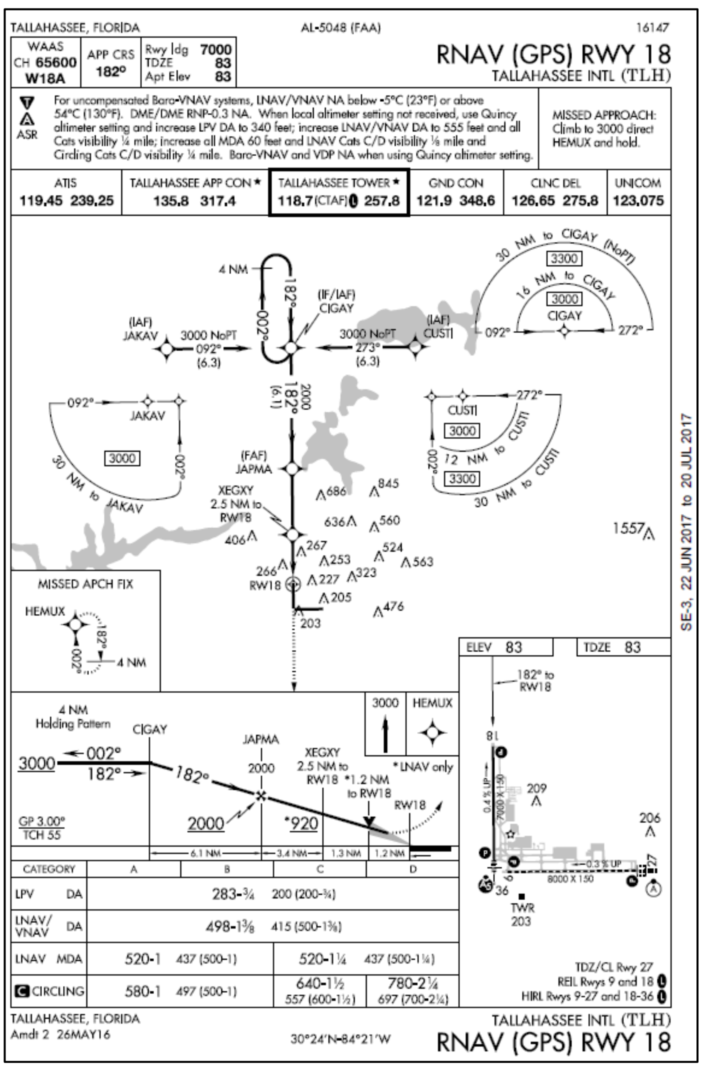


Figure 7-14 RNAV (GPS) RWY 17

Pilots should fly the full approach from an Initial Approach Waypoint (IAWP) or feeder fix unless specifically cleared otherwise. Randomly joining an approach at an intermediate fix does not assure terrain clearance.

When an approach has been loaded in the flight plan, GPS receivers will arm the approach 30 NM straight line distance from the airport/heliport reference point. With the approach armed (some receivers arm automatically), CDI and RAIM sensitivity will change from ±5 NM enroute (KLN 900) or ± 2 NM enroute (GTN 650) to ±1 NM (terminal). Where the IAWP is inside this 30-mile point, a CDI sensitivity change will occur once the approach mode is armed and the aircraft is inside 30 NM. Where the IAWP is beyond 30 NM from the airport/heliport reference point, CDI sensitivity will not change until the aircraft is within 30 miles of the airport/heliport reference point even if the approach is armed earlier. Feeder route obstacle clearance is predicated on the receiver being in terminal (+1 NM) CDI sensitivity and RAIM within 30 NM of the airport/heliport reference point, therefore, the receiver should always be armed (if required) no later than the 30 NM.

When within 2 NM of the FAWP with the approach mode armed, the GPS will switch to an active mode, which results in RAIM changing to approach sensitivity and a change in CDI sensitivity. Beginning 2 NM prior to the FAWP, the full scale CDI sensitivity will smoothly change from +1 NM, to +0.3 NM at the FAWP. As sensitivity changes from +1 NM to +0.3 NM approaching the FAWP, with the CDI not centered, the corresponding increase in CDI displacement may give the impression the aircraft is moving further away from the intended course even though it is on an acceptable intercept heading. Referencing the digital track displacement information (cross track error); if it is available in the approach mode, may help the pilot remain position oriented in this situation. Being established on the final approach course prior to the beginning of the sensitivity change at 2 NM will help prevent problems in interpreting the CDI display during ramp down. Therefore, requesting or accepting vectors which will cause the aircraft to intercept the final approach course within 2 NM of the FAWP is not recommended.

When receiving vectors to final, most receiver operating manuals suggest placing the receiver in the non-sequencing mode on the FAWP and manually setting the course. This provides an extended final approach course in cases where the aircraft is vectored onto the final approach course outside of any existing segment which is aligned with the runway. Assigned altitudes must be maintained until established on a published segment of the approach. Required altitudes at waypoints outside the FAWP or stepdown fixes must be considered.

Overriding an automatically selected sensitivity during an approach will cancel the approach mode annunciation. If the approach mode is not armed by 2 NM prior to the FAWP, the approach mode will not become active at 2 NM prior to the FAWP, and the equipment will flag. In these conditions, the RAIM and CDI sensitivity will not ramp down, and the pilot should not descend to MDA, but fly to the MAWP and execute a missed approach. The approach active annunciator and/or the receiver should be checked to ensure the approach mode is active prior to the FAWP.

Do not attempt to fly an approach unless the procedure is contained in the current GPS database. Flying point-to-point on the approach does not assure compliance with the published approach procedure. The proper RAIM sensitivity will not be available and the CDI sensitivity will not automatically change to +0.3 NM. Manually setting CDI sensitivity does not automatically change the RAIM sensitivity on some receivers. Some existing non-precision approach procedures cannot be coded for use with GPS and will not be available as overlays.

Pilots should pay particular attention to the exact operation of their GPS receivers for performing holding patterns and in the case of overlay approaches, operations such as procedure turns. These procedures may require manual intervention by the pilot to stop the sequencing of waypoints by the receiver and to resume automatic GPS navigation sequencing once the maneuver is complete. The same waypoint may appear in the route of flight more than once consecutively (e.g., IAWP, FAWP, MAHWP on a procedure turn). Care must be exercised to ensure the receiver is sequenced to the appropriate waypoint for the segment of the procedure being flown, especially if one or more fly-overs are skipped (e.g., FAWP rather than IAWP if the procedure turn is not flown). The pilot may have to sequence past one or more fly-overs of the same waypoint in order to start GPS automatic sequencing at the proper place in the sequence of waypoints.

Copter only GPS approaches are limited to 90 KIAS or less while flying any segment of the procedure, except ***GPS Copter approaches at civilian fields are designed to be flown at a maximum speed of 70 KIAS on final and through the missed approach segments.*** Copter approaches at military fields are designed to be flown at a maximum speed of 90 KIAS.

