



U.S. Department  
of Transportation  
Federal Aviation  
Administration

# Advisory Circular

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**Subject:** Approval Guidance for RNP  
Operations and Barometric Vertical  
Navigation in the U.S. National  
Airspace System

**Date:** 1/23/2009

**AC No:** 90-105

**Initiated by:** AFS-400

**Change:**

**1. PURPOSE.** This advisory circular (AC) provides system and operational approval guidance for operators to conduct Title 14 of the Code of Federal Regulations (14 CFR) part 97, Required Navigation Performance (RNP) instrument approach procedures (IAP). This AC provides system and operational approval guidance for the conduct of RNP Instrument Departure Procedures (RNP 1 DPs), Standard Terminal Arrival Routes (STAR) (RNP 1 STARs), and RNP 2 routes within the U.S. National Airspace System (NAS) where domestic air traffic control (ATC) procedures are applied. This AC also provides operational approval guidance for the conduct of barometric vertical navigation (baro-VNAV) RNP IAPs with the lateral navigation (LNAV)/vertical navigation (VNAV) minimums within the NAS.

## **2. APPLICABILITY.**

**a. Guidance.** The guidance contained in this AC applies to all operators conducting RNP operations under 14 CFR parts 91, 121, 125, 129, and 135 within the United States (U.S.) NAS. This AC does not apply to RNP Special Aircraft and Aircrew Approval Required (SAAAR) operations, which are covered by AC 90-101, Approval Guidance for RNP Procedures with SAAAR. Mandatory terms used in this AC such as “must” are used only in the sense of ensuring applicability of these particular methods of compliance when the acceptable means of compliance described herein are used. This AC does not change, add, or delete regulatory requirements or authorize deviations from regulatory requirements. In lieu of following the guidance in this AC without deviation, operators may elect to follow an alternative method, provided the alternative method is found to be acceptable by the Federal Aviation Administration (FAA).

**b. Structure.** After the initial paragraphs which include terminology and references, this AC is structured as follows:

- General Information (paragraph 7).
  - Operational Considerations (paragraph 8).
  - Operator Responsibilities (paragraph 9).
  - Approval for Operations in Alaska (paragraph 10).
  - Appendix 1. Qualification Criteria for RNP Approach Operations.
  - Appendix 2. Qualification Criteria for RNP 1 (Terminal) Operations.
  - Appendix 3. Qualification Criteria for RNP 2 (En Route) Operations.
  - Appendix 4. Use of Barometric VNAV.
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- Appendix 5. Advanced Features.

**3. CANCELLATION.** AC 90-94, Guidelines for Using Global Positioning System Equipment for IFR En Route and Terminal Operations and for Nonprecision Instrument Approaches in the U.S. National Airspace System, dated 12/14/1994, and AC 90-97, Use of Barometric Vertical Navigation (VNAV) for Instrument Approach Operations Using Decision Altitude, dated 10/19/2000 are canceled. However, previous approvals under these two ACs are still valid for the operations and conditions stated.

**4. RELATED REGULATIONS.** Title 14 CFR.

- Part 91, §§ 91.123, 91.175, and 91.205,
- Part 95,
- Part 97, § 97.20,
- Part 121, §§ 121.349 and 121.567,
- Part 125, §§ 125.203, 125.287, and 125.325,
- Part 129, § 129.17, and
- Part 135, § 135.165.

**5. TERMINOLOGY.**

**a. Aircraft-Based Augmentation System (ABAS).** An augmentation system that augments and/or integrates the information obtained from the other GPS elements with information on board the aircraft. The most common form of ABAS is receiver autonomous integrity monitoring (RAIM).

**b. Area Navigation (RNAV).** A method of navigation which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

**NOTE: RNAV includes performance based navigation as well as other operations that do not meet the definition of performance based navigation.**

**c. Area Navigation (RNAV) System.** A navigation system which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these. A RNAV system may be included as part of a flight management system (FMS).

**d. Barometric Vertical Navigation (baro-VNAV).** A function of certain RNAV systems which presents computed vertical guidance to the pilot referenced to a specified vertical path. The computed vertical guidance is based on barometric altitude information and is typically computed as a geometric path between two waypoints or an angle based on a single waypoint.

**e. Decision Altitude (DA).** In an approach with vertical guidance, DA is a specified altitude expressed in feet above mean sea level at which a missed approach must be initiated if the required visual references to continue the approach have not been established.

**f. Distance Measuring Equipment (DME) DME/DME (D/D) RNAV.** Refers to navigation using DME ranging from at least two DME facilities to determine position.

**g. DME/DME/Inertial (D/D/I) RNAV.** Refers to navigation using DME ranging from at least two DME facilities to determine position along with use of inertial systems, Inertial Reference System (IRS) or Inertial Reference Unit (IRU), to provide sufficient position information during limited DME gaps.

**h. Estimate of Position Uncertainty (EPU).** A measure based on a defined scale in nautical miles, which conveys the current position estimation performance, also known as Actual Navigation Performance (ANP) or Estimate of Position Error (EPE) in certain aircraft. The EPU is not an estimate of the actual error, but a defined statistical indication of potential error.

**i. Flight Management System (FMS).** An integrated system, consisting of airborne sensor, receiver and computer with both navigation and aircraft performance databases, which provides performance and area navigation guidance to a display and automatic flight control system.

**j. Flight Technical Error (FTE).** Accuracy with which an aircraft is controlled, as measured by the indicated aircraft position with respect to the indicated command or desired position. It does not account for procedural blunder errors.

**k. Global Positioning System (GPS).** GPS is a U.S. satellite based radio navigation system that provides a positioning service anywhere in the world. The service provided by GPS for civil use is defined in the GPS Standard Positioning System Signal Specification. GPS is the U.S. core GNSS satellite constellation providing space-based positioning, velocity, and time. GPS is composed of space, control, and user elements.

**l. Global Navigation Satellite System (GNSS).** GNSS is a generic term for a worldwide position, velocity, and time determination system, which includes one or more satellite constellations, aircraft receivers, and system integrity monitoring. GNSS includes GPS, Satellite Based Augmentation Systems (SBAS) such as the Wide Area Augmentation System (WAAS), Ground-Based Augmentation System (GBAS) such as the Local Area Augmentation System (LAAS), Global Orbiting Navigation Satellite System (GLONASS), GALILEO, and any other satellite navigation system approved for civil use. GNSS can be augmented as necessary to support the required navigation performance for the actual phase of operation.

**m. Lateral Navigation (LNAV).** The function of RNAV systems that computes, displays, and provides lateral guidance to a profile or path.

**n. Navigation System Error (NSE).** The difference between the true position and estimated position.

**o. Path Definition Error (PDE).** The difference between defined path and desired path.

**p. Position Estimation Error (PEE).** PEE is the difference between true position and estimated position.

**q. Primary Field of View (FOV).** For the purpose of this AC, the primary FOV is within 15 degrees of the pilot's primary line of sight.

**r. Radius to a Fix (RF) Leg.** A RF leg is defined as a constant radius circular path around a defined turn center that starts and terminates at a fix.

**s. Receiver Autonomous Integrity Monitoring (RAIM).** An algorithm that verifies the integrity of the position output using GPS measurements, or GPS measurements and barometric aiding.

**t. Required Navigation Performance (RNP).** RNP is a statement of the 95 percent navigation accuracy performance that meets a specified value for a particular phase of flight or flight segment and incorporates associated on-board performance monitoring and alerting features to notify the pilot when the RNP for a particular phase or segment of a flight is not being met.

**u. RNP Procedure.** A RNP Procedure includes instrument departure procedures, standard terminal arrivals, and instrument approaches.

**v. RNP System.** An RNAV system which supports on-board performance monitoring and alerting. For the purposes of this AC, RNP systems comply with Appendix 1 and/or 2.

**w. RNP Accuracy.** The RNP value designates the 95 percent LNAV performance (in nautical miles (NM)) and the related monitoring and alerting requirements associated with an RNP instrument flight operation or a particular segment of that instrument flight. For RNP instrument approach operations, the values are RNP 1 in the Initial, Intermediate, and Missed Approach Segments and RNP 0.3 in the Final Approach Segment.

**x. Total System Error (TSE).** TSE is the difference between the true position and the desired position and is equal to the vector sum of the path steering error, path definition error, and position estimation error. This value includes signal-in-space error, airborne receiver error, path definition error, display system error, and flight technical error.

## **6. RELATED READING MATERIAL (current editions).**

**a. FAA ACs and Orders.** Copies of the following ACs and Orders may be obtained from the U.S. Department of Transportation, Publications Department, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD, 20785.

(1) AC 20-129, Airworthiness Approval for Vertical Navigation (VNAV) Systems for Use in the U.S. National Airspace System (NAS) and Alaska.

(2) AC 20-130, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors.

(3) AC 20-138, Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment.

(4) AC 20-153, Acceptance of Data Processes and Associated Navigation Databases.

(5) AC 23-1309-1, Equipment, Systems and Installations in Part 23 Airplanes.

(6) AC 25-1309-1, System Design and Analysis.

(7) AC 25-15, Approval of Flight Management Systems in Transport Category Airplanes.

(8) AC 120-29, Criteria for Approval of Category I and Category II Weather Minima for Approach.

(9) Order 8260.54, The United States Standard For Area Navigation (RNAV).

**b. FAA Technical Standard Orders (TSO).**

(1) TSO-C106, Air Data Computer.

(2) TSO-C115B, Airborne Area Navigation Equipment Using Multi-Sensor Inputs.

(3) TSO-C129A, Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS).

