U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

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

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FOREWORD

This advisory circular (AC) provides guidance for operators to conduct Required Navigation Performance (RNP) operations in the United States, in oceanic and remote continental airspace, and in foreign countries which adopt International Civil Aviation Organization (ICAO) standards for RNP operations. Guidance is provided for the following:

- Required Navigation Performance Approach (RNP APCH) procedures;
- Barometric vertical navigation (baro-VNAV);
- RNP 1 (terminal) operations;
- RNP 0.3 (rotorcraft) operations;
- RNP 2 domestic, offshore, oceanic, and remote continental operations;
- RNP 4 oceanic and remote continental operations;
- RNP 10 (Area Navigation (RNAV) 10) oceanic and remote continental operations;
- Advanced Required Navigation Performance (A-RNP), and
- Additional Capabilities.

This AC does not apply to those approaches which require unique authorization (Required Navigation Performance Authorization Required (RNP AR), as described in AC 90-101( ), Approval Guidance for RNP Procedures with AR, nor does it address instrument approach procedures (IAP) using localizer performance with vertical guidance (LPV) or localizer performance without vertical guidance (LP), which are addressed in AC 90-107( ), Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System.

ORIGINAL SIGNED by

/s/ John Barbagallo
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CHAPTER 1. GENERAL INFORMATION

1.1 Purpose. This advisory circular (AC) provides aircraft eligibility and operational guidance for operators to conduct Required Navigation Performance (RNP) operations in the United States, in oceanic and remote continental airspace, and in foreign countries which adopt International Civil Aviation Organization (ICAO) standards for RNP operations. Guidance is provided for the following:

- Required Navigation Performance Approach (RNP APCH) Procedures: Appendix A, Qualification Criteria for Required Navigation Performance Approach (RNP APCH) Operations.
- RNP APCH Procedures to LNAV/VNAV Approach Minimums: Appendix B, Use of Barometric Vertical Navigation (baro-VNAV) for Required Navigation Performance Approach (RNP APCH) Operations.
- RNP 1 Arrival and Departure Procedures: Appendix C, Qualification Criteria for Required Navigation Performance (RNP) 1 (Terminal) Operations.
- RNP 0.3 En Route and Terminal Operations for Rotorcraft: Appendix D, Qualification Criteria for Required Navigation Performance (RNP) 0.3 (Rotorcraft) Operations.
- RNP 2 En Route Operations: Appendix E, Qualification Criteria for Required Navigation Performance (RNP) 2 Domestic, Offshore, Oceanic, and Remote Continental Operations.
- RNP 4 Operations in Oceanic and Remote Continental Airspace: Appendix F, Qualification Criteria for Required Navigation Performance (RNP) 4 Oceanic and Remote Continental Operations.
- RNP 10 Operations in Oceanic and Remote Continental Airspace: Appendix G, Qualification Criteria for Required Navigation Performance (RNP) 10 Oceanic and Remote Continental Operations.

Note: Area Navigation (RNAV) 10 is designated and authorized as RNP 10. This document uses the designation of RNP 10.

- Advanced RNP En Route, Terminal, or Approach Operations: Appendix H, Advanced Required Navigation Performance (A-RNP).
- Additional Capabilities: Appendix I.

Note: The contents of this AC reflect and harmonize with ICAO Doc 9613, fourth edition, Performance-Based Navigation (PBN) Manual (see Table 5-1).

1.2 Alternative Method. 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).

CHAPTER 2. APPLICABILITY

2.1 Audience. The guidance contained in this advisory circular (AC) applies to all operators conducting Required Navigation Performance (RNP) operations under Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 91 subpart K (91K), 121, 125, 129, and 135 within the U.S. National Airspace System (NAS). It also applies to all U.S. operators conducting RNP operations offshore as defined by the Federal Aviation Administration (FAA) Order JO 7400.9( ), Airspace Designations and Reporting Points; and oceanic and remote continental airspace. This AC also applies to all U.S. operators conducting RNP operations in foreign airspace, where the foreign authority has implemented RNP in accordance with International Civil Aviation Organization (ICAO) Doc 9613.

2.2 Approach Guidance Not Applicable to this AC. This AC does not apply to Required Navigation Performance Authorization Required (RNP AR) covered by AC 90-101( ), Approval Guidance for RNP Procedures with AR. Guidance for operators to conduct 14 CFR part 97 instrument flight rules (IFR), Area Navigation (RNAV) global positioning system (GPS), instrument approach procedures (IAP) with localizer performance with vertical guidance (LPV), and localizer performance without vertical guidance (LP) lines of minima using the wide area augmentation system (WAAS) is covered in AC 90-107( ), Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System.

2.3 Terms. 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 (AMC) described herein are used. This AC does not change, add, or delete regulatory requirements or authorize deviations from regulatory requirements.

2.3.1 Major and Minor Failures. The terms of major and minor failure conditions are referenced from ICAO Doc 9613. Refer to AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, for specific failure conditions and system performance requirements.

2.4 References. Most of the document references in this AC are the most current version as designated by parentheses ( ) placed at the end of the document title. In some cases, the actual version will be indicated by a letter. Documents without ( ) or a letter after the end of the document title designates all versions apply. As a convenience, most references are hyperlinked to the appropriate Web site containing the most current document. To navigate to the most current AC, Order, or Technical Standard Order (TSO), use the following links:

- Advisory Circulars,
- FAA Order, and
- Technical Standard Orders.

2.5 Aircraft Eligibility and Aircraft Modification. Aircraft eligibility provided in this AC provides guidance for an operator to determine if their aircraft is capable of conducting these operations. This guidance is not appropriate for conducting any modifications to aircraft type design. Detailed and complete airworthiness guidance is available in AC 20-138( ) and should be used by all airworthiness applicants.

CHAPTER 3. DOCUMENTATION

3.1 Cancellation. Advisory Circular (AC) 90-105, Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System is cancelled. 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) were cancelled with the publication of AC 90-105 (dated 1/23/2009).

Note: Guidance from Federal Aviation Administration (FAA) Order 8400.33, Procedures for Obtaining Authorization for Required Navigation Performance 4 (RNP-4) Oceanic and Remote Area Operations, and FAA Order 8400.12C, Required Navigation Performance 10 (RNP 10) Operational Authorization, are included in this AC.

3.2 FAA ACs and Orders. Please refer to the links provided in the bullets of paragraph 2.4 to obtain the latest ACs and/or orders.

- AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems.
- AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases.
- AC 23.1309-1( ), System Safety Analysis and Assessment for Part 23 Airplanes.
- AC 25.1309-1( ), System Design and Analysis.
- AC 25-15( ), Approval of Flight Management Systems in Transport Category Airplanes.
- AC 90-100( ), U.S. Terminal and En Route Area Navigation (RNAV) Operations.
- AC 90-101( ), Approval Guidance for RNP Procedures with AR.
- AC 90-107( ), Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System.
- AC 91-70( ), Oceanic and International Operations.
- AC 120-29( ), Criteria for Approval of Category I and Category II Weather Minima for Approach.
- AC 120-70( ), Operational Authorization Process for Use of Data Link Communication System.
- Order 7110.82, Reporting Oceanic Errors.
- Order 7400.9( ), Airspace Designations and Reporting Points.
- Order 8260.3B CHG 26, United States Standard for Terminal Instrument Procedures (TERPS).
- Order 8260.19F, Flight Procedures and Airspace.

- Order 8260.42B, United States Standard for Helicopter Area Navigation (RNAV).
- Order 8260.46E, Departure Procedure (DP) Program.
- Order 8260.53, Standard Instrument Departures that Use Radar Vectors to Join RNAV Routes.
- Order 8260.58, United States Standard for Performance Based Navigation (PBN) Instrument Procedure Design.

3.3 Related Regulations Title 14 of the Code of Federal Regulations (14 CFR).

- Part 71, §§ 71.31 and 71.71.
- Part 91, § 91.123, 91.175, 91.205, and Subpart H.
- Part 95.
- Part 97, § 97.20.
- Part 121, §§ 121.349, 121.351, and 121.567, Appendix G.
- Part 125, §§ 125.203, 125.287, and 125.325.
- Part 129, § 129.17.
- Part 135, § 135.165.

3.4 FAA Technical Standard Orders (TSO).

- TSO-C106, Air Data Computer.
- TSO-C115b, Airborne Area Navigation Equipment Using Multisensor Inputs.
- TSO-C115c or later, Airborne Area Navigation Equipment Using Multisensor Inputs.
- TSO-C129a, Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS).
- TSO-C145, Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).
- TSO-C146, Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).
- TSO-C196, Airborne Supplemental Navigation Sensors for Global Positioning System Equipment using Aircraft-Based Augmentation.

3.5 RTCA Documents. Copies of the following RTCA, Inc. 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/store_list.asp.

- RTCA/DO-178( ), Software Considerations in Airborne Systems and Equipment Certification.
- RTCA/DO-187( ), Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Multisensor Inputs.
- RTCA/DO-201( ), Standards for Aeronautical Information.
- RTCA/DO-208( ), Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS).
- RTCA/DO-229( ), Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment.
- RTCA/DO-236( ), Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation.
- RTCA/DO-283( ), Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation.
- RTCA/DO-316( ), Minimum Operational Performance Standards for Global Positioning System/Aircraft -based Augmentation System Airborne Equipment.

3.6 Other Documents. Copies of the International Civil Aviation Organization (ICAO) documents may be obtained from Document Sales Unit, ICAO, 999 University Street, Montreal, Quebec, H3C 5H7, Canada:

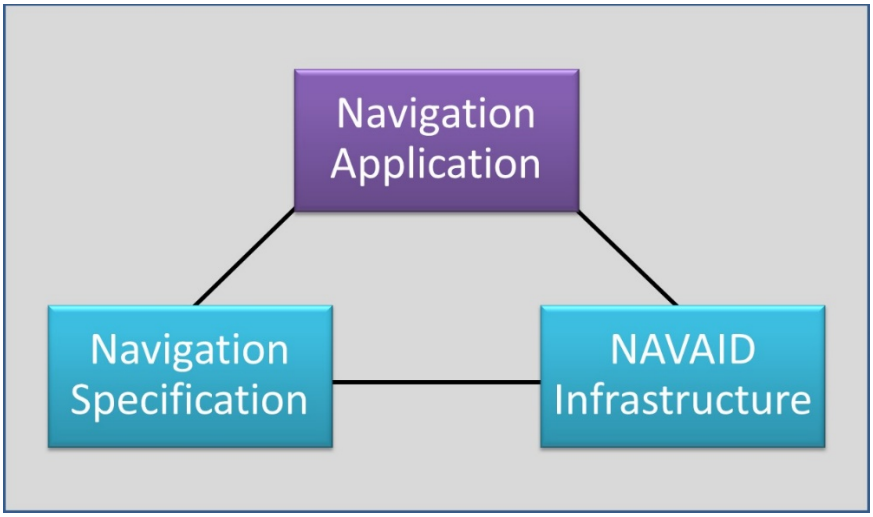
- ICAO Doc 9613, Performance Based Navigation (PBN) Manual.
- ICAO Doc 4444 PANS ATM, Procedures for Air Navigation Services, Air Traffic Management.
- ICAO Doc 7030, Regional Supplementary Procedures (SUPPS).
- Aeronautical Information Publications (AIP), United States, 2014.

CHAPTER 4. GENERAL INFORMATION

4.1 Performance-Based Navigation (PBN) Concept. The PBN concept represents a shift from ground-based navigation to Area Navigation (RNAV). Performance requirements are identified in navigation specifications (Nav Spec) (e.g., the requirements in this advisory circular (AC)), which also identify the choices of navigation sensors, navigation equipment, operational procedures, and training needed to meet the performance requirements.

4.1.1 Components. The PBN concept specifies aircraft Required Navigation Performance (RNP) system performance requirements in terms of accuracy, integrity, availability, continuity, and functionality needed for particular operations or airspace. The Navigation Application is achieved by the use of a Navigational Aid (NAVAID) infrastructure and associated Nav Spec (See Figure 4-1, Performance-Based Navigation Concept).

Figure 4-1. Performance-Based Navigation Concept



4.1.1.1 Navigation Application. This is defined as the application of a Nav Spec and the supporting NAVAID infrastructure, to routes, procedures, and/or defined airspace volume, in accordance with the intended airspace concept. For example, in the terminal area, the Nav Spec is RNP 1 with an accuracy of 1 nautical mile (NM). The NAVAID infrastructure would be Global Navigation Satellite System (GNSS) or distance measuring equipment (DME)/DME.

4.1.1.2 NAVAID Infrastructure. NAVAID infrastructure refers to space-based and/or ground-based NAVAIDs available to meet the requirements in the Nav Spec.

4.1.1.3 Nav Spec. A set of aircraft and aircrew requirements needed to support PBN operations within a defined airspace. There are two kinds of Nav Spec:

1. **RNAV specification.** A Nav Spec based on area navigation that does not include the requirement for onboard performance monitoring and alerting, designated by the prefix RNAV (e.g., RNAV 5, RNAV 1).
2. **RNP specification.** A Nav Spec based on area navigation that includes the requirement for onboard performance monitoring and alerting, designated by the prefix RNP (e.g., RNP 4, Required Navigation Performance Approach (RNP APCH).

Note: The Performance-based Navigation Manual (Doc 9613), Volume II, contains additional information on Nav Specs.

4.1.2 Lateral Performance. For oceanic/remote, en route and terminal phases of flight, PBN is limited to operations with linear lateral performance requirements and time constraints due to legacy reasons associated with the previous RNP concept. In the approach phases of flight, PBN accommodates both linear and angular laterally guided operations.

4.1.2.1 **RNP Values.** The RNP value (also known as lateral navigation accuracy) designates the 95 percent lateral navigation (LNAV) performance (in NM) and the related monitoring and alerting requirements associated with an RNP instrument flight operation or a particular segment of that instrument flight. RNP values are specified in NM (e.g., RNP 0.3).

4.1.3 Vertical Performance. Some Nav Specs include requirements for vertical guidance using augmented GNSS or barometric vertical navigation (baro-VNAV) (see Appendix B). However, these requirements do not constitute vertical RNP which is neither defined nor included in the PBN Concept.

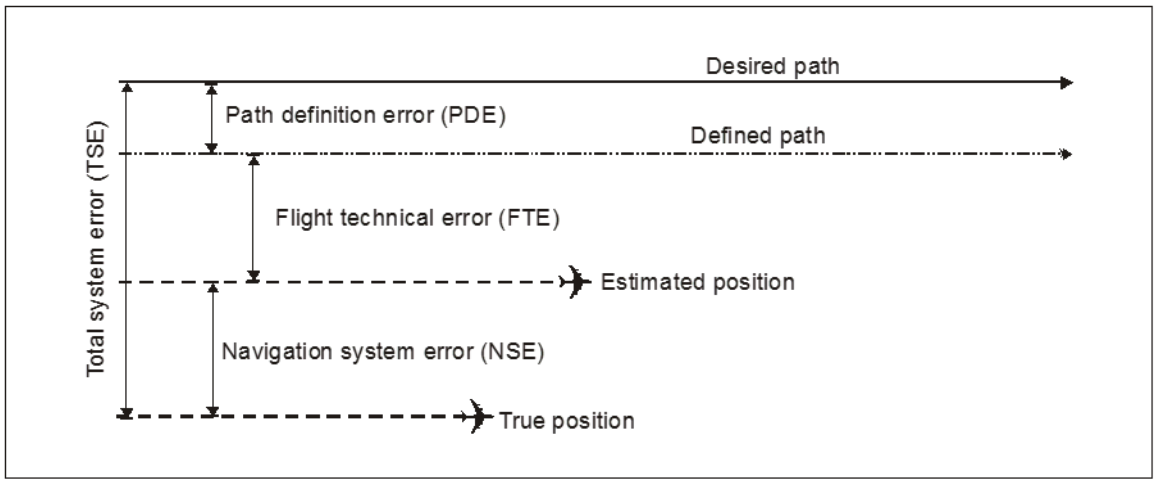
4.1.4 Onboard Performance Monitoring and Alerting. Onboard performance monitoring and alerting is the main element that determines if the navigation system complies with the necessary safety level associated to an RNP application. It relates to both lateral and longitudinal navigation performance; and it allows the aircrew to detect that the navigation system is not achieving, or cannot guarantee with 10^{-5} integrity, the navigation performance required for the operation. RNP systems provide improvements on the integrity of operations; this may permit closer route spacing and can provide sufficient integrity to allow only RNP systems to be used for navigation in a specific airspace. The use of RNP systems may therefore offer significant safety, operational and efficiency benefits.

