1-1-21. GLOBAL POSITIONING SYSTEM (GPS)

a. System Overview.

1. GPS is a U.S. 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 U.S. and allied military, federal government, and civil users who can satisfy specific U.S. requirements.

{New-2001-7 3. Revised July 12, 2001}

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 coarse acquisition (C/A) 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.

{New-2001-7 4. Revised July 12, 2001}

4. The GPS receiver matches each satellite's C/A code with an identical copy of the code contained in the receiver's data base. 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: ionospheric and tropospheric delays and multipath.

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 transmits 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 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, ground speed, etc., by using the aircraft's known latitude/longitude and referencing these to a data base 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 a minimum of

four satellites above the mask angle (the lowest angle above the horizon at which it can use a satellite).

8. 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. 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 a minimum of 5 satellites in view, or 4 satellites and a barometric altimeter (baro-aiding) to detect an integrity anomaly. For receivers capable of doing so, 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. Baro-aiding is a method of augmenting the GPS integrity solution by using a nonsatellite input source. GPS derived altitude should not be relied upon to determine aircraft altitude since the vertical error can be quite large. To ensure that baro-aiding is available, the current altimeter setting must be entered into the receiver as described in the operating manual.

9. RAIM messages vary somewhat between receivers; however, generally there are two types. One type indicates that there are not enough satellites available to provide RAIM integrity monitoring and another type indicates that the RAIM integrity monitor has detected a potential error that exceeds the limit for the current phase of flight. Without RAIM capability, the pilot has no assurance of the accuracy of the GPS position.

10. The DOD declared initial operational capability (IOC) of the U.S. GPS on December 8, 1993. The 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 en route, 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 as well as approved air carrier operations specifications.

{New-2001-4 b. revised January 25, 2001}

b. VFR Use of GPS

1. GPS navigation has become a great asset to VFR pilots, providing increased navigation capability and enhanced situational awareness, while reducing operating costs due to greater ease in flying direct routes. While GPS has many benefits to the VFR pilot, care must be exercised to ensure that system capabilities are not exceeded.

2. Types of receivers used for GPS navigation under VFR are varied, from a full IFR installation being used to support a VFR flight, to a VFR only installation (in either a VFR or IFR capable aircraft) to a hand-held receiver. The limitations of each type of receiver installation or use must be understood by the pilot to avoid misusing navigation information. (See TBL 1-1-8.) In all cases, VFR pilots should never rely solely on one system of navigation. GPS navigation must be integrated with other forms of electronic navigation (when possible), as well as pilotage and dead reckoning. Only through the integration of these techniques can the VFR pilot ensure accuracy in navigation.

3. Some critical concerns in VFR use of GPS include RAIM capability, data base currency and antenna location.

(a) RAIM Capability. Many VFR GPS receivers and all hand-held units have no RAIM alerting capability. Loss of the required number of satellites in view, or the detection of a position error, cannot be displayed to the pilot by such receivers. In receivers with no RAIM capability, no alert would be provided to the pilot that the navigation solution had deteriorated, and an undetected navigation error could occur. A systematic cross-check with other navigation techniques would identify this failure, and prevent a serious deviation. See subparagraphs a8 and a9 for more information on RAIM.

(b) Database Currency

(1) In many receivers, an up-datable database is used for navigation fixes, airports, and instrument procedures. These databases must be maintained to the current update for IFR operation, but no such requirement exists for VFR use.

(2) However, in many cases, the database drives a moving map display which indicates Special Use Airspace and the various classes of airspace, in addition to other operational information. Without a current database the moving map display may be outdated and offer erroneous information to VFR pilots wishing to fly around critical airspace areas, such as a Restricted Area or a Class B airspace segment. Numerous pilots have ventured into airspace they were trying to avoid by using an outdated database. If you don't have a current database in the receiver, disregard the moving map display for critical navigation decisions.

(3) In addition, waypoints are added, removed, relocated, or renamed as required to meet operational needs. When using GPS to navigate relative to a named fix, a current database must be used to properly locate a named waypoint. Without the update, it is the pilot's responsibility to verify the waypoint location referencing to an official current source, such as the Airport/Facility Directory, Sectional Chart, or En Route Chart.