(4) TSO-C145C, Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).

(5) TSO-C146C, Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).

**c. RTCA Documents.** Copies of the following RTCA documents may be obtained from RTCA, Inc., 1828 L Street, NW, Suite 805, Washington, DC 20036, or purchased on-line at <http://www.rtca.org/>.

(1) RTCA/DO-178B, Software Considerations in Airborne Systems and Equipment Certification.

(2) RTCA/DO-187, Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Multi-Sensor Inputs.

(3) RTCA/DO-189, Minimum Operational Performance Standards for Airborne Distance Measuring Equipment (DME) Operating Within the Radio Frequency Range of 960-1215 Megahertz.

(4) RTCA/DO-200A, Standards for Processing Aeronautical Data.

(5) RTCA/DO-201A, Standards for Aeronautical Information.

(6) RTCA/DO-208, Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS).

(7) RTCA/DO-229D, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment.

(8) RTCA/DO-236B, Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation.

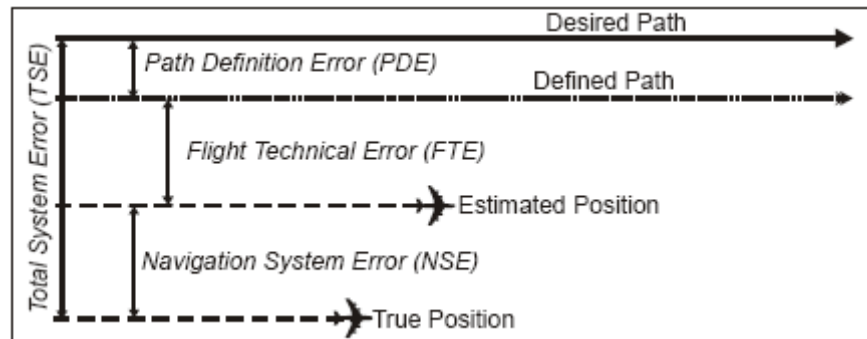
(9) RTCA/DO-283A, Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation.

## 7. GENERAL INFORMATION.

**a. The Performance-Based Navigation Concept (PBN).** The PBN concept represents a shift from sensor-based to PBN. The PBN concept specifies aircraft RNP system performance requirements in terms of accuracy, integrity, availability, continuity and functionality needed for particular operations or airspace. Performance requirements are identified in navigation specifications (e.g., the requirements in this AC), which also identify the choices of navigation sensors, navigation equipment, operational procedures, and training needed to meet the performance requirements.

**b. RNP procedures and routes require the use of RNAV systems with onboard performance monitoring and alerting.** A critical component of RNP is the ability of the aircraft navigation system in combination with the pilot to monitor its achieved navigation performance and to identify for the pilot whether the operational requirement is or is not being met during an operation.

**NOTE: Compliance with the performance monitoring and alerting requirement does not imply an automatic monitor of FTE. The on-board monitoring and alerting function should consist at least of a NSE monitoring and alerting algorithm and a lateral deviation display enabling the crew to monitor the FTE. To the extent operational procedures are used to monitor FTE, the crew procedure, equipment characteristics, and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures. PDE is considered negligible due to the quality assurance process and crew procedures. (See Figure 1.)**

**FIGURE 1. TOTAL SYSTEM ERROR (TSE)**

**c. Operations with RNP Systems.** RNP operations:

- (1) Do not require the pilot to monitor ground-based navaids used in position updating unless required by the AFM;
- (2) Base obstacle clearance assessments on the associated required system performance;
- (3) Rely on conventional compliance with descent profiles and altitude requirements.

**NOTE: Pilots operating aircraft with an approved baro-VNAV system may continue to use their baro-VNAV system while executing U.S. RNP routes, DPs and STARs. Operators must ensure compliance with all altitude constraints as published in the procedure by reference to the barometric altimeter.**

(4) All routes/procedures must be based upon World Geodetic System (WGS) 84 coordinates.

(5) The navigation data published for the routes, procedures and supporting navigation aids must meet the requirements of ICAO Annex 15, Aeronautical Information Services.

## **8. OPERATIONAL CONSIDERATIONS.**

**a. General.** This section provides guidance on the operational aspects that must be considered for conduct of RNP operations. In addition to this guidance, the operator must continue to ensure they comply with the general operating requirements, including checking Notices to Airmen (NOTAMS), availability of Navigational Aids (NAVAID), airworthiness of aircraft systems, and aircrew qualification. Any non-standard speeds or climb gradients will be indicated on the procedure, and the operator must ensure they can comply with any published restrictions before conducting the operation.

**b. Navigation Data Validation Program.**

(1) The navigation database should be obtained from a supplier complying with AC 20-153 or equivalent, and should be compatible with the intended function of the equipment.

Discrepancies that invalidate a procedure (e.g., data base errors) must be reported to the navigation database supplier and the use of affected procedures must be prohibited by an operator's notice to its flightcrew.

**NOTE: Navigation databases are also expected to be current for the duration of the flight. If the AIRAC cycle will change during flight, operators and pilots must establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the routes and procedures for flight. Traditionally, this has been accomplished by verifying electronic data against paper products. One acceptable means is to compare aeronautical charts (new and old) to verify navigation fixes prior to departure. If an amended chart is published for the procedure, the database must not be used to conduct the operation.**

(2) For part 91 (except subpart K) operators, pilots must confirm at system initialization that the navigation database is current. As a minimum, part 91 (except subpart K) operators using RNP systems meeting the functional and performance requirements of this AC, and following operational guidance in this AC, may consider navigation database validation complete when checking the navigation database currency.

(3) Parts 121, 125, 129, 135, and 91 subpart K operators should establish a database program that meets the following requirements:

(a) Data Process.

- The operator must identify within their procedures the responsible manager for the data updating process.
- The operator must document a process for accepting, verifying and loading navigation data into the aircraft.
- The operator must place their documented data process under configuration control.

(b) The pilots must confirm at system initialization that the navigation database is current.

## **9. OPERATOR RESPONSIBILITIES.**

**a. Operations Manuals and Checklists.** Part 91 operators should use relevant Aircraft Flight Manuals (AFM) and checklists. Operations manuals and checklists for parts 121, 125, 129, 135, and 91 subpart K operators must address information/guidance on the standard operating procedures detailed in Appendix 1, 2, 4 and 5 (as appropriate). The appropriate manuals should also contain navigation operating instructions and contingency procedures. Manuals and checklists must be submitted as part of the application process for review and acceptance, or approval, as appropriate.

**b. Training Documentation.**



(1) Part 91 operators (except for subpart K) must be familiar with the procedures and operations associated with the use of RNP systems and, if applicable, VNAV systems and RF legs.

(2) Parts 121, 125, 129, 135, and 91 subpart K operators must have a training program in accordance with FAA Order 8900.1 where applicable, addressing the operational practices, procedures and training items related to RNP operations (e.g., initial, upgrade or recurrent training for flightcrew, dispatchers and maintenance personnel). If baro-VNAV systems are used, the training program should also address baro-VNAV operation.

**NOTE: A separate training program or regimen is not required if RNAV training is integrated in the current training program. However, it should be possible to identify the training elements from this AC within the existing training program.**

**c. Minimum Equipment List (MEL) Considerations.** If an MEL is required, it must include any revisions necessary to address RNP flight operations, and, if applicable, baro-VNAV operations. These provisions must be approved. Operators must adjust the MEL, or equivalent, and specify the required dispatch conditions.

**d. Operator Approval.** The assessment of a particular operator is made by the FAA in accordance with the applicable criteria in this AC. The operator should provide documentation to support the following factors:

(1) All operators: Evidence of aircraft eligibility including, if applicable, RF legs and LNAV/VNAV operations.

(2) Parts 121, 125, 129, 135, and 91 subpart K operators:

- (a) Establishment of acceptable operating procedures for the RNP system.
- (b) Control of those procedures through acceptable entries in the operations manual.
- (c) Identification of flightcrew training requirements.
- (d) Control of navigation database process.

**e. Credit for Previous RNAV (GPS) Instrument Approach Approval.** Part 91 operators (except subpart K operators) previously conducting RNAV (GPS) or GPS IAPs in accordance with AC 90-94 may continue to use approved equipment. Part 121, 125, 129, 135, or 91 subpart K operators with an appropriate operational approval (e.g., operations specifications (OpSpec), letter of authorization (LOA), or management specifications (MSpecs)) may continue to use the approved equipment to conduct RNAV (GPS) or GPS IAPs in accordance with the authorizations and restrictions in that operational approval. For all operators, these approaches must be conducted in accordance with previous FAA accepted procedures and limitations.

**f. Credit for Existing RNP SAAAR Approvals.** Operators with a current and approved RNP SAAAR approval meet the requirements for equivalent RNP operations as described in this AC.

**g. Pilot Knowledge/Training.** Part 91 operators must be familiar with the following training items. Parts 121, 125, 129, 135, and 91 subpart K operators must address the following specific elements. The training program should provide sufficient training (for example, computer based training, simulator, training device, or aircraft) on the aircraft's RNP system to the extent that the pilots are familiar with the following:

- (1) The information in this AC, as applicable.
- (2) The meaning and proper use of Aircraft Equipment/Navigation Suffixes.
- (3) Procedure characteristics as determined from chart depiction and textual description.
- (4) Depiction of waypoint types (fly-over and fly-by) and path terminators and any other types used by the operator as well as associated aircraft flight paths.
- (5) Required navigation equipment for RNP operations.
- (6) Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradations.
- (7) Functional integration with other aircraft systems.
- (8) Meaning of route discontinuities and appropriate flightcrew procedures.
- (9) Types of navigation sensors used by the RNP system and their weighting.
- (10) Turn anticipation with consideration to speed and altitude effects.
- (11) Interpretation of electronic displays and symbols.
- (12) Understanding the operational conditions used to support RNP operations (e.g., appropriate selection of course deviation indicator (CDI) scaling (lateral deviation display scaling)).
- (13) If applicable, the importance of maintaining the published path and maximum airspeeds while performing RNP operations with RF legs.