4.2 **Procedures and Routes.** 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 Flight Technical Error (FTE). The

onboard monitoring and alerting function should consist at least of a Navigation System Error (NSE) or Position Estimation Error (PEE) 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. Path Definition Error (PDE) is considered negligible due to the database integrity process (see Chapter 10, Database Integrity) and crew procedures.

Figure 4-2. Total System Error (TSE)



Note 1: When evaluating RNP compliance, consideration must be given to possible error sources. Figure 4-2 displays possible cross track (XTK) errors that can occur with definitions provided in paragraph 4.3.

Note 2: PDE is negligible and assumed to be zero. NSE is used instead of PEE and FTE is used instead of Path Steering Error (PSE) because they are considered equivalent and are the industry preferred terms.

4.3 Navigation Error Components/Definitions. Also in Appendix J, Administrative Information.

4.3.1 Flight Technical Error (FTE) or Path Steering Error (PSE). The accuracy with which the aircraft is controlled as measured by the indicated aircraft position, with respect to the indicated command or desired position is the FTE. It does not include blunder errors.

4.3.1.1 Display Error. As a component of FTE, these errors may include error components contributed by any input, output, or signal conversion equipment used by the display as it presents either aircraft position or guidance commands (e.g., course deviation or command heading) and by any course definition entry device employed.

4.3.2 Path Definition Error (PDE). This is the difference between the defined path and the desired path at a specific point.

4.3.3 Navigation System Error (NSE) or Position Estimation Error (PEE). The difference between true position and estimated position.

4.3.4 Total System Error (TSE). The difference between the true position and the desired position and is equal to the vector sum of the FTE, PDE, and NSE.

4.3.5 Position Estimation Error (PEE) or Navigation System Error (NSE). PEE or NSE is the difference between true position and estimated position.

CHAPTER 5. APPLICATIONS OF REQUIRED NAVIGATION PERFORMANCE (RNP) OPERATIONS

5.1 Overview. RNP operations as defined in this advisory circular (AC) are the application of navigation specification (Nav Spec) to a particular phase of flight. The columns of Table 5-1 contain RNP values (if applicable) for RNP operations in each phase of flight. RNP 1 requires an RNP value of 1 for arrival and departures in the terminal area and is also used in the initial, intermediate, and missed approach phase. RNP 2 is for both domestic and oceanic/remote continental operations with an RNP value of 2. RNP 4 and 10 are for oceanic and remote continental operations only with RNP values of 4 and 10 respectively. Advanced Required Navigation Performance (A-RNP) includes an RNP value of 2 for oceanic and remote continental operations and may have a 2 or 1 value for domestic en route segments. Except for the Final Approach Segment (FAS), advanced RNP allows scalability with a range from 1 to 0.3 as routing boundaries will gradually expand from 0.3 to greater values on departures/missed approaches and narrow on arrivals/approaches. Required Navigation Performance Approach (RNP APCH) operations have RNP values of 1 until the FAS where the boundaries narrow to RNP 0.3; the RNP value expands back to RNP 1 in the missed approach segment. Lastly, rotorcraft RNP 0.3 requires an RNP value of 0.3 for all phases of flight except for oceanic and remote continental and the FAS.

Table 5-1. Applications of RNP Operations

	Flight Phase							
			Terminal	**Approach**				**Terminal**
Navigation Specifications	En route Oceanic/Remote Continental	En route Domestic	Arrival	Initial	Intermediate	Final	Missed	Departure
RNP 1	N/A	N/A	1	1	1	N/A	1	1
RNP 2	2	2	N/A	N/A	N/A	N/A	N/A	N/A
RNP 4	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RNP 10	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
A-RNP	2	2 or 1	1 – 0.3	1 – 0.3	1 – 0.3	N/A	0.3 - 1	0.3 - 1
RNP APCH	N/A	N/A	N/A	1	1	0.3	1	N/A
RNP 0.3	N/A	0.3	0.3	0.3	0.3	N/A	0.3	0.3

Note 1: N/A: Not Applicable

Note 2: Except for RNP APCH, all the final blocks are intentionally labeled N/A.

Note 3: RNP 1 and A-RNP may be used in combination with any type of approach (RNP, instrument landing system (ILS), Ground Based Augmentation System (GBAS) Landing System (GLS)).

Note 4: RNP 0.3 applies to Domestic (Rotorcraft) Operations.

CHAPTER 6. OPERATIONAL GUIDANCE FOR REQUIRED NAVIGATION PERFORMANCE (RNP) OPERATIONS

6.1 General. This section provides guidance on the operational aspects that must be considered for conduct of all RNP operations. Additional guidance that is specific to each RNP navigation specification (Nav Spec) is provided in the appendices to this advisory circular (AC), including how to determine if your aircraft is eligible for the operation. In addition to this guidance, the operator must continue to ensure they comply with the general operating requirements, including checking Notices to Airmen (NOTAM), availability of Navigational Aids (NAVAID), airworthiness of aircraft systems, and aircrew qualification.

6.2 Centerline. All pilots are expected to maintain centerline, as depicted by onboard lateral deviation indicators and/or flight guidance during all RNP operations described in this AC unless authorized to deviate by air traffic control (ATC) or under emergency conditions. For normal operations, the cross-track (XTK) error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) should be limited to ±½ the RNP value. Brief deviations from this standard (e.g., overshoots or undershoots) during track changes (flyby and flyover turns), up to a maximum of one times the RNP value are allowable.

6.3 RNP En Route, RNP Terminal, and RNP APCH Operations:

1. The pilot is not required to monitor ground-based NAVAIDs used in position updating unless specified by the Airplane Flight Manual (AFM).
2. The pilot must comply with published and assigned altitudes, and airspeeds.

Note: Pilots operating aircraft with a barometric vertical navigation (baro-VNAV) system must ensure compliance with all altitude constraints as published in the procedure by reference to the barometric altimeter.

6.4 RNP Operational Transitions.

6.4.1 <u>Transitions to Instrument Landing System (ILS), Ground Based Augmentation System (GBAS) Landing System (GLS), Localizer Performance with Vertical Guidance (LPV) or Conventional Approach Procedures</u>. In order to fly RNP transitions to an ILS or GLS final approach course, or from an ILS or GLS approach with an RNP missed approach, pilots must comply with the operating requirements of this AC (see Appendices A (Required Navigation Performance Approach (RNP APCH)), C (RNP 1), and/or H (Advanced Required Navigation Performance (A-RNP)). RNP systems used for this type of operation must allow for a means to become established prior to the final approach fix (FAF) on an ILS or GLS or LPV final with minimal overshoot or undershoot. The pilot must ensure the appropriate navigation mode is selected/armed and that the Final Approach Segment (FAS) course and glideslope are correctly captured. Pilots must verify lateral and vertical capture on ILS procedures.

Note 1: Charts for ILS and GLS procedures with RNP transitions will contain notes specifying the requirement for suitable RNP capability. These RNP transitions are also identified by the use of waypoint symbols on the procedure.

Note 2: Pilots must pay close attention to the navigation source of both lateral and vertical axis. When transitioning from an RNP segment to a precision approach segment, it is possible for the lateral precision navigation source to acquire prior to capture of the vertical precision navigation source.

Note 3: Additional criteria for operation on ILS, LPV final and GLS approaches with Radius to Fix (RF) transitions are covered in Appendix I, Additional Capabilities.

6.5 Oceanic/Remote Continental Airspace and Offshore Airspace.

6.5.1 Airspace Distinction. For continuity purposes, there is a distinction between oceanic, remote continental, and offshore operations. The paragraphs below define these Areas of Operation.

6.5.1.1 **Oceanic.** Oceanic airspace is defined as international airspace over oceans where separation and procedures are in accordance with the International Civil Aviation Organization (ICAO), and outside the area defined as offshore. Responsibility for the provision of ATC service in this airspace is delegated to various countries. Controllers provide Air Traffic Services (ATS) utilizing procedural control and procedural separation.

6.5.1.2 **Remote Continental.** Remote continental airspace is defined as airspace above terrain where line-of-sight communications, independent surveillance and reliable ground-based NAVAIDs is not available. Controllers provide ATS utilizing procedural control and procedural separation.

6.5.1.3 **Offshore.** Offshore airspace is defined by Title 14 of the Code of Federal Regulations (14 CFR) part 71, §§ 71.31 and 71.71, and part 91, § 91.511. It is designated in international airspace within areas of domestic radio navigational signal or ATC radar coverage, and within which domestic ATC procedures are applied. For more details, refer to Federal Aviation Administration (FAA) Order 7400.9( ), Airspace Designations and Reporting Points. All certificated operators, and all large and turbine-powered multiengine aircraft, must have two independent RNP navigation systems appropriate for the route to be flown, or a single RNP navigation system and a second navigation system capable of proceeding to a safe landing from anywhere on the route.

CHAPTER 7. OPERATIONAL APPROVAL PROCESS

7.1 Part 91 Operators. A letter of authorization (LOA) is not required for Title 14 of the Code of Federal Regulations (14 CFR) part 91 operators (other than part 91 subpart K (part 91K)) except for oceanic operations (see Appendices E, F, and G) or if required in foreign airspace. Part 91 operators (other than 91K) should comply with the aircraft eligibility and operational guidance in this advisory circular (AC).

7.2 Operational Authorization. To obtain operational authorization, aircraft eligibility must be determined in accordance with the applicable appendix of this AC. Operational authorizations issued under a previous version of this AC or other canceled ACs does not need to be reissued or reevaluated.

Note: Previous approvals under FAA Order 8400.12C, Required Navigation Performance 10 (RNP 10) Operational Authorization, and FAA Order 8400.33, Procedures for Obtaining Authorization for Required Navigation Performance 4 (RNP-4) Oceanic and Remote Area Operations, are still valid for these operations. Operators must ensure their operations remain consistent with the performance and functional requirements of this AC.

7.3 Parts 91K, 121, 125, 129, and 135 Operators. Title 14 CFR parts 91K, 121, 125, 129, and 135 operators receive approval to fly RNP operations as described in this AC via operations specifications (OpSpecs), management specifications (MSpecs), or LOAs as follows:

- OpSpec/MSpec/optional LOA, paragraph C063, Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations;
- OpSpec/MSpec, paragraph B035, Class 1 Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems;
- OpSpec/MSpec/LOA (to include Part 91 operators), paragraph B036, Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (M-LRNS); or
- Helicopter Specification (HSpec)/LOA, paragraph H123, Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.

Note: This AC only addresses the navigation equipment and operating requirements for these operations. The pilot and operator, as applicable, must comply with all requirements for the operation. Those requirements are specified in 14 CFR for all U.S. operators, and may be augmented by additional requirements for operations outside of the United States as specified in other documents, such as the Aeronautical Information Publications (AIP) and the International Civil Aviation Organization (ICAO) Doc 7030, Regional Supplementary Procedures (SUPPS).

7.4 Preapplication Meeting. Certificate holders, operators, and program managers should schedule a preapplication meeting with the certificate-holding district office (CHDO), certificate management office (CMO), or the Flight Standards District Office (FSDO). This meeting allows the operator an opportunity to discuss the requirements for operational approval.

7.5 Multiple OpSpecs/MSpecs/LOAs. The operator should consolidate all applications for relevant RNP OpSpecs, MSpecs, or LOAs as appropriate per the operator's present/future operational plans and capabilities (see Chapter 12, Bundling Concept).

7.5.1 Application. All operators seeking an initial approval should provide relevant documentation in support of the following areas/topics:

1. Evidence of aircraft eligibility,

Note: This may be documented in manufacturer documentation (e.g., Service Letters (SL), etc.). Airplane Flight Manual (AFM) entries are not required provided the Federal Aviation Administration (FAA) accepts the manufacturer's documentation.

2. Establishment of operating procedures for the RNP system,
3. Control of those procedures through the operations manual (as required),
4. Identification of flightcrew training requirements, and
5. Control of process for updating the navigation database.

7.5.2 Amendments. Operators who hold an approval and propose to amend due to a change in equipment or operating procedures should provide appropriate evidence that the change does not affect compliance.

CHAPTER 8. OPERATOR RESPONSIBILITIES

8.1 Operational Manuals and Checklists. Title 14 of the Code of Federal Regulations (14 CFR) part 91 operators should use relevant Airplane Flight Manuals (AFM) and checklists. Operations manuals and checklists for 14 CFR parts 91 subpart K (91K), 121, 125, 129, and 135 operators must address information/guidance on the standard operating procedures (SOP) detailed in Appendices A-I (as appropriate). The appropriate manuals should also contain navigation operating instructions and contingency procedures.

8.2 Training Documentation.

8.2.1 Part 91 Operator Training. Part 91 operators should be knowledgeable with the procedures and operations associated with the use of Required Navigation Performance (RNP) systems.

8.2.2 Parts 91K, 121, 125, and 135 Operator Training. Parts 91K, 121, 125, and 135 operators should have a training program addressing the operational practices, procedures and training items related to RNP operations (e.g., initial, upgrade, or recurrent training for flightcrew, operational control personnel, and maintenance personnel).

Note: A separate training program is not required if RNP training is integrated in the current training program. However, the applicant must identify the training elements from this advisory circular (AC) within the existing training program.

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

8.4 Pilot Knowledge/Training. Parts 91K, 121, 125, and 135 operators should maintain training syllabi (e.g., initial, upgrade, recurrent) and other appropriate materials that include operational practices and procedures. Training for other personnel must be included where appropriate (e.g., operational control personnel, maintenance).

8.4.1 Flightcrew Training. Parts 91K, 121, 125, and 135 operators should ensure their programs contain training for flightcrews on equipment requirements, normal and non-normal operations and flight procedures, and limits of their RNP navigation capability.

8.4.2 RNP Authorization Requests. Parts 91K, 121, 125, 129, and 135 operators requesting an RNP authorization must ensure that crewmembers are knowledgeable on the material contained in this AC. Training “acceptable” to the Federal Aviation Administration (FAA) is not a prerequisite for issuing an RNP authorization.

8.4.3 Pilot Knowledge. Pilots must be familiar with the following:

1. The information in this AC, as applicable;
2. The meaning and proper use of aircraft equipment/navigation capability codes used on the flight plan;
3. Procedure characteristics as determined from chart depiction and textual description;
4. Depiction of waypoint types (flyover and flyby) as well as associated aircraft flightpaths;
5. A waypoint may be a flyover in one procedure and the same waypoint may also be a flyby in another procedure;
6. Required equipment for RNP operations;
7. Aircraft automation, mode annunciations, changes, alerts, interactions, reversions, and degradations;
8. Functional integration with other aircraft systems;
9. Meaning of route discontinuities and appropriate flightcrew procedures;
10. Types of navigation sensors used by the RNP system and their annunciations;
11. Turn anticipation with consideration to speed and altitude effects;
12. Interpretation of electronic displays and symbols;
13. Understanding the operational conditions used to support RNP operations (e.g., appropriate selection of course deviation indicator (CDI) scaling (lateral deviation display scaling));
14. If applicable, the importance of maintaining the published path and maximum airspeeds while performing RNP operations with Radius to Fix (RF) legs;
15. Depiction of path terminators, associated aircraft flightpaths, altitude, and speed restrictions;
16. Monitoring procedures for each phase of flight (e.g., monitor PROG or LEGS page);
17. Automatic and/or manual setting of the required RNP value;
18. Understanding of the navigation equipment regarding lateral and vertical capture from an RNP routing to an instrument landing system (ILS) or Ground Based Augmentation System (GBAS) Landing System (GLS);
19. Awareness of possible false vertical and lateral captures during a transition on an ILS capture;
20. Know how offsets are applied, the functionality of their particular navigation system and the need to advise air traffic control (ATC) if this functionality is not available;

21. Operator-recommended automation use for phase of flight and workload, including methods to minimize cross-track (XTK)error to maintain route centerline;
22. Receiver/transmitter (R/T) phraseology for RNP applications;
23. Flightcrew contingency procedures for a loss of RNP capability; and
24. Understanding the performance requirement to couple the autopilot (AP)/flight director (FD) to the navigation system's lateral guidance on RNP procedures, if required.