(c) Antenna Location

(1) In many VFR installations of GPS receivers, antenna location is more a matter of convenience than performance. In IFR installations, care is exercised to ensure that an adequate clear view is provided for the antenna to see satellites. If an alternate location is used, some portion of the aircraft may block the view of the antenna, causing a greater opportunity to lose navigation signal.

(2) This is especially true in the case of hand-helds. The use of hand-held receivers for VFR operations is a growing trend, especially among rental pilots. Typically, suction cups are used to place the GPS antennas on the inside of cockpit windows. While this method has great utility, the antenna location is limited to the cockpit or cabin only and is rarely optimized to provide a clear view of available satellites. Consequently, signal losses may occur in certain situations of aircraft-satellite geometry, causing a loss of navigation signal. These losses, coupled with a lack of RAIM capability, could present erroneous position and navigation information with no warning to the pilot.

(3) While the use of a hand-held GPS for VFR operations is not limited by regulation, modification of the aircraft, such as installing a panel- or yoke-mounted holder, is governed by 14 CFR Part 43. Consult with your mechanic to ensure compliance with the regulation, and a safe installation.

4. As a result of these and other concerns, here are some tips for using GPS for VFR operations:

(a) Always check to see if your unit has RAIM capability. If no RAIM capability exists, be suspicious of your GPS position when any disagreement exists with the position derived from other radio navigation systems, pilotage, or dead reckoning.

(b) Check the currency of the database, if any. If expired, update the database using the current revision. If an update of an expired database is not possible, disregard any moving map display of airspace for critical navigation decisions. Be aware that named waypoints may no longer exist or may have been relocated since the database expired. At a minimum, the waypoints planned to be used should be checked against a current official source, such as the Airport/Facility Directory, or a Sectional Aeronautical Chart.

(c) While hand-helds can provide excellent navigation capability to VFR pilots, be prepared for intermittent loss of navigation signal, possibly with no RAIM warning to the pilot. If mounting the receiver in the aircraft, be sure to comply with 14 CFR Part 43.

(d) Plan flights carefully before taking off. If you wish to navigate to user-defined waypoints, enter them before flight, not on-the-fly. Verify your planned flight against a current source, such as a current sectional chart. There have been cases in which one pilot used waypoints created by another pilot that were not where the pilot flying was expecting. This generally resulted in a navigation error. Minimize head-down time in the aircraft and keep a sharp lookout for traffic, terrain, and obstacles. Just a few minutes of preparation and planning on the ground will make a great difference in the air.

(e) Another way to minimize head-down time is to become very familiar with your receiver's operation. Most receivers are not intuitive. The pilot must take the time to learn the various keystrokes, knob functions, and displays that are used in the operation of the receiver. Some manufacturers provide computer-based tutorials or simulations of their receivers. Take the time to learn about your particular unit before you try to use it in flight.

5. In summary, be careful not to rely on GPS to solve all your VFR navigational problems. Unless an IFR receiver is installed in accordance with IFR requirements, no standard of accuracy or integrity has been assured. While the practicality of GPS is compelling, the fact remains that only the pilot can navigate the aircraft, and GPS is just one of the pilot's tools to do the job.

{New-2001-4 c. revised January 25, 2001}

c. VFR Waypoints

1. VFR waypoints provide VFR pilots with a supplementary tool to assist with position awareness while navigating visually in aircraft equipped with area navigation receivers. VFR waypoints should be used as a tool to supplement current navigation procedures. The uses of VFR waypoints include providing navigational aids for pilots unfamiliar with an area, waypoint definition of existing reporting points, enhanced navigation in and around Class B and Class C airspace, and enhanced navigation around Special Use Airspace. VFR pilots should rely on appropriate and current aeronautical charts published specifically for visual navigation. If operating in a terminal area, pilots should take advantage of the Terminal Area Chart available for that area, if published. The use of VFR waypoints does not relieve the pilot of any responsibility to comply with the operational requirements of 14 CFR Part 91.

2. VFR waypoint names (for computer-entry and flight plans) consist of five letters beginning with the letters "VP" and are retrievable from navigation databases. NOTICE: Effective on 6/15/00 VFR waypoint names shall consist of five letters beginning with the letters "VP." The change is effective for all GPS databases and aviation publications. The Los Angeles Helicopter Route Chart depicts VFR waypoint names beginning with "VV." The chart will be updated to the "VP" naming convention at the next publication of the chart.