**h. RNP System-Specific Information, including:**

(1) Understanding the performance requirement to couple the autopilot/flight director to the navigation system's lateral guidance on RNP procedures, if required.

(2) The equipment shall not permit the flightcrew to select a procedure or route that is not supported by the equipment, either manually or automatically (e.g., a procedure is not supported if it incorporates an RF leg and the equipment does not provide RF leg capability).The system

must also restrict pilot access to procedures requiring RF leg capability if the system can select the procedure, but the aircraft is not otherwise equipped (e.g., the aircraft does not have the required roll steering autopilot or flight director installed).

(3) RNP system operating procedures, as applicable, including how to perform the following actions:

- (a) Verify currency of aircraft navigation data.
- (b) Verify successful completion of system self-tests.
- (c) Initialize navigation system position.
- (d) Retrieve and fly a RNP procedure.
- (e) Adhere to speed and/or altitude constraints associated with RNP operations.
- (f) Verify waypoints and flight plan programming.
- (g) Fly direct to a waypoint.
- (h) Fly a course/track to a waypoint.
- (i) Intercept a course/track to a waypoint.
- (j) Rejoining a RNP procedure from 'heading' mode.
- (k) Change arrival airport and alternate airport.

(l) Flightcrew contingency procedures for a loss of RNP capability. Due to the lack of navigation guidance, the training should emphasize the flightcrew contingency actions that achieve separation from terrain and obstacles.

(m) Obtain a RAIM prediction. (Systems are only required to provide non-precision approach RAIM predictions.)

**10. APPROVAL FOR OPERATIONS IN ALASKA.** For operations in Alaska, see FAA Order 8900.1 Volume 4, Chapter 1, Section 1, General Navigation Concepts, Policies, and Guidance.

a. For parts 121, 125, 129, 135, and 91 subpart K operators, OpSpec B030 is issued to those certificate holders and operators identified in section 1 of SFAR 97 for IFR RNAV en route operations in the State of Alaska and its airspace on published air traffic routes using navigation systems certified, in accordance with TSO-C145 (or subsequent revision)/C146 (or subsequent revision), as the only means of IFR navigation appropriate for the route to be flown.

**b.** Additional guidance for this authorization is outlined in FAA Order 8900.1 Volume 3, Chapter 18, Section 4, OpSpec B030, IFR Navigation Using GPS/WAAS RNAV Systems.

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**APPENDIX 1. QUALIFICATION CRITERIA FOR RNP APPROACH OPERATIONS**

**1. Introduction.** This Appendix provides guidance on the performance and functional requirements for systems used to conduct Required Navigation Performance (RNP) approach operations, which are designated under Title 14 of the Code of Federal Regulations (14 CFR) part 97 as Area Navigation (RNAV) Global Positioning System (GPS) or GPS and categorized as RNP Approach (APCH) by the International Civil Aviation Organization (ICAO). Localizer performance (LP) and localizer performance with vertical guidance (LPV) operations are not covered by this AC. The barometric vertical navigation (baro-VNAV) aspects of RNP approaches are specified in Appendix 4. Baro-VNAV systems are optional capabilities that are not a minimum requirement to fly RNAV (GPS) or GPS approaches using the LNAV line of minima. The requirements for RF legs are specified in Appendix 5.

**2. Aircraft and System Requirements.** Notes below apply to entire paragraph.

**a.** Aircraft with approval to conduct RNAV (GPS) or GPS approaches meet the performance and functional requirements in this AC for RNP instrument approaches without RF legs.

**b.** Aircraft with a statement of compliance with the criteria in this AC in their Aircraft Flight Manual (AFM), AFM Supplement, pilot operating handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this AC.

**c.** Aircraft with a statement from the manufacturer documenting compliance with the criteria in this AC meet the performance and functional requirements of this AC. These statements should include the airworthiness basis for compliance. Compliance with the sensor requirements will have to be determined by the equipment or aircraft manufacturer, while compliance with the functional requirements in Appendix 1 and, if applicable Appendix 2 may be determined by the manufacturer or by inspection by the operator.

**d.** GPS stand-alone systems should be approved in accordance with TSO-C129 (or subsequent revision) Class A1 or TSO-C146a (or subsequent revision) operational class 1, 2 or 3 and meet the functionality requirements of this Appendix.

**e.** GPS sensors used in multi-sensor system (e.g., FMS) equipment should be approved in accordance with TSO-C129 (or subsequent revision) Class B1, C1, B3, C3 or TSO-C145 (or subsequent revision) Class 1, 2 or 3 and meet the functionality requirements of this Appendix.

**f.** Multi-sensor systems using GPS should be approved in accordance with AC 20-130 or TSO-C115b and meet the functionality requirements of this Appendix.

**NOTE: GPS equipment approved to TSO-C129 must meet the system functions specified in this Appendix. In addition, integrity should be provided by ABAS. It is recommended that GPS receivers include the pseudo-range step detection and health word checking functions.**

**NOTE: Multi-sensor systems that use DME/DME or DME/DME/IRU as the only means of RNP compliance are not authorized to conduct RNP**

**approaches. However, operators still retain the option to develop Special RNP approaches using these systems.**

### **3. Performance and Functionality Requirements for RNP Systems.**

**a. Accuracy.** The aircraft must comply with section 2.1.1 of RTCA/DO-236B. During operations on the initial and intermediate segments and for the missed approach of a RNP approach procedure, the lateral total system error must be within  $\pm 1$  NM for at least 95 percent of the total flight time. The along-track error must also be within  $\pm 1$  NM for at least 95 percent of the total flight time.

(1) During operations on the final approach segment, the lateral total system error must be within  $\pm 0.3$  NM for at least 95 percent of the total flight time. The along-track error must also be within  $\pm 0.3$  NM for at least 95 percent of the total flight time.

(2) To satisfy the accuracy requirement, the FTE should not exceed 0.5 NM on the initial, intermediate and missed approach segments of a RNP approach procedure. The FTE should not exceed 0.25 NM on the final approach segment of the approach.

**NOTE: Where the navigation system provides for RNP performance monitoring and alerting and where the integration of operational modes and configurations account for accuracy and FTE, this requirement is considered satisfied as long as the TSE for each segment is not exceeded.**

**NOTE: The use of a deviation indicator with 1 NM full-scale deflection on the initial, intermediate and missed approach segments and 0.3 NM full-scale deflection on the final approach segment is an acceptable means of compliance.**

**b. Integrity.** Malfunction of the aircraft navigation equipment that causes the total system error (TSE) to exceed 2 times the RNP value is classified as a major failure condition under airworthiness regulations (i.e.,  $10^{-5}$  per hour).

**c. Continuity.** Loss of function is classified as a minor failure condition if the operator can revert to a different navigation system and safely proceed to a suitable airport.

**d. Performance Monitoring and Alerting.** During operations on the initial, intermediate segment and the missed approach segment, the RNP system or the RNP system and pilot in combination shall provide an alert if the accuracy requirement is not met or if the probability that the lateral TSE exceeds 2 NM is greater than  $10^{-5}$ . During operations on the final approach segment, the RNP system or the RNP system and pilot in combination shall provide an alert if the accuracy requirement is not met or if the probability that the lateral TSE exceeds 0.6 NM is greater than  $10^{-5}$ .

**e. Signal-in-Space.** During operations on the initial, intermediate, and missed approach segments, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds  $10^{-7}$  per hour. During operations on the final approach segment, the aircraft navigation equipment shall provide an alert

if the probability of signal-in-space errors causing a navigation system error greater than 0.6 NM exceeds  $10^{-7}$  per hour.

**NOTE: There are no RNP requirements for the missed approach if it is based on conventional means (VOR, DME, and NDB) or on dead reckoning.**

**f. Path Definition.** Aircraft performance is evaluated around the path defined by the published procedure and RTCA/DO-236B section 3.2.5.4.1 and 3.2.5.4.2.

**g. Functional Requirements of Navigation Displays.** The following navigation displays and functions are required, as installed in accordance with AC 20-130 and AC 20-138 or equivalent system installation advisory material. Navigation data, including a to/from indication and a failure indicator, must be displayed on a lateral deviation display (CDI, EHSI) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for maneuver anticipation and for failure/status/integrity indication. A non-numeric lateral deviation display (for example, CDI, EHSI), with a to/from indication and a failure annunciation, for use as primary flight instruments for navigation of the aircraft, for maneuver anticipation, and for failure/status/integrity indication, should have the following attributes:

(1) The displays must be visible to the pilot and located in the primary field of view (FOV) when looking forward along the flight path.

(2) The lateral deviation display scaling should agree with any alerting and annunciation limits, if implemented.

(3) The lateral deviation display must have a full-scale deflection suitable for the current phase of flight and must be based on the TSE requirement. Scaling of  $\pm 1$  NM for the initial, intermediate, and missed approach segments and  $\pm 0.3$  NM for the final segment is acceptable.

(4) The display scaling may be set automatically by default logic or set to a value obtained from a navigation database. The full-scale deflection value must be known or must be available for display to the pilot commensurate with approach values.