Note: Operators are encouraged to use manufacturer recommended training and operating procedures.

8.4.4 Pilot Knowledge and Actions. Pilots must have adequate knowledge to perform the following actions if required by navigation specification(s) (Nav Spec(s)):

1. Verify currency and integrity of aircraft navigation data;
2. If applicable, obtain a receiver autonomous integrity monitoring (RAIM) prediction for the planned RNP operation;
3. Verify successful completion of RNP system self-tests;
4. Initialize navigation system position;
5. Retrieve and fly an RNP procedure (e.g., Standard Instrument Departure (SID) or a standard terminal arrival (STAR) with appropriate transition);
6. Adhere to speed and/or altitude constraints associated with RNP operations;
7. Select the appropriate STAR or SID for the active runway in use and be familiar with procedures to deal with a runway change;
8. Verify waypoints and flight plan programming;
9. Perform a manual or automatic runway update (with takeoff point shift for Inertial Reference Units (IRU) only);
10. Fly direct to a waypoint;
11. Fly a course/track to a waypoint;
12. Intercept a course/track;
13. Fly vectors, and rejoin an RNP route/procedure from the 'heading' mode;
14. Selecting/arming the navigation system for an ILS or GLS transition;
15. Insert and delete route discontinuity;
16. Remove and reselect navigation sensor input;
17. When required, confirm exclusion of a specific navigation aid or navigation aid type (distance measuring equipment (DME) and very high frequency omni-directional range (VOR) only);

18. Change arrival airport and alternate airport;
19. Verify the RNP value set in the flight management system (FMS) matches the equipment capability and authorizations as annotated in the flight plan; and
20. Perform parallel offset function if capability exists.

8.5 Operation, Procedure, or Route Selection. The equipment should not permit the flightcrew to select an operation, procedure (instrument approach procedure (IAP), SID, or STAR) or route that is not supported by the equipment, either manually or automatically (e.g., a procedure is not supported if it incorporates a RF leg or a fixed radius transition (FRT) and the equipment does not provide RF leg or FRT capability). The system should also restrict pilot access to procedures requiring RF leg capability or FRT 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 AP or FD installed).

Note: Equipment manufacturers and airworthiness applicants should refer to AC 20-138( ), Chapter 6, Equipment Performance - RNAV Multi-Sensor Equipment.

CHAPTER 9. FLIGHT PLANNING

9.1 Required Navigation Performance (RNP) Flight Planning Requirements. Pilots and operators must use all available information in planning their flight, to ensure suitable navigation performance.

Note: Oceanic and remote continental RNP operations have unique flight planning requirements to ensure reliable navigation if a Global Positioning System (GPS) satellite fails.

9.1.1 RNP 2, RNP 4, and RNP 10. The specific requirements for RNP 2, RNP 4, and RNP 10 can be found in:

- Appendix E, Qualification Criteria for Required Navigation Performance (RNP) 2 Domestic, Offshore, Oceanic, and Remote Continental Operations,
- Appendix F, Qualification Criteria for Required Navigation Performance (RNP) 4 Oceanic and Remote Continental Operations, and
- Appendix G, Qualification Criteria for Required Navigation Performance (RNP) 10 Oceanic and Remote Continental Operations, respectively.

9.2 Notices to Airmen (NOTAM). All operators should review NOTAMs, as the Federal Aviation Administration (FAA) may indicate that GPS is unreliable in certain airspace and at certain times. For example, the FAA may do this in the event of interference to GPS. The FAA also provides a NOTAM service for Satellite-based Augmentation System (SBAS) (e.g., wide area augmentation system (WAAS)) receivers for all domestic RNP operations covered by this advisory circular (AC), which will identify any performance outages affecting Technical Standard Order (TSO)-C145 or TSO-C146 equipment. Operators flying aircraft equipped with SBAS do not need to conduct a preflight availability prediction for domestic RNP operations if WAAS coverage is confirmed to be available along the entire route of flight. For operations outside of the United States and using SBAS equipment, the operator should determine if the Air Navigation Service Provider (ANSP) monitors the performance of SBAS equipment or if it is appropriate to use a receiver autonomous integrity monitoring (RAIM) prediction program for the flight.

9.3 GPS Performance Prediction.

9.3.1 Equipment in Accordance with TSO-C129 or TSO-C196. If TSO-C129( ) or TSO-C196 equipment is used to solely satisfy the RNP monitoring and alerting requirement, GPS RAIM availability must be confirmed for the intended route of flight (route and time) using available GPS satellite information. Therefore, pilots should prepare to assess their capability to navigate (potentially to an alternate destination) in case of failure of Global Navigation Satellite System (GNSS) navigation.

9.3.2 Prediction Methods. Operators may satisfy the predictive RAIM requirement through any one of the following methods:

1. Operators of large fleets of aircraft or users of flight planning programs may wish to use their own preflight availability verification tool. The operator is responsible for selecting a tool that accurately predicts the performance for their aircraft. The tool must consider the GPS satellites that are in service at the time of the prediction, and may take into account unique characteristics of the GPS receiver, aircraft integration or installation; including performance better than required in FAA standards or use of inertial information integrated into the navigation position solution. The FAA does not evaluate or approve a particular tool, but may evaluate the basis of the operator's determination that the tool is appropriate to their aircraft, particularly if its use results in unexpected loss of RNP navigation.
2. Operators may use the FAA en route and terminal RAIM prediction: Service Availability Prediction Tool (SAPT) (http://sapt.faa.gov). Refer to the SAPT User Guide (current edition) for specific instructions on its use;
3. Operators may use a third party interface, incorporating FAA RAIM prediction data without altering performance values, to predict RAIM outages for the aircraft's predicted flightpath and times;
4. Operators may use the receiver's installed RAIM prediction capability (for TSO-C129a/Class A1/B1/C1 or TSO-C196( ) equipment) to provide Nonprecision Approach (NPA) RAIM, accounting for the latest GPS constellation status (e.g., NOTAMs or Notice Advisories to Navstar Users (NANU)). Receiver NPA RAIM should be checked at airports spaced at intervals not to exceed 60 nautical miles (NM) along the Area Navigation (RNAV) 1 procedures flight track. Terminal or approach RAIM must be available at the estimated time of arrival (ETA) over each airport checked.

9.3.3 Prediction Model Parameters. The operator should use a model appropriate to their equipment, including the type of GPS receiver and the demonstrated capability to track satellites at a given mask angle. When selecting a mask angle, the operator should consider the equipment qualification, installation in the aircraft, and the effects of normal maneuvering. Aircraft are typically qualified with a five-degree mask angle, and operational experience has indicated that a two-degree mask angle can be achieved by some equipment installations. If using the SAPT, each prediction is valid for the operation within 5 minutes of the plan time and 7.5 NM of the route. The operator may wish to submit additional requests for predictions for varying times around the proposed departure time to ensure compliance at the actual departure time.

9.3.4 Flight Planning Guidance. Predictions can be used for initial flight planning as early as 72 hours prior to the planned departure. However, the operator should conduct a performance prediction as close to departure time as feasible, but with sufficient time to re-plan the flight or obtain air traffic control (ATC) prior approval in the event a segment of the flight will not be compliant. The prediction should be reevaluated if a new NOTAM identifies an unscheduled GPS satellite outage.

9.3.5 Resolving Predicted Outages in Performance. In the event of a predicted, continuous loss of RAIM of more than 5 minutes for any part of the intended flight, the flight must be delayed, canceled, or re-routed where RAIM requirements can be met. Alternatively, the flight may be re-planned based on a different form of navigation.

9.4 Distance Measuring Equipment (DME) Flight Planning Requirements. For multisensor aircraft with operating GPS and DME/DME/Inertial Reference Unit (IRU) positioning, a RAIM check for continental operations is not required as long as DME is identified as an available navigation service for the route and critical DME's are functioning normally. However, when planning for an Required Navigation Performance Approach (RNP APCH) (Appendix A, Qualification Criteria for Required Navigation Performance Approach (RNP APCH) Operations), a RAIM check is still required as this exception does not apply to RNP APCH operations.

9.5 Contingency Planning for Alternate Airport.

9.5.1 Alternate Airport Considerations. For the purposes of flight planning, any required alternate airport must have an available instrument approach procedure (IAP) that does not require the use of GPS. This restriction includes conducting a conventional approach at the alternate airport using a substitute means of navigation that is based upon the use of GPS. For example, these restrictions would apply when planning to use GPS equipment as a substitute means of navigation for an out-of-service very high frequency omni-directional range (VOR) that supports an instrument landing system (ILS) Missed Approach Procedure (MAP) at an alternate airport. In this case, some other approach not reliant upon the use of GPS must be available. This restriction does not apply to pilots with navigation systems meeting the requirements below.

9.5.1.1 For flight planning purposes, TSO-C129( ) and TSO-C196( ) equipped users (GPS users) whose navigation systems have fault detection and exclusion (FDE) capability, who perform a preflight RAIM prediction at the airport where the RNAV (GPS) approach will be flown, and have proper knowledge and any required training and/or approval to conduct a GPS-based IAP, may file based on a GPS-based IAP at either the destination or the alternate airport, but not at both locations. At the alternate airport, pilots may plan for applicable alternate airport weather minimums using:

1. Lateral navigation (LNAV) or circling minimum descent altitude (MDA);
2. LNAV/vertical navigation (VNAV) descision altitude (DA), if equipped with and using approved barometric vertical navigation (baro-VNAV) equipment;
3. RNP 0.3 DA on an RNAV (RNP) IAP, if they are specifically authorized users using approved baro-VNAV equipment and the pilot has verified RNP availability through an approved prediction program.

Note: If the above conditions cannot be met, any required alternate airport must have an approved IAP other than GPS that is anticipated to be operational and available at the ETA, and which the aircraft is equipped to fly.

9.5.1.2 Pilots with WAAS receivers, TSO-C145( ) or TSO-C146( ), may flight plan to use any IAP authorized for use with their WAAS avionics as the planned approach at a required alternate, with the following restrictions. When using WAAS at an alternate airport, flight planning must be based on flying the RNAV (GPS) LNAV or circling minima line, or minima on a GPS approach procedure, or conventional approach procedure with “or GPS” in the title. Properly trained and approved, as required, TSO-C145( ) and TSO-C146( ) equipped users (WAAS users) with and using approved baro-VNAV equipment may plan for LNAV/VNAV DA at an alternate airport. Specifically authorized WAAS users with and using approved baro-VNAV equipment may also plan for RNP 0.3 DA at the alternate airport as long as the pilot has verified RNP availability through an approved prediction program. Code of Federal Regulation (CFR) Part 91 nonprecision weather requirements must be used for planning. Upon arrival at an alternate, when the WAAS navigation system indicates that LNAV/VNAV or localizer performace with vertical guidance (LPV) service is available, then vertical guidance may be used to complete the approach using the displayed level of service.

CHAPTER 10. DATABASE INTEGRITY

10.1 Database Suppliers. Navigation databases must be obtained from a database supplier holding an Federal Aviation Administration (FAA) Letter of Acceptance (LOA) in accordance with Advisory Circular (AC) 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases. This LOA provides recognition of a data supplier's compliance with the data quality, integrity, and quality management practices of RTCA, Inc.'s document, RTCA DO-200( ), Standards for Processing Aeronautical Data. The operator's supplier (e.g., flight management system (FMS) manufacturer) must have a Type 2 LOA. AC 20-153( ) contains procedures for database LOAs.

10.2 Navigation Data Requirements. The onboard navigation data must be current and appropriate for the region of intended operation and should include the navigation aids, waypoints, and relevant coded terminal airspace procedures for the departure, arrival, and alternate airfields.

10.3 Terminal and En Route Requirements. Further database guidance for terminal and en route requirements may be found in AC 90-100( ), U.S. Terminal and En Route Area Navigation (RNAV) Operations.

10.4 Database Validity. Prior to using a procedure or waypoint retrieved from the airborne navigation database, the pilot should verify the validity of the database.

Note: Navigation databases are also expected to be current for the duration of the flight. If the Aeronautical Information Regulation and Control (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 or Electronic Flight Bag (EFB) products. One acceptable means is to compare aeronautical charts (new and old) to verify navigation fixes prior to departure. If an amended chart (hard copy amendment not in the database) is published for the procedure, the database must not be used to conduct the operation.

10.5 Navigation Data Validation Program. Navigation databases should be obtained from a supplier complying with AC 20-153( ) or equivalent, and should be compatible with the equipment.

10.6 Data Process for Part 91 Operators. For Title 14 of the Code of Federal Regulations (14 CFR) part 91 (except part 91 subpart K (91K)) operators, pilots must confirm at system initialization that the navigation database is current. Part 91 (except 91K) operators may consider navigation database validation complete when checking the navigation database currency and applicable Notice to Airmen (NOTAM).

10.7 Data Process for Parts 91K, 121, 125, 129, and 135. For Title 14 CFR parts 91K, 121, 125, 129, and 135, operators should establish a database program that meets the following requirements:

1. The operator must identify within their procedures the responsible manager for the data updating process,
2. The operator must document a process for accepting and verifying applicability,
3. The operator must place their documented data process under configuration control, and
4. The pilots must confirm at system initialization that the navigation database is current.
5. Discrepancies that invalidate a procedure (e.g., database 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. The affected procedure can be reinstated for flightcrew use only after the operator has verified that the database error has been corrected.

CHAPTER 11. AIRCRAFT AND SYSTEM REQUIREMENTS

11.1 References. Refer to the appendices below for aircraft and system requirements:

1. Appendix A, Qualification Criteria for Required Navigation Performance Approach (RNP APCH) Operations.
2. Appendix B, Use of Barometric Vertical Navigation (baro-VNAV) for Required Navigation Performance Approach (RNP APCH) Operations.
3. Appendix C, Qualification Criteria for Required Navigation Performance (RNP) 1 (Terminal) Operations.
4. Appendix D, Qualification Criteria for Required Navigation Performance (RNP) 0.3 (Rotorcraft) Operations.
5. Appendix E, Qualification Criteria for Required Navigation Performance (RNP) 2 Domestic, Offshore, Oceanic, and Remote Continental Operations.
6. Appendix F, Qualification Criteria for Required Navigation Performance (RNP) 4 Oceanic and Remote Continental Operations.
7. Appendix G, Qualification Criteria for Required Navigation Performance (RNP) 10 Oceanic and Remote Continental Operations.
8. Appendix H, Advanced Required Navigation Performance (A-RNP).
9. Appendix I, Additional Capabilities.

CHAPTER 12. BUNDLING CONCEPT

12.1 Performance-based Navigation (PBN) Authorization. The Federal Aviation Administration (FAA) allows PBN authorizations to be bundled. This concept provides the FAA more latitude in granting a wider range of authorizations on a single operator application. Each flight phase contains a hierarchy of PBN authorizations where bundling can be accomplished. PBN authorizations within an operation specification (OpSpec), management specification (MSpec) or letter of authorization (LOA) are combined with less restrictive PBN authorization(s) within each phase of flight, if applicable. This reduces cost and workload for both the operator and the FAA.

12.2 Visual of Bundling Options. Figure 12-1, Bundling Options, illustrates this concept of bundling by flight phase into approach, terminal, en route, and oceanic/remote continental. Each phase contains a hierarchy of PBN operations within the applicable OpSpec, MSpec, or LOA.

