

UNOFFICIAL DRAFT AIM INPUT

As stated in an FAA cover letter requesting an informal review of a draft document:

The FAA is “in the final stages of preparing an input to the [Airman's Information Manual] which will significantly increase the amount of information available concerning GPS navigation.... [It is intended that this draft be finalized] in order to make the July 97 AIM change.”

At the time that this draft was published (December 19, 1996), “[t]he document [was] still undergoing FAA internal review, so some changes in wording and content [were to] be expected before it [was] finalized.”

The following is provided for use as general background information only, *as is*, with no assertions as to transcriptional accuracy, or to the document's relationship to what is actually, eventually, published on this subject in the AIM. This draft document has no endorsement, official or otherwise, of the FAA or anyone else.

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1-1-22. GLOBAL POSITIONING SYSTEM (GPS)

a. SYSTEM OVERVIEW

1. The Global Positioning System (GPS) is a United States satellite-based radio navigational, positioning, and time transfer system operated by the Department of Defense (DoD). The system provides highly accurate position and velocity information and precise time on a continuous global basis to an unlimited number of properly-equipped users. 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.
2. GPS provides two levels of service: Standard Positioning Service (SPS) and Precise Positioning Service (PPS). SPS provides, to all users, horizontal positioning accuracy of 100 meters, or less, with a probability of 95 percent and 300 meters with a probability of 99.99 percent. PPS is more accurate than SPS; however, this is limited to authorized US and allied military, federal government, and civil users who can satisfy specific US requirements.
3. GPS operation is based on the concept of ranging and triangulation from a group of satellites in space which act as precise reference points. A GPS receiver measures distance from a satellite using the travel time of a radio signal. Each satellite transmits a specific code, called a course/acquisition (CA) code, which contains information on the satellite's position, the GPS system time, its clock error, and the health and accuracy of transmitted data. GPS satellites have very accurate atomic clocks in order to calculate signal travel time. 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.
4. 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; for example, an ionospheric delay and time disparities between the atomic clocks in the satellites and the GPS receiver.
5. In addition to knowing the distance to a satellite, a receiver needs to know the satellite's exact position in space; this is known as its ephemeris. Each satellite's signal transmits ephemeris information

about its exact orbital location. The GPS receiver uses this information to precisely establish the position of the satellite.

6. 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 three satellites, with timing corrections from a fourth satellite, to yield an unaided, unique, and true three-dimensional position (latitude, longitude, and altitude) and time solution. The GPS receiver computes navigational values such as distance and bearing to a waypoint, ground speed, by using the aircraft's known latitude/longitude and referencing these to a database built into the receiver.

7. The GPS constellation of 24 satellites is designed so that a minimum of five are always observable by a user anywhere on earth. The receiver uses data from the best four satellites above its horizon, adding signals from one as it drops signals from another, to continually calculate its position.

8. The GPS receiver verifies the integrity of the signals received from the GPS constellation through receiver autonomous integrity monitoring (RAIM) by determining if a satellite is providing corrupted information. At least one satellite, in addition to those required for navigation, must be in view for the receiver to perform the RAIM function; thus, RAIM needs 5 satellites in view, or 4 satellites and baro-aiding to detect an integrity problem. Baro-aiding is a method of augmenting the GPS integrity solution equation by using a non-satellite input source. Baro-aiding is used only to improve GPS integrity and should not be relied upon to determine aircraft altitude since the vertical error can still be quite large (up to 150% of the horizontal error). RAIM messages vary somewhat between receivers, however, generally there are two types. One type tells the pilot that there are not enough satellites available to provide RAIM integrity monitoring and another type says that the RAIM integrity monitor has detected a potential error that exceeds the limit for the current phase of flight. RAIM needs 6 satellites in view (or 5 satellites with baro-aiding) to isolate the corrupt satellite signal and remove it from the navigation solution. To ensure that baro-aiding is available, the current altimeter setting must be entered into the receiver as described in the operating manual. **Without RAIM capability, the pilot has no assurance or the accuracy of the GPS position.**

9. The Department of Defense declared initial operational capability (IOC) of the US GPS on December 8, 1993. The Federal Aviation Administration (FAA) has granted approval for US civil operators to use GPS equipment as a primary means of navigation in oceanic airspace and certain remote areas GPS equipment may be used as a supplemental means of IFR navigation for domestic enroute, terminal operations, and certain instrument approach procedures (IAP's). This approval permits the use of GPS in a manner that is consistent with current navigation requirements and approved air carrier operations specifications.

b. GENERAL REQUIREMENTS

1. Authorization to conduct any GPS operation under IFR requires that:

(a) GPS navigation equipment used must be approved in accordance with requirements specified in TSO C-129, or equivalent, and the installation must be done in accordance with Notice 8110.47 or 8110.48, or the Flight Standards/Aircraft Certification (AFS/AIR) joint guidance memorandum dated July 20, 1992. Equipment approved in accordance with TSO C-115a does not meet the requirements of TSO C-129.

(b) 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 installation uses RAIM for integrity monitoring. For these Systems, active monitoring by the flight crew is only required when the RAIM capability of GPS equipment is lost.

(c) 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.