(5) The lateral deviation display must be automatically slaved to the RNP computed path. It is recommended that the course selector of the deviation display be automatically slewed to the RNP computed path.

**NOTE: This does not apply for installations where an electronic map display contains a graphical display of the flight path and path deviation.**

(6) As an alternate means, a navigation map display must provide equivalent functionality to a lateral deviation display with appropriate map scales (scaling may be set manually by the pilot). To be approved as an alternative means, the navigation map display must be shown to meet the TSE requirements and be located in the primary FOV.

**h. System Capabilities.** The following system capabilities are required as a minimum:

(1) The capability to continuously display to the pilot flying (PF), on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNP computed desired path and aircraft position relative to the path. For operations where the required minimum flightcrew is two pilots, a means for the pilot-not-flying (PNF) (pilot monitoring) to verify the desired path and the aircraft position relative to the path must also be provided.

(2) A navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the Aeronautical Information Regulation and Control (AIRAC) cycle. The stored resolution of the data must be sufficient to achieve the required track keeping accuracy. The database must be protected against pilot modification of the stored data.

(3) The means to display the validity period of the navigation data to the pilot.

(4) The means to retrieve and display data stored in the navigation database relating to individual waypoints and navigation aids, to enable the pilot to verify the route to be flown.

(5) Capability to load from the database into the RNP system the whole approach to be flown. The approach must be loaded from the database, into the RNP system, by its name.

(6) The means to display the following items, either in the pilot's primary FOV, or on a readily accessible display page:

- (a) Distance between flight plan waypoints;
- (b) Distance to go to the waypoint selected by the pilot;
- (c) Along track distances between waypoints;
- (d) Active navigation sensor type;
- (e) The identification of the active (To) waypoint;
- (f) The ground speed or time to the active (To) waypoint; and
- (g) The distance and bearing to the active (To) waypoint.

(7) The capability to execute a "Direct to" function.

(8) The capability for automatic leg sequencing with display to the pilots.

(9) The capability to execute RNP instrument approach procedures (IAP) extracted from the onboard database including the capability to execute fly-over and fly-by turns.

(10) The capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators, or their equivalent.

- (a) Initial Fix (IF).



(b) Track to Fix (TF).

(c) Direct to Fix (DF).

**NOTE: Path terminators are defined in ARINC Specification 424, and their application is described in more detail in RTCA documents DO-236B and DO-201A.**

**NOTE: Numeric values for tracks must be automatically loaded from the RNP system database.**

(11) The capability to display an indication of the RNP system failure, in the pilot's primary FOV.

(12) The capability to indicate to the crew when the NSE alert limit is exceeded (alert provided by the "onboard performance monitoring and alerting function").

**i. Flight Director/Autopilot.** It is recommended that the flight director and/or autopilot remain coupled for RNP approaches. If the lateral Total System Error (TSE) cannot be demonstrated without these systems, then coupling becomes mandatory. In this instance, operating guidance must indicate that coupling to the flight director and/or automatic pilot from the RNP system is mandatory for approaches.

**j. Database Integrity.** The navigation database suppliers should comply with RTCA DO-200A. A letter of acceptance (LOA), issued by the appropriate regulatory authority to each of the participants in the data chain, demonstrates compliance with this requirement. Type 2 LOAs issued prior to this AC shall be considered compliant.

#### **4. Special Characteristics of RNP Instrument Approaches.**

**a. Navaid infrastructure.** GPS is the primary navigation system to support RNP APCH procedures. The missed approach segment may be based upon the conventional Navaid (e.g., VOR, DME, NDB).

##### **b. Unique Features and Requirements of RNP Approaches.**

(1) **Lines of Minima.** RNP approaches normally include at least two lines of minima; LNAV and LNAV/VNAV. The LNAV/VNAV minima are based on the use of systems meeting the performance criteria for baro-VNAV systems in Appendix 4.

(2) **Use of RF Legs.** Discussed in Advanced Features, Appendix 5.

(3) **Go-Around or Missed Approach.** Unless the pilot has in sight the visual references required to continue the approach, the procedure must be discontinued if any of the following conditions occurs:

(a) The navigation display is flagged invalid,

- (b) Loss of integrity alerting function, and
- (c) The integrity alerting function is activated before passing the FAF.

**NOTE: Discontinuing the procedure may not be necessary for a multi-sensor RNP system that includes demonstrated RNP capability without GPS. Manufacturer documentation should be examined against functional and performance requirements to determine the extent the system may be used in such a configuration.**

## **5. System Eligibility and Approval for RNP Operations.**

**a. Introduction.** The Original Equipment Manufacturer (OEM) or the holder of installation approval for the aircraft (e.g., STC holder), must demonstrate compliance with the appropriate provisions of this AC to the FAA and the approval can be documented in manufacturer documentation (e.g., Service Letters, etc.). Aircraft Flight Manual (AFM) entries are not required provided the FAA accepts the manufacturer's documentation.

**b. Eligibility for RNP Instrument Approach Operations.** Systems meeting the requirements in paragraph 2 of this Appendix are eligible for RNP instrument approach operations. Aircraft qualified by AC 90-101 are considered qualified for RNP approach operations without further examination.

### **c. System Eligibility for RNP Approach Operations.**

#### **(1) LNAV Line of Minima Qualification.**

**(a) Standalone Systems.** Standalone systems meeting TSO-C129 Class A1 or TSO-C146 Class 1, 2, or 3 meet the aircraft qualification requirements for RNP instrument approach operations using the LNAV line of minima provided the IFR installations were performed in accordance with AC 20-138. RNP systems must be approved in accordance with AC 20-138 or equivalent.

**(b) Multi-Sensor Systems.** Multi-sensor systems using TSO-C129 Class B1, B3, C1, or C3 sensors meet the aircraft qualification requirements for RNP instrument approach operations using the LNAV line of minima, provided the installations meet the criteria of this AC and Appendix 1, the associated flight management system (FMS) complies with TSO-C115b and are installed in accordance with AC 20-130, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors. Multi-sensor systems using TSO-C145 Class 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP instrument approach operations using the LNAV line of minima, provided the installations meet the criteria of this AC and Appendix 1 and are installed in accordance with AC 20-138, Airworthiness Approval of Global Navigation Satellite System (GNSS).

#### **(2) LNAV/VNAV Line of Minima Qualification.**

**(a) Standalone Systems.** Standalone TSO-C146 Class 2 or 3 systems meet the aircraft qualification requirements for RNP instrument approach operations using the

LNAV/VNAV line of minima provided that the installations meet at least the performance and functional requirements of this AC. Systems meeting TSO-C129 can be used for RNP approaches using the LNAV/VNAV line of minima if the criteria in Appendix 1 and Appendix 4 are met. RNP systems must be approved in accordance with AC 20-138 or equivalent and those systems that utilize conventional baro-VNAV must provide vertical navigation system performance that meets or exceeds the criteria in Appendix 4.

**(b) Multi-Sensor Systems.** Multi-sensor systems using TSO-C129 Class B1, B3, C1, or C3 sensors or TSO-C145 Class 1, 2 or 3 sensors meet the aircraft qualification requirements for RNP instrument flight operations using the LNAV/VNAV line of minima provided the installations meet the requirements of this AC (including appendices 1 and 4). RNP systems that utilize conventional baro-VNAV must provide vertical navigation system performance that meets or exceeds the criteria in Appendix 4. The RNP systems must be installed in accordance with AC 20-138 and/or the associated FMS must comply with TSO-C115b and must be installed in accordance with AC 20-130.

## **6. Operational Approval for RNP Approach Operations.**

### **a. Aircraft Qualification Documentation.**

**(1)** For aircraft currently conducting RNAV(GPS) or GPS approaches under AC 90-94: Documentation is not required for aircraft with an AFM or AFM Supplement which states the aircraft is approved to fly RNAV(GPS), or GPS approaches, to the LNAV line of minima.

**(2)** For aircraft without approval to fly RNAV(GPS) or GPS instrument approach procedures: The aircraft or avionics manufacturers should develop RNP qualification documentation showing compliance with this Appendix provided equipment is properly installed and operated.

**NOTE: Prior to application, operators and manufacturers of their equipment should review all performance requirements. Installation of equipment by itself does not guarantee operational approval or permit operational use.**

**b. RNP Operational Documentation Developed by the Manufacturer.** The aircraft or avionics manufacturer must have operational documentation for using the equipment. The operational documentation consists of recommended operational procedures and pilot knowledge and training recommendations to assist operators in complying with the requirements of this AC.

### **c. FAA Acceptance of Documentation.**

**(1) New Aircraft/Equipment.** The aircraft/equipment qualification documentation can be approved as part of an aircraft certification project and reflected in the AFM and related documents.

**(2) Existing Aircraft/Equipment.** Previous approvals to conduct RNAV (GPS) or GPS instrument approaches according to AC 90-94 do not require further evaluation. For installations/equipment not eligible to conduct RNAV (GPS) or GPS instrument approaches, the

aircraft or avionics manufacture should submit the aircraft qualification and RNP documentation to AFS-400.

(3) AFS-400 will coordinate with other FAA offices to review the RNP operation application package. Acceptance will be documented in a letter to the aircraft or avionics manufacturer, as applicable.

## 7. Operational Considerations.

### a. Preflight Planning.

(1) Operators and pilots intending to conduct operations on RNP IAPs must file the appropriate flight plan suffixes.

(2) At system initialization, pilots must confirm the navigation database is current and includes appropriate procedures. Pilots must also verify that the aircraft position is correct.