12.3 Approach Phase Composition. The approach phase has two distinct divisions of Required Navigation Performance Authorization Required Approach (RNP AR APCH) and Required Navigation Performance Approach (RNP APCH). For the purpose of bundling, Required Navigation Performance Authorization Required (RNP AR) is excluded from bundling because of unique requirements for authorization.

Note: Localizer performance with vertical guidance (LPV) and localizer performance without vertical guidance (LP) minimums are authorized through OpSpec/MSpec/LOA C052, but are excluded as a bundling option.

12.4 Credit for Existing RNP AR Approvals. Operators with a current and approved RNP AR approval meet the requirements the Required Navigation Performance (RNP) operations as described in this advisory circular (AC).

12.5 RNP 2 Areas of Operation. The Areas of Operation for RNP 2 are within the U.S. National Airspace System (NAS) or offshore airspace where domestic air traffic control (ATC) procedures are applied and also in oceanic and remote continental airspace.

Note: Oceanic and remote continental airspace often have additional surveillance, communication, and higher navigation continuity requirements.

12.6 Terminal and En Route Phases of Flight. The terminal and en route phases of flight contains RNP 1, RNP 2, Area Navigation (RNAV) 1, RNAV 2, and RNAV 5 for terminal and en route operations (see Figure 12-1). An operator with an RNP 1 authorization as described in Appendix C, Qualification Criteria for Required Navigation Performance (RNP) 1 (Terminal) Operations, would also be granted authorization for RNAV 1. Additionally, an RNP 2 (domestic) authorization as described in Appendix E, Qualification Criteria for Required Navigation Performance (RNP) 2 Domestic, Offshore, Oceanic, and Remote Continental Operations, would also be granted RNAV 2 and RNAV 5 authorizations.

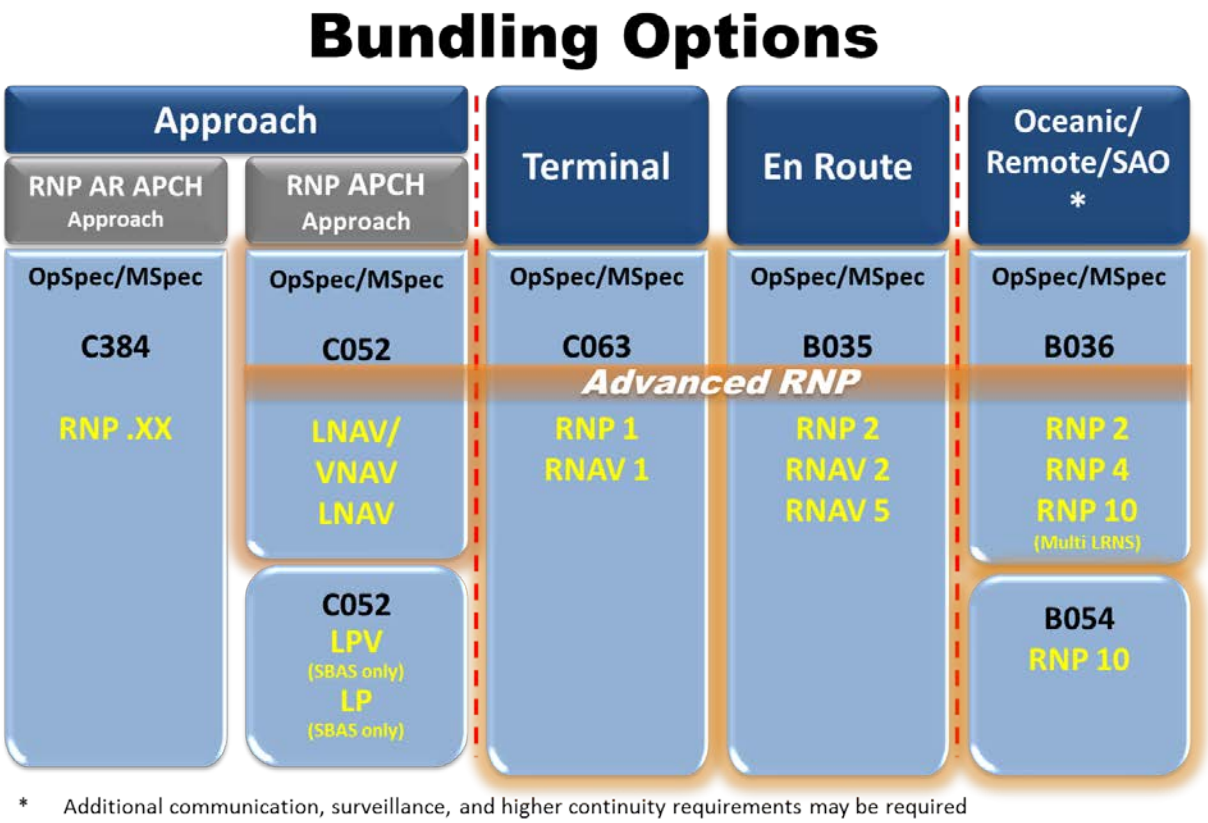
12.7 Oceanic/Remote Continental RNP 2 Authorization. An operator with an oceanic/remote continental RNP 2 authorization (Figure 12-1) will also be granted RNP 4 and RNP 10 navigation authorizations. Authorizations in oceanic and remote continental airspace also depend upon the operator's qualification to meet international surveillance and communication requirements. Those requirements are specified in other documents, such as the Aeronautical Information Publications (AIP) and the International Civil Aviation Organization (ICAO) Doc 7030, Regional Supplementary Procedures (SUPPS) and AC 91-70( ), Oceanic and International Operations.

12.8 Advanced Required Navigation Performance (A-RNP). In order to be A-RNP qualified (see Appendix H, Advanced Required Navigation Performance (A-RNP)), operators must be operationally and functionally qualified to perform the following three required functions:

1. Scalability,
2. Radius to Fix (RF), and
3. Parallel offset.

Note: Higher continuity may be required for oceanic and remote continental airspace. Currently, fixed radius transition (FRT) and Time of Arrival Control (TOAC) are optional. For each applicable OpSpec, MSpec, or LOA, A-RNP functions are added to the bundled hierarchy of PBN authorizations (see Figure 12-1).

Figure 12-1. Bundling Options



APPENDIX A. QUALIFICATION CRITERIA FOR REQUIRED NAVIGATION PERFORMANCE APPROACH (RNP APCH) OPERATIONS

A.1 Introduction. This appendix provides guidance on the performance and functional requirements for systems used to conduct RNP APCH 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 APCH by the International Civil Aviation Organization (ICAO). Localizer performance without vertical guidance (LP) and localizer performance with vertical guidance (LPV) operations can be found in Advisory Circular (AC) 90-107( ), Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System. The barometric vertical navigation (baro-VNAV) aspects of RNP APCHs are specified in Appendix B, Use of Barometric Vertical Navigation (baro-VNAV) for Required Navigation Performance Approach (RNP APCH) Operations. Baro-VNAV systems are optional capabilities that are not a minimum requirement to fly RNAV (GPS) or GPS approaches using the lateral navigation (LNAV) line of minima. The requirements for Radius to Fix (RF) legs are specified in Appendix I, Additional Capabilities.

A.2 Aircraft and System Requirements.

A.2.1 Approval for RNAV (GPS) or GPS Approaches. Aircraft with approval to conduct RNAV (GPS) or GPS approaches meet the performance and functional requirements in this AC for RNP APCH instrument approaches without RF legs.

A.2.2 Statement of Compliance (SOC). Aircraft with a SOC with the criteria in this AC in their Airplane Flight Manual (AFM), Airplane Flight Manual Supplement (AFMS), pilot's operating handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this AC.

A.2.3 Statement from the Manufacturer. Aircraft with a statement from the manufacturer documenting compliance with the criteria in AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, meet the performance and functional requirements of this AC. Manufacturer documentation can include Service Bulletins (SB) or Service Letters (SL). These statements should include the airworthiness basis for compliance. AFM/Rotorcraft Flight Manual (RFM) entries are not required provided the Federal Aviation Administration (FAA) accepts the manufacturer's documentation.

A.2.4 Qualified Avionics Equipment and Airworthiness Approval. Aircraft with the following avionics equipment and an appropriate airworthiness approval automatically qualify for RNP APCH to LNAV minima capability without further documentation by virtue of the avionics Technical Standard Order (TSO) and airworthiness approval:

1. GPS stand-alone systems approved in accordance with TSO-C129( ), Class A1, or TSO-C146 operational Class 1, 2, or 3 and installed in accordance with AC 20-138( ).

2. Aircraft with a TSO-C115c or later flight management system (FMS) with a TSO-C129( ) (Class B1, C1, B3, C3), TSO-C145( ), or TSO-C196( ) sensors installed in accordance with AC 20-138( ).
3. Aircraft with a TSO-C115b FMS using a TSO-C129( ) Class B1/C1, TSO-C145( ), or TSO-C196( ) sensor with documented compliance to the RNP requirements in RTCA, Inc.'s document, RTCA/DO-236 (revision 'B' or later) or RTCA/DO-283 (revision 'A' or later) as part of the approval basis.

A.2.5 GPS-Equipped Multisensor Systems. Multisensor systems using GPS should be approved in accordance with AC 20-138( ) or TSO-C115b or later and meet the functionality requirements of this appendix. Multisensor systems that use distance measuring equipment (DME)/DME or DME/DME/Inertial Reference Unit (IRU) as the only means of Required Navigation Performance (RNP) compliance are not authorized to conduct RNP APCHs. However, operators still retain the option to develop special RNP APCHs using these systems.

A.2.6 Other Equipment. For equipment other than what is listed in A.2, the Original Equipment Manufacturer (OEM) or the holder of installation approval for the aircraft (e.g., Supplemental Type Certificate (STC) holder) must demonstrate compliance with the criteria in this AC.

A.3 Performance and Functionality Requirements for RNP APCH Systems.

A.3.1 Accuracy. The aircraft must comply with Section 2.1.1 of RTCA/DO-236C. During operations on the initial and intermediate segments and for the missed approach of an RNP APCH procedure, the lateral Total System Error (TSE) must be within ±1 nautical mile (NM) for at least 95 percent of the total flight time. The along-track (ATRK) error must also be within ±1 NM for at least 95 percent of the total flight time.

Note: There are no RNP requirements for the missed approach if it is based on conventional means (very high frequency omni-directional range (VOR), DME, and Non-Directional Beacon (NDB)) or on dead reckoning.

A.3.1.1 During operations on the Final Approach Segment (FAS), the lateral TSE must be within ±0.3 NM for at least 95 percent of the total flight time. The ATRK must also be within ±0.3 NM for at least 95 percent of the total flight time.

A.3.1.2 To satisfy the accuracy requirement, the 95 percent Flight Technical Error (FTE) should not exceed 0.5 NM on the initial and intermediate segments, and for the RNAV missed approach, of an RNP APCH. The 95 percent FTE should not exceed 0.25 NM on the FAS of an RNP APCH.

Note: The use of a deviation indicator with 1 NM full-scale deflection on the initial and intermediate segments, and for the RNAV missed approach and 0.3 NM full-scale deflection on the FAS, has been found to be an acceptable means of compliance (AMC). The use of an

autopilot (AP) or flight director (FD) has been found to be an AMC (roll stabilization systems do not qualify).

A.3.2 Integrity. Malfunction of the aircraft navigation equipment that causes the TSE to exceed 2 times the RNP APCH value is classified as a major failure condition under airworthiness regulations (i.e., 10^{-5} per hour).

A.3.3 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.

A.3.4 Performance Monitoring and Alerting. During operations on the initial, intermediate, and the missed approach segment, the RNP system or the RNP system and pilot in combination must 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 FAS, the RNP system or the RNP system and pilot in combination must 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}.

A.3.5 Signal in Space (SIS). During Global Navigation Satellite System (GNSS) operations on the initial, intermediate, and missed approach segments, the aircraft navigation equipment must provide an alert if the probability of SIS errors causing a lateral position error greater than 2 NM exceeds 10^{-7} per hour. During GNSS operations on the FAS, the aircraft navigation equipment must provide an alert if the probability of SIS errors causing a Navigation System Error (NSE) greater than 0.6 NM exceeds 10^{-7} per hour.

Note 1: There are no RNP requirements for the missed approach if it is based on conventional means (VOR, DME, and NDB) or on dead reckoning.

Note 2: Aircraft with an approved multisensor RNP system where GNSS integrity is incorporated into an RNP integrity alert consistent with DO-236( ) do not require a separate GNSS integrity alert when performance cannot be met.

A.3.6 Path Definition. Aircraft performance is evaluated around the path defined by the published procedure and RTCA/DO-236C.

A.3.7 Functional Requirements of Navigation Displays. The following navigation displays and functions are required, as installed in accordance with 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, course deviation indicator (CDI), electronic horizontal-situation indicator (EHSI), and/or a navigation map display. These must be used as primary flight instruments for aircraft navigation, for maneuver anticipation, and for failure/status/integrity indication.

A.3.7.1 RNP systems using TO/TO navigation algorithms do not require a navigation display with a TO/FROM indication during RNP instrument procedures. Displays supporting TO/TO navigation computers can fully comply with all RNP-related criteria in this AC without a TO/FROM indication. At a minimum, the navigation display supporting a TO/TO RNP system should

display the active waypoint and active waypoint name. However, TO/TO RNP systems must have the ability accommodate route discontinuities and continue providing navigation information.

A.3.7.2 A non-numeric lateral deviation display (e.g., CDI, EHSI), with TO/FROM indication and a failure annunciation, used as primary flight instruments for aircraft navigation, 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 flightpath.
2. 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 ± 1 NM for the initial, intermediate, and missed approach segments and ±0.3 NM for the final segment is acceptable. It is also acceptable for the scaling to be more conservative than the TSE (e.g., ±0.3 NM for the initial, intermediate, and missed approach segments).
3. 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.
4. 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 flightpath and path deviation.

5. 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.
6. It is not necessary for navigation displays, particularly primary flight displays (PFD), to include an Actual Navigation Performance (ANP) or Estimate of Position Error (EPE) value. The displays only need to provide an alert if the RNP for the operation cannot be met.

A.3.8 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 APCH-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.

Note: Numeric values for database defined procedures must be automatically loaded from the RNP system database.

6. The means to display the following items, either in the pilot's primary FOV, or on a readily accessible display page:
   - Distance between flight plan waypoints,
   - Distance to go to the waypoint selected by the pilot,
   - Active navigation sensor type,
   - The identification of the active (To) waypoint,
   - The ground speed or time to the active (To) waypoint, and
   - 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 an RNP APCH instrument approach procedure (IAP) extracted from the onboard database, including the capability to execute flyover and flyby turns.

10. The capability to automatically execute leg transitions and maintain tracks consistent with the following Aeronautical Radio, Inc. (ARINC) 424 path terminators, or their equivalent:
    - Initial Fix (IF),
    - Track to Fix (TF), and
    - Direct to Fix (DF).

Note: Path terminators are defined in ARINC Specification 424, and their application is described in more detail in RTCA, Inc. documents, DO-236( ) and DO-201( ).

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 or Position Estimation Error (PEE) alert limit is exceeded (alert provided by the onboard performance monitoring and alerting function).
13. The system must allow for a means to become established prior to the final approach fix (FAF) on an instrument landing system (ILS) or Ground Based Augmentation System (GBAS) Landing System (GLS) with minimal overshoot or undershoot.

A.3.9 FD/AP. For aircraft equipped with FD and/or AP, it is recommended the FD is engaged and/or AP remain coupled for RNP APCH. If the lateral TSE cannot be demonstrated without these systems, then coupling becomes mandatory. In this instance, operating guidance must indicate FD engagement and/or automatic pilot coupling from the RNP system is mandatory for approaches.

A.4 Database.

A.4.1 Database Integrity. The operator must ensure their navigation database supplier possesses a Type 2 Letter of Acceptance (LOA) in accordance with AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases.

A.4.2 Path Terminators. The database supplier should not substitute path terminators in lieu of those specified in the original State Aeronautical Information Publication (AIP) data.