If a Visual Descent Point (VDP) is published, it will not be included in the waypoint sequence. Pilots are expected to use normal piloting techniques for beginning the visual descent.

Impact of Magnetic Variation on Performance-Based Navigation (PBN) Systems (AIM 1-1-17)

Differences may exist between PBN systems and the charted magnetic courses on ground−based NAVAID instrument flight procedures (IFP), enroute charts, approach charts, and Standard Instrument Departure/Standard Terminal Arrival (SID/STAR) charts. These differences are due to the magnetic variance used to calculate the magnetic course. Every leg of an instrument procedure is first computed along a desired ground track with reference to true north. A magnetic variation correction is then applied to the true course in order to calculate a magnetic course for publication. The type of procedure will determine what magnetic variation value is added to the true course. A ground−based NAVAID IFP applies the facility magnetic variation of record to the true course to get the charted magnetic course. Magnetic courses on PBN procedures are calculated two different ways. SID/STAR procedures use the airport magnetic variation of record, while IFR enroute charts use magnetic reference bearing. PBN systems make a correction to true north by adding a magnetic variation calculated with an algorithm based on aircraft position, or by adding the magnetic variation coded in their navigational database. This may result in the PBN system and the procedure designer using a different magnetic variation, which causes the magnetic course displayed by the PBN system and the magnetic course charted on the IFP plate to be different. It is important to understand, however, that PBN systems, (with the exception of VOR/DME RNAV equipment) navigate by reference to true north and display magnetic course only for pilot reference. As such, a properly functioning PBN system, containing a current and accurate navigational database, should fly the correct ground track for any loaded instrument procedure, despite differences in displayed magnetic course that may be attributed to magnetic variation application. Should significant differences between the approach chart and the PBN system avionics' application of the navigation database arise, the published approach chart, supplemented by NOTAMs, holds precedence.

Regarding this situation, CNAF M-3710.7 (5.3.2.2) provides the following guidance:

"Any discrepancy between the charted approach and the database approach shall require compliance with the charted approach."

709. GPS WAYPOINTS

GPS receivers navigate from one defined point to another retrieved from the aircraft's onboard GPS database. These points are waypoints with 5-letter pronounceable names, existing VHF intersections, DME fixes with 5-letter pronounceable names and 3-letter NAVAID identifiers. Each waypoint is a geographical location with latitude and longitude.

GPS approaches make use of both fly-over and fly-by waypoints (Figure 7-15). Fly-by waypoints connect two route segments by allowing the aircraft to turn prior to the current waypoint in order to roll out on course. This is known as turn anticipation and is compensated for in the airspace and terrain clearances. Approach waypoints, except for the MAWP and the missed approach holding waypoint (MAHWP), are normally fly-by waypoints. Fly-over waypoints are used when the aircraft must fly over the point prior to starting a turn (waypoint symbol with a circle around it). Overlay approach charts and some early stand-alone GPS approach charts may not reflect this convention.

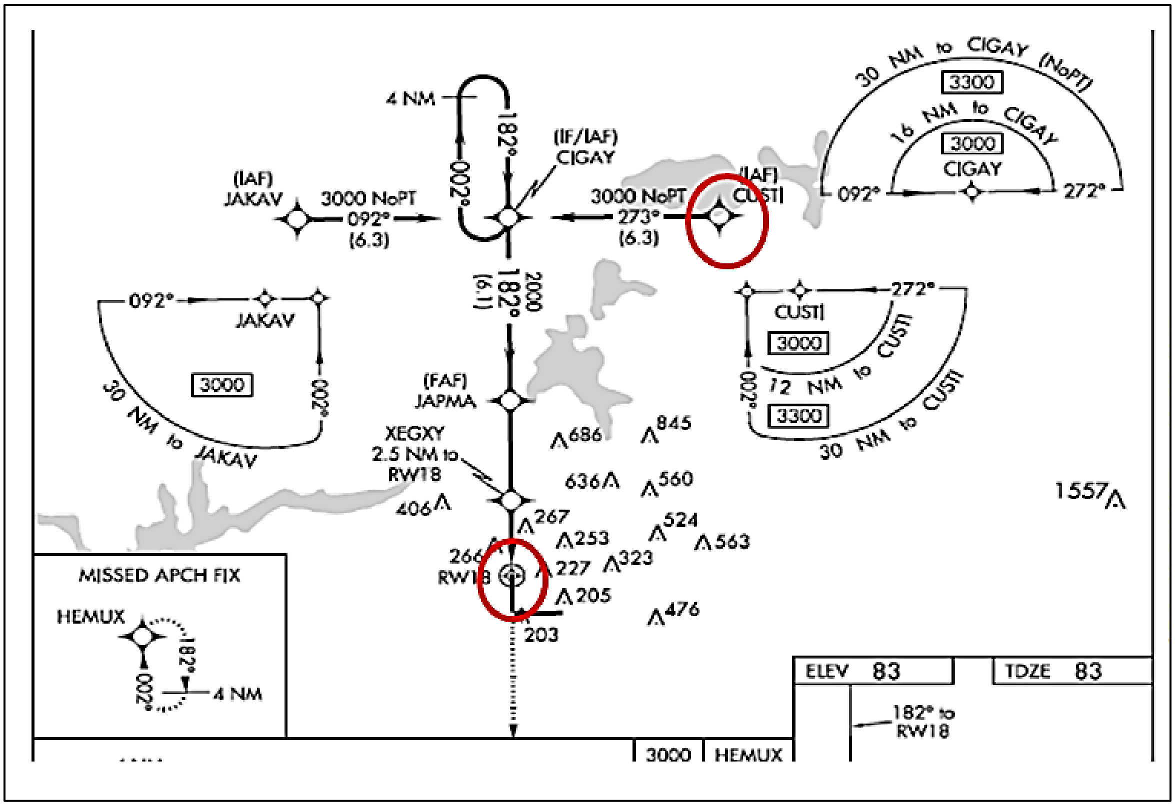


Figure 7-15 Example RNAV Approach with Fly-by and Fly-over Waypoints

Unnamed waypoints in the database will be uniquely identified for each airport but may be repeated for another airport (e.g., RW36 will be used at each airport with a runway 36 but will be at the same location for all approaches at a given airport).

The runway threshold waypoint, which is normally the MAWP, may have a five-letter identifier (e.g., SNEEZ) or be coded as RW## (e.g., RW36, RW36L). Those thresholds which are coded as five-letter identifiers are being changed to the RW## designation. This may cause the approach chart and database to differ until all changes are complete. The runway threshold waypoint is also used as the center of the MSA on most GPS approaches. MAWPs not located at the threshold will have a five-letter identifier.

Position Orientation

Pilot should pay particular attention to position orientation while using GPS. Distance and track information are provided to the next active waypoint, not to a fixed navigation aid. Receivers may sequence when the pilot is not flying along an active route, such as when being vectored or deviating for weather, due to the proximity to another waypoint in the route. This can be prevented by placing the receiver in the non-sequencing mode. When the receiver is in the non-sequencing mode, bearing and distance are provided to the selected waypoint and the receiver will not sequence to the next waypoint in the route until placed back in the auto sequence mode or the pilot selects a different waypoint.