The VFR waypoint names are not intended to be pronounceable, and they are not for use in ATC communications. On VFR charts, stand-alone VFR waypoints will be portrayed using the same four-point star symbol used for IFR waypoints. VFR waypoints collocated with visual check points on the chart will be identified by small magenta flag symbols. VFR waypoints collocated with visual check points will be pronounceable based on the name of the visual check point and may be used for ATC communications. Each VFR waypoint name will appear in parentheses adjacent to the geographic location on the chart. Latitude/longitude data for all established VFR waypoints may be found in the appropriate regional Airport/Facility Directory (A/FD).

3. VFR waypoints shall not be used to plan flights under IFR. VFR waypoints will not be recognized by the IFR system and will be rejected for IFR routing purposes.

4. When filing VFR flight plans, pilots may use the five letter identifier as a waypoint in the route of flight section if there is an intended course change at that point or if used to describe the planned route of flight. This VFR filing would be similar to how a VOR would be used in a route of flight. Pilots must use the VFR waypoints only when operating under VFR conditions.

5. Any VFR waypoints intended for use during a flight should be loaded into the receiver while on the ground and prior to departure. Once airborne, pilots should avoid programming routes or VFR waypoint chains into their receivers.

6. Pilots should be especially vigilant for other traffic while operating near VFR waypoints. The same effort to see and avoid other aircraft near VFR waypoints will be necessary, as was the case with VOR's and NDB's in the past. In fact, the increased accuracy of navigation through the use of GPS will demand even greater vigilance, as off-course deviations among different pilots and receivers will be less. When operating near a VFR waypoint, use whatever ATC services are available, even if outside a class of airspace where communications are required. Regardless of the class of airspace, monitor the available ATC frequency closely for information on other aircraft operating in the vicinity. It is also a good idea to turn on your landing light(s) when operating near a VFR waypoint to make your aircraft more conspicuous to other pilots, especially when visibility is reduced. See paragraph 7-5-2, VFR in Congested Areas, for more information.

{New-2001-4 d. revised January 25, 2001}

d. The Gulf of Mexico Grid System

1. On October 8, 1998, the Southwest Region of the FAA, with assistance from the Helicopter Safety Advisory Conference (HSAC), implemented the world's first Instrument Flight Rules (IFR) Grid System in the Gulf of Mexico. This navigational route structure is completely independent of ground-based navigation aids (NAVAID's) and was designed to facilitate helicopter IFR operations to offshore destinations. The Grid System is defined by over 300 offshore waypoints located 20 minutes apart (latitude and longitude). Flight plan routes are routinely defined by just 4 segments; departure point (lat/long), first en route grid waypoint, last en route grid waypoint prior to approach procedure, and destination point (lat/long). There are over 4,000 possible offshore landing sites. Upon reaching the waypoint prior to the destination, the pilot may execute an Offshore Standard Approach Procedure (OSAP), a Helicopter En Route Descent Areas (HEDA) approach, or an Airborne Radar Approach (ARA). For more information on these helicopter instrument procedures, refer to FAA AC 90-80B, Approval of Offshore Standard Approach Procedure (OSAP), Airborne Radar Approaches (ARA), and Helicopter En Route Areas (HEDA) Criteria, on the Flight Standards web site http://terps.faa.gov. The return flight plan is just the reverse with the requested stand-alone GPS approach contained in the remarks section.

2. The large number (over 300) of waypoints in the grid system makes it difficult to assign phonetically pronounceable names to the waypoints that would be meaningful to pilots and controllers. A unique naming system was adopted that enables pilots and controllers to derive the fix position from the name. The five-letter names are derived as follows:

(a) The waypoints are divided into sets of 3 columns each. A three-letter identifier, identifying a geographical area or a NAVAID to the north, represents each set.

(b) Each column in a set is named after its position, i.e., left (L), center (C), and right (R).

(c) The rows of the grid are named alphabetically from north to south, starting with A for the northern most row.

EXAMPLE -

LCHRC would be pronounced "Lake Charles Romeo Charlie." The waypoint is in the right-hand column of the Lake Charles VOR set, in row C (third south from the northern most row).