A.5 Special Characteristics of RNP APCH Instrument Approaches.

A.5.1 Navigational Aid (NAVAID) Infrastructure. GPS is the primary navigation system to support RNP APCH procedures. DME/DME-based systems are not acceptable for RNP APCH. The missed approach segment may be based upon a conventional NAVAID (e.g., VOR, DME, and NDB).

A.5.2 Lines of Minima. RNP APCH may have multiple lines of minima. This appendix addresses the LNAV and LNAV/vertical navigation (VNAV) lines of minima. In

addition, the use of baro-VNAV for an RNP APCH to the LNAV/VNAV minima is addressed in Appendix B. Reference AC 90-107( ) for an RNP APCH to the LP and LPV lines of minima.

Note: AC 20-138( ) addresses aircraft integration that includes baro-VNAV and GPS/Satellite-based Augmentation System (SBAS) and/or GPS/Ground Based Augmentation System (GBAS) for vertical guidance.

A.6 Aircraft Eligibility for RNP APCH Operations.

A.6.1 Introduction. The 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 Federal Aviation Administration (FAA), and the approval can be documented in manufacturer documentation (e.g., SLs, etc.). AFM/RFM entries are not required.

A.6.2 System Eligibility for RNP APCH LNAV and LNAV/VNAV Minima. Systems meeting the requirements in AC 20-138( ) are eligible for RNP APCH operations. Aircraft qualified by AC 90-101( ), Approval Guidance for RNP Procedures with AR, are considered qualified for RNP APCH operations without further examination.

A.6.3 LNAV Line of Minima Qualification.

A.6.3.1 **Stand-Alone Systems.** Stand-alone systems meeting TSO-C129a Class A1 or TSO-C146( ) Class 1, 2, or 3 meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima provided the instrument flight rules (IFR) installations were performed in accordance with AC 20-138( ).

A.6.3.2 **Multisensor Systems.** Multisensor systems using TSO-C196, TSO-C129a Class B1, B3, C1, or C3, or TSO-C145 Class 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided the installations meet the criteria of this AC and Appendix A, the associated FMS complies with TSO-C115b or later and are installed in accordance with AC 20-138( ).

A.6.4 LNAV/VNAV Line of Minima Qualification.

A.6.4.1 **Stand-Alone Systems.** Stand-alone TSO-C146 Class 2 or 3 systems meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima provided that the installations meet at least the performance and functional requirements of this AC.

A.6.4.2 **Multisensor Systems.** Multisensor systems using TSO-C129a Class B1, B3, C1, or C3 sensors, TSO-C145 Class 1 sensors, or TSO-C196( ) with baro-VNAV meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima provided the installations meet the requirements of this AC (including Appendix A and Appendix B). Multisensor systems using TSO-C145 Class 2 or 3 meet the requirements for

RNP APCH operations to LNAV/VNAV minima without baro-VNAV when using SBAS-based vertical guidance. The RNP systems including the FMS must be installed in accordance with AC 20-138( ) and the associated FMS must comply with TSO-C115b or later.

A.6.4.3 **Demonstrations.** Demonstration of aircraft performance in accordance with AC 20-138( ) does not constitute operations approval to conduct RNP operations.

A.7 Operational Considerations.

A.7.1 Preflight Planning.

A.7.1.1 Operators and pilots intending to conduct operations on RNP APCH IAPs must file the appropriate flight plan suffixes.

A.7.1.2 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 1: 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. This may be accomplished by verifying electronic data against paper or Electronic Flight Bag (EFB) products. One acceptable means is to compare aeronautical charts (new and old) to verify navigation fixes prior to dispatch. If an amended chart (hard copy amendment not in the database) is published for the procedure, the database must not be used to conduct the operation.

Note 2: On U.S. IAPs only, the “Procedure Amendment Effective Date” may be used to ensure the accuracy of the navigation data contained in an expired database. If the Procedure Amendment Effective Date falls on or after the navigation database expiry date, the procedure should not be flown using the out-of-date database.

A.7.1.3 Pilots must verify proper entry of their air traffic control (ATC)-assigned route upon initial clearance and any subsequent change of route. Pilots must ensure the waypoint sequence depicted by their navigation system matches their assigned route and the route depicted on the appropriate chart(s).

A.7.1.4 The flightcrew may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3 degrees or less may result from equipment manufacturer’s application of magnetic variation and are operationally acceptable.

A.7.1.5 Manually selecting aircraft bank limiting functions can reduce the aircraft's ability to maintain the desired track (DTK) and is not recommended.

A.7.1.6 The aircraft RNP APCH capability is dependent on operational aircraft equipment. The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP APCH operation and take appropriate action. When the dispatch of a flight is predicated on flying an RNP APCH requiring the use of the AP or FD at the destination and/or alternate, the operator must determine that the AP and/or FD is installed and operational.

A.7.1.7 The availability of the navigation infrastructure, required for the intended routes, procedures, 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., receiver autonomous integrity monitoring (RAIM) or SBAS signal) is required, the availability of these should also be determined, as appropriate (see Chapter 9, Flight Planning, of this AC).

A.7.1.8 The pilot must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action. If unable to comply with the requirements of an RNP APCH procedure, pilots must advise the Air Traffic Service (ATS) as soon as possible. The loss of RNP APCH capability includes any failure or event causing the aircraft to no longer satisfy the RNP APCH requirements of the procedure. The operator should develop contingency procedures in order to react safely following the loss of the RNP APCH capability during the approach.

A.7.2 <u>During the Procedure</u>. Pilots must comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this AC.

A.7.2.1 Pilots must confirm the system has initiated transition from terminal mode to approach mode by 2 NM prior to the FAF.

A.7.2.2 The appropriate displays must be selected so that the following information can be monitored:

1. The RNP APCH computed DTK and
2. Aircraft position relative to the path cross-track (XTK) deviation for FTE monitoring.

A.7.2.3 All pilots are expected to maintain procedure centerline, 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.

A.7.2.4 While operating on RNP APCH segments, pilots are encouraged to use FD and/or AP in LNAV mode and VNAV mode, if available.

A.7.2.5 For aircraft requiring two pilots, crews must verify that each pilot's altimeter has the current setting before beginning the final approach of an RNP APCH 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.

A.7.2.6 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., ±1.0 NM for the initial and intermediate segments, ±0.3 NM for the FAS, and ±1.0 NM for the missed approach segment).

A.7.2.7 RNP APCH procedures require flightcrew monitoring of lateral and, if installed, vertical track deviations on the pilot's PFDs to ensure the aircraft remains within the bounds defined by the procedure.

A.7.2.8 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.

A.7.2.9 For normal operations, XTK/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 FAS, 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 RNP value (i.e., 1.0 NM for the initial and intermediate segments) are allowable.

A.7.2.10 Flightcrew accomplishing RNP APCH IAPs (RNAV (GPS) or RNAV (GNSS) are required to monitor lateral and, if approved for operational credit, vertical guidance deviations. For baro-VNAV approach operations on an RNP APCH using the LNAV/VNAV minimums, aircraft qualified using AC 20-138( ) must allow the pilot to readily distinguish if the XTK deviation exceeds the RNP value (or a smaller value) or if the vertical deviation exceeds 75 feet (or a smaller value). This information must be published in the AFM, a STC, or verified by the Aircraft Evaluation Group (AEG).

Note: Aircraft approved under previous AC guidance using baro-VNAV with LNAV/VNAV minimums, the legacy vertical deviation limits of +100/-50 feet remains valid.

A.8 Go-Around or Missed Approach.

A.8.1 Visual References. 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 occur:

1. The navigation display is flagged invalid,
2. Loss of integrity alerting function,
3. The integrity alerting function is activated before passing the FAF, or
4. Lateral or vertical deviation exceeds the limits in paragraphs A.8.2.6, A.8.2.9, and A.8.2.10.

APPENDIX B. USE OF BAROMETRIC VERTICAL NAVIGATION (BARO-VNAV) FOR REQUIRED NAVIGATION PERFORMANCE APPROACH (RNP APCH) OPERATIONS

B.1 Introduction. This appendix addresses those systems using barometric altitude and navigation system information in the definition of vertical flightpaths and vertical tracking to a path. Baro-VNAV provides vertical path information defined by vertical angles or altitudes at fixes in the RNP APCH 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.

B.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, 91 subpart K (91K), 121, 125, 129, and 135 within the U.S. National Airspace System (NAS). This appendix also provides guidance for approval to use baro-VNAV equipment to perform 14 CFR part 97 Area Navigation (RNAV) (Global Positioning System (GPS)) or GPS instrument approach procedures (IAP) published with a lateral navigation (LNAV)/VNAV line of minima with a decision altitude (DA).

B.3 Aircraft Eligibility.

B.3.1 Required Navigation Performance (RNP) System Capability. Eligible aircraft are those which meet the performance and functional requirements outlined in Appendix A, Qualification Criteria for Required Navigation Performance Approach (RNP APCH) Operations, and Appendix C, Qualification Criteria for Required Navigation Performance (RNP) 1 (Terminal) Operations, as appropriate for the RNP operation.

B.3.2 Baro-VNAV Capability. Eligible aircraft are those with an Airplane Flight Manual (AFM)/Rotorcraft Flight Manual (RFM) or Airplane Flight Manual Supplement (AFMS)/Rotorcraft Flight Manual Supplement (RFMS) which explicitly states that the VNAV system is approved for approach operations in accordance with Advisory Circular (AC) 20-138( ), Airworthiness Approval of Positioning and Navigation Systems. Aircraft accomplishing RNP APCH operations (RNAV (GPS) or RNAV (Global Navigation Satellite System (GNSS)) are required to monitor lateral and, if approved for operational credit, vertical guidance deviations. Aircraft qualified using AC 20-138( ) must allow the pilot to readily distinguish if the cross-track (XTK) deviation exceeds the RNP value (or a smaller value) or if the vertical deviation exceeds 75 feet (or a smaller value). Aircraft with an authorization for Required Navigation Performance Authorization Required (RNP AR) operations are considered eligible for baro-VNAV operations conducted in accordance with this AC.

Note: Aircraft approved under previous AC guidance using baro-VNAV with LNAV/VNAV minimums, the legacy vertical deviation limits of +100/-50 feet remains valid.

B.3.2.1 Part 91 operators should review their AFM or AFMS to establish navigation system eligibility as detailed in paragraph B.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 B.4 and B.5. After these actions have been completed, the operator may begin to conduct 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.

B.3.3 Documentation. Parts 91K, 121, 125, 129, and 135 operators should present the following documentation to their certificate-holding district office (CHDO):

1. Sections of the AFM or AFMS which document RNAV/RNP airworthiness approval for approach operations in accordance with B.3; and
2. Sections of the training and operations manuals which reflect the operating policies of B.4 and B.5.

B.3.4 CHDO Satisfaction. 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.3.5 Eligibility Not Based on the AFM or AFMS (Special Approval). The operator may not be able to determine baro-VNAV approach eligibility from the AFM or AFMS. 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 parts 91K, 121, 125, 129, and 135 operators should request that the CHDO make the eligibility assessment. The operator should provide the FSDO or CHDO with the baro-VNAV system make, model, and part number, any evidence of instrument flight rules (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 Federal Aviation Administration (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 IAPs applying a DA rather than a 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 (AIR) may be consulted.

B.3.5.1 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.

B.3.5.2 For parts 91K, 121, 125, 129, and 135 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 B.4 and B.5.

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.

B.4 Operating Procedures (General). For baro-VNAV approach operations, the flightcrew should be familiar with the following operating procedures.

B.4.1 Actions at DA. The pilot/crew is expected to fly the aircraft along the published vertical path and execute a Missed Approach Procedure (MAP) upon reaching DA, unless the visual references specified in part 91, § 91.175 for continuing the approach are present.

B.4.2 Temperature Limitation. Because of the pronounced effect of nonstandard temperature on baro-VNAV systems, RNAV (GPS) approaches with an LNAV/VNAV line of minima should contain a low and high temperature limitation. Uncompensated baro-VNAV systems may not operate to the LNAV/VNAV DA when the actual temperature is below or above the temperature limitations. The temperature limitation will be shown as a note on the procedure. If the aircraft contains a temperature compensation capability, manufacturer instructions should be followed for use of the baro-VNAV function.

B.4.3 VNAV Path Mode Selection. Crews should be knowledgeable on selection of the appropriate vertical mode(s) that command VNAV via the published vertical path. Other vertical modes such as Vertical Speed (VS) are not applicable to baro-VNAV approach operations.

B.4.4 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.

B.4.5 Altimetry Cross-Check.

B.4.5.1 Pilots must verify the current local altimeter at the airport of intended landing is set not later than the final approach fix (FAF). Remote altimeter settings are not allowed.

B.4.5.2 Where two pilots are required, the flightcrew must complete an altimetry cross-check ensuring both pilots' altimeters agree within ±100 feet prior to the FAF after receiving the current local altimeter setting at the airport of intended landing. If the altimetry cross-check fails then the procedure should not be conducted or, if in progress, it must not be continued. The flightcrew procedures should also address actions to take if a comparator warning for the pilots' altimeters occurs while conducting a RNP APCH procedure.

Note: This operational cross-check is not necessary if the aircraft automatically compares the altitudes to within 100 feet.

B.4.6 VNAV System Cross-Check. For baro-VNAV operations to the LNAV/VNAV line of minima, pilots must cross-check the vertical guidance displayed by the navigation system against other available data at the FAF. If the difference between the displayed glidepath and the published altitude at FAF exceeds 75 feet, the LNAV/VNAV line of minima may not be used. Pilots should revert to the LNAV line of minima and comply with any published stepdown fix altitude.

Note 1: This cross-check is not required when GPS/Satellite-based Augmentation System (SBAS) vertical guidance is used with the LNAV/VNAV line of minima.

Note 2: For systems that provide temperature compensation capability, the displayed temperature compensated glidepath should be compared to the temperature compensated altitude computed by system when crossing the FAF.

Note 3: This cross-check may be accomplished by ensuring that the glidepath displacement from center does not exceed 75 feet when crossing the FAF at the published crossing altitude, or if descending on a centered glidepath, ensuring that the aircraft's altitude crossing the FAF is within 75 feet of the altitude published at the FAF.

Note 4: Aircraft approved under previous AC guidance using baro-VNAV with LNAV/VNAV minimums, the legacy vertical deviation limits of +100/-50 feet remains valid.

B.5 Pilot Knowledge. Pilot knowledge should include the following:

1. 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.
2. Barometric altimeters are calibrated to indicate true altitude under International Standard Atmosphere (ISA) conditions.
3. The effect of temperature on true altitude vs. indicated altitude (i.e., warmer than ISA, the true altitude will be higher than indicated altitude and colder than ISA, the true altitude will be lower than indicated altitude).
4. Understanding the VNAV system capabilities relating to geometric or performance-based VNAV paths.
5. Understanding the use of VNAV angles and altitude restrictions during arrival.
6. Interpretation of electronic displays and symbols.
7. Levels of automation, mode annunciations, changes, alerts, interactions, reversions, degradation.
8. Turn anticipation with consideration to speed and altitude effects.
9. Functional integration with other aircraft systems.

10. The meaning of vertical path discontinuities as well as related flightcrew procedures.
11. VNAV equipment operating procedures, including how to determine vertical-track error/deviation.
12. Procedures for change in arrival/runway assignment.
13. Understanding of possible conflicts between aircraft performance and flight management system (FMS) functions (e.g., airspeed and descent angles).
14. Failures and mode reversions, which adversely impact the aircraft's ability to conduct baro-VNAV approach operations.
15. Contingency downgrade actions (i.e., reverting to LNAV MDA following VNAV failures).
16. Contingency abort actions (i.e., understand which failures and performance parameters require discontinuing the approach and executing an early missed approach).
17. Altimeter cross-check procedures.
18. VNAV system-specific information, including VNAV vertical deviation scaling provided in the Final Approach Segment (FAS). Pilot and flightcrews should be knowledgeable in applying this scaling to the baro-VNAV display cross-check required at the FAF when conducting an approach to the LNAV/VNAV line of minima.