Conventional Versus GPS Navigation Data

There may be slight differences between the heading information portrayed on navigational charts and the GPS navigation display when flying an overlay approach or along an airway. All magnetic tracks defined by a VOR radial are determined by the application of magnetic variation at the VOR; however, GPS operations may use an algorithm to apply the magnetic variation at the current position, which may produce small differences in the displayed course. Both operations should produce the same desired ground track. Due to the use of great circle courses, and the variations in magnetic variation, the bearing to the next waypoint and the course from the last waypoint (if available) may not be exactly 180° apart when long distances are involved. Variations in distances will occur, since GPS distance-to-waypoint values are along track (straight-line) distances (ATD) computed to the next waypoint and the DME values published on underlying procedures are slant range distances measured to the station. This difference increases with aircraft altitude and proximity to the NAVAID.

710. DEPARTURES AND DEPARTURE PROCEDURES (DP)

It is possible to load instrument Departure Procedures that are available in the GPS database. The GPS receiver must be set to terminal (+1 NM) CDI sensitivity and terminal RAIM should be automatically provided (as long as the waypoints are part of the active flight plan rather than proceeding direct to the first destination). Certain segments may require manual pilot intervention, especially when radar vectored to a course or required to intercept a specific course to a waypoint. The database may not contain all of the transitions or departures from all runways and some GPS receivers do not contain DPs in the database. Also, be aware ***helicopter departure procedures should be flown at 70 KIAS or less, since helicopter departure procedures and missed approaches are based on a much steeper obstacle clearance surface (OCS) gradient than fixed-wing procedures (20:1 vice 40:1).***

711. MISSED APPROACH

A GPS missed approach requires pilot action to sequence the receiver past the MAWP to the missed approach portion of the procedure. The pilot must be thoroughly familiar with the activation procedure for the particular GPS receiver installed in the aircraft and must initiate appropriate action after the MAWP. Activating the missed approach prior to the MAWP will cause CDI sensitivity to immediately change to terminal (+1 NM) sensitivity and the receiver will continue to navigate to the MAWP. The receiver will not sequence past the MAWP. Turns should not begin prior to the MAWP. If the missed approach is not activated, the GPS receiver will display an extension of the inbound final approach course and the ATD will increase from the MAWP until it is manually sequenced after crossing the MAWP.

Missed approach routings in which the first track is via a course rather than direct to the next waypoint require additional action by the pilot to set the course. Being familiar with all of the inputs required is especially critical during this phase of flight.

712. THE KLN 900 GPS SYSTEM

The basic KLN 900 system consists of a panel-mounted KLN 900 GPS sensor/navigation computer, a database card, and an antenna. Additional system components are integrated to increase the capabilities of the system (including the CDI, HSI, and RMI). With these components the GPS becomes a complete and very powerful navigation system. This section is a brief overview of the system and is not intended to be an in-depth instruction on all of its functions and usages. Please take advantage of NATOPS, the KLN 900 user's manual, computer-based trainers, as well as the GPS practice systems in order to gain a complete understanding and to become proficient with the KLN 900 GPS system.

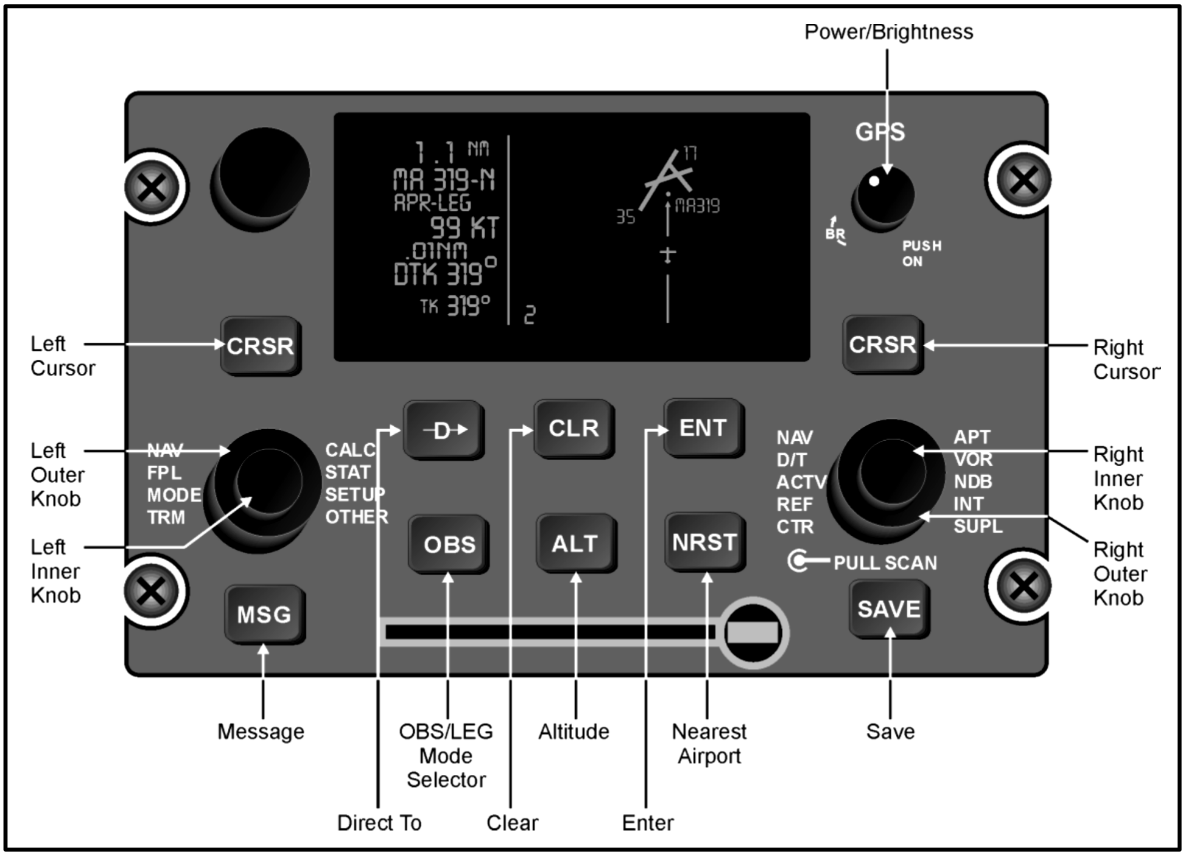


Figure 7-16 KLN-900 GPS Interface

The KLN 900 Database

The database provides two functions. First, it makes pilot interface with the GPS sensor much easier. Rather than having to manually look up and then enter the latitude and longitude for a specific waypoint, it allows you to merely enter a simple waypoint identifier. The database will automatically look up and display the pertinent information. Secondly, it serves as a means to store and easily access a vast amount of aeronautical information. Want to know the tower frequency or length of the runways at a specific airport? No need to look them up in a book just turn a couple knobs and the information is easily displayed.