3. Since the grid system's implementation, IFR delays (frequently over 1 hour in length) for operations in this environment have been effectively eliminated. The comfort level of the pilots, knowing that they will be given a clearance quickly, plus the mileage savings in this near free-flight environment, is allowing the operators to carry less fuel. Less fuel means they can transport additional passengers, which is a substantial fiscal and operational benefit, considering the limited seating on board helicopters.

4. There are 3 requirements for operators to meet before filing IFR flight plans utilizing the grid:

(a) The helicopter must be IFR certified and equipped with IFR certified TSO C-129 GPS navigational units.

(b) The operator must obtain prior written approval from the appropriate Flight Standards District Office through a Certificate of Authorization or revision to their Operations Specifications, as appropriate.

(c) The operator must be a signatory to the Houston ARTCC Letter of Agreement.

5. FAA/NACO publishes the grid system waypoints on the IFR Gulf of Mexico Vertical Flight Reference Chart. A commercial equivalent is also available. The chart is updated annually and is available from a FAA chart agent or FAA directly, website address: http://acc.nos.noaa.gov.

{New-2001-4 e. revised January 25, 2001}

e. General Requirements

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

(a) GPS navigation equipment used must be approved in accordance with the requirements specified in Technical Standard Order (TSO) C-129, or equivalent, and the installation must be done in accordance with Advisory Circular AC 20-138, Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Supplemental Navigation System, or Advisory Circular AC 20-130A, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, or equivalent. Equipment approved in accordance with TSO C-115a does not meet the requirements of TSO C-129. Visual flight rules (VFR) and hand-held GPS systems are not authorized for IFR navigation, instrument approaches, or as a principal instrument flight reference. During IFR operations they may be considered only an aid to situational awareness.

(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 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.

(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, receiver 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 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.

(e) Aircraft navigating by IFR approved GPS are considered to be area navigation (RNAV) aircraft and have special equipment suffixes. File the appropriate equipment suffix in accordance with TBL 5-1-2, on the ATC flight plan. 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 NOTAM's and aeronautical information. (See GPS NOTAM's/Aeronautical Information.)

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

{New-2001-4 f. revised January 25, 2001}

f. Use of GPS for IFR Oceanic, Domestic En Route, and Terminal Area Operations

1. GPS IFR operations in oceanic areas can be conducted as soon as the 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 may be used to replace one of the other approved means of long-range navigation, such as dual INS or dual Omega. (See TBL 1-1-7 and TBL 1-1-8.) A single GPS installation with these classes of equipment which provide RAIM for integrity monitoring may also be used on short oceanic routes which have only required one means of long-range navigation.

TBL 1-1-8 GPS Approval Required/Authorized Use

EQUIPMENT TYPE 1	INSTALLATION APPROVAL REQUIRED	OPERATIONAL APPROVAL REQUIRED	IFR EN ROUTE 2	IFR TERMINAL 2	IFR APPROACH 3	OCEANIC REMOTE	IN LIEU OF ADF AND/OR DME 3
Hand held4	X 5						
VFR Panel Mount 4	X						
IFR En Route and Terminal	X	X	X				X
IFR Oceanic/Remote	X	X	X		X		X
IFR En Route, Terminal, and Approach	X	X	X	X			X

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2. GPS domestic en route 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 nonprecision instrument approach procedures, except LOC, LDA, and simplified directional facility (SDF) procedures. Only those approaches included in the receiver data base 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.

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 U.S. 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 U.S. must be authorized by the appropriate sovereign authority.

5. Subject to the restrictions below, operators in the U.S. NAS are authorized to use GPS equipment certified for IFR operations in place of ADF and/or DME equipment for en route and terminal operations. For some operations there is no requirement for the aircraft to be equipped with an ADF or DME receiver, see subparagraphs f.6.(g) and (h) below. The ground based NDB or DME facility may be temporarily out of service during these operations. Charting will not change to support these operations.

(a) Determining the aircraft position over a DME fix. GPS satisfies the 14 CFR Section 91.205(e) requirement for DME at and above 24,000 feet mean sea level (MSL) (FL 240).

(b) Flying a DME arc.