(d) The GPS operation must be conducted in accordance with the FAA-approved aircraft flight manual (AFM) or flight manual supplement. Flight crew members must be thoroughly familiar with the particular GPS equipment installed in the aircraft, the receiver operation manual, and the AFM or flight manual supplement. Unlike ILS and VOR, the basic operation, aircraft instrument panel presentation to the pilot, and some capabilities of the equipment can vary greatly. Due to these differences, operation of different brands or even models of the same brand of GPS receiver should not be attempted without thorough study of the operation of that particular receiver. 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.

(e) The appropriate equipment suffix must be included in the ATC flight plan. Aircraft navigating by IFR approved GPS are considered to be RNAV aircraft. File the appropriate equipment suffix in accordance with Table 5-1-2. If GPS avionics become inoperative, the pilot should advise ATC and amend the equipment suffix.

(f) Prior to any GPS IFR operation, the pilot must review appropriate NOTAMS. NOTAMS will be issued to announce outages. Pilots may obtain these NOTAMS from FSS briefers on request.

(g) Air carrier and commercial operators must meet the appropriate provisions of their approved operations specifications.

C. USE OF GPS FOR IFR OCEANIC, DOMESTIC ENROUTE, AND TERMINAL AREA OPERATIONS

1. GPS IFR operations in oceanic areas can be conducted as soon as proper avionics systems are installed, provided all general requirements are met. A GPS installation with TSO C-129 authorization in class A1, A2, B1, B2, C1, or C2 (See Table 1-1-10) may be used to replace one of the other approved means of long-range navigation, such as dual INS or dual Omega. A single GPS installation with these classes of equipment which provides RAIM for integrity monitoring may also be used on short oceanic routes which only required one means of long-range navigation.

2. GPS domestic enroute and terminal IFR operations can be conducted as soon as proper avionics systems are installed, provided all general requirements are met. The avionics necessary to receive all of the ground-based facilities appropriate for the route to the destination airport and any required alternate airport must be installed and operational. Ground-based facilities necessary for these routes must also be operational.

3. The GPS Approach Overlay Program is an authorization for pilots to use GPS avionics under IFR for flying designated existing instrument approach procedures, except Localizer (LOC), Localizer directional aid (LDA), and simplified directional facility (SDF) procedures. Only those approaches included in the receiver database are authorized.

4. GPS IFR approach operations can be conducted as soon as proper avionics systems are installed and the following requirements are met:

A. The authorization to use GPS to fly instrument approaches is limited to US airspace.

B. The use of GPS in any other airspace must be expressly authorized by the FAA Administrator.

C. GPS instrument approach operations outside the United States must be authorized by the appropriate sovereign authority.

d. EQUIPMENT AND DATABASE REQUIREMENTS

1. Authorization to fly approaches under IFR using GPS avionics systems requires that:

- (a) A pilot use GPS avionics with TSO C-129 authorization in class A1, B1, B3, C1, or C3; and
- (b) All approach procedures to be flown must be retrievable from the current airborne navigation database supplied by the TSO C-129 equipment manufacturer.

NOTE—[CERTAIN] GPS AVIONICS SYSTEMS INSTALLED AND OPERATED IN ACCORDANCE WITH [wording to be added] ARE NOT APPROVED FOR “OVERLAY” PROGRAM PHASE II OR III.

e. PHASES OF THE APPROACH OVERLAY PROGRAM

- 1. **Phase I:** Phase I has been completed.
- 2. **Phase II:** Under Phase II, GPS avionics can be used as the IFR flight guidance system for an approach without actively monitoring the ground-based NAVAID(s) which defines the approach. However, the ground-based NAVAID(s) must be operational. In addition, the related avionics must be installed and operational but need not be turned on during the approach. Approaches must be requested and approved using the published title of the existing approach procedure, such as “VOR RWY 24.”
- 3. **Phase III:** Phase III begins when FAR Part 97 instrument approach procedures are retitled “or GPS” (e.g., VOR or GPS RWY 24). In this phase, ground-based NAVAID’s are not required to be operational and associated aircraft avionics need not be installed, operational, turned on, or monitored. GPS approaches will be requested and approved using the GPS title, such as “GPS RWY 24.” Stand alone GPS approaches will be developed and authorized on a case-by-case basis.

NOTE—IN EACH PHASE, ANY REQUIRED ALTERNATE AIRPORT MUST HAVE AN APPROVED INSTRUMENT APPROACH PROCEDURE OTHER THAN GPS OR LORAN-C, WHICH IS ANTICIPATED TO BE OPERATIONAL AND AVAILABLE AT THE ESTIMATED TIME OF ARRIVAL AND WHICH THE AIRCRAFT IS EQUIPPED TO FLY.

f. GPS STANDARD INSTRUMENT APPROACH PROCEDURE (SIAP) DESIGN CONCEPTS.