Database coverage is worldwide, though broken down into ten different regions. The TH-57's database coverage is based on the U.S. alone, containing information on public and military use airports with a runway of at least 1000 feet in length.

Information Input and Retrieval

Obviously, with this much information available, one must be able to access it quickly and easily. The KLN 900 is user-friendly once you have figured out how to work its two main controls, the right and left inner and outer control knobs. By rotating first the outer knob and then the inner knob you are able to flip through the numerous screens, each of which contain several pages. Each screen and page then allows you to access information, input a flight plan or destination, or determine numerous in-flight calculations.

From Figure 7-17 you can see that the right and left knobs will control your right and left screen functions with the inner knob controlling the pages found within each screen function.

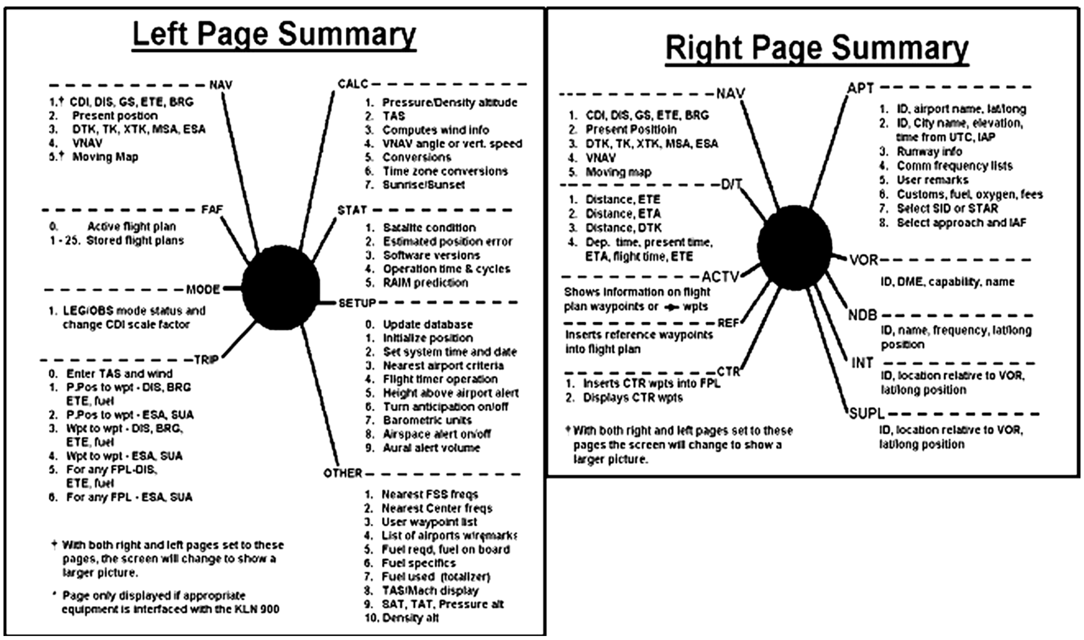


Figure 7-17 Left and Right Page Summary

Flight Plan Input

The KLN 900 has a Direct To function, that when a waypoint is inputted or highlighted in a flight plan and the "DIRECT TO" button is pushed, the GPS will give the distance and heading to that location. This is the primary feature of the GPS, but it can make it rather work-intensive on a long flight. For this reason the pilot is able to input an entire flight plan into the GPS. Up to 25 flight plans can be stored with 30 locations in each plan. To input a flight plan:

1. Select flight plan (FPL) with the left outer knob. Use the inner knob then to select a blank flight plan page (preferably not FPL 0, as this will automatically become the active page).

2. Hit the left "CRSR" button.

3. Use the left inner knob to select the first character of the departure waypoint identifier (the departure point should always be the first waypoint or else it will not sequence properly). Ensure to put a "K" as the first of the four-letter identifier for all airports.

4. Turn the left outer knob one step clockwise to move the flashing portion of the cursor over the second character position, and then use the left inner knob to select the desired waypoint.

5. Press "ENT" to enter the waypoint. The location will be displayed on the right screen, so you can be sure the right waypoint is entered. If correct, press "ENT" again to lock it in and the cursor will move to the next position.

6. When all waypoints and the destination have been entered in the flight plan, the left outer knob may be rotated to move the cursor up and down and to manually "scroll" through the waypoints making up this flight plan. Continue to scroll up until the "USE?" is highlighted at the top. Press "ENT" and the flight plan will then be displayed as FPL 0.

7. A "C" shaped arrow will indicate the sequencing of the flight from one point to another.

8. Changes can be made in flight by using the "CRSR" button and highlighting points in flight.

9. Once a flight plan is entered, numerous changes can be made by merely highlighting a waypoint and then using the appropriate knobs to enter the new waypoint, approach, or departure (Section 714).

713. THE GTN-650 GPS SYSTEM

The Garmin GTN-650 is TSO-C146c certified and supports airway navigation and flexible flight planning, including arrival and departure procedures and GPS approaches. All features are accessed with a touchscreen display that provides a visual display of both controls and functions. The VHF radio, LOC/VOR and glideslope receivers, and transponder are also controlled through the GTN-650. The LOC/VOR and glideslope receiver can also be controlled through the KNS-81. The GTN-650 uses a Secure Digital (SD) card to load and store various types of data. The datacard is required for Terrain, FliteChart, and Chartview database storage and all database updates.

NOTE

> Do not remove the SD card on the ground or in flight. Maintenance is responsible for uploading current databases and are the only personnel authorized to manipulate the SD card.

The GTN-650 is capable of non-precision LPV and LNAV/VNAV APV approaches, as well as LP and LNAV approaches without approved vertical guidance. See paragraph 703 for a discussion of APV approaches (LPV and LNAV/VNAV) and LP approaches that use WAAS position data. LNAV approaches are based on satellite position information and are not dependent on ground-based navigation aids. LNAV approaches are flown to an MDA and the vertical guidance is advisory only. The GTN will store up to 1,000 user-defined waypoints, up to six characters long. It is possible to build up to 99 reversible flight plans with up to 100 waypoints each.

The WAAS-certified, 15-channel GPS receiver generates five position updates per second. The GTN-650 will preload NAV frequencies for you to manually switch to and can auto-select the VHF NAV source for ILS approaches when you load procedures. When a VOR is selected, it displays the radial and distance to the VOR.

It is possible to create user waypoints within the GTN-650 using latitude/longitude, radial/DME, or the Mark-on-Target (MOT) functionality. The MOT pushbutton on the center console will create a new user-defined waypoint at the selected location, which can be edited from the Waypoint Info Page.

Figure 7-18 GTN 650 Interface

The GTN-650 System is integrated with the aircraft electrical system and receives power from the Essential #1 Bus. The GTN-650 and supporting sub-systems include both power-on and continuous built-in test features that exercise the processor, memory, external inputs, and outputs to ensure safe operation.