**NOTE: Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots should establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the routes and procedures for flight. Traditionally, this has been accomplished by verifying electronic data against paper products. One acceptable means is to compare aeronautical charts (new and old) to verify navigation fixes prior to dispatch. If an amended chart is published for the procedure, the database must not be used to conduct the operation.**

(3) Pilots must verify proper entry of their ATC assigned route upon initial clearance and any subsequent change of route. Pilots must ensure the waypoints sequence depicted by their navigation system matches their assigned route and the route depicted on the appropriate chart(s).

**NOTE: Pilots may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display heading. Differences of three degrees or less may result from equipment manufacturer's application of magnetic variation and are operationally acceptable.**

**NOTE: Manually selecting aircraft bank limiting functions can reduce the aircraft's ability to maintain the desired track and is not recommended.**

(4) The aircraft RNP capability is dependent on operational aircraft equipment. The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action. When the dispatch of a flight is predicated on flying a RNP approach requiring the use of the autopilot or flight director at the destination and/or alternate, the operator must determine that the autopilot and/or flight director is installed and operational.

(5) The availability of the navigation infrastructure, required for the intended routes, procedure, or instrument approaches (including any non-RNP contingencies) must be confirmed for the period of intended operations using all available information. Since GPS integrity (e.g., RAIM or SBAS signal) is required, the availability of these should also be determined, as appropriate.

(6) RAIM prediction should be performed prior to departure.

(a) This predictive capability must account for known and predicted outages of GPS satellites or other impacts on the navigation system's sensors. The prediction program should not use a mask angle below five degrees, as operational experience indicates that satellite signals at low elevations are not reliable. RAIM availability prediction should take into account the latest GPS constellation NOTAMs and use the identical algorithm to that used in the airborne equipment, or an algorithm based on assumptions for RAIM prediction that give a more conservative result. RAIM availability may be confirmed by using model-specific RAIM prediction software, by using the FAA RAIM prediction Web site: [www.raimprediction.net](http://www.raimprediction.net), or by contacting a Flight Service Station.

(b) RAIM availability prediction software does not guarantee the service; they are tools to assess the expected capability to meet the required navigation performances. Because of unplanned failure of some GPS elements, pilots must realize that RAIM or GPS navigation may be lost while airborne which may require reversion to an alternative means of navigation. Therefore, pilots should assess their capability to navigate (potentially to an alternate destination) in case of failure of GPS navigation.

(c) In the event of a predicted, continuous loss of RAIM of more than 5 minutes for any part of the intended flight, the flight should be delayed, canceled, or re-routed where RAIM requirements can be met.

(7) For aircraft navigating with SBAS receivers (all TSO-C145/C146 systems), operators should take into account the latest GPS constellation and SBAS NOTAMs. If NOTAMs indicate the SBAS signal is not available over the intended route of flight, operators should check appropriate GPS RAIM availability.

(8) The operator's contingency procedures need to address at least the following conditions:

(a) Failure of the RNP system components, including those affecting lateral or vertical deviation performances (e.g., failures of a GPS sensor, flight director, or automatic pilot);

(b) Loss of navigation signal-in-space (loss or degradation of external signal) and;

(c) The pilot must ensure the capability to navigate and land at an alternate if loss of RNP approach capability occurs.

**b. During the Procedure.**

(1) Pilots must comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this AC.

(2) Pilots must confirm the system is in approach mode within 2 NM prior to the FAF.

(3) The appropriate displays must be selected so that the following information can be monitored:

(a) The RNP computed desired track (DTK), and

(b) Aircraft position relative to the path Cross-track deviation (XTK) for FTE monitoring.

(4) All pilots are expected to maintain procedure centerlines, as depicted by onboard lateral deviation indicators and/or flight guidance during the approach procedure unless authorized to deviate by ATC or under emergency conditions.

(5) While operating on RNP segments, pilots are encouraged to use flight director and/or autopilot in lateral navigation mode and vertical navigation mode, if available.

(6) For aircraft requiring two pilots, crews must verify that each pilot's altimeter has the current setting before beginning the final approach of a RNP approach procedure. The crew must also observe any operational limitations associated with the source(s) for the altimeter setting and the latency of checking and setting the altimeters approaching the FAF.

(7) Although scaling should change automatically, pilots of aircraft with a lateral deviation indicator (e.g., CDI) must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the various segments of the procedure (i.e.,  $\pm 1.0$  NM for the Initial and intermediate segments,  $\pm 0.3$  NM for the final approach segment, and  $\pm 1.0$  NM for the missed approach segment).

(8) RNP approach procedures require flightcrew monitoring of lateral and, if installed, vertical track deviations on the pilot's primary flight displays (PFD) to ensure the aircraft remains within the bounds defined by the procedure.

(9) The flightcrew must initiate a go-around if either a lateral or vertical deviation is too large unless the visual conditions required to continue the approach exist between the aircraft and the runway of intended landing. For normal operations, cross-track error/deviation (the difference between the displayed computed path and the displayed aircraft position relative to the path) should be limited to the values specified for the segment of the procedure (i.e., 0.5 NM for the initial and intermediate segments, 0.25 NM for the final approach segment, and 0.5 NM for the missed approach segment). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the navigation accuracy (i.e., 1.0 NM for the initial and intermediate segments), are allowable. Vertical deviation limits are +100/-50 feet.

**APPENDIX 2. QUALIFICATION CRITERIA FOR RNP 1 (TERMINAL) OPERATIONS**

**1. Introduction.** This Appendix provides guidance on the performance and functional requirements for systems used to conduct Required Navigation Performance (RNP) Instrument Departure Procedures (RNP Obstacle Departure Procedures (ODPs) and Standard Instrument Departure (SIDs)) and Standard Terminal Arrival Routes (RNP STARs) within the U.S. National Airspace System (NAS) where domestic air traffic control procedures are applied.

**2. Aircraft and System Requirements for RNP Terminal Operations.** Notes below apply to entire paragraph.

**a.** Aircraft with a statement of compliance with the criteria in this AC, in their Aircraft Flight Manual (AFM), AFM Supplement, Pilot Operating Handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this AC.

**b.** Aircraft with a statement from the manufacturer documenting compliance with the criteria in this AC meet the performance and functional requirements of this AC. These statements should include the airworthiness basis for compliance. Compliance with the sensor requirements will have to be determined by the equipment or aircraft manufacturer, while compliance with the functional requirements in this Appendix may be determined by the manufacturer or by inspection by the operator.

**c.** GPS stand-alone systems, equipment should be approved in accordance with TSO-C129a Class A1 or TSO-C146 and operational class 1, 2, or 3, (without deviating from the functionality described in this Appendix), that are installed for IFR use in accordance with AC 20-138.

**d.** Aircraft with TSO-C129 sensor(s) (Class B or C) or TSO-C145 sensor(s) and FMS(s) that meet the requirements of TSO-C115b and are installed for IFR use in accordance with FAA AC 20-130.

**e.** Aircraft/equipment with approval under AC 90-100 for use of GPS are approved under this AC for RNP 1 operations.

**f.** RNP aircraft with P-RNAV approval based on GPS capability meet the functional requirements of this AC for RNP 1 operations, such as RNP DPs, RNP SIDs, and RNP STARs. GPS equipment approved in accordance with TSO-C129 and satisfying the step-detection and health word checking contained in TSO-C129A meet P-RNAV performance requirements.

**NOTE: RNP 1 operations are based on GPS positioning and, if adequate coverage is available, DME/DME/IRU. Positioning data from other types of navigation sensors may be integrated with the GPS data provided it does not cause position errors exceeding the Total System Error (TSE) budget. Otherwise, means should be provided to deselect the other navigation sensor types.**

**NOTE: TSO-C145 or TSO-C146 equipment may also be authorized, in accordance with this AC, for use as the only means of navigation for conducting RNP operations in U.S. airspace where Domestic ATC**

**procedures are applied, including RNP operations (Class I Navigation operations) outside the navigational service volume of ICAO standard ground-based NAVAIDs.**

### **3. System Performance, Monitoring and Alerting.**

**a. Accuracy.** The aircraft must comply with section 2.1.1 of RTCA/DO-236B. During operations in airspace or on routes designated as RNP 1, the lateral total system error must be within  $\pm 1$  NM for at least 95 percent of the total flight time. The along-track error must also be within  $\pm 1$  NM for at least 95 percent of the total flight time. To satisfy the accuracy requirement, the 95 percent, FTE should not exceed 0.5 NM.

**NOTE: The use of a lateral deviation indicator with 1 NM full-scale deflection has been found to be an acceptable means of compliance. The use of an autopilot or flight director has been found to be an acceptable means of compliance (roll stabilization systems do not qualify).**

**b. Integrity.** Malfunction of the aircraft navigation equipment that causes the total system error (TSE) to exceed two times the RNP value is classified as a major failure condition under airworthiness regulations (i.e.,  $10^{-5}$  per hour).

**c. Continuity.** Loss of function is classified as a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport.

**d. Performance Monitoring and Alerting.** The RNP system, or the RNP system and pilot in combination, shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 2 NM is greater than  $10^{-5}$  for RNP 1 operations.

**e. Path Definition.** RNP systems should provide lateral guidance so aircraft remain within the lateral boundaries of the fly-by transition area as defined in RTCA/DO-236B, section 3.2.5.4.1.

**f. Signal-in-Space.** If using GPS, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds  $10^{-7}$  per hour for RNP 1 operations.

**4. Functional Requirements of Navigation Data Displays.** The following navigation displays and functions are required and must be installed in accordance with AC 20-130 and AC 20-138 or equivalent airworthiness installation advisory material.