(c) Navigating to/from an NDB/compass locator.

(d) Determining the aircraft position over an NDB/compass locator.

(e) Determining the aircraft position over a fix defined by an NDB/compass locator bearing crossing a VOR/LOC course.

(f) Holding over an NDB/compass locator.

NOTE - This approval does not alter the conditions and requirements for use of GPS to fly existing nonprecision instrument approach procedures as defined in the GPS approach overlay program.

6. Restrictions

(a) GPS avionics approved for terminal IFR operations may be used in lieu of ADF and/or DME. Included in this approval are both stand-alone and multi-sensor systems actively employing GPS as a sensor. This equipment must be installed in accordance with appropriate airworthiness installation requirements and the provisions of the applicable FAA approved AFM, AFM supplement, or pilot's guide must be met. The required integrity for these operations must be provided by at least en route RAIM, or an equivalent method; i.e., Wide Area Augmentation System (WAAS).

(b) For air carriers and operators for compensation or hire, Principal Operations Inspector (POI) and operations specification approval is required for any use of GPS.

(c) Waypoints, fixes, intersections, and facility locations to be used for these operations must be retrieved from the GPS airborne database. The database must be current. If the required positions cannot be retrieved from the airborne database, the substitution of GPS for ADF and/or DME is not authorized.

(d) The aircraft GPS system must be operated within the guidelines contained in the AFM, AFM supplement, or pilot's guide.

(e) The CDI must be set to terminal sensitivity (normally 1 or 1 1/4 NM) when tracking GPS course guidance in the terminal area. This is to ensure that small deviations from course are displayed to the pilot in order to keep the aircraft within the smaller terminal protected areas.

(f) Charted requirements for ADF and/or DME can be met using the GPS system, except for use as the principal instrument approach navigation source.

(g) Procedures must be established for use in the event that GPS integrity outages are predicted or occur (RAIM annunciation). In these situations, the flight must rely on other approved equipment; this may require the aircraft to be equipped with operational NDB and/or DME receivers. Otherwise, the flight must be rerouted, delayed, canceled or conducted VFR.

(h) A non-GPS approach procedure must exist at the alternate airport when one is required. If the non-GPS approaches on which the pilot must rely require DME or ADF, the aircraft must be equipped with DME or ADF avionics as appropriate.

7. Guidance. The following provides general guidance which is not specific to any particular aircraft GPS system. For specific system guidance refer to the AFM, AFM supplement, pilot's guide, or contact the manufacturer of your system.

(a) To determine the aircraft position over a DME fix:

(1) Verify aircraft GPS system integrity monitoring is functioning properly and indicates satisfactory integrity.

(2) If the fix is identified by a five letter name which is contained in the GPS airborne database, you may select either the named fix as the active GPS waypoint (WP) or the facility establishing the DME fix as the active GPS WP.

NOTE - When using a facility as the active WP, the only acceptable facility is the DME facility which is charted as the one used to establish the DME fix. If this facility is not in your airborne database, you are not authorized to use a facility WP for this operation.

(3) If the fix is identified by a five letter name which is not contained in the GPS airborne database, or if the fix is not named, you must select the facility establishing the DME fix or another named DME fix as the active GPS WP.

NOTE - An alternative, until all DME sources are in the database, is using a named DME fix as the active waypoint to identify unnamed DME fixes on the same course and from the same DME source as the active waypoint.

CAUTION -

Pilots should be extremely careful to ensure that correct distance measurements are used when utilizing this interim method. It is strongly recommended that pilots review distances for DME fixing during preflight preparation.

(4) If you select the named fix as your active GPS WP, you are over the fix when the GPS system indicates you are at the active WP.

(5) If you select the DME providing facility as the active GPS WP, you are over the fix when the GPS distance from the active WP equals the charted DME value and you are on the appropriate bearing or course.

(b) To fly a DME arc:

(1) Verify aircraft GPS system integrity monitoring is functioning properly and indicates satisfactory integrity.

(2) You must select, from the airborne database, the facility providing the DME arc as the active GPS WP.

NOTE - The only acceptable facility is the DME facility on which the arc is based. If this facility is not in your airborne database, you are not authorized to perform this operation.

(3) Maintain position on the arc by reference to the GPS distance in lieu of a DME readout.