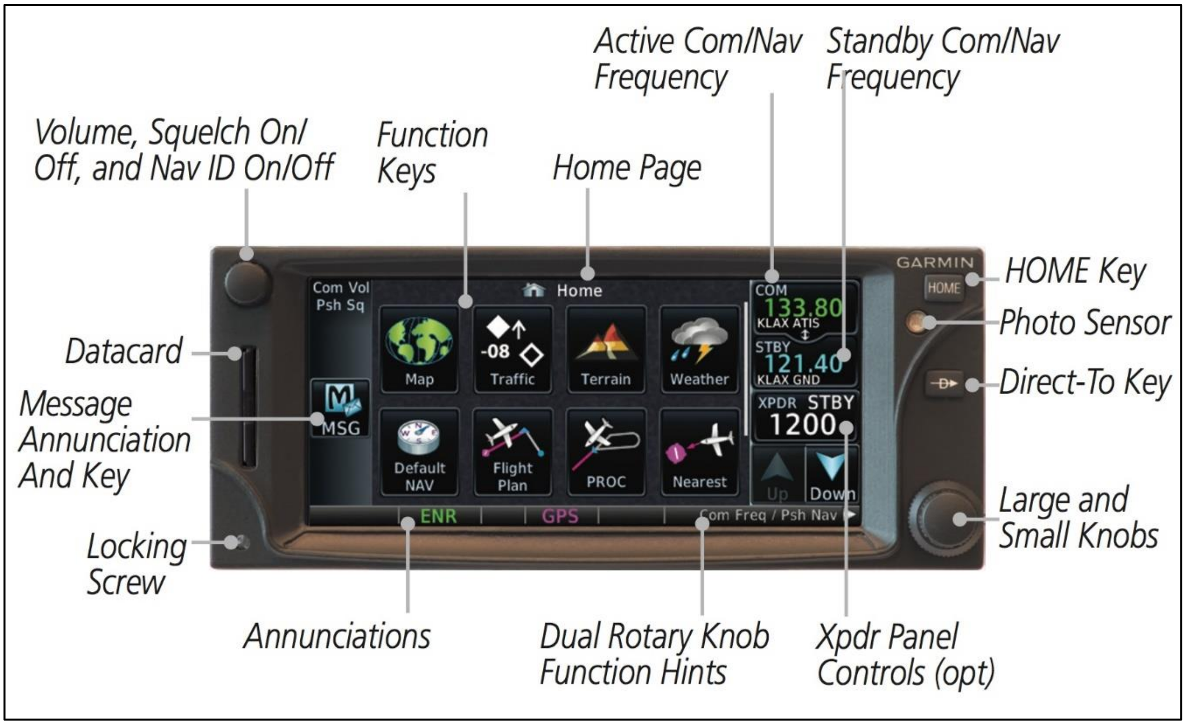


Figure 7-19 GTN-650 Home Page

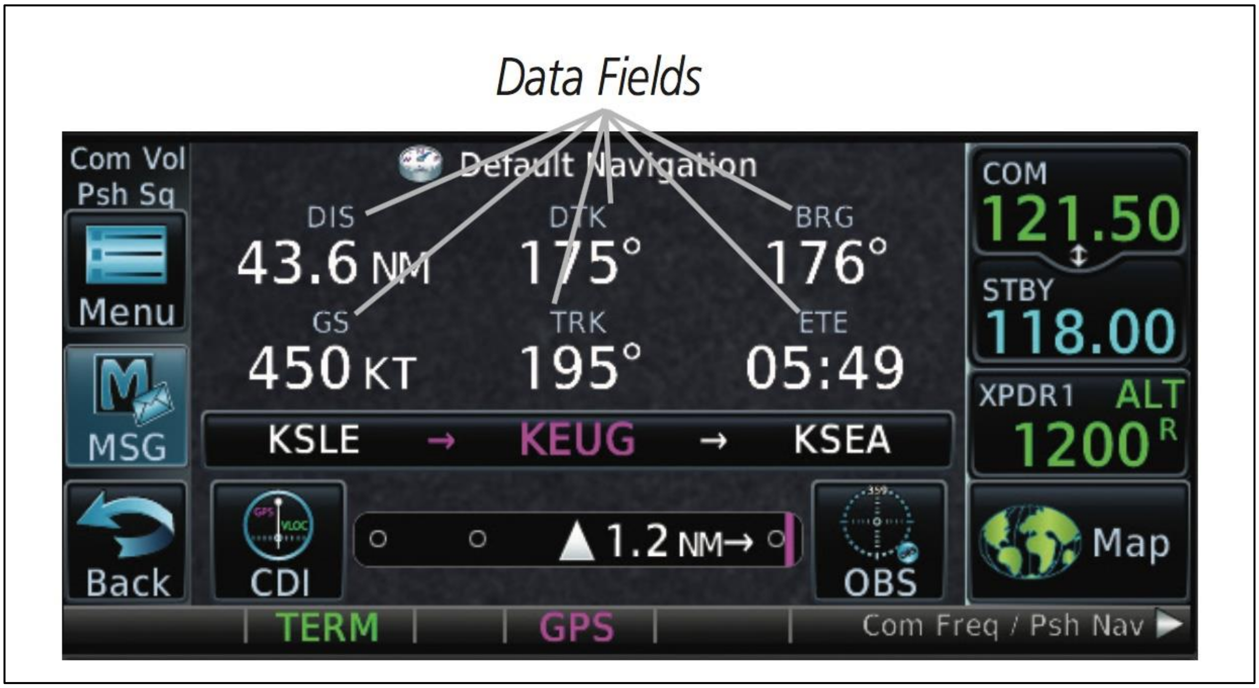


Figure 7-20 GTN-650 Default Navigation Page

GTN-650 Important Messages and Failure Modes

There are a number of messages that are specific to the GTN-650, and pilots must be completely familiar with them prior to flying. Selected messages and the appropriate pilot actions are listed below:

Message and Meaning	Description	Pilot Action
ABORT APPROACH GPS approach no longer available.	This message is triggered outside the MAP if the GTN cannot provide approach level of service. Vertical guidance will be removed from the external CDI/HSI display.	Abort the approach, initiate a climb to the MSA, and execute a non-GPS based approach.
APPROACH DOWNGRADE Approach downgraded. Use LNAV minima.	Approach has been downgraded from LPV or LNAV/VNAV to an LNAV approach. Vertical guidance will be removed from the external CDI/HSI display.	Continue to fly the approach using published LNAV minima.
APPROACH NOT ACTIVE Do not continue GPS approach.	GPS approach could not transition to active (GTN did not have the required horizontal and vertical positional accuracy to reach at least LNAV, so receiver is still in TERM mode).	Abort the approach, and execute a non-GPS based approach.
CDI SOURCE Select appropriate CDI source for approach.	Aircraft is on a GPS approach but CDI is set to VLOC, or aircraft is on VLOC approach and CDI is set to GPS *and* aircraft is less than 2nm from the FAF.	Select appropriate CDI source for the approach.
DATALINK	Multiple causes, specific message will reference an ADS-B or GDL-88 error.	Further flight allowed if flight can be continued with remaining navigational equipment. Contact Maintenance after landing.
GPS RECEIVER	Multiple causes, specific message will reference precise failure mode.	Use a non-based GPS receiver for continued flight. Contact Maintenance after landing.