**a. Navigation Data Displays.** A to/from indication and a failure indicator, must be displayed on a lateral deviation display (CDI, EHSI) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for maneuver anticipation and for failure/status/integrity indication. A non-numeric lateral deviation display (for example, CDI, EHSI), with a to/from indication and a failure annunciation, for use as primary flight instruments for navigation of the aircraft, for maneuver anticipation, and for failure/status/integrity indication, should have the following attributes:



(1) The displays must be visible to the pilot and located in the primary field of view when looking forward along the flight path.

(2) The lateral deviation display scaling should agree with any alerting and annunciation limits, if implemented.

(3) The lateral deviation display must have a full-scale deflection suitable for the current phase of flight and must be based on the required total system accuracy.

(4) The display scaling may be set automatically by default logic or set to a value obtained from a navigation database. The full-scale deflection value must be known or must be available for display to the pilot commensurate with terminal area values.

(5) The lateral deviation display must be automatically slaved to the RNP computed path. It is recommended that the course selector of the deviation display be automatically slewed to the RNP computed path.

**NOTE: This does not apply for installations where an electronic map display contains a graphical display of the flight path and path deviation.**

(6) As an alternate means, a navigation map display must give equivalent functionality to a lateral deviation display with appropriate map scales (scaling may be set manually by the pilot), and giving equivalent functionality to a lateral deviation display. To be approved as an alternative means, the navigation map display must be shown to meet the TSE requirements and be located in the primary FOV.

**b. System Capabilities.** The following system capabilities are required as a minimum within any RNP 1 equipment:

(1) The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNP computed desired path and aircraft position relative to the path. For operations where the required minimum flightcrew is two pilots, a means for the pilot not flying to verify the desired path and the aircraft position relative to the path must also be provided.

(2) A navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the Aeronautical Information Regulation and Control (AIRAC) cycle and from which ATS routes can be retrieved and loaded into the area navigation system. The stored resolution of the data must be sufficient to achieve the required track keeping accuracy. The database must be protected against pilot modification of the stored data.

(3) The means to display the validity period of the navigation data to the pilot.

(4) The means to retrieve and display data stored in the navigation database relating to individual waypoints and navigation aids, to enable the pilot to verify the route to be flown.

(5) Capability to load from the database into the RNP 1 system the entire segment of the SID, ODP, or STAR to be flown.

**NOTE: Due to variability in systems, this document defines the segment from the first occurrence of a named waypoint, track, or course to the last occurrence of a named waypoint, track, or course. Heading legs prior to the first named waypoint or after the last named waypoint do not have to be loaded from the database.**

(6) The means to display the following items, either in the pilot's primary field of view, or on a readily accessible display page:

- (a) The active navigation sensor type;
- (b) The identification of the active (To) waypoint;
- (c) The ground speed or time to the active (To) waypoint; and
- (d) The distance and bearing to the active (To) waypoint.

(7) The capability to execute a "Direct to" function.

(8) The capability for automatic leg sequencing with display to the pilots.

(9) The capability to execute RNP 1 terminal procedures extracted from the onboard database including the capability to execute fly-over and fly-by turns.

(10) The system must have the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators, or their equivalent.

- (a) Initial Fix (IF),
- (b) Course to Fix (CF),
- (c) Direct to Fix (DF), and
- (d) Track to Fix (TF).

**NOTE:** Path terminators are defined in ARINC Specification 424, and their application is described in more detail in RTCA documents DO-236B and DO-201A.

(11) The aircraft must have the capability to automatically execute leg transitions consistent with VA, VM and VI ARINC 424 path terminators, or must be able to be manually flown on a heading to intercept a course or to go direct to another fix after reaching a procedure-specified altitude.

(12) The aircraft must have the capability to automatically execute leg transitions consistent with Course to Altitude (CA) and from a Fix to a Manual termination ARINC 424

path terminators, or the RNP system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint.

(13) The capability to load a RNP 1 procedure from the database, by procedure name, into the area navigation system.

(14) The capability to display an indication of the RNP 1 system failure, in the pilot's primary FOV.

**c. Database Integrity.** The navigation database suppliers must comply with RTCA DO-200A, Standards for Processing Aeronautical Data. A Type 2 letter of acceptance (LOA), issued by the appropriate regulatory authority to each of the participants in the data chain, demonstrates compliance with this requirement.

## **5. Special Characteristics of RNP 1 Operations.**

### **a. Operation on RNP ODPs, SIDs, STARs.**

(1) Pilots are not required to monitor ground-based navigation facilities used in position updating unless required by the Aircraft Flight Manual (AFM).

(2) The navigation performance needed to fly RNP 1 procedures must be clearly designated on all appropriate charts.

### **b. Requirements for Navigation Infrastructure.**

(1) If DME is used, the DME navigation infrastructure supporting the design of a procedure must be assessed and validated by the FAA or an FAA authorized third-party service provider. This includes a computer model assessment and an analysis by FAA flight inspection assets. DME coverage may use Expanded Service Volume (ESV) for select DME facilities so there is no requirement to use VOR, LOC, NDB, or Attitude and Heading Reference System (AHRS) during normal operation of the DME/DME RNP system. ESV facilities require a satisfactory flight inspection prior to use.

(2) DME signals must meet signal-in-space accuracy tolerances everywhere the signals are received in that procedure.

(3) For DME-based RNP operations where reliance is placed upon the IRU/IRS, some aircraft systems revert to VOR/DME-based navigation before reverting to inertial coasting. When the VOR is within 40 NM from the procedure and there is insufficient DME/DME navigation infrastructure, the impact of VOR radial accuracy must be evaluated by the FAA and determined to not affect aircraft position accuracy.

(4) The FAA must monitor the navigation infrastructure and issue timely warnings of outages (NOTAM).

(5) All RNP 1 procedures must be flown by aircraft meeting the performance requirements in this AC using DME/DME/IRU and/or GPS.

(6) If any critical DME facilities exist, they must be identified within the relevant U.S. Flight Information Publications (FLIP). All DME ground stations used to define the availability of these ODPs, SIDS, and STARs must comply with applicable ICAO standards.

## **6. System Eligibility and Approval for RNP 1 Operations.**

**a. Eligibility for RNP Terminal Area Operations.** The following systems meet the requirements defined in this AC. This equipment still requires evaluation by the manufacturer against all the functional and performance requirements in this AC.

(1) Aircraft with a TSO-C129 Class A1 system (without deviation from the functionality in Appendix 2) or a TSO-C146 system (without deviation from the functionality in Appendix 2) that are installed for IFR use in accordance with AC 20-138.

(2) Aircraft with a TSO-C129 sensor (Class B or C) installed in a FMS that meets the requirements of TSO-C115b and is installed for IFR use in accordance with AC 20-130.

(3) Aircraft with a TSO-C145 sensor installed in a FMS that meets the requirements of TSO-C115b and is installed for IFR use in accordance with AC 20-130 or AC 20-138.

### **b. System Eligibility for RNP 1 Operations.**

(1) **Standalone Systems.** Standalone TSO-C129 Class A1 or A2 systems (without deviation from the functionality in Appendix 1), or TSO-C146 Class 1, 2, or 3 systems (without deviation from the functionality in Appendix 2) meet the aircraft qualification requirements for RNP 1 operations. GPS systems must be approved in accordance with AC 20-138.

(2) **Multi-Sensor Systems.** Multi-sensor systems using TSO-C129 Class B or Class C sensors or TSO-C145 Class 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP 1 operations provided that the installations comply with the criteria in this Appendix. RNP systems must be installed in accordance with AC 20-138, Airworthiness Approval of Global Navigation Satellite System (GNSS), and the associated flight management system must comply with TSO-C115b and AC 20-130, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors.

(3) **Multi-Sensor Systems That Rely on Ground-based Nav aids.** Multi-sensor systems that require the use of ground-based nav aids, such as DME/DME, can be used to conduct RNP 1 operations provided that the AFM or Flight Manual Supplement shows the aircraft is approved for RNP instrument flight operations, the aircraft meets the functional and performance requirements in this Appendix (e.g., RNP performance monitoring and alerting), and the requirements of AC 90-100A appendix 1 or appendix 2, as applicable.

## **7. Operational Approval for RNP 1 Operations.**

### **a. Aircraft Qualification Documentation.**

(1) The aircraft or avionics manufacturers should develop aircraft qualification documentation that shows compliance with the applicable criteria, as appropriate. For aircraft

without approval to fly RNP 1 procedures: the aircraft or avionics manufacturers should develop RNP 1 qualification documentation showing compliance with this Appendix provided equipment is properly installed and operated. The necessary documentation should also define the recommended RNP maintenance procedures. This is not required for aircraft with an AFM or AFM Supplement which explicitly states that the RNP system is approved for IFR operations with RNP values at least as low as RNP 1 and the equipment meets the performance and reliability requirements of AC 20-138, AC 20-130 and TSO-C115B, and AC 20-129, as applicable.

(2) Prior to application, operators and manufacturers of their equipment should review all performance requirements. Installation of equipment by itself does not guarantee operational approval or permit operational use.

#### **b. FAA Acceptance of Documentation.**

(1) New Aircraft/Equipment. The aircraft/equipment qualification documentation can be approved as part of an aircraft certification project and reflected in the AFM and related documents.

(2) Existing Aircraft/Equipment. Previous approvals to conduct RNAV 1 procedures using GPS, according to AC 90-100, do not require further evaluation. For installations/equipment not eligible to conduct RNAV 1 procedures, the aircraft or avionic manufacturer should submit the aircraft qualification and RNP documentation to the Flight Technologies and Procedures Division (AFS-400).