(c) To navigate to or from an NDB/compass locator:

NOTE - If the chart depicts the compass locator collocated with a fix of the same name, use of that fix as the active WP in place of the compass locator facility is authorized.

(1) Verify aircraft GPS system integrity monitoring is functioning properly and indicates satisfactory integrity.

(2) Select terminal CDI sensitivity in accordance with the AFM, AFM supplement, or pilot's guide if in the terminal area.

(3) Select the NDB/compass locator facility from the airborne database as the active WP.

(4) Select and navigate on the appropriate course to or from the active WP.

(d) To determine the aircraft position over an NDB/compass locator:

(1) Verify aircraft GPS system integrity monitoring is functioning properly and indicates satisfactory integrity.

(2) Select the NDB/compass locator facility from the airborne database as the active WP.

NOTE - When using an NDB/compass locator, that facility must be charted and be in the airborne database. If this facility is not in your airborne database, you are not authorized to use a facility WP for this operation.

(3) You are over the NDB/compass locator when the GPS system indicates you are at the active WP.

(e) To determine the aircraft position over a fix made up of an NDB/compass locator bearing crossing a VOR/LOC course:

(1) Verify aircraft GPS system integrity monitoring is functioning properly and indicates satisfactory integrity.

(2) A fix made up by a crossing NDB/compass locator bearing will be identified by a five letter fix name. You may select either the named fix or the NDB/compass locator facility providing the crossing bearing to establish the fix as the active GPS WP.

NOTE - When using an NDB/compass locator, that facility must be charted and be in the airborne database. If this facility is not in your airborne database, you are not authorized to use a facility WP for this operation.

(3) If you select the named fix as your active GPS WP, you are over the fix when the GPS system indicates you are at the WP as you fly the prescribed track from the non-GPS navigation source.

(4) If you select the NDB/compass locator facility as the active GPS WP, you are over the fix when the GPS bearing to the active WP is the same as the charted NDB/compass locator bearing for the fix as you fly the prescribed track from the non-GPS navigation source.

(f) To hold over an NDB/compass locator:
(1) Verify aircraft GPS system integrity monitoring is functioning properly and indicates satisfactory integrity.
(2) Select terminal CDI sensitivity in accordance with the AFM, AFM supplement, or pilot's guide if in the terminal area.
(3) Select the NDB/compass locator facility from the airborne database as the active WP.
NOTE - When using a facility as the active WP, the only acceptable facility is the NDB/compass locator facility which is charted. If this facility is not in your airborne database, you are not authorized to use a facility WP for this operation.
(4) Select nonsequencing (e.g. "HOLD" or "OBS") mode and the appropriate course in accordance with the AFM, AFM supplement, or pilot's guide.
(5) Hold using the GPS system in accordance with the AFM, AFM supplement, or pilot's guide.
8. Planning. Good advance planning and intimate knowledge of your navigational systems are vital to safe and successful use of GPS in lieu of ADF and/or DME.
(a) You should plan ahead before using GPS systems as a substitute for ADF and/or DME. You will have several alternatives in selecting waypoints and system configuration. After you are cleared for the approach is not the time to begin programming your GPS. In the flight planning process you should determine whether you will use the equipment in the automatic sequencing mode or in the nonsequencing mode and select the waypoints you will use.
(b) When you are using your aircraft GPS system to supplement other navigation systems, you may need to bring your GPS control panel into your navigation scan to see the GPS information. Some GPS aircraft installations will present localizer information on the CDI whenever a localizer frequency is tuned, removing the GPS information from the CDI display. Good advance planning and intimate knowledge of your navigation systems are vital to safe and successful use of GPS.
(c) The following are some factors to consider when preparing to install a GPS receiver in an aircraft. Installation of the equipment can determine how easy or how difficult it will be to use the system.
(1) Consideration should be given to installing the receiver within the primary instrument scan to facilitate using the GPS in lieu of ADF and/or DME. This will preclude breaking the primary instrument scan while flying the aircraft and tuning, and identifying waypoints. This becomes increasingly important on approaches, and missed approaches.
(2) Many GPS receivers can drive an ADF type bearing pointer. Such an installation will provide the pilot with an enhanced level of situational awareness by providing GPS navigation information while the CDI is set to VOR or ILS.
(3) The GPS receiver may be installed so that when an ILS frequency is tuned, the navigation display defaults to the VOR/ILS mode, preempting the GPS mode. However, if the receiver installation requires a manual selection from GPS to ILS, it allows the ILS to be tuned and identified while navigating on the GPS. Additionally, this prevents the navigation display from automatically switching back to GPS when a VOR frequency is selected. If the navigation display automatically switches to GPS mode when a VOR is selected, the change may go unnoticed and could result in erroneous navigation and departing obstruction protected airspace.