- 1. The objective of GPS procedures design is to supply seamless (no turn reversal required) navigation for all GPS equipped aircraft. GPS allows the most direct routing to the initial approach waypoints for standardized approaches at the maximum number of locations. The concepts described in this section provide the pilot and the air traffic controller with an efficient method for routing traffic to a particular destination.
- 2. GPS approaches are usually designed utilizing a Basic “T” concept with connecting terminal routes to the enroute airway structure. The Basic “T” design normally aligns the procedure on runway centerline, with the missed approach point (MAP) located at threshold, the final approach fix (FAF) 5 nautical miles (NM) from threshold, and the intermediate fix (IF) 5 NM from the FAF. Two initial approach fixes (IAF’s) are located 4 or 5 NM from the IF (one on each side of the IF), normally at points 90 degrees to the intermediate course. Missed approaches will normally be predicated on courses and turn waypoints to the missed approach holding fix. (See Fig 1-1-27)
- 3. When terrain, airspace, or air traffic requirements preclude use of standard Basic “T” approach construction, the flexibility of GPS allows alternatives that exploit the benefits of seamless navigation. Design possibilities include:
 - a. Modification to the Basic “T” by eliminating one of the IAF’s, changing the length of the initial legs, or the angle at which they intercept the intermediate segment.
 - b. Use of an approach design which consists of intermediate and final approach segments. This variation requires terminal routes to an IAF at the IF; and, depending on the angle of arrival at the fix, may

require a holding pattern course reversal to align the aircraft with the final approach course. (See Fig 1-1-29)

c. Where terminal routes are not published the approach will be annotated with the note: “RADAR REQUIRED.” Air Traffic must vector to a published segment of the GPS approach procedure.

4. Recent applications of “free flight” concepts advance seamless GPS procedure design philosophy, eliminate terminal routes, and use the Basic “T” enhanced by the Terminal Arrival Area (TAA). The objective of the TAA is to identify an area suitable for GPS navigation from the enroute structure direct to the Basic “T.” To the maximum extent possible, except where restricted by limitations imposed by air traffic control, surrounding terrain limitations, etc., this design is used for new or revised stand-alone GPS SIAP’s. The TAA is composed of three areas: The straight-in area, the right base area, and the left base area. These areas establish minimum terminal area IFR altitudes for procedural entry.

5. The straight-in area is semi-circular with a 30 NM radius arc beyond the top of the basic “T” centered on the IF. The arc boundary of the straight-in area is equivalent to an IAF. After crossing the boundary or when released by ATC within the TAA, aircraft are expected to proceed on a direct course to the IF. The left base and right base areas are bounded by the top of the basic “T” and the extension of the intermediate segment course, with 30 NM radius arcs centered on the IAF on each side of the “T.” (See Fig 1-1-29) The arc boundaries of the base areas are equivalent to feeder fixes. After crossing the TAA boundary from the enroute phase of flight or when released by ATC within the TAA, aircraft are expected to proceed on a direct course to the appropriate corner IAF, depending on their geographic position. Course reversals normally are not required with a TAA because routing through the “T” IAF’s provides flexibility and standardization in maneuvering to the final approach course. When circumstances require a course reversal it will be established as a holding pattern in lieu of procedure turn at the IF which will be designated as an IF (IAF).

6. Normally, the TAA will be designed with only one minimum altitude. There will be locations, especially in mountainous areas, where it will be necessary to sectorize the TAA to provide for lower altitudes prior the reaching the IAF’s. Sectors may be delineated using wedges of the circle and/or GPS nautical mile stepdown arcs. (See Fig 1-1-30) Where a stepdown arc or sector is not practical to establish lower altitudes at the IAF’s, a holding pattern course reversal will be provided. If certain parts of the TAA encompass terrain or airspace which does not allow for the establishment of an IAF within descent criteria, it may be necessary to eliminate a portion of a quadrant (or even eliminate the entire TAA). When a portion of the Basic “T” or TAA is unusable, it may be necessary to establish a terminal route to the center IF (IAF) for either a straight-in (NoPT) approach or a holding pattern course reversal. Additionally, modifications to the Basic “T,” e.g., leg length, or angle of turn to the intermediate segment, may also be used when obstructions or airspace restrict use of the basic approach design. (See Fig 1-1-31)

7. Whenever a complete TAA is charted, the minimum safe altitude (MSA) depiction found in the plan view of the approach will be omitted as the TAA altitudes provide the minimum obstacle clearances of the MSA. *Bearings and distances are to the IAF for that area of the TAA. Determination of which area of the TAA the aircraft will enter is based on the IF (IAF).* (See Fig 1-1-27)

8. Helicopter Only procedures.

a. To promote flight safety by expanding helicopter instrument flight operations and eliminating operations under visual flight rules with marginal weather conditions (scud running), the FAA has developed helicopter nonprecision instrument approach criteria that provides heliport/airport-to-heliport/airport and point-in-space operations. For these “Copter GPS” instrument approaches to be practical in metropolitan areas with obstacle rich environments, limited airspeed permits the obstacle clearance airspace to be reduced, resulting in the lowest possible approach minimums.

b. Obstacle environment permitting, Copter GPS approaches can have a minimum descent altitude (MDA) and visibility as low as 250 feet and 1/2 mile. Airspace requirements are minimized by: high accuracy of the GPS, restricting the approach speed to 70 knots from the final approach waypoint until reaching the missed approach holding waypoint; segment lengths shorter than airplanes; allowing turns up

to sixty degrees at the final approach waypoint; and taking advantage of the improved performance in the terminal mode of the GPS receiver by requiring it to be armed 30 nm from the heliport/airport reference point (HRP/ARP).

g. Receiver Autonomous Integrity Monitoring (RAIM)

1. RAIM prediction information is an “on request” item 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 GPS departure, a RAIM prediction should also be requested for the departure airport. RAIM predictions may also be accomplished using most GPS receivers.