NOTE: This list is ***not*** all-inclusive. Reference the Garmin Pilot's Guide and Cockpit Reference Guide for a full list of GTN-650 error messages and appropriate actions.

Figure 7-21 GTN-650 Important Messages and Failure Modes

714. INPUTTING AND FLYING GPS APPROACHES

Once a flight plan is entered, it is possible to input the approach desired. The general procedures to input and shoot a GPS approach are as follows. Reference the P-458 FTI for complete GPS approach procedures.

1. **Select and load the approach into the flight plan.** Can be done at any time, but must be completed by the Final Approach Fix. If aircraft is greater than 30 NM from the airport, then the CDI scale factor will remain at the default 5 NM full-scale deflection for the KLN-900 and 2 NM for the GTN-650.

   a. KLN-900

      i. Approaches are selected from the "APT 8" page (on the right side of the display) for the airport to which you desire to shoot the approach. Use the "CRS" to highlight the current airport and then select the airport using the right inner and outer knobs.

      ii. Rotate the knobs then to move the cursor down to the given approaches; highlight the one you want and hit "ENT."

      iii. The display will then present a list of IAFs corresponding with the approach. Highlight the one you want and hit "ENT." Be aware that ATC may not give you an IAF, in which case you must choose the one that is correct for your inbound course to the airfield.

      iv. The display will then list the waypoints that make up the approach. Review these to ensure you have selected the right course.

      v. Continue to move the cursor down to highlight "LOAD IN FPL" and hit "ENT." This will automatically sequence the approach into your current flight plan (FPL 0).

   b. GTN-650

      i. Approaches can be selected via the “PROC” key from the Home page or selecting the airport from the flight plan.

      ii. Select the “Approach” key, find the desired approach, and select via the touchscreen.

      iii. Select the “Transitions” key. Find the desired IAF listed or “Vectors” if receiving Radar Vectors to Final and select via the touchscreen.

      iv. Select “Preview” to ensure the appropriate transition appears for the approach.

v. Select "Load Approach" to place the approach at the end of the flight plan or "Load Approach and Activate" to activate a leg Direct-to the selected transition point.

2. **Transition to the approach arm mode**. This will occur automatically when the aircraft is within 30 NM of the airport and there is an approach loaded into the flight plan (KLN 900). Terminal mode will occur automatically in the GTN 650 within 30 NM of both the departure and destination airports in the flight plan, whether or not an approach is loaded. The CDI scale will smoothly change to Terminal deviation of 1 NM for both the KLN-900 and the GTN-650.

a. KLN-900

i. External annunciator will indicate ARM. As you approach the IAF, the KLN will provide waypoint alerting on the annunciator as well as on the screen and then will automatically sequence onto the next waypoint.

ii. Select the Super NAV 5 page at this time if you have not already done so.

b. GTN-650

– Annunciator on bottom of touchscreen will change from ENR to TERM. Failure of this to occur will be accompanied by an error message.

3. **Get established on the final approach course.** This can be via NoPT arrival route, Radar Vectors (KLN-900: remain in OBS mode; GTN-650: select "Vectors to Final" transition on the procedure page, as required), Procedure turn or holding pattern (remain in non-sequencing mode for the KLN-900). GPS should transition the approach to active mode.

a. KLN-900 - This change is automatic when:

i. The aircraft is 2 NM from the FAF and the approach mode is armed.

ii. The LEG mode is selected.

iii. The FAF is the active waypoint.

iv. The KLN 900 confirms that adequate integrity monitoring is available to complete the approach.

v. RAIM is available to FAF and MAP.

NOTE

If any of these conditions are not met, the KLN 900 will not transition to the approach active mode and a missed approach will be required if the conditions do not change before reaching the

FAR. If all of these conditions are met, the CDI scale factor will start to change to 0.3 NM and the external annunciator will indicate "ACTV."

b. GTN-650

i. The change will be automatic within 2 NM from the FAF (with a final integrity check 60 seconds prior to the FAF) and can be verified on the bottom of the GTN screen which will transition from TERM to the approach selected, e.g., LPV, LNAV, L/VNAV, etc. CDI scaling for LPV approaches will shift from 1 NM to an initial angular full-scale deflection of 2 degrees so that the total width of the FAC is 700 feet at the runway threshold. CDI scaling for other than LPV approaches will shift from 1 NM to either 2 degrees or 0.3 NM full-scale deflection, whichever is smaller.

ii. With "Vectors to Final" selected, the HSI/CDI needle remains off center until established on the final approach course. With the approach activated, the Map Page displays an extension of the final approach course in magenta.

iii. If the GTN-650 is unable to continue the GPS approach, a message will appear (see figure 7-15). Crews shall be vigilant for messages once on the final approach course, and it is recommended the PNAC immediately read any messages that appear.

iv. If an ILS approach was loaded using the GTN-650, when the ILS approach is activated and the correct ILS frequency is active in the NAV window, the GTN-650 will automatically switch to VLOC when within 1.2 NM left or right of the final approach course. This switch can take place anywhere from 2-15 NM from the FAF. The CDI Auto-Switch feature can be selected from the CDI Setup Page. Figure 7-22 shows multiple locations along the approach path and the CDI selection that you can expect the automatic switch to occur. Within the area of the shaded box, the automatic switch from GPS to VLOC will occur; however, if the "Vectors to Final" transition is selected and the approach is activated, the GTN will immediately switch from GPS navigation to VLOC.

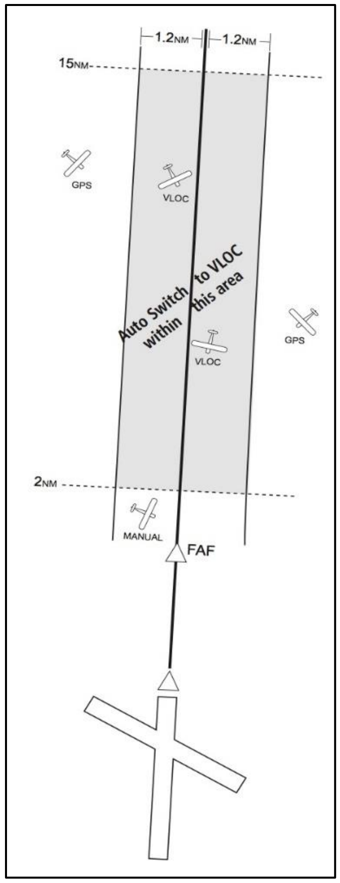


Figure 7-22 GTN-650 GPS to VLOC Transition Illustration

4. **At the FAF**.

a. KLN 900: The CDI scale factor will be at 0.3 NM and will remain at this scale factor until you manually cancel the approach mode by either pressing the external GPS APR button to change to the ARM mode, by initiating a Direct To operation, or by changing to OBS mode.

b. GTN-650: For LPV approaches, as you approach the FAF, the GTN will begin to automatically rescale in an angular fashion from TERM deflection of 1 NM to 2 degrees, allowing the LPV approach to be flown in an identical fashion to a standard ILS. At 2 NM from the FAF, scaling is tightened from 1 NM to the angular full-scale deflection of 2 degrees. 60 seconds prior to the FAF, the GTN will ensure GPS position integrity is within limits to continue the LPV approach. Capture the glideslope as you would an ILS glideslope. If LPV accuracy cannot be verified, the GTN-650 will downgrade to an LNAV approach and the approach may be continued to LNAV minimums. CDI scaling for other than LPV approaches will shift from 1 NM to either 2 degrees or 0.3 NM full-scale deflection, whichever is smaller.