(4) GPS is a supplemental navigation system in part due to signal availability. There will be times when your system will not receive enough satellites with proper geometry to provide accurate positioning or sufficient integrity. Procedures should be established by the pilot in the event that GPS outages occur. In these situations, the pilot should rely on other approved equipment, delay departure, reroute, or discontinue IFR operations.

{New-2001-4 g. revised January 25, 2001}

g. Equipment and Data Base Requirements

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

(a) A pilot uses GPS avionics with TSO C-129, or equivalent, 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 data base supplied by the TSO C-129 equipment manufacturer or other FAA approved source.

{New-2001-4 h. revised January 25, 2001}

h. 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 (monitoring backup navigation is always recommended when available). Approaches must be requested and approved using the published title of the existing approach procedure, such as "VOR RWY 24."
3. Phase III: In this phase, instrument approach procedures were retitled "or GPS" (e.g., VOR or GPS RWY 24). Ground-based NAVAID's are not required to be operational and associated aircraft avionics need not be installed, operational, turned on or monitored. (Monitoring of the underlying approach is suggested when equipment is available and functional.) GPS approaches are requested and approved using the GPS title, such as "GPS RWY 24."

NOTE - In each phase, any required alternate airport must have an approved instrument approach procedure other than GPS, which is anticipated to be operational and available at the estimated time of arrival and which the aircraft is equipped to fly.

{New-2001-4 i. revised January 25, 2001}

i. GPS NOTAM's/Aeronautical Information

1. GPS satellite outages are issued as GPS NOTAM's 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.
2. Civilian pilots may obtain GPS RAIM availability information for nonprecision approach procedures by specifically requesting GPS aeronautical information from an Automated 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.
3. The military provides airfield specific GPS RAIM NOTAM's for nonprecision approach procedures at military airfields. The RAIM outages are issued as M-series NOTAM's and may be obtained for up to 24 hours from the time of request.

{New-2001-4 j. revised January 25, 2001}
j. Receiver Autonomous Integrity Monitoring (RAIM).
1. 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.
2. 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.
3. 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. The receiver performs a RAIM prediction by 2 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 the detection of a satellite anomaly, failure to arm the receiver (if required), or other problems which preclude completing the approach.
4. 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 Minimum Descent Altitude (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.
5. If a RAIM failure occurs after the FAWP, the receiver is allowed to continue operating without an annunciation for up to 5 minutes to allow completion of the approach (see receiver operating manual). If the RAIM flag/status annunciation appears after the FAWP, the missed approach should be executed immediately.

{New-2001-4 k. revised January 25, 2001}
k. Waypoints.
1. GPS approaches make use of both fly-over and fly-by waypoints. Fly-by waypoints are used when an aircraft should begin a turn to the next course prior to reaching the waypoint

separating the two route segments. 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. New approach charts depict fly-over waypoints as a circled waypoint symbol. Overlay approach charts and some early stand alone GPS approach charts may not reflect this convention.