2. RAIM problems may occur due to an insufficient number of satellites or due to unsuitable satellite geometry which causes error in the position solution to become too large. While not affected by weather and range from the station, the accuracy of GPS position data can be affected by ionospheric disturbances, equipment installation, and terrain. Variations in the ionosphere may cause slight delays in the satellite signal, resulting in small positional errors which vary with location and time. Loss of satellite reception and RAIM warnings may occur due to terrain masking or aircraft dynamics (changes in pitch or bank angle). Antenna location on a given 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.

3. 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 during the flight. This may provide early indications that an unscheduled satellite outage has occurred since takeoff.

4. If a RAIM failure occurs during the approach, the approach cannot be completed since GPS may no longer provide the required accuracy. The receiver performs a RAIM prediction 3 NM prior to the FAWP to ensure that RAIM is available at the FAWP as a condition for entering the approach mode. The pilot should ensure that 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 RAIM failure, failure to arm the receiver, or other problems to the FAWP.

5. If the receiver does not sequence into the approach mode or a RAIM failure indication occurs prior to the FAWP, the pilot should proceed to the MAWP via the FAWP, perform a missed approach, and contact ATC as soon as practical. Pilots should be especially careful to keep the CDI centered in order to remain in the obstruction clearance area, since CDI sensitivity is now at least ± 1 NM, which allows much larger deviation than the ± 0.3 NM CDI sensitivity on which the area was predicated. Refer to the receiver operating manual for specific indications and instructions associated with loss of RAIM prior to the FAF. Improper pilot actions could lead to the loss of navigation information at the FAWP. Coordinate with ATC for further instructions.

6. If a RAIM failure indication occurs after the FAWP, pilots should climb, proceed to the MAWP via the approach routing, and complete the missed approach procedure or comply with ATC instructions. If a RAIM failure occurs after the FAWP, the receiver is allowed to coast for up to 5 minutes to allow completion of the approach. The RAIM failure indication will not appear while the receiver is coasting. If the RAIM failure indication appears after the FAWP, the time limit for coasting has expired or some other problem has occurred and the missed approach should be executed immediately.

h. WAYPOINTS

1. GPS approaches make use of both fly-over and fly-by waypoints. Fly-by waypoints are used where turn anticipation is compensated for in the airspace and terrain clearances. Waypoints, except for the Missed Approach Waypoint (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. New approach charts depict fly-over waypoints as a circled waypoint symbol to differentiate between these two types of waypoints. Overlay approach charts and some initial stand alone GPS approach charts may not reflect this convention.

2. On overlay approaches (titled “or GPS”), if no five character name is published for the approach waypoint or fix, it will normally be coded with a database identifier consisting of letters and numbers. These points will appear in the list of waypoints in the approach procedure database, but may not appear on the approach chart. Procedures without a Final Approach Fix (FAF), for instance, have a Sensor Final Approach Waypoint (FAWP) added to the database at least 4 NM prior to the MAWP to allow the receiver to transition to the approach mode. Some approaches also contain an additional waypoint in the holding pattern when the MAWP and MAHWP are co-located. Arcing and radial approaches have an additional waypoint that is used for turn anticipation computation where the arc joins the final approach course. These coded names will not be used by ATC.

3. Unnamed waypoints in the database will be uniquely identified for the airport specified. Refer to the receiver manuals for the abbreviations used by that manufacturer.

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

i. CURVED PATH GUIDANCE

Some GPS receivers provide curved path guidance. Flying a curved path using the CDI is a new task for most pilots and will require some practice to become proficient. Air carrier operators may be required to receive this training as part of their FAA approved training programs. The amount of turn anticipation, method of notification, and whether guidance is provided through the turn varies between GPS receivers. Accelerating or decelerating during a turn may lead to the CDI jumping as GPS recomputes the turn radius during the turn. Overshoots or undershoots will result if the airspeed change is large and the receiver or pilot does not compensate.

j. POSITION ORIENTATION

Pilots must 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 even when the pilot is not flying along the 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. The pilot may have to compute the along track distance to stepdown own fixes and other points due to the receiver showing along track distance to the next waypoint rather than DME to the VOR or ILS ground station.

k. CONVENTIONAL VERSUS GPS NAVIGATION DATA

There may be slight differences between the navigation information portrayed on navigation 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 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. Variations in distances will occur due to GPS distance-to-waypoint values being along track (straight-line) distances computed to the next waypoint and the DME values published on underlying procedures being slant range distances measured to the station.

m. DEPARTURES AND STANDARD INSTRUMENT DEPARTURES (SIDs)

Since terminal operations are predicated on terminal (\pm NM) RAIM and CDI sensitivity, the GPS receiver must be set to terminal (\pm 1 NM) CDI sensitivity and RAIM prior to takeoff for IFR departures and SIDs. (Some receivers do not use enroute RAIM and will automatically be in terminal RAIM. Departure RAIM may not be available unless the waypoints are part of the active flight plan rather than proceeding direct.) Flying SIDs will normally require some manual intervention by the pilot, especially when radar vectored to a course or required to intercept a specific course to a waypoint. The data base may not contain all of the transitions or departures from all runways, and may require insertion of additional waypoints or deletion depending on the departure clearance. Some GPS receivers do not contain SIDs in the database. Since helicopter departure procedures and missed approaches use a much steeper 20:1 obstacle clearance surface (OCS) which is double the fixed-wing OCS, it is important that airspeed not exceed 70 knots on a GPS departure or missed approach until reaching the specified altitude in the procedure.