APPENDIX C. QUALIFICATION CRITERIA FOR REQUIRED NAVIGATION PERFORMANCE (RNP) 1 (TERMINAL) OPERATIONS

C.1 Introduction. This appendix provides guidance on the performance and functional requirements for systems used to conduct RNP in terminal operations. This appendix includes:

1. Instrument departure procedures (DP) RNP Obstacle Departure Procedures (ODPs),
2. RNP Standard Instrument Departures (SID), and
3. RNP Standard Terminal Arrival Routes (STAR).

C.2 Aircraft and System Requirements for RNP Terminal Operations.

C.2.1 Performance and Airworthiness Guidance. Refer to Advisory Circular (AC) 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, for performance and airworthiness guidance on aircraft and system criteria.

C.2.2 Statement of Compliance (SOC). Aircraft with an SOC with the criteria in this AC or AC 20-138( ) in their Airplane Flight Manual (AFM), Airplane Flight Manual Supplement (AFMS), pilot's operating handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this AC.

C.2.3 Qualified Avionics Equipment and Airworthiness Approval. Aircraft with the following avionics equipment and an appropriate airworthiness approval automatically qualify for RNP 1 capability without further documentation by virtue of the avionics Technical Standard Order (TSO) and airworthiness approval:

1. Global Positioning System (GPS) stand-alone systems approved in accordance with TSO-C146( ) operational Class 1, 2, or 3.
2. A TSO-C115c flight management system (FMS) (or later revision) with a TSO-C129( ) Class B1 or C1, TSO-C145( ), or TSO-C196( ) sensor.

Note: TSO-C129a has been cancelled, but equipment with an existing TSO-C129a Technical Standard Order Authorization (TSOA) may still be installed.

3. A TSO-C115b FMS using a TSO-C129( ) Class B1 or C1, TSO-C145( ), or TSO-C196( ) sensor with documented compliance to the RNP requirements in RTCA, Inc.'s document, RTCA/DO-236 (revision 'B' or later) or RTCA/DO-283A.
4. Aircraft with a Required Navigation Performance Authorization Required (RNP AR) approval per AC 90-101( ), Approval Guidance for RNP Procedures with AR, or AC 20-138( ).

C.2.3.1 Aircraft/equipment with approval under AC 90-100( ), U.S. Terminal and En Route Area Navigation (RNAV) Operations, for use of GPS are approved under this AC for RNP 1 operations.

C.2.3.2 GPS stand-alone systems approved in accordance with TSO-C129( ) Class A1 typically supports RNP 1 operations associated with instrument approach and DPs, but might not support other operations requiring RNP 1. TSO-C129( ) avionics manufacturers should provide an RNP capabilities document stating compliance with the criteria in AC 20-138( ) for RNP 1 capability. Avionics or aircraft manufacturers may provide a Service Bulletin (SB) for a pilot or equipment operating handbook entry or other notification stating aircraft with this equipment has RNP 1 capability based on the avionics manufacturer's SOC.

C.2.3.3 RNP 1 aircraft with European Precision Area Navigation (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-C129a and satisfying the step-detection and health word checking contained in TSO-C129a meet P-RNAV performance requirements.

Note 1: RNP 1 operations are based on GPS positioning and, if adequate coverage is available, distance measuring equipment (DME)/DME/Inertial Reference Unit (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 2: 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 1 operations in the U.S. airspace where domestic air traffic control (ATC) procedures are applied. This includes RNP operations outside the navigational service volume of the Federal Aviation Administration (FAA) or the International Civil Aviation Organization (ICAO) standard ground-based Navigational Aids (NAVAID).

Note 3: Operators are encouraged to retain back-up navigation systems to guard against outages and interference events.

C.3 System Performance, Monitoring, and Alerting.

C.3.1 Accuracy. The aircraft must comply with Section 2.1.1 of RTCA/DO-236( ). During operations in airspace or on routes designated as RNP 1, the lateral TSE must be within ±1 nautical mile (NM) for at least 95 percent of the total flight time. The along-track (ATRK) error must also be within ±1 NM for at least 95 percent of the total flight time.

To satisfy the 95 percent accuracy requirement, Flight Technical Error (FTE) should not exceed 0.5 NM for autopilot (AP) or flight director (FD) or 0.8 NM for manual control.

Note: The use of a lateral deviation indicator with 1 NM full-scale deflection has been found to be an acceptable means of compliance (AMC). An AP or FD may also be used for maintaining TSE, but roll stabilization systems do not qualify.

C.3.2 Integrity. Malfunction of the aircraft navigation equipment that causes the TSE to exceed two times the RNP value is classified as a major failure condition under airworthiness guidance (i.e., 10^{-5} per hour).

C.3.3 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.

C.3.4 Performance Monitoring and Alerting. The RNP system, or the RNP system and pilot in combination, must 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.

C.3.5 Path Definition. Aircraft performance is evaluated around the path defined by the published procedure and RTCA/DO-236C.

C.3.6 Signal in Space (SIS). If using GPS, the aircraft navigation equipment must provide an alert if the probability of SIS errors causing a lateral position error greater than 2 NM exceeds 10^{-7} per hour for RNP 1 operations.

Note: Aircraft with an approved multisensor RNP system where Global Navigation Satellite System (GNSS) integrity is incorporated into a 2 x RNP integrity alert consistent with DO-236( ) do not require a separate GNSS integrity alert when performance cannot be met.

C.3.7 Functional Requirements of Navigation Data Displays. The following navigation displays and functions are required and must be installed in accordance with AC 20-138( ) or equivalent airworthiness installation advisory material.

C.3.7.1 Navigation data, including a TO/FROM indication and a failure indicator, must be displayed on a lateral deviation display (course deviation indicator (CDI), electronic horizontal-situation indicator (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 (e.g., 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 flightpath.
2. The lateral deviation display scaling must agree with any alerting and annunciation limits.
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; ±1 NM for RNP 1. It is also acceptable for the scaling to be more conservative (e.g., ±0.5 NM for an RNP 1 route).
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 1 computed path. It is recommended that the course selector of the deviation display be automatically slewed to the RNP-computed path.

C.3.7.2 As an alternative 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). 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.

C.3.7.3 It is not necessary for navigation displays, particularly primary flight displays (PFD), to include an Actual Navigation Performance (ANP) or RNP value. The displays only need to provide an alert if the RNP for the operation cannot be met.

C.3.8 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 (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) 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 RNP 1 procedure and/or route to be flown.

Note 1: It is acceptable to manually load en route and terminal waypoints from the database into a flight plan page and manually set the scaling and alerting (Refer to AC 90-100( )).

Note 2: 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 capability to automatically set RNP 1 from the onboard navigation database for each leg segment of a RNP 1 route or procedure.

Note: If the navigation system does not automatically retrieve and set RNP 1 from the onboard navigation database for the entirety of the RNP 1 operation, the flightcrew's operating procedures must manually set RNP 1.

7. The means to display the following items, either in the pilot's primary FOV, or on a readily accessible display page:
   - The active navigation sensor type,
   - The identification of the active (To) waypoint,
   - The ground speed or time to the active (To) waypoint, and
   - The distance and bearing to the active (To) waypoint.
8. The capability to execute a "Direct to" function.
9. The capability for automatic leg sequencing with display to the pilots.
10. The capability to execute RNP 1 terminal procedures extracted from the onboard database including the capability to execute flyover and flyby turns.
11. The system must have the capability to automatically execute leg transitions and maintain tracks consistent with the following Aeronautical Radio, Inc. (ARINC) Specification 424 path terminators:
    - Initial Fix (IF),
    - Course to Fix (CF),
    - Direct to Fix (DF), and
    - 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-236( ) and DO-201( ).

12. The system must have either automatic or manual capability to fly on a heading to intercept a course or to go direct to another fix after reaching a procedure-specified altitude. The system may use heading to altitude (VA), heading to manual (VM) and heading to intercept (VI) path terminators for automatic capability.
13. The aircraft must have the capability to automatically execute leg transitions consistent with Course to Altitude (CA) and Fix to Manual Termination (FM) ARINC Specification 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.
14. For paths defined by a course (e.g., CF and Fix to an Altitude (FA) path terminators), the navigation system should use the appropriate magnetic variation value of the recommended NAVAID in the navigation database.
15. The capability to load a RNP 1 procedure from the database, by procedure name, into the RNAV system.
16. The capability to display an indication of the RNP 1 system failure, in the pilot's primary FOV.
17. The system must allow for a means to become established prior to the final approach fix (FAF) on an instrument landing system (ILS) or Ground Based Augmentation System (GBAS) Landing System (GLS) with minimal overshoot or undershoot.

C.3.9 Database Integrity. The operator must ensure their navigation database supplier possesses a Type 2 Letter of Acceptance (LOA) in accordance with AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases.

C.3.10 Path Terminators. For RNP procedures, the database supplier should not substitute path terminators in lieu of those specified in the original Aeronautical Information Publication (AIP) data.

C.4 Special Characteristics of RNP 1 Operations.

C.4.1 Operation on RNP ODPs, SIDs, STARs. DME/DME/IRU and/or GNSS are the primary navigation systems supporting RNP 1 operations. Refer to AC 20-138( ), Chapter 6, Sections 6-4, 6-6, and 6-8 for additional aircraft and system qualification criteria when using DME/DME/IRU. Pilots are not required to monitor ground-based navigation facilities used in position updating unless required by the AFM.

C.4.2 Navigation Infrastructure. The FAA will monitor the navigation infrastructure and issue timely warnings of outages and facilities designated out of service (i.e., issue Notices to Airmen (NOTAM)).

C.4.3 Source Data. FAA source data contains the navigation performance needed to fly each RNP procedure and must be clearly designated on all appropriate charts.

C.4.4 DME/DME/IRU. If DME/DME/IRU is used, the available DME navigation infrastructure supporting the design of a procedure will be assessed and validated by the FAA or an FAA-authorized third party service provider.

C.4.4.1 The FAA will ensure all DME signals within reception distance of U.S. airspace meet ICAO standards. These could include non-U.S. DME facilities, or Department of Defense (DOD)-maintained DME facilities excluded from the U.S. National Airspace System (NAS) database. Procedure designs will only use DME facilities listed in the Airport/Facility Directory (A/FD).

C.4.4.2 DME signals will meet SIS accuracy tolerances everywhere the signals are received in that procedure.

C.4.4.3 For DME-based RNP operations where reliance is placed upon the IRU/inertial reference system (IRS), some aircraft systems revert to very high frequency omni-directional range (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 will be evaluated by the FAA to determine the effect on aircraft position accuracy.

C.4.5 DME Facilities. If any critical DME facilities exist for ODPs, SIDs, and STARs, they will be identified within the relevant U.S. Flight Information Publications (FLIP) and comply with applicable ICAO standards.

Note: Procedures with (GPS) in the title or with a GPS required are not evaluated for critical DMEs.

C.5 System Eligibility and Approval for RNP 1 Operations.

C.5.1 Requirements. Systems meeting the requirements in AC 20-138( ) are eligible for RNP 1 operations. Aircraft qualified by AC 90-101( ) are considered qualified for RNP 1 operations without further examination. Additionally, aircraft approved to conduct RNAV 1 procedures using GPS, according to AC 90-100( ), do not require further evaluation (see paragraph C.6.3.2).

1. Stand-Alone Systems. GPS stand-alone systems should be approved in accordance with TSO-C129a Class A1 or TSO-C146( ) Class 1, 2, or 3 and meet the functionality requirements of this appendix. GPS systems must be installed in accordance with AC 20-138( ).
2. Multisensor Systems. Aircraft with a TSO-C129 Class B1, C1, B3, or C3, TSO-C145( ), Class 1, 2, or 3, or TSO-C196 sensors installed in an FMS that

meets the requirements of TSO-C115b or later and is installed for instrument flight rules (IFR) use in accordance with AC 20-138( ).

3. Multisensor Systems That Rely on Ground-Based NAVAIDs. Multisensor systems that require the use of ground-based NAVAIDs, such as DME/DME, can be used to conduct RNP 1 operations provided that the documentation described in this appendix shows the aircraft is approved for RNP instrument flight operations, the aircraft meets the functional and performance requirements for RNP 1 (e.g., RNP performance monitoring and alerting) and the requirements of AC 90-100( ), Appendix 1, or Appendix 2, as applicable.

Note: Manufacturers should also ensure the equipment in paragraph C.5.1, Items 1, 2, and 3 meet all functional requirements in this AC.

C.5.2 Demonstrations. Demonstration of aircraft performance in accordance with AC 20-138( ) does not constitute operations approval to conduct RNP operations.

C.6 Operational Approval for RNP 1 Operations.

C.6.1 Aircraft Qualification Documentation. The aircraft or avionics manufacturers should develop aircraft qualification documentation that shows compliance with the applicable criteria, as appropriate. This is not required for aircraft with an AFM or AFMS 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( ).

C.6.2 Performance Requirements. 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.

C.6.3 FAA Acceptance of Documentation.

C.6.3.1 **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.

C.6.3.2 **Existing Aircraft/Equipment.** Previous approvals to conduct RNAV 1 procedures using GPS, according to AC 90-100( ), do not require further evaluation.

C.6.3.3 **Previously Unapproved Installations/Equipment.** For installations/equipment not previously approved to conduct RNAV 1 procedures, the aircraft or avionics manufacturer should submit the RNP 1 documentation in accordance with AC 20-138( ). The operator will submit the RNP operational application package (if required) to the FAA.

C.7 Operational Considerations.

C.7.1 Preflight Planning. For systems with receiver autonomous integrity monitoring (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. Preflight integrity checks and the various capabilities that can be utilized to perform them can be found in the Chapter 9, Flight Planning, of this AC.

C.7.2 Multisensor Systems with RNP 1 Approval. For multisensor systems with RNP 1 approval based on DME/DME, pilots must confirm the availability of critical DME for ODPs, SIDs, and STARs.

Note: Procedures with (GPS) in the title and with a GPS required are not evaluated for critical DMEs.

C.7.3 Radius to Fix (RF) Legs. For RNP 1 operations employing RF legs, confirmation of RF leg aircraft eligibility must be confirmed during preflight planning. Refer to Appendix I, Additional Capabilities, for aircraft RF leg eligibility requirements.

C.7.4 General In-Flight Considerations. 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 for fixed, published routes is not permitted. Additionally, pilots must not change any database waypoint type from a flyby to a flyover or vice versa.

C.7.4.1 During RNP 1 operations, pilots must use a navigation system textual display or navigation map display.

C.7.4.2 If the navigation system does not automatically retrieve and set RNP 1 from the onboard navigation database for the entirety of the RNP 1 operation, the flightcrew's operating procedures must manually set RNP 1.

C.7.4.3 For RNP 1 operations, pilots must use a lateral deviation indicator, FD, or AP in lateral navigation (LNAV) mode. Pilots of aircraft with a lateral deviation display must ensure lateral deviation scaling is suitable for the RNP value associated with the procedure.

Note: If the RNP 1 operation extends beyond 30 NM from the airport and a lateral deviation indicator is used, its full-scale sensitivity must be selected to not greater than 1 NM.

C.7.4.4 Pilots are not required to monitor ground-based navigation facilities used in position updating unless required by the AFM.

C.7.4.5 All pilots are expected to maintain centerline, 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 (XTK) 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 RNP value 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 RNP value (i.e., 1.0 NM for RNP 1), are allowable.

Note: Some aircraft do not display or compute a path during flyby turns. As such, pilots of these aircraft may not be able to adhere to half the LNAV accuracy during turns but are still expected to satisfy the standard during intercepts following turns and on straight segments. This does not apply to the execution of either fixed radius transition (FRT) or RF procedures.

C.7.4.6 Operational qualification for RNP procedures requires flightcrew monitoring of lateral and, if installed, vertical deviations on the pilot's PFDs 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.

C.7.4.7 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.