(3) AFS-400 will coordinate with other FAA offices to review the RNP operation application package. Acceptance will be documented in a letter to the aircraft or avionics manufacturer, as applicable.

### **8. Operational Considerations.**

#### **a. Pre-Flight Planning.**

(1) For systems with RAIM-based integrity, RAIM prediction must be performed prior to departure. This capability can be a ground service and need not be resident in the aircraft's avionics equipment.

(2) Operators should be familiar with the prediction information available for the intended route. RAIM availability prediction should take into account the latest GPS constellation NOTAMs and avionics model (when available). The service may be provided by the FAA, avionics manufacturer, other entities, or through an airborne receiver RAIM prediction capability. RAIM availability may be confirmed by using model-specific RAIM prediction software, by using the FAA en route and terminal RAIM prediction Web site: [www.raimprediction.net](http://www.raimprediction.net), or by contacting a Flight Service Station.

(3) This predictive capability must account for known and predicted outages of GPS satellites or other impacts on the navigation system's sensors. The prediction program should not use a mask angle below five degrees, as operational experience indicates that satellite signals at

low elevations are not reliable. RAIM availability prediction should take into account the latest GPS constellation NOTAMs and use the identical algorithm to that used in the airborne equipment, or an algorithm based on assumptions for RAIM prediction that give a more conservative result.

(4) In the event of a predicted, continuous loss of appropriate level of fault detection of more than 5 minutes, for any part of the RNP operation, the flight planning should be revised (e.g., delaying the departure or planning a different departure procedure).

(5) RAIM availability prediction software does not guarantee the service. They are rather tools to assess the expected capability to meet the required navigation performances. Because of unplanned failure of some GPS elements, pilots must realize that RAIM or GPS navigation may be lost while airborne which may require reversion to an alternative means of navigation. Therefore, pilots should assess their capability to navigate (potentially to an alternate destination) in case of failure of GPS navigation. The RAIM prediction program, if required to verify system integrity, should comply with the criteria in AC 20-138, paragraph 12.

(6) For aircraft navigating with SBAS receivers (all TSO-C145/C146 systems), operators should take into account the latest GPS constellation and SBAS NOTAMs. Operators should also check appropriate GPS RAIM availability in areas where SBAS signal is unavailable.

(7) For multi-sensor systems with RNP 1 approval based on DME/DME, pilots must confirm the availability of critical DME facilities (e.g., check NOTAMS for critical DME's listed on chart).

#### **b. General Inflight Considerations.**

(1) Pilots must not fly an RNP 1 procedure unless it is retrievable by the procedure name from the onboard navigation database and conforms to the charted procedure. Numeric values for courses and tracks should be automatically loaded from the RNP navigation database for required leg types. However, the procedure may subsequently be modified through the insertion or deletion of specific waypoints in response to ATC clearances. The manual entry or creation of new waypoints, by manual entry of latitude and longitude or rho/theta values is not permitted. Additionally, pilots must not change any database waypoint type from a fly-by to a fly-over or vice versa.

(2) The pilot must confirm the correct procedure is selected. This process includes confirmation of the waypoint sequence, reasonableness of track angles and distances, and any other parameters that can be altered by the pilot, such as altitude or speed constraints. A navigation system textual display or navigation map display must be used.

(3) For RNP 1 procedures, pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation (LNAV) mode. Pilots of aircraft with a lateral deviation display must ensure lateral deviation scaling is suitable for the navigation accuracy associated with the procedure.

(4) All pilots are expected to maintain centerlines, as depicted by onboard lateral deviation indicators and/or flight guidance during all RNP operations described in this AC unless

authorized to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the displayed path and the displayed aircraft position relative to the displayed path, (i.e., FTE) should be limited to half the navigation accuracy associated with the procedure (i.e., 0.5 NM for RNP 1). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the navigation accuracy (i.e., 1.0 NM for RNP 1), are allowable.

**NOTE: Some aircraft do not display or compute a path during turns. As such, pilots of these aircraft may not be able to adhere to half the lateral navigation accuracy during turns but are still expected to satisfy the standard during intercepts following turns and on straight segments.**

(5) Operational qualification for RNP procedures requires flightcrew monitoring of lateral and, if installed, vertical deviations on the pilot's primary flight displays (PFD) to ensure the aircraft remains within the bounds defined by the procedure. The deviation must be monitored, and action taken to minimize errors during all RNP operations.

(6) If ATC issues a heading assignment taking the aircraft off a procedure, the pilot should not modify the primary flight plan in the RNP system until a clearance is received to rejoin the route or the controller confirms a new route clearance. The specified accuracy requirement does not apply when the aircraft is not on the published RNP 1 procedure.

(7) The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action.

(8) Pilots operating aircraft with an approved baro-VNAV system may continue to use their baro-VNAV system while executing U.S. RNP 1 STARs. Operators must ensure compliance with all altitude constraints as published in the procedure by reference to the barometric altimeter.

**c. Prior to Commencing the RNP Procedure.** In addition to normal operating procedures, prior to commencing the procedure the flightcrew should accomplish the following:

(1) The flightcrew must confirm that the correct procedure has been selected. This process includes confirmation of the waypoint sequence, reasonableness of track angles, distances, and any other parameters that can be altered by the pilot, such as altitude or speed constraints. A procedure must not be used if validity of the navigation database is in doubt. A navigation system textual display or navigation map display must be used.

(2) For multi-sensor systems, crew must verify that the correct sensor is being used for position computation.

1/23/09

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Appendix 3

**APPENDIX 3. QUALIFICATION CRITERIA FOR RNP 2 (EN ROUTE) OPERATIONS**

**(Reserved)**



## APPENDIX 4. USE OF BAROMETRIC VNAV

**1. Purpose.** This Appendix addresses those systems using barometric altitude and navigation system information in the definition of vertical flight paths and vertical tracking to a path. Barometric vertical navigation (baro-VNAV) provides vertical path information defined by vertical angles or altitudes at fixes in the procedure. This specification provides system and operational criteria for the approval of a vertical navigation (VNAV) system using barometric altimetry as a basis for its vertical navigation capability.

**2. Applicability.** This Appendix applies to all operators conducting baro-VNAV operations under Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 91K, 121, 125, 129, and 135 within the United States (U.S.) National Airspace System (NAS). This Appendix also provides guidance for approval to use baro-VNAV equipment to perform 14 CFR part 97 RNAV(GPS) or GPS instrument approach procedures (IAP) published with a lateral navigation (LNAV)/ vertical navigation (VNAV) line of minima with a Decision Altitude (DA).

### 3. Aircraft Eligibility.

**a. RNP System Capability.** Eligible aircraft are those which meet the performance and functional requirements outlined in Appendix 1 or Appendix 2 as appropriate for the RNP operation.

**b. Barometric VNAV Capability.** Eligible aircraft are those with an Aircraft Flight Manual (AFM) or AFM Supplement which explicitly states that the VNAV system is approved for approach operations in accordance with AC 20-129 or AC 20-138. In addition, for a VNAV system to be approved for approach operations under AC 20-129, or AC 20-138 it must have a vertical deviation indicator (VDI). Since VDI scaling/sensitivity values vary widely, eligible aircraft must also be equipped with and operationally using either a flight director or autopilot capable of following the vertical path. Pilot deviation of +100/-50 feet is considered acceptable for adherence to the depicted VNAV path.

**NOTE: Aircraft with an authorization for RNP special aircraft and aircrew authorization required (SAAAR) operations are considered eligible for baro-VNAV operations conducted in accordance with this AC.**

**c. Data Base Requirement.** The electronic data base must include the waypoints and associated VNAV information, i.e., altitudes and vertical angles, for the procedure to be flown.

**4. Operator/Aircraft Approvals.** Part 91 operators should review their AFM or AFM Supplement to establish navigation system eligibility as detailed in paragraph 3. Once the operator establishes system eligibility, the operator should take steps to ensure that baro-VNAV approach operations are conducted in accordance with the guidance in paragraphs 5 and 6. After these actions have been completed, the operator may begin to conduct barometric baro-VNAV approach operations to the published LNAV/VNAV line of minima. A letter of authorization (LOA) is not required when eligibility is based on the AFM and provisions of this AC.

**a. Documentation.** Parts 121, 125, 129,135 and 91K operators should present the following documentation to their certificate-holding district office (CHDO): sections of the AFM or AFM

Supplement which document RNAV/RNP airworthiness approval for approach operations in accordance with paragraph 3 and sections of the training and operations manuals which reflect the operating policies of paragraphs 5 and 6. Once the operator has addressed the guidance in these paragraphs to the satisfaction of the CHDO, the operator may begin to conduct baro-VNAV approach operations to the published LNAV/VNAV line of minima.

**b. Eligibility not Based on the AFM or AFM Supplement (Special Approval).**

(1) The operator may not be able to determine baro-VNAV approach eligibility from the AFM or AFM Supplement. In this case, a part 91 operator should request that the local Flight Standards District Office (FSDO) assess the equipment for baro-VNAV approach eligibility while a parts 121, 125, 129, 135 and 91K operators should request that the CHDO make the eligibility assessment. The operator should provide the FSDO or CHDO with the RNP system make, model and part number, any evidence of IFR navigation system approval, and pertinent information from crew operating procedures. If the FSDO or CHDO is unable to determine equipment eligibility, it should forward the request and supporting data through the appropriate FAA Flight Standards Regional Division to the appropriate Aircraft Evaluation Group (AEG). The AEG will verify that the aircraft and RNP system meet the criteria for baro-VNAV, and that the system can safely fly specified VNAV paths associated with instrument approach procedures applying a DA rather than an minimum descent altitude (MDA). The AEG will provide written documentation (i.e., amend Flight Standards Bulletin Report or other official documentation) to verify the eligibility of that equipment. Additionally, the Aircraft Certification Service may be consulted.