n. FLYING GPS APPROACHES

1. 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 Fig 1-1-29 and 30)

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

3. When an approach has been loaded in the flight plan, GPS receivers will give an “arm” annunciation 30 NM straight line distance from the airport/heliport reference point. Pilots should arm the approach mode at this time, if it has not already been armed (some receivers arm automatically). Without arming, the receiver will not change the CDI and RAIM sensitivity from \pm 5 NM enroute sensitivity either side of centerline to \pm 1 NM terminal sensitivity. Where the IAWP is inside this 30 mile point, a course deviation indicator (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. Obstacle clearance is predicated on terminal (\pm 1 NM) CDI sensitivity and RAIM within 30 NM of the airport/heliport reference point, therefore, the receiver should always be armed not later than the 30 NM annunciation.

4. The pilot must be aware of what bank angle/turn rate the particular receiver uses to compute turn anticipation, and whether wind and airspeed are included in the receiver’s calculations. This information should be in the receiver operating manual. Over or under banking the turn onto the final approach course may significantly delay getting on course and may result in high descent rates to the next altitude.

5. When within 2 NM of the FAWP with the approach mode armed the approach mode will switch to active, 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 \pm 1 NM, to \pm 0.3 NM at the FAWP. As sensitivity increases from \pm 1 NM to \pm 0.3 NM approaching the FAWP, the corresponding increase in CDI displacement, if it is not centered, may give the impression that the aircraft is moving further away from the intended course even though it is in fact on an acceptable intercept heading. Care must be taken not to misinterpret increasing CDI displacement, due to increasing GPS CDI sensitivity when approaching the FAWP, as a deviation from the planned course. 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. This will also preclude the heading or distance from being outside the parameters for the receiver to capture the approach at the FAWP. 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 receivers suggest placing the receiver in the nonsequencing mode on the FAWP and manually setting the course. This provides an extended final approach course in cases where it is intercepted further from the airport than any existing segment which is aligned with the runway. However, required altitudes at waypoints outside the FAWP on stepdown fixes must be considered. Calculating the along track distance to the FAWP may be required in order to descend at the proper location. Joining the approach at another point outside the FAWP, which is aligned with the final approach course and allows the receiver to sequence through the remainder of the approach[,] may be desirable in some situations.

6. Overriding an automatically selected sensitivity during an approach will cancel the approach mode annunciation. If the approach mode is not armed at 3 NM prior to the FAWP, the approach mode will not become active at 2 NM prior to the FAWP, the equipment will flag (GPS navigation guidance may be removed), the RAIM and CDI sensitivity will not ramp down, and the approach cannot be flown beyond the FAWP. [Annunciators] and/or the receiver should be checked to ensure the approach mode is active prior to the FAWP.

7. Do not attempt to fly an approach which is not in the 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 increase to ± 0.3 NM. Manually setting CDI sensitivity does not automatically change the RAIM on some receivers. Some existing procedures cannot be coded for use with GPS and will not be available as overlays.

8. Pilots should pay particular attention to the exact operation of their GPS receivers for performing holding patterns and overlay operations such as holding in lieu of 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. These approach procedures may require the pilot to fly over the same point more than once. Care must be exercised to ensure that 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., 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.

9. Incorrect inputs into the GPS receiver are especially critical during approaches. In some cases, an incorrect entry can cause the receiver to leave the approach mode. Studying and understanding how to recover from incorrect entries is an important part of learning to use the GPS receiver.

10. A fix on an overlay approach identified by a DME fix will not be displayed on the GPS receiver unless there is a published name assigned to it. When a name is assigned, the along track to the waypoint may be 0 rather than the DME stated on the approach chart. If the fix is not assigned a waypoint name, the along track distance displayed on the GPS receiver may not agree with the approach chart DME reference distance. The pilot should be alert for this on any overlay procedure where the original approach used DME.

11. The Visual Descent Point (VDP) is not included in the sequence of waypoints. Pilots are expected to use normal piloting techniques for beginning the visual descent. In addition, unnamed step-down fixes in the final approach segment will not be coded in the waypoint sequence and must be identified using Along Track Distance (ATD). If the step-down fix is used as a Sensor FAWP on a no-FAF overlay approach procedure, it will be included in the waypoint sequence.

12. MISSED APPROACH

a. 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 immediately after the MAWP. Activating the missed approach prior to the MAWP will cause CDI sensitivity to immediately increase to terminal sensitivity even though the receiver continues to navigate to the MAWP, The receiver will still not sequence past the MAWP in this case. Turns should not begin prior

to the MAWP, Sequencing the receiver at the MAWP is especially critical if a turn is required at the MAWP, since the GPS receiver will display an extension of the inbound final approach course and increasing distance from the MAWP until the missed approach is selected. Following this guidance when a turn is required could result in exceeding the protected airspace for the missed approach procedure.

b. 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.