C.7.4.8 The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action.

C.7.4.9 Pilots of aircraft with RNP input selection capability should select RNP 1 or smaller values, for RNP 1 operations.

C.7.4.10 Pilots operating aircraft with an approved vertical navigation (VNAV) system based on barometric altimetry and having airworthiness approval for climb functionality may use it when executing RNP 1 ODPs and SIDs. Pilots operating aircraft with an approved VNAV system based on baro altimetry and having airworthiness approval for descent functionality may use it when executing RNP 1 STARs.

C.7.5 Prior to Commencing the RNP 1 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 multisensor systems, crew must verify that the correct sensor is being used for position computation.

APPENDIX D. QUALIFICATION CRITERIA FOR REQUIRED NAVIGATION PERFORMANCE (RNP) 0.3 (ROTORCRAFT) OPERATIONS

D.1 Introduction.

D.1.1 Performance and Functional Requirments. This appendix provides guidance on the performance and functional requirements for rotorcraft systems used to conduct RNP 0.3 for en route and terminal operations. Consult Advisory Circular (AC) 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, for the latest guidance on aircraft and system qualification criteria for rotorcraft en route and terminal RNP 0.3. This authorization is applicable to operators conducting operations under Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 91 subpart K (91K), and 135.

D.1.2 Heliports and Offshore Rig Service. This appendix provides guidance for rotorcraft RNP 0.3 en route and terminal operations servicing offshore rigs and where RNP 0.3 accuracy may be needed to support low level mountainous operations and also in high density airspace.

D.2 Application of RNP 0.3 for Rotorcraft.

D.2.1 Benefits. Operational benefits include:

1. Reduced protected areas, enabling simultaneous fixed-wing and rotorcraft operations in dense terminal airspace.
2. Low level routes in obstacle rich environments reducing exposure to icing environments.
3. Seamless transition from en route to terminal route.
4. More efficient terminal routing in an obstacle rich or noise sensitive terminal environment, specifically in consideration of helicopter emergency medical service (HEMS) instrument flight rules (IFR) operations between hospitals.
5. Transitions to rotorcraft point in space (PinS) approaches (prior to the final approach fix (FAF) and after the Missed Approach Procedure (MAP)).

D.2.2 Design. RNP 0.3 is designed for operation in en route, on arrival/departure routes, and approaches (prior to the FAF and after the MAP).

Note: A rotorcraft RNP 0.3 qualification is not a qualification for Required Navigation Performance Authorization Required (RNP AR) procedures.

D.2.3 Area Navigation Capability. The area navigation capability required for RNP 0.3 will encompass the lateral aspects of the desired flightpath. The predictability and performance monitoring and alerting for the lateral flightpath will support a number of applications including closely-spaced tracks, RNP departures/arrivals, RNP airways, and missed approach segments.

D.3 System Requirements for Rotorcraft RNP 0.3 Operations.

D.3.1 Qualification Methods. The following qualification methods are:

1. Rotorcraft with a statement of compliance (SOC) with the criteria in AC 20-138( ), in their Rotorcraft Flight Manual (RFM) or Rotorcraft Flight Manual Supplement (RFMS). Rotorcraft conducting RNP 0.3 operations must have an airworthiness approval for Satellite-based Augmentation System (SBAS)-based IFR operations. Any limitations required for IFR operations will also apply to RNP 0.3 operations.
2. Rotorcraft without an RFM or RFMS statement from the manufacturer documenting compliance must meet the following criteria:
   - Global Positioning System (GPS) stand-alone systems should be approved in accordance with Technical Standard Order (TSO)-C146a or later operational Class 1, 2, or 3 and must be installed for IFR operations in accordance with AC 20-138( ).
   - Rotorcraft with TSO-C145a or later operational Class 1, 2, or 3 sensor installed with a flight management system (FMS) that meets the requirements of TSO-C115b or later and is installed for IFR use in accordance with AC 20-138( ).

D.3.2 Demonstrations. Demonstration of aircraft performance in accordance with AC 20-138( ) does not constitute operations approval to conduct RNP operations.

D.4 System Performance, Monitoring, and Alerting.

D.4.1 Accuracy. The aircraft must comply with Section 2.1.1 of RTCA/DO-236( ). During operations in airspace or on Air Traffic Service (ATS) routes designated as RNP 0.3, the lateral Total System Error (TSE) must be within ±0.3 nautical mile (NM) for at least 95% of the total flight time. The along-track (ATRK) error must also be within ±0.3 NM for at least 95% of the total flight time. To meet this performance requirement, a Flight Technical Error (FTE) of 0.25 NM (95%) may be assumed.

Note: For all RNP 0.3 operations, the use of an autopilot (AP) and/or flight director (FD) is an acceptable means of complying with this FTE assumption (see AC 20-138( ), Table 9). Any alternative means of FTE bounding, other than coupled flight guidance system (FGS), may require FTE substantiation through an airworthiness demonstration.

D.4.2 Integrity. Malfunction of the rotorcraft navigation equipment that causes the TSE to exceed 2 times the RNP value without annunciation is classified as a major failure condition under airworthiness regulations (i.e., 1×10^{-5} per hour).

D.4.3 Continuity. For the purpose of this specification, loss of function is a major failure condition for oceanic and remote continental operations. The carriage of dual independent long-range navigation systems (LRNS) may satisfy the continuity requirement. Loss of function is classified as a minor failure condition for other

RNP 0.3 operations if the operator can revert to a different available navigation system and proceed to a suitable airport.

D.4.4 Performance Monitoring and Alerting. The RNP system, or the RNP system and the pilot in combination, is required to monitor TSE and provides 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}.

D.4.5 Path Definition. RNP systems should provide lateral guidance so aircraft remain within the lateral boundaries of the flyby transition area per TSO-C146( ) or as defined in RTCA/DO-236C.

D.4.6 Signal in Space (SIS). The rotorcraft navigation equipment must provide an alert if the probability of SIS errors causing a lateral position error greater than 0.6 NM exceeds 1×10^{-7} per hour.

D.5 Functional Requirements.

D.5.1 Navigation Data Displays. The following navigation displays and functions are required and must be installed in accordance with AC 20-138( ) or equivalent airworthiness installation advisory material.

D.5.2 Navigation Displays and Functions Requirements. The RNP 0.3 system must have the following navigation displays and functions installed:

1. Navigation data, including a TO/FROM indication and a failure indicator must be displayed on a lateral deviation display (course deviation indicator (CDI), electronic horizontal-situation indicator (EHSI)) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the rotorcraft, for maneuver anticipation and for failure/status/integrity indication.
2. The capability to continuously display to the Pilot Flying (PF), on the primary flight instruments for navigation of the rotorcraft (primary navigation display), the computed path and rotorcraft position relative to the path. For operations where the required minimum flightcrew is two pilots, the means for the pilot-not-flying (PNF) to verify the desired path and the rotorcraft position relative to the path must also be provided.
3. The displays must be visible to the pilot and located in the primary field of view (FOV) when looking forward along the flightpath.
4. The lateral deviation display scaling must agree with the RNP 0.3 alerting and annunciation limits.
5. The lateral deviation display must have ±0.3 NM full-scale deflection based on the required total system accuracy.
6. The display scaling may be set automatically by default logic; automatically to a value obtained from a navigation database; or manually by flightcrew

procedures. The full-scale deflection value must be known or must be available for display to the pilot commensurate with the required accuracy.

7. 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 1: This does not apply for installations where an electronic map display contains a graphical display of the flightpath and path deviation.

Note 2: As an alternate means of compliance, a navigation map display may provide equivalent functionality to a lateral deviation display as described in 1 to 7 above, with appropriate map scales and giving equivalent functionality to a lateral deviation display. The map scale may be set manually to a value appropriate for RNP 0.3 operations. To be approved as an alternative means, the navigation map display should meet the TSE criteria and be located in the primary FOV.

D.5.3 System Capabilities. The following system capabilities and functions are required as a minimum within any RNP 0.3 equipment:

1. The capability to continuously display to the PF, on the primary flight instruments for navigation of the rotorcraft (primary navigation display), the RNP-computed desired path and rotorcraft position relative to the path. For operations where the required minimum flightcrew is two pilots, a means for the PNF (pilot monitoring) to verify the desired path and the rotorcraft 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 negligible Path Definition Error (PDE). 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. The capability to load from the database into the RNP system the RNP 0.3 procedure and/or route to be flown.

Note 1: It is acceptable to manually load en route and terminal waypoints from the database into a flight plan page and manually set the scaling and alerting.

Note 2: 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 capability to automatically set RNP 0.3 from the onboard navigation database for each leg segment of a RNP 0.3 route or procedure.
7. The means to display the following items, either in the pilot's primary FOV, or on a readily accessible display page:
   - Along track distances between waypoints,
   - Active navigation sensor type,
   - The identification of the active (To) waypoint,
   - The ground speed or time to the active (To) waypoint, and
   - The distance and bearing to the active (To) waypoint.
8. The capability to execute a "Direct to" function.
9. The capability for automatic leg sequencing with display of sequencing to the pilot.
10. The capability to execute RNP 0.3 terminal procedures extracted from the onboard database, including the capability to execute flyby turns.
11. The capability to automatically execute leg transitions and maintain tracks consistent with the following Aeronautical Radio, Inc. (ARINC) Specification 424 path terminators, or their equivalent:
    - Initial Fix (IF),
    - Track to Fix (TF),
    - Course to Altitude (CA),
    - Direct to Fix (DF), and
    - Course to Fix (CF).

Note 1: Path terminators are defined in ARINC Specification 424, and their application is described in more detail in RTCA, Inc.'s documents, DO-236( ) and DO-201( ).

Note 2: The system must be capable of loading numeric values for courses and tracks from the onboard navigation database.

12. The capability to automatically or manually fly on a heading to intercept (VI) a course or to go direct to another fix after reaching a procedure-specified altitude. The system may use heading to altitude (VA), heading to manual (VM) and VI path terminators for automatic capability.

13. The capability to automatically or manually permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint. The system may use CA and Fix to Manual Termination (FM) path terminators for automatic capability.
14. The capability for the flightcrew to build an en route or offshore segment in the equipment flight plan function using individual waypoints from the database. This is similar to existing en route capability.

Note: It is also acceptable for the navigation system to automatically load all route waypoints from the database by selecting the route name.

15. The capability to load numeric values for courses and tracks from the onboard navigation database.
16. The capability to display an indication of the RNP 0.3 system failure, in the pilot's primary FOV.
17. The capability to indicate to the crew when the Navigation System Error (NSE) alert limit is exceeded (alert provided by the onboard performance monitoring and alerting function).

D.5.4 FD/AP. For all rotorcraft RNP 0.3 operations, the use of an AP and/or FD is an acceptable means of complying with FTE assumption in Chapter 4, General Information, of this AC. Any alternate means of FTE bounding will require a demonstration.

D.6 Navigation Database Integrity.

D.6.1 Type 2 Letter of Acceptance (LOA). The operator must ensure their navigation database supplier possesses a Type 2 LOA in accordance with AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases.

D.6.2 Path Terminators. The database supplier should not substitute path terminators in lieu of those specified in the original State Aeronautical Information Publication (AIP) data.

D.7 Operational Approval for RNP 0.3 Operations.

D.7.1 Rotorcraft Qualification Documentation. The rotorcraft and avionics manufacturers should develop rotorcraft qualification documentation that shows compliance. For rotorcraft without RFM approval for RNP 0.3 operations, the rotorcraft and avionics manufacturers should develop RNP 0.3 qualification documentation showing compliance with this appendix. The necessary documentation should also define the recommended operations and maintenance procedures. This is not required for rotorcraft with an RFM or RFMS which explicitly states that the RNP system is approved for IFR operations with RNP values as low as RNP 0.3.

D.7.2 RNP Capability Statement. The GPS/SBAS-enabled navigation system equipment manufacturer should provide an RNP capability statement that the equipment meets the performance and functional criteria in AC 20-138( ), Chapter 9, Section 9-5 for rotorcraft

en route and terminal RNP 0.3 operations. If an RNP capability statement is provided, it must include a description of the equipment procedures for pilots to select the rotorcraft en route and terminal RNP 0.3 capability.

D.7.3 Functional and Performance Requirements Review. Manufacturers and commercial operators should review all functional and performance requirements before providing any qualification documentation. Installation of equipment by itself does not guarantee operational approval or permit operational use.

D.8 Federal Aviation Administration (FAA) Acceptance of Documentation.

D.8.1 New Rotorcraft/Equipment. The GPS/SBAS equipment must be installed according to a type certificate (TC), amended TC, or Supplemental Type Certificate (STC) and any rotorcraft limitations required for IFR operations also apply to rotorcraft en route and terminal RNP 0.3 capability. The equipment manufacturer should provide an RNP capability statement (see paragraph D.7.1). It is also acceptable for the TC, air traffic control (ATC), or STC holder to document rotorcraft en route and terminal RNP 0.3 capability in the RFM/RFMS.

D.8.2 Existing Rotorcraft/Equipment. The GPS/SBAS equipment must be installed according to a TC, ATC, or STC and any rotorcraft limitations required for IFR operations also apply to rotorcraft en route and terminal RNP 0.3 capability. The equipment manufacturer should provide an RNP capability statement (see paragraph D.7.1). The operator will submit the RNP operational application package (if required) to the FAA.

D.9 Operational Procedures.

D.9.1 Operational Approval. Airworthiness certification and recognition of RNP 0.3 rotorcraft qualification alone does not authorize RNP 0.3 operations.

D.9.2 Normal and Contingency Procedures. Commercial operations must include normal and contingency RNP 0.3 operational procedures for their particular equipment installation.

D.9.3 Commercial Operators and Approval. Commercial operators must receive approval to fly RNP 0.3 rotorcraft operations via helicopter specification (HSpec).

D.9.3.1 Part 91 operators are not required to have operational approval for RNP 0.3 operations.

D.9.3.2 The operator must have a configuration list and if necessary, a minimum equipment list (MEL) detailing the required aircraft equipment for RNP 0.3 operations.

D.9.4 Preflight Planning. RNP 0.3 is predicated on wide area augmentation system (WAAS) integrity. The availability of WAAS integrity should be confirmed by checking WAAS Notices to Airmen (NOTAM) prior to flight (see Chapter 9, Flight Planning).

D.9.5 General In-Flight Considerations. At system initialization, the pilot must confirm the navigation database is current and check the proper departure entry and correct route depiction. Shortly before takeoff, the pilot must also verify proper entry of their desired ATS route and any ATC changes to that ATS route upon initial clearance and any subsequent change of ATS route. The pilot must ensure the waypoints sequence depicted by their navigation system matches the ATS route depicted on the appropriate chart(s).

Note: Flightcrew may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3 degrees or less may result from equipment manufacturer's application of magnetic variation and are operationally acceptable.

D.9.5.1 The pilot must not attempt to fly an RNP 0.3 Instrument Flight Procedure (IFP) unless it is retrievable by name from the onboard navigation database and conforms to the charted procedure. However, the pilot may subsequently modify a procedure by inserting or deleting specific waypoints in response to ATC clearances. The pilot may select the ATS route to be flown for the en route section of the flight from the database or may construct the ATS route by means of selection of individual en route waypoints from the database. The manual entry or creation of new waypoints by manual entry of latitude and longitude or rho/theta values for fixed, published routes is not permitted. Additionally, pilots must not change any Standard Instrument Departure (SID) or Standard Terminal Arrival Route (STAR) database waypoint type from a flyby to a flyover or vice versa.

D.9.5.2 Refer to Appendix H, Advanced Required Navigation Performance (A-RNP) for guidance on scalability and Appendix I, Additional Capabilities, for Radius to Fix (RF).

D.9.5.3 The pilot should cross-check the flight plan clearance by comparing charts or other applicable resources with the navigation system textual display and the rotorcraft map display, if applicable.