5. **Flying to the Missed Approach Point**. The GPS will not automatically sequence to the next waypoint. Pilot action is required to sequence to the appropriate waypoint according to the situation.

a. KLN-900: By default, the receiver will nominate the first waypoint of the published missed approach procedure when the DIRECT TO button is pressed, the active waypoint is the MAP, and you have flown past the MAP.

b. GTN-650: Upon reaching the MAP, automatic sequencing will be suspended and an option on the touchscreen will appear to either activate the missed approach procedure or continue to suspend waypoint sequencing. Select the appropriate option.

Figure 7-23 GTN-650 Missed Approach Message

715. GDL-88 ADS-B TRANSCEIVER CAPABILITIES

The Garmin GDL-88 is an Automatic Dependent Surveillance-Broadcast (ADS-B) transceiver which provides ADS-B Out functions to meet FAR 91.227 requirements and ADS-B In functions to provide traffic and datalink weather data. The GDL-88 transmits ADS-B Out data on the 978 MHz (UAT) frequency to be received by other aircraft, vehicles, and ATC. The GDL-88 receives ADS-B data transmitted by other ADS-B-equipped aircraft on the 1090 MHz frequency and displays traffic information on the GTN-650’s display screen. The GDL-88 also receives additional TIS-B traffic information and FIS-B weather information from ground radio stations on the 978 MHz UAT link (figure 7-X). ADS-B, TIS-B, and FIS-B information are displayed and controlled via the GTN-650’s display and touchscreen menus. The following is a brief description of ADS-B, TIS-B, and FIS-B services.

Automatic Dependent Surveillance-Broadcast (ADS-B) Services

ADS-B is a surveillance technology composed of aircraft avionics and a ground infrastructure. Onboard avionics determine the position of the aircraft using the GPS and transmit its GPS-derived position and other information such as velocity over a data link, which is received by a ground-based transmitter/receiver for processing and display at ATC ground-based facilities.

This information is transmitted at a rate of approximately once per second. All TH-57s with the GTN-650 and GDL-88 installed have ADS-B capability to be in compliance with FAR 91.225. FARs require that after January 1, 2020, all aircraft must have ADS-B Out capability in order to legally operate within the national airspace system. In the United States, ADS-B equipped aircraft exchange information via 978 and 1090 MHz. ADS-B-In equipped aircraft receive traffic proximity information air-to-air from ADS-B-Out equipped aircraft.

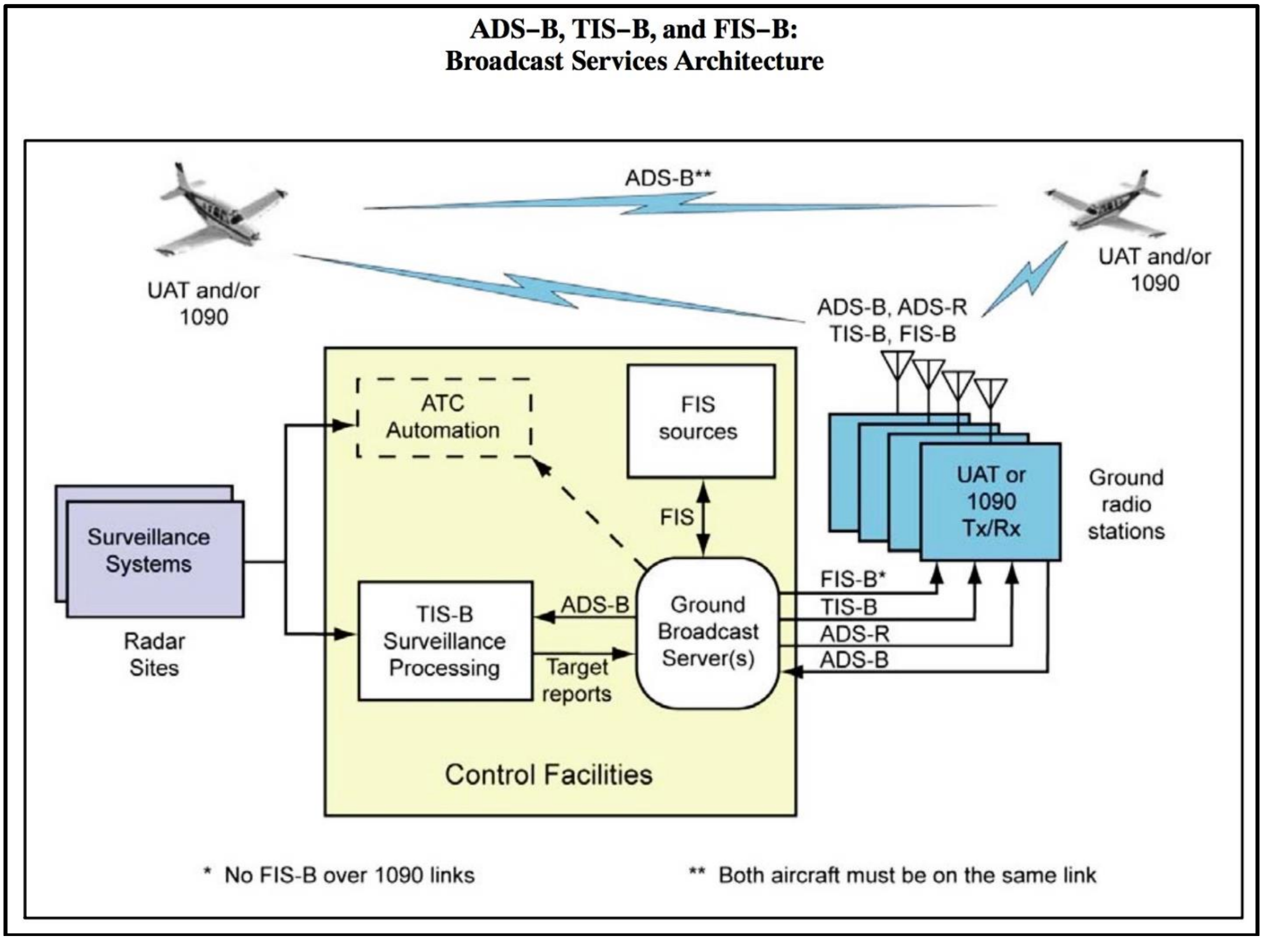


Figure 7-24 ADS-B, TIS-B, FIS-B Broadcast Services Architecture

ADS-B enables improved surveillance services, both air-to-air and air-to-ground, especially in areas where radar is ineffective due to terrain or where it is impractical or cost prohibitive. The traffic display in the cockpit is not intended as a collision avoidance system and does not relieve the pilot's responsibility to "see and avoid" while VFR.