13. Pilots should practice GPS approaches under visual meteorological conditions (VMC) until thoroughly proficient with all aspects of their equipment (receiver and installation) prior to attempting flight by instrument flight rules (IFR) in instrument meteorological conditions (IMC). Some of the areas in which proficiency should be established are:

- a. Utilizing the receiver autonomous integrity monitoring (RAIM) prediction function,
- b. Programming a SID, including terminal CDI sensitivity, if required, and the conditions under which terminal RAIM is available for departure (some receivers are not SID or STAR capable),
- c. Programming the destination airport,
- d. Programming and flying the overlay (especially procedure turns and arcs), airport and copter approaches,
- e. Changing to another approach after selecting an approach,
- f. Programming and flying “direct” missed approaches,
- g. Programming and flying “routed” missed approaches,
- h. Entering, flying and exiting holding patterns, particularly on overlay approaches with a second waypoint in the holding pattern,
- i. Programming and flying a “route” from a holding pattern,
- j. Programming and flying an approach with radar vectors to the intermediate segment,
- k. Indication of [the] actions required for RAIM failure both before and after the FAWP
- l. Programming a radial and distance from a VOR (often used in departure instructions)

PILOT CONTROLLER GLOSSARY INPUTS

Airport Reference Point (ARP) - The approximate geometric center of all usable runway surfaces.

Desired Course

- a. True - A predetermined desired course direction to be followed (measured in degrees from true north).
- b. Magnetic - A predetermined desired course direction to be followed (measured in degrees from local magnetic north).

Desired Track - The planned or intended track between two waypoints. It is measured in degrees from either magnetic or true north. The instantaneous angle may change from point to point along the great circle track between waypoints.

Cross Track Error

FAWP - Final Approach Waypoint

Heliport Reference Point (HRP) - The geographic center of a heliport.

IAWP - Initial Approach Waypoint

IFWP - Intermediate Fix Waypoint

IF/IAWP - Intermediate Fix/Initial Approach Waypoint The waypoint where the final approach course of a T approach meets the crossbar of the T. When designated (in conjunction with a TAA) this waypoint will be used as an IAWP when approaching the airport from certain directions, and as an IFWP when beginning the approach from another IAWP.

Integrity - The ability of a system to provide timely warnings to users when the system should not be used for navigation.

MAHWP - Missed Approach Holding Waypoint

MAWP - Missed Approach Waypoint

Receiver Autonomous Integrity Monitoring (RAIM) - A technique whereby a civil GNSS receiver/processor determines the integrity of the GNSS navigation signals without reference to sensors or non-DoD integrity systems other than the receiver itself. This determination is achieved by a consistency check among redundant pseudorange measurements.

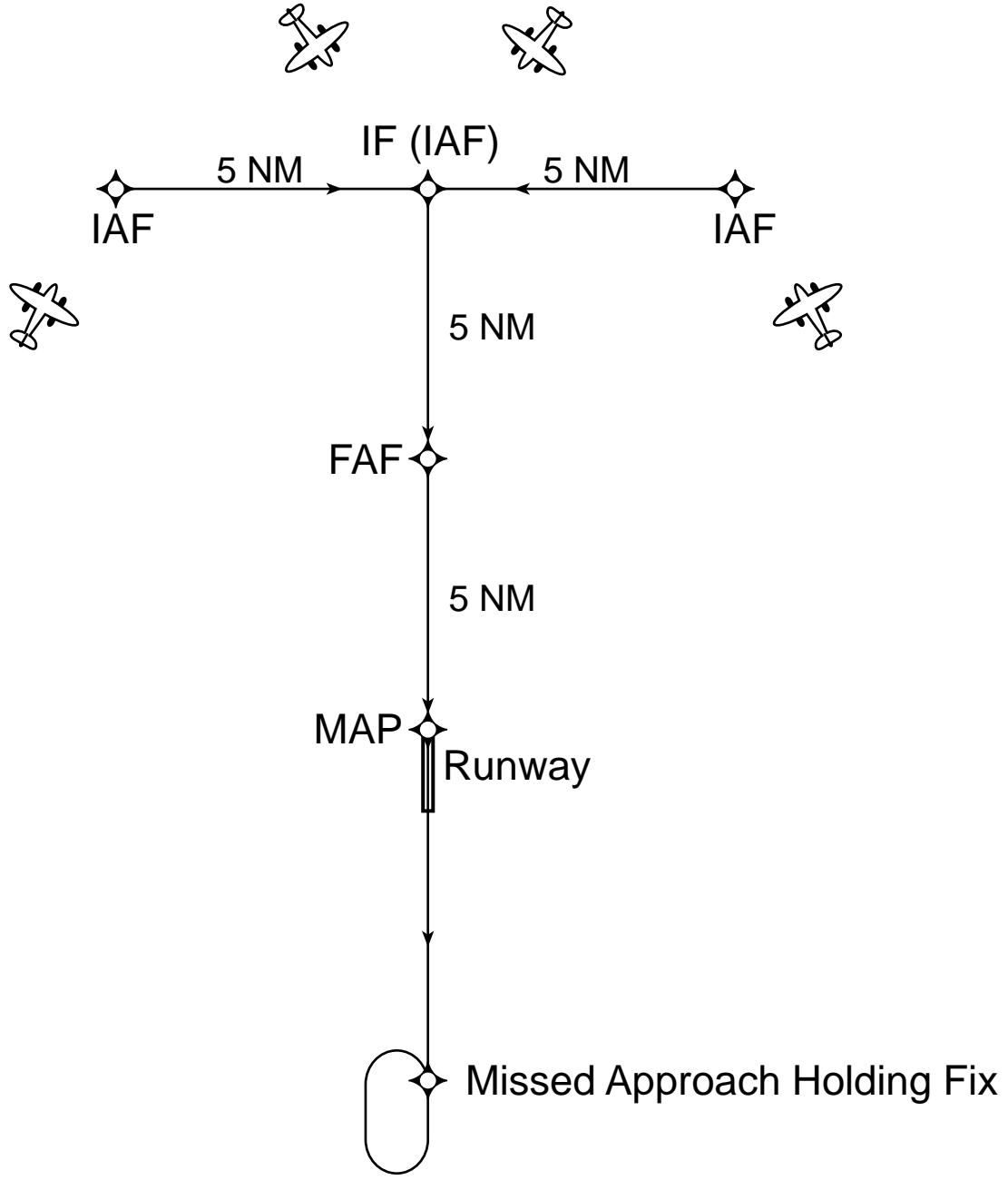
Turn Anticipation - (maneuver anticipation)