{New-2000-4 2. Revised February 24, 2000}
2. Since GPS receivers are basically "TO-TO" navigators, they must always be navigating to a defined point. On overlay approaches, if no pronounceable five-character name is published for an approach waypoint or fix, it was given a data base identifier consisting of letters and numbers. These points will appear in the list of waypoints in the approach procedure data base, but may not appear on the approach chart. A point used for the purpose of defining the navigation track for an airborne computer system (i.e., GPS or FMS) is called a Computer Navigation Fix (CNF). CNF's include unnamed DME fixes, beginning and ending points of DME arcs and sensor final approach fixes (FAF's) on some GPS overlay approaches. To aid in the approach chart/data base correlation process, the FAA has begun a program to assign five-letter names to CNF's and to chart CNF's on various National Oceanic Service aeronautical products. These CNF's are not to be used for any air traffic control (ATC) application, such as holding for which the fix has not already been assessed. CNF's will be charted to distinguish them from conventional reporting points, fixes, intersections, and waypoints. The CNF name will be enclosed in parenthesis, e.g., (MABEE), and the name will be placed next to the CNF it defines. If the CNF is not at an existing point defined by means such as crossing radials or radial/DME, the point will be indicated by an "X." The CNF name will not be used in filing a flight plan or in aircraft/ATC communications. Use current phraseology, e.g., facility name, radial, distance, to describe these fixes.
3. Unnamed waypoints in the data base 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).

4. 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 data base to differ until all changes are complete. The runway threshold waypoint is also used as the center of the Minimum Safe Altitude (MSA) on most GPS approaches. MAWP's not located at the threshold will have a five letter identifier.

{New-2001-4 l. revised January 25, 2001}
l. Position Orientation.
As with most RNAV systems, pilots 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

nonsequencing mode. When the receiver is in the nonsequencing 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. On overlay approaches, the pilot may have to compute the along track distance to stepdown 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.

{New-2001-4 m. revised January 25, 2001}

m. 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.

{New-2001-4 n. revised January 25, 2001}

n. Departures and Instrument Departure Procedures (DP's).

The GPS receiver must be set to terminal (± 1 NM) CDI sensitivity and the navigation routes contained in the data base in order to fly published IFR charted departures and DP's. Terminal RAIM should be automatically provided by the receiver. (Terminal RAIM for departure may not be available unless the waypoints are part of the active flight plan rather than proceeding direct to the first destination.) Certain segments of a DP may 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 some GPS receivers do not contain DP's in the data base. It is necessary that helicopter procedures be flown at 70 knots or less since helicopter departure procedures and missed approaches use a 20:1 obstacle clearance surface (OCS), which is double the fixed-wing OCS, and turning areas are based on this speed as well.

{New-2001-4 o. revised January 25, 2001}

o. Flying GPS Approaches

{New-2001-4 o1. revised January 25, 2001}

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 5-4-4 and FIG 5-4-5.)

2. 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.

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 from en route CDI and RAIM sensitivity of ± 5 NM either side of centerline to ± 1 NM terminal sensitivity. 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) 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 achieve the next segment 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 ± 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 that 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.

6. When receiving vectors to final, most receiver operating manuals 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 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. Calculating the distance to the FAWP may be required in order to descend at the proper location.

7. 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.

8. Do not attempt to fly an approach unless the procedure is contained in the current GPS data base. 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 nonprecision approach procedures cannot be coded for use with GPS and will not be available as overlays.

9. 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 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., 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.

10. 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.

11. A fix on an overlay approach identified by a DME fix will not be in the waypoint sequence 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 zero rather than the DME stated on the approach chart. The pilot should be alert for this on any overlay procedure where the original approach used DME.

12. If a visual descent point (VDP) is published, it will not be 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 ATD.

{New-2001-4 p. revised January 25, 2001}

p. Missed Approach

1. 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.

2. 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.

{New-2001-4 q. revised January 25, 2001}

q. GPS Familiarization

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 IFR in instrument meteorological conditions (IMC). Some of the areas which the pilot should practice are:

1. Utilizing the receiver autonomous integrity monitoring (RAIM) prediction function;
2. Inserting a DP into the flight plan, including setting terminal CDI sensitivity, if required, and the conditions under which terminal RAIM is available for departure (some receivers are not DP or STAR capable);
3. Programming the destination airport;
4. Programming and flying the overlay approaches (especially procedure turns and arcs);
5. Changing to another approach after selecting an approach;
6. Programming and flying "direct" missed approaches;
7. Programming and flying "routed" missed approaches;
8. Entering, flying and exiting holding patterns, particularly on overlay approaches with a second waypoint in the holding pattern;
9. Programming and flying a "route" from a holding pattern;
10. Programming and flying an approach with radar vectors to the intermediate segment;
11. Indication of the actions required for RAIM failure both before and after the FAWP; and
12. Programming a radial and distance from a VOR (often used in departure instructions).