The following ADS-B Out data is transmitted: GPS position, altitude, position integrity, ground track and/or heading, groundspeed, velocity integrity, air/ground state, and identifying information (transponder squawk code, call sign, registration number, and Flight Identification). An aircraft's Flight Identification (Flight ID) is comprised of a maximum seven alphanumeric characters and also corresponds to the aircraft identification annotated on the ATC flight plan. For example, a general aviation aircraft may have a FLT ID N235RA which matches their registration number. ATC systems use transmitted FLT IDs to uniquely identify each aircraft within a given airspace and correlate then to a filed flight plan. This allows for better service, providing surveillance and appropriate airspace separation. ***It is imperative that the correct Flight ID is entered before flight to prevent any delays in traffic services provided by ATC.***

ADS-B systems are integrated with the aircraft transponder and will automatically set the applicable emergency status, e.g., 7700 or 7600, if it is entered into the transponder. ADS-B is intended for in-flight and surface use. ADS-B systems should be turned ON (and remain ON) whenever operating in the air or moving on airport surfaces. Civil and military Mode A/C transponders and ADS-B systems should be adjusted to the ON or normal operating position as soon as practical, unless the change to standby is requested by ATC.

Traffic Information Service-Broadcast (TIS-B)

TIS-B is the broadcast of ATC derived traffic information to ADS-B equipped aircraft from ground radio stations. It is intended to provide ADS-B equipped aircraft with a more complete traffic picture in situations where not all nearby aircraft are equipped with ADS-B Out. The quality level of traffic information provided by TIS-B is dependent upon the number and type of ground sensors available and the timeliness of the reported data. TIS-B position updates will occur approximately once every 3-13 seconds depending on the type of radar system in use within the coverage area. There is no indication provided when any aircraft is operating inside or outside the TIS-B service volume, therefore it is difficult to know if one is receiving uplinked TIS-B traffic information. The GTN-650 will display up to eight traffic targets within a 7.5 NM radius, from 3000 feet below to 3500 feet above the aircraft. TIS-B (and ADS-B traffic) is not intended to be used as a collision avoidance system and does not relieve the pilot's responsibility to "see and avoid" other aircraft, in accordance with FAR 91.113.

It is important to understand that TIS-B (and ADS-B) traffic information is not a TCAS system. Only transponder-equipped targets are transmitted through the ATC ground system architecture. Non-ADS-B equipped aircraft may trigger a traffic alert if the aircraft is equipped with a transponder and they are received by a ground radar surveillance site which will transmit it to a TIS-B control station and then to the Ground Broadcast Server(s), which transmit information via TIS-B to our GTN-650 via the GDL-88 (Figure 7-24). A non-ADS-B equipped aircraft out of range of a ground radar surveillance site will not be identified, and will not trigger a traffic alert on the GTN-650. Aircraft that do not have either a transponder or ADS-B capability will not be detected by the ground site, and will not be visible via ADS-B or TIS-B.

Flight Information Service-Broadcast (FIS-B)

FIS-B is a ground broadcast service provided through the ADS-B Services network over the 978 MHz UAT data link. The FAA FIS-B system provides pilots with graphical representations of NEXRAD imagery, NOTAM/TFRs, and other weather information. FIS-B reception is line-of-sight within the service volume of the ground infrastructure. FIS-B is supplemental only and does not replace a preflight weather briefing, or inflight updates from an FSS or ATC.

REVIEW QUESTIONS

1. A minimum of _____ satellites are always observable anywhere on Earth.

   a. 24
   b. 12
   c. 10
   d. 5

2. Aircraft equipped with KLN-900 require an alternate source of navigation.

   a. True b. False

3. Aircraft equipped with GTN-650 require an alternate source of navigation.

   a. True b. False

4. GPS systems like the GTN-650 use WAAS ground reference stations to correct for GPS signal errors caused by _________.

   a. Satellite transmission errors
   b. ionospheric disturbances, timing and satellite orbit errors
   c. User interface and satellite orbit errors
   d. Ionospheric disturbances and satellite failures

5. GPS position accuracy with WAAS is less than ___ meters as compared to GPS-only position accuracy of about ___ meters.

   a. 10, 100
   b. 3, 30
   c. 3, 15
   d. 5, 13

6. Which Approach Procedures with Vertical Guidance (APV) are flown to a DA?

   a. LPV
   b. LNAV
   c. LNAV/VNAV
   d. LPV and LNAV/VNAV

7. RAIM is not required to perform a GPS approach.

a. True b. False

8. If a RAIM flag/annunciation appears after the FAWP, you should _____.

a. Notify ATC
b. Turn RAIM
c. execute missed approach immediately
d. continue on with the approach

9. ADS-B and TIS-B serves as a TCAS system in GTN-650/GDL-88 equipped aircraft.

a. True b. False

10. ADS-B is intended for _____.

a. Surface use only
b. In-flight use only
c. in-flight and surface use
d. flight at OLFs only

11. TIS-B position updates will occur approximately once every ____ seconds depending on the type of radar system in use within the coverage area.

a. 10-20
b. 3-13
c. 5-15
d. 1-2

12. The three areas for a standard TAA are:

a. Alpha, Bravo, and Charlie
b. Forward, Left, and Right
c. Bow, Starboard, and Port
d. Straight-in, Right Base, and Left Base

13. If cleared direct to an IAF without an approach clearance, the pilot may descend to the lower TAA altitude.

a. True b. False

14. GPS Helicopter DPs, when available, should be flown at what airspeed?

a. 65 KIAS
b. 70 KIAS
c. 90 KIAS
d. 50 KIAS

15. Slight differences between heading information portrayed on navigational charts and the GPS navigation display occur due to the fact that headings defined by a VOR airway apply magnetic variation at each individual VOR while GPS __________.

a. Applies magnetic variations stored in its database
b. References updated variations sent via satellite
c. Uses complex algorithms based on your current position
d. Does not take into account magnetic variation

16. At the FAWP, the CDI scale factor will be at _____ and will remain until manually canceling the approach, proceeding past the MAP, or sequencing to the missed approach.

a. +0.3 NM
b. +0.5 NM
c. +1 NM
d. +0.2 NM

17. The GPS (GTN-650 or KLN-900) will automatically sequence to the missed approach upon reaching the MAWP.

a. True b. False

18. Activating the missed approach sequence prior to the MAWP will cause CDI sensitivity to immediately change to ___ NM.

a. 1.0
b. 0.5
c. 0.3
d. 3.0