GPS IFR Equipment Classes/Categories

<i>TSO-C129</i>						
<i>EQUIPMENT CLASS</i>	<i>RAIM</i>	<i>INT. NAV SYS. TO PROVIDE RAIM EQUIV.</i>	<i>OCEANIC</i>	<i>EN ROUTE</i>	<i>TERMINAL</i>	<i>NONPRECISION APPROACH CAPABLE</i>
Class A — GPS sensor and navigation capability.						
A1	yes		yes	yes	yes	yes
A2	yes		yes	yes	yes	no
Class B — GPS sensor data to an integrated navigation system (i.e., multi-sensor navigation system, etc.)						
B1	yes		yes	yes	yes	
B2	yes		yes	yes	yes	no
B3		yes	yes	yes	yes	
B4		yes	yes	yes	yes	no
Class C — GPS sensor data to an integrated navigation system (as in Class B) which provides enhanced guidance to an autopilot or flight director, to reduce flight technical errors [FTE]. Limited to FAR 121 or equivalent criteria.						
C1	yes		yes	yes	yes	
C2	yes		yes	yes	yes	no
C3		yes	yes	yes	yes	
C4		yes	yes	yes	yes	no

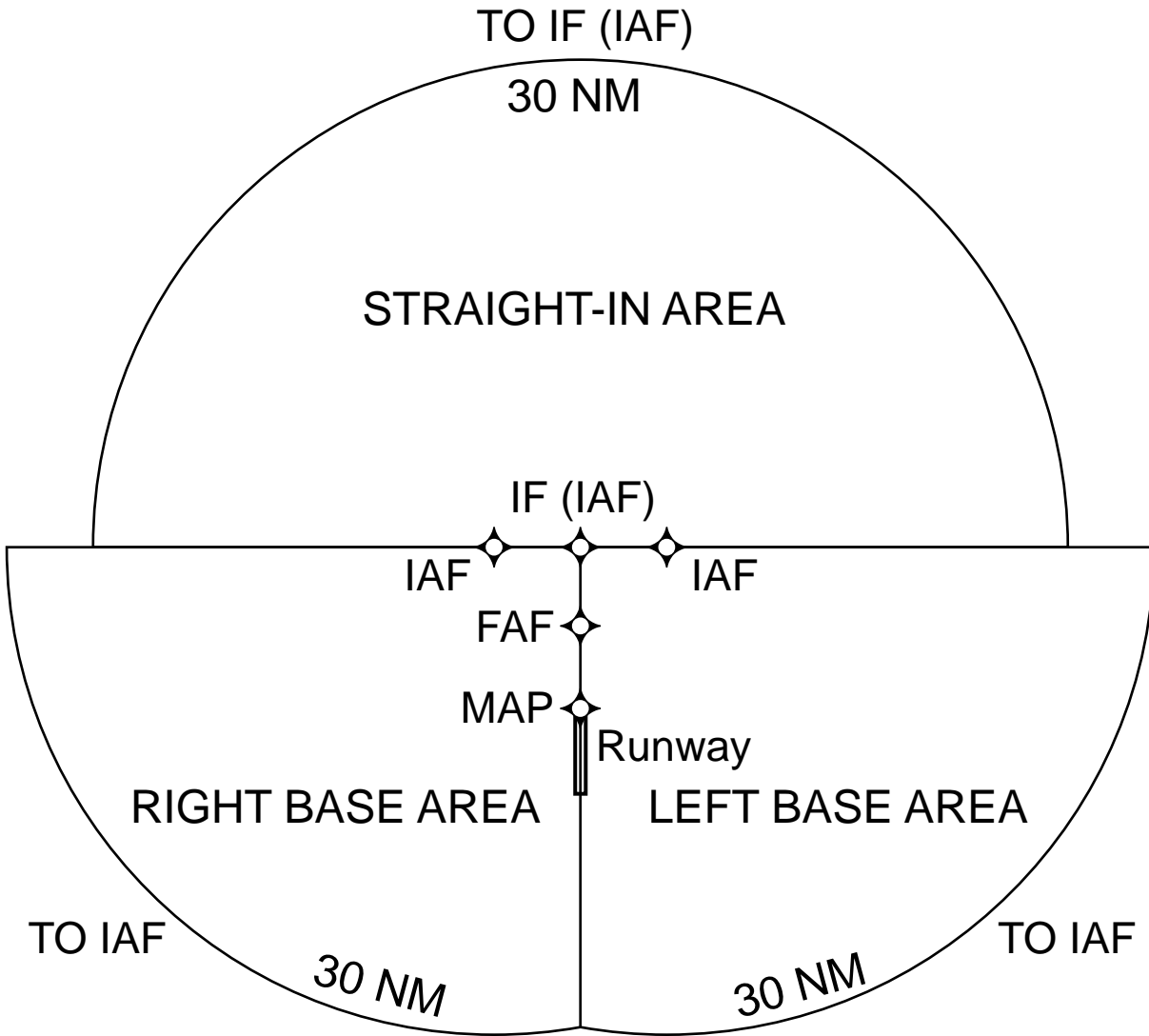
TBL 1-1-10

Plan View



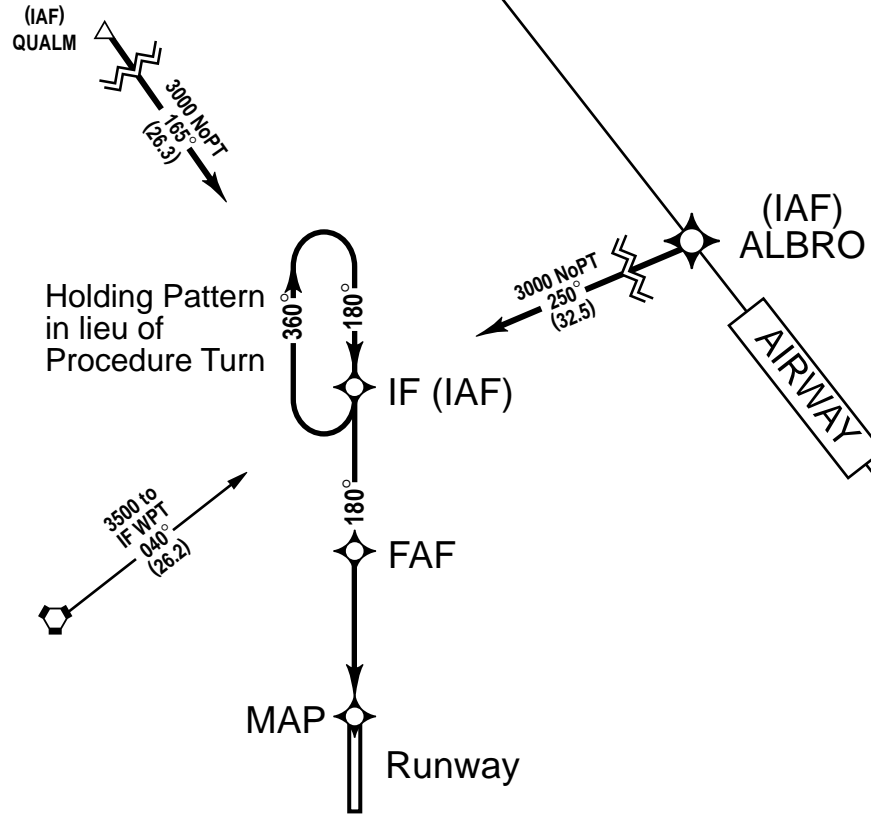
BASIC "T" DESIGN

Plan View

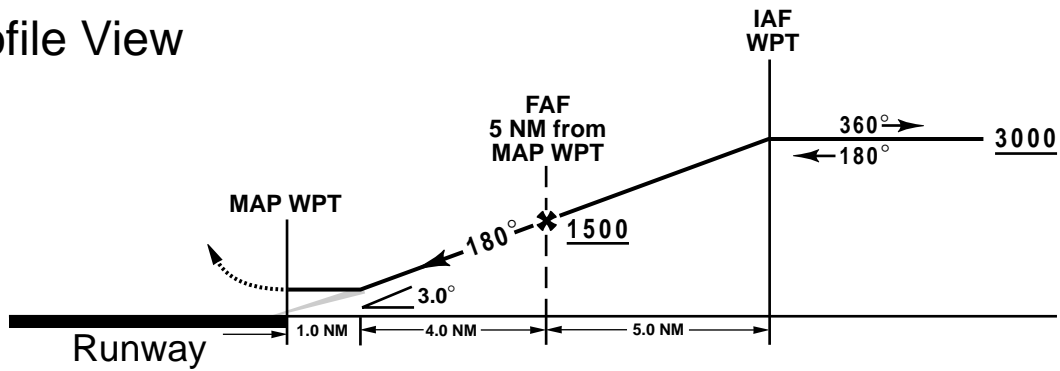


BASIC "T" & TAA DESIGN

Plan View



Profile View



ROUTE ARRIVALS AND NO TAA