D.9.5.4 There is no pilot requirement to cross-check the navigation system's performance with conventional Navigational Aids (NAVAID) as the absence of an integrity alert is considered sufficient to meet the integrity requirements. However, the pilot should monitor the reasonableness of the navigation solution and report any loss of RNP 0.3 capability to ATC. In addition, the pilot must continuously monitor the lateral deviation indicator (or equivalent navigation map display) during all RNP 0.3 operations.

D.9.5.5 All pilots are expected to maintain centerline, as depicted by onboard lateral deviation indicators and/or flight guidance during all RNP operations described in this appendix unless authorized to deviate by ATC or under emergency conditions. For normal operations, cross-track (XTK) error/deviation (the difference between the displayed path and the displayed rotorcraft position relative to the displayed path, (i.e., FTE)) should be limited

to half the RNP value associated with the procedure (i.e., 0.15 NM for RNP 0.3). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the RNP value (i.e., 0.3 NM for RNP 0.3), are allowable.

Note: Some rotorcraft avionics do not display or compute a path during turns. As such, pilots of rotorcraft 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.

D.9.5.6 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 rotorcraft remains within the bounds defined by the procedure. The deviation must be monitored, and action taken to minimize errors during all RNP operations.

D.9.5.7 If ATC issues a heading assignment taking the rotorcraft 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 rotorcraft is not on a published RNP 0.3 procedure.

D.9.5.8 The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action.

D.9.5.9 Whenever possible, RNP en route and terminal segments should be extracted from the database in their entirety, rather than loading RNP route waypoints from the database into the flight plan individually. Selecting and inserting individual, named fixes from the database is permitted, provided all fixes along the published route to be flown are inserted.

D.9.5.10 Manually selecting rotorcraft bank limiting functions may reduce the rotorcraft's ability to maintain its desired track (DTK) and is not recommended. The pilot should recognize manually selectable rotorcraft bank-limiting functions might reduce the ability to satisfy path requirements of the procedure, especially when executing large angle turns. This should not be construed as a requirement to deviate from RFM procedures; rather, pilots should be encouraged to avoid the selection of such functions except where needed for flight safety reasons.

D.9.5.11 Any limitations required for normal IFR operation will also apply to rotorcraft en route and terminal RNP 0.3.

D.9.6 Manual Entry of RNP. If the navigation system does not automatically retrieve and set RNP 0.3 from the onboard navigation database for each leg segment of the RNP 0.3 operation, the flightcrew's operating procedures must verify manually setting RNP 0.3 into the RNP system.

D.9.7 Engagement of FGS after Takeoff. When required, the pilot must be able to engage (i.e., couple) the FGS prior to reaching the first waypoint defining a procedure requiring RNP 0.3 in accordance with this specification.

D.9.8 RNP 0.3 SID Specific Requirements. Prior to commencing takeoff, the pilot must verify the rotorcraft RNP system is available, operating correctly, and the correct airport/heliport and departure data are loaded and properly depicted (including the rotorcraft's initial position). A pilot assigned an RNP 0.3 departure procedure (DP) and subsequently issued a change to the procedure or a transition from the procedure must verify that the appropriate changes are entered and available for navigation prior to takeoff. This includes confirmation of the waypoint sequence, reasonableness of track angles and distances, any altitude or speed constraints, and, where possible, identification of which waypoints are flyby and which are flyover or which represent the beginning or end of a RF leg segment. An ATS route must not be used if the pilot has any reason to doubt the validity of the ATS route in the navigation database.

Note: As a minimum, the departure checks can be a simple inspection of a suitable map display that achieves the objectives of this paragraph.

D.9.9 RNP 0.3 STAR Specific Requirements. Prior to the arrival phase, the pilot should verify loading of the correct terminal route. The active flight plan should be checked by comparing the charts (paper or electronic) with the map display (if applicable) and the multipurpose control and display unit (MCDU). This includes confirmation of the waypoint sequence, reasonableness of track angles and distances, any altitude or speed constraints, and, where possible, identification of which waypoints are flyby and which are flyover or which represent the beginning or end of a RF leg segment. An ATS route must not be used if the pilot has any reason to doubt the validity of the ATS route in the navigation database.

Note: As a minimum, the arrival checks can be a simple inspection of a suitable map display that achieves the objectives of this paragraph.

D.9.10 Contingency Procedures. The pilot must notify ATC of any loss of the RNP capability (integrity alerts or loss of navigation), together with the proposed course of action. If unable to comply with the requirements of an RNP procedure, pilots must advise ATS as soon as possible. The loss of RNP capability includes any failure or event causing the rotorcraft to no longer satisfy the RNP 0.3 requirements of the route.

D.10 Pilot Knowledge and Training.

D.10.1 Training Program. Operators with an approved training program should address the elements listed below. Part 91 operators should be familiar with the practices and procedures identified in this section.

D.10.2 Knowledge. The training program should provide sufficient training (e.g., simulator, training device, or rotorcraft) to the extent that the pilot is familiar with the following as applicable to the rotorcraft RNP system:

1. The information in this appendix,
2. The meaning and proper use of rotorcraft navigation suffixes,
3. Procedure characteristics as determined from chart depiction and textual description,
4. Depiction of waypoint types (flyover and flyby) and any other types used by the operator as well as associated aircraft flightpaths,
5. Required navigation equipment and MEL for operation on RNP 0.3 ATS routes,
6. RNP 0.3 system-specific information:
   - Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
   - Functional integration with other rotorcraft systems;
   - The meaning and appropriateness of route discontinuities as well as related flightcrew procedures;
   - Pilot procedures consistent with the operation (e.g., monitor PROG or LEGS page);
   - Types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic/limitations;
   - Turn anticipation with consideration for airspeed and altitude effects;
   - Interpretation of electronic displays and symbols used to conduct an RNP 0.3 operation; and
   - Understanding of the rotorcraft configuration and operational conditions required to support RNP 0.3 operations (i.e., appropriate selection of CDI scaling/lateral deviation display scaling).
7. RNP equipment operating procedures, as applicable, including how to perform the following actions:
   - Verifying currency and integrity of rotorcraft navigation data.
   - Verifying successful completion of RNP system self-tests.
   - Entry of and update to the rotorcraft navigation system initial position.
   - Retrieving and flying an IFP with appropriate transition.
   - Adhering to speed and/or altitude constraints associated with an RNP 0.3 IFP.
   - Impact of pilot selectable bank limitations on rotorcraft ability to achieve the required accuracy on the planned route.
   - Selecting the appropriate STAR or SID for the active runway in use and be familiar with flightcrew procedures required to deal with a runway change.
   - Verifying waypoint and flight plan programming.

- Flying direct to a waypoint.
- Flying a course/track to a waypoint.
- Intercepting a course/track.
- Following vectors and rejoining an RNP ATS route from “heading” mode.
- Determining XTK/deviation. More specifically, the maximum deviations allowed to support RNP 0.3 must be understood and respected.
- Inserting and deleting route discontinuities.
- Removing and reselecting navigation sensor inputs.
- When required, confirming exclusion of a specific NAVAID or NAVAID type.
- Changing the arrival airport/heliport and the alternate airport.
- Performing a parallel offset (Appendix I) function, if the capability exists. The pilot should know how to apply offsets within the functionality of their particular RNP system and the need to advise ATC if this functionality is not available.
- Performing a conventional holding pattern.

8. Operator-recommended levels of automation for phase of flight and workload, including methods to minimize XTK to maintain route centerline,
9. Receiver/Transmitter (R/T) phraseology for RNP applications, and
10. Contingency procedures for RNP failures.

D.10.3 Oversight of Operators. The FAA may consider any navigation error reports in determining remedial action for an operator. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment.

D.10.4 Training Program Modification. Information that indicates the potential for repeated errors may require modification of an operator’s training program. Information that attributes multiple errors to a particular pilot may necessitate remedial training or certificate review.

APPENDIX E. QUALIFICATION CRITERIA FOR REQUIRED NAVIGATION PERFORMANCE (RNP) 2 DOMESTIC, OFFSHORE, OCEANIC, AND REMOTE CONTINENTAL OPERATIONS

E.1 Introduction. RNP 2 is primarily intended for a diverse set of en route applications; particularly in geographic areas with little or no ground Navigational Aid (NAVAID) infrastructure, limited or no Air Traffic Service (ATS) surveillance, and low to medium density traffic. This appendix provides guidance on the performance and functional requirements for systems used to conduct RNP en route within the U.S. National Airspace System (NAS) and offshore where domestic air traffic control (ATC) procedures are applied. Additionally, this appendix provides guidance for operation in remote continental airspace including oceanic and Special Areas of Operation (SAO). This appendix does not address communications or surveillance requirements that may be specified to operate on a particular route or in a particular area. Those requirements are specified in other documents, such as the Aeronautical Information Publications (AIP), the International Civil Aviation Organization (ICAO) Doc 7030, Regional Supplementary Procedures (SUPPS) and ICAO Doc 4444 PANS ATM, Procedures for Air Navigation Services, Air Traffic Management.

E.2 Aircraft and System Requirements for RNP 2.

E.2.1 Statement of Compliance. Aircraft with a statement of compliance (SOC) with RNP 2 criteria Advisory Circular (AC) 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, in their Airplane Flight Manual (AFM)/Rotorcraft Flight Manual (RFM), Airplane Flight Manual Supplement (AFMS)/Rotorcraft Flight Manual Supplement (RFMS), pilot's operating handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this appendix.

E.2.2 Service Bulletin (SB). Avionics or aircraft manufacturers may provide an SB for a pilot or equipment operating handbook entry, or other notification stating aircraft with the equipment in paragraph E.2.4, and an appropriate airworthiness approval, has RNP 2 capability.

E.2.3 Approval Basis. RNP 2 approvals are based on Global Navigation Satellite System (GNSS), including GNSS/Inertial Reference Unit (IRU), due to implementation in remote continental/oceanic areas. Therefore distance measuring equipment (DME)/DME/IRU should not be the basis for any RNP 2 approvals.

E.2.4 Qualified Avionics Equipment and Airworthiness Approval. Aircraft with the following avionics equipment and an appropriate airworthiness approval automatically qualify for RNP 2 minima capability without further documentation by virtue of the avionics Technical Standard Order (TSO) and airworthiness approval:

1. Global Positioning System (GPS) stand-alone systems approved in accordance with TSO-C146( ) operational Class 1, 2, or 3.

2. A TSO-C115c (or later revision) flight management system (FMS) with a TSO-C129( ) Class B1 or C1, TSO-C145( ) Class 1, 2, or 3, or TSO-C196 sensor.

Note 1: TSO-C129a has been cancelled, but equipment with an existing TSO-C129a Technical Standard Order Authorization (TSOA) may still be installed.

Note 2: TSO-C129( ) equipment needs to comply with AC 20-138( ), Appendix 1 for oceanic operations.

3. A TSO-C115b FMS using a TSO-C129( ) Class B1 or C1, TSO-C145( ) Class 1, 2, or 3, or TSO-C196) sensor with documented compliance to the RNP requirements in RTCA, Inc.'s document, RTCA/DO-236 (revision 'B' or later) or RTCA/DO-283A as part of the approval basis.

Note: TSO-C129( ) equipment needs to comply with AC 20-138( ), Appendix 1 for oceanic operations.

4. Aircraft with a Required Navigation Performance Authorization Required (RNP AR) approval per AC 90-101( ), Approval Guidance for RNP Procedures with AR, or AC 20-138( ).

E.2.5 GPS Stand-Alone Systems and TSO-C129( ) Class A1. GPS stand-alone systems approved in accordance with TSO-C129( ) Class A1 typically supports RNP 1 operations associated with instrument approach and departure procedures (DP), but might not support other operations requiring RNP 2. TSO-C129( ) avionics manufacturers should provide an RNP capabilities document stating compliance with the criteria in AC 20-138( ) for RNP 2 capability. Avionics or aircraft manufacturers may provide an SB for a pilot or equipment operating handbook entry or other notification stating aircraft with this equipment has RNP 2 capability based on the avionics manufacturer's SOC.

Note 1: TSO-C129( ) equipment needs to comply with AC 20-138( ), Appendix 1 for oceanic operations.

Note 2: If the equipment supports RNP 2 capability, equipment manufacturers can use their AC 90-100A, U.S. Terminal and En Route Area Navigation (RNAV) Operations, reference as an acceptable RNP SOC.

E.2.6 Demonstrations. Demonstration of aircraft performance in accordance with AC 20-138( ) does not constitute operations approval to conduct RNP operations.

E.3 RNP 2 Oceanic and Remote Continental/RNP 2 Domestic or Offshore Operations.

E.3.1 Area of Application. For RNP 2 routes, the area of application (i.e., domestic/offshore or oceanic/remote continental) will determine the applicable RNP continuity requirement (dual or single long-range navigation system (LRNS)).

E.3.2 Navigation Equipment Requirements. Navigation equipage for oceanic/remote continental RNP 2 operations must require dual independent GPS LRNS where higher continuity is specified. Navigation equipage for all RNP 2 domestic and offshore operations areas must have at least a single GPS LRNS.

E.3.3 Specification Basis. The RNP 2 specification is based upon GNSS. Positioning data from other types of navigation sensors may be integrated with the GPS data provided they do not cause position errors exceeding the Total System Error (TSE) budget. Otherwise, means should be provided to deselect the other navigation sensor types.

E.3.4 Knowledge of Operational Requirements. Operators and pilots are required to take account of all operational requirements relating to RNP 2 airspace as required by the appropriate state or regional authority before conducting flights into that airspace.

E.3.5 Fault Detection and Exclusion (FDE) Function. An FDE function must be available when conducting RNP 2 oceanic or remote continental operations.

E.3.6 GNSS Fault Detection. Operators are required to have the means to predict the availability of GNSS fault detection (e.g., Aircraft-Based Augmentation System (ABAS) receiver autonomous integrity monitoring (RAIM)) to support operations along the RNP 2 ATS route. The onboard RNP system, GNSS avionics, the Air Navigation Service Provider (ANSP), or other entities may provide a prediction capability.

E.3.7 GNSS Signal Interference. RNP 2 must not be used in areas of known GNSS signal interference.

E.4 System Performance, Monitoring, and Alerting.

E.4.1 Accuracy. The aircraft must comply with Section 2.1.1 of RTCA/DO-236( ). During operations in airspace or on routes designated as RNP 2, the lateral TSE must be within ±2 nautical miles (NM) for at least 95 percent of the total flight time. The along-track (ATRK) error must also be within ±2 NM for at least 95 percent of the total flight time. To satisfy the 95 percent accuracy requirement, the Flight Technical Error (FTE) should not exceed 1 NM.

Note: The use of a lateral deviation indicator with 2 NM full-scale deflection has been found to be an acceptable means of compliance (AMC) integrity. An autopilot (AP) or flight director (FD) may also be used for maintaining TSE, but roll stabilization systems do not qualify.

E.4.2 Integrity. Malfunction of the aircraft navigation equipment that causes the TSE to exceed two times the RNP value is classified as a major failure condition under airworthiness guidance (i.e., 10^{-5} per hour).

E.4.2.1 **Continuity.** For RNP 2 oceanic and remote continental operations, loss of function is a major failure condition. For RNP 2 in the U.S. NAS or offshore airspace areas, 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.

Note: Operators and pilots are required to use the specified continuity requirements of the governing state or regional authority before conducting flights outside of the U.S. NAS.

E.4.2.2 **Performance Monitoring and Alerting.** The RNP system, or the RNP system and pilot in combination, must provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 4 NM is greater than 10^{-5} for RNP 2 operations.

E.4.2.3 **Path Definition.** Aircraft performance is evaluated around the path defined by the published procedure and RTCA/DO-236C.

E.4.2.4 **Signal in Space (SIS).** The aircraft navigation equipment must provide an alert if the probability of SIS errors causing a lateral position error greater than 4 NM exceeds 10^{-7} per hour for RNP 2 operations.

E.5 Maintenance Requirements.

E.5.1 LRNS. Aircraft must have established maintenance procedures for all LRNS intended for use in oceanic and remote continental area operations.

E.6 Functional Requirements of Navigation Data Displays.

E.6.1 Installation. The following