(2) For Part 91 operators, if the FAA determines that the navigation equipment is eligible for baro-VNAV instrument approach operations to a published DA, the FSDO will provide documentation that the aircraft equipment is approved for these baro-VNAV operations.

(3) For parts 121, 125, 129, 135 and 91K operators, the FAA will attempt to establish system eligibility and ensure that the operator's training and operations manuals reflect the operating policies of paragraphs 5 and 6. Once these steps are successfully completed, the operator may begin using this baro-VNAV equipment to fly to the LNAV/VNAV DA as published on the procedure.

**5. VNAV Operating Procedures (General).** For baro-VNAV approach operations, the flightcrew should be familiar with the operating procedures detailed below.

**a. Actions at DA.** The pilot/crew is expected to fly the aircraft along the published vertical path and execute a missed approach procedure upon reaching DA, unless the visual references specified in 14 CFR § 91.175 for continuing the approach are present.

**b. Temperature Limitation.** Because of the pronounced effect of nonstandard temperature on baro-VNAV operations, VNAV approaches will contain a temperature limitation below which use of the VNAV DA, based on baro-VNAV, is not authorized. The temperature limitation will be shown as a note on the procedure. If the airborne system contains a temperature compensation capability, manufacturer instructions should be followed for use of the baro-VNAV function.

**c. VNAV Path Mode Selection.** Crews should be knowledgeable on selection of the appropriate vertical mode(s) that command vertical navigation via the published vertical path. Other vertical modes such as vertical speed are not applicable to baro-VNAV approach operations.

**d. Remote Altimeter Setting Restriction.** Use of baro-VNAV to a DA is not authorized with a remote altimeter setting. A current altimeter setting for the landing airport is required. Where remote altimeter minima are shown, the VNAV function may be used but only to the published LNAV MDA.

**e. Manual Adjustments.** If manual adjustments to stored altitude information are necessary, e.g., cold temperature adjustments, the crew should make appropriate adjustments to procedure altitudes and revert to use of the temperature adjusted LNAV MDA.

**6. Pilot Knowledge.** Pilots/crews should be knowledgeable in the following areas:

**a.** The aeronautical instrument approach chart that will promulgate LNAV/VNAV procedures including, but not limited to, temperature and altimeter source limitations for baro-VNAV operations.

**b.** Barometric altimeters are calibrated to indicate true altitude under International Standard Atmosphere (ISA) conditions. If on a given day the temperature is warmer than ISA, the true altitude will be higher than indicated altitude. Conversely, on a day colder than ISA, the true altitude will be lower than indicated altitude. These errors increase in magnitude as the altitude above the altimeter setting source increases.

**c.** VNAV system-specific information.

**d.** Functional integration with other aircraft systems.

**e.** The meaning of vertical path discontinuities as well as related flightcrew procedures.

**f.** VNAV equipment operating procedures, including how to determine vertical-track error/deviation.

**g.** The pilot/flightcrew should be knowledgeable of failures and mode reversions, which adversely impact the aircraft's ability to conduct baro-VNAV approach operations. In addition, pilot/crew should be aware of contingency actions (i.e., reverting to LNAV MDA following VNAV failures).

**h.** Where two pilots are required, the flightcrew must complete an altimetry crosscheck ensuring both pilots' altimeters agree within  $\pm 100$  feet prior to the final approach fix (FAF). If the altimetry crosscheck fails then the procedure should not be conducted or, if in progress, it must not be continued. If the avionics systems provide a comparator warning system for the pilots' altimeters, the flightcrew procedures should also address actions to take if a comparator warning for the pilots' altimeters occurs while conducting a RNP procedure.

**NOTE: This operational crosscheck is not necessary if the aircraft automatically compares the altitudes to within 100 feet.**

## APPENDIX 5. ADVANCED FEATURES

**1. Introduction.** This Appendix provides guidance on the performance, functional and additional operational requirements for RNP systems containing advanced features.

**2. Radius to Fix (RF) leg capability.** RF legs are an optional capability rather than a minimum requirement for RNP operations. This capability can be used in the initial, intermediate, and missed approach segments of instrument approaches, RNP departure procedures (DP) and RNP STARS. Additional information on RF legs may be found in the Aeronautical Information Manual (AIM). For RNP systems incorporating RF Leg capability, the systems must comply with the requirements in Appendix 1 for RNP Approach, and Appendix 2 for RNP 1.

**NOTE: RF legs will not be used in the Final Approach Segment of an RNP approach.**

**a. System Requirements.**

**(1) Path Definition.** The RNP lateral accuracy requirement is evaluated around the path defined by the published procedure and RTCA/DO-236B, section 3.2.5.4.1 and 3.2.5.4.2.

**NOTE: Industry standards for paths can be found in RTCA/DO-236B.**

**(2) Demonstration of Path Steering Performance.** The navigation system must have the capability to execute leg transitions and maintain tracks consistent with an RF leg between two fixes.

**(3) Flight Technical Error (FTE).** System documentation should support maintenance of FTE (95 percent of the flying time) during straight and curved path segments, for each phase of flight and each autopilot and/or flight director mode requested. If using FTE values other than those listed in DO-283A, the applicant must complete the demonstration in accordance with AC 120-29, paragraphs 5.19.2.2 and 5.19.3.1.

**NOTE: The applicant may use AC 120-29A, paragraphs 5.19.22 and 5.19.3.1 to compute accepted FTE values.**

**(4) Interface to Flight Guidance System (FGS).** An acceptable autopilot and/or flight director response to an RNP system failure or loss must be verified in each autopilot and flight director mode, as applicable.

**NOTE: If Autopilot malfunction testing was performed for worst case failures, no further validation is required. In this case, the manufacturer must provide a statement of confirmation.**

**(5) Failure Modes/Annunciation.** System documentation should identify any failure modes potentially affecting RNP system RF Leg capability. Failure modes may include loss of electrical power, loss of signal reception, and RNP equipment failure including degradation of navigation performance resulting in a loss of RNP containment integrity. The applicant should

verify that a visible alert occurs within the flightcrew's primary field of view when loss of navigation capability and/or loss of integrity are experienced.

**b. Functional Requirements.**

(1) Autopilot and Flight Director. RNP procedures with RF legs require the use of an autopilot or flight director with at least "roll-steering" capability that is driven by the RNP system. The autopilot/flight director must operate with suitable accuracy to track the lateral and, as appropriate vertical paths required by a specific RNP procedure.

(2) The aircraft must have an electronic map display depicting the RNP computed path of the selected procedure.

(3) The flight management computer, the flight director system, and the autopilot must be capable of commanding a bank angle up to 25 degrees above 400 feet AGL.

(4) Maintaining LNAV in missed approach. If abandoning a procedure while on an RF Leg or initiating a go-around or missed approach (through activation of TOGA or other means), the flight guidance mode should remain in LNAV to enable display of deviation and display of positive course guidance during an RF leg. If the aircraft does not provide this capability, crew procedures must be used that assure the aircraft will adhere to the specified flight path during the RF Leg segment.

**NOTE: For missed approaches with a RF Leg, the flightcrew must be able to couple the autopilot or flight director to the RNP system (engage LNAV) by 500 feet AGL.**

**c. System Approval.** Eligibility Airworthiness Documents. The flight manual or referenced document should contain the following information:

(1) A statement indicating the aircraft meets the requirements for RNP operations with RF legs and has demonstrated the established minimum capabilities for these operations. This documentation should include the phase of flight, mode of flight (e.g., FD on or off; and/or AP on or off, and applicable lateral and vertical modes), minimum demonstrated RNP value, and sensor limitations, if any.

(2) Any conditions or constraints on path steering performance (e.g., A/P engaged, FD with map display, including lateral and vertical modes, and/or CDI/map scaling requirements) should be identified. Use of manual control with CDI only is not allowed on RF legs.

(3) The criteria used for the demonstration of the system, acceptable normal and non-normal procedures, the demonstrated configurations, type of facilities used, and any constraints or limitations necessary for safe operation should be identified.

**d. Additional Operational Requirements.**

(1) Requirements for RF legs will be indicated on the charts, in the notes section, or at the applicable initial approach fix for instrument approaches. When flying an RF leg, flightcrew

compliance with the desired path is essential to maintain the intended ground track and to assure obstacle clearance.

(2) Pilots must not exceed maximum airspeeds where published, while performing RNP operations containing RF legs.

(3) When the dispatch of a flight is predicated on flying a RNP approach with a RF leg at the destination and/or alternate, the dispatcher/pilot must determine that the autopilot/flight director is installed and operational.

**e. Modification of Flight Plan.** Pilots are not authorized to fly a published RNP procedure unless it is retrievable by the procedure name from the aircraft navigation database and conforms to the charted procedure. The lateral path must not be modified, with the exception of complying with ATC clearances/instructions. (However, the aircraft must be on course prior to beginning the RF leg.). The only other modification to the loaded procedure is to change altitude and/or airspeed waypoint constraints on the initial, intermediate, or missed approach segments (e.g., comply with an ATC clearance/instruction).

**3. Time of Arrival Controls (TOAC).** Criteria for systems with TOAC will be provided at a future date.

**4. Offsets.** Criteria for systems with lateral offsets will be provided at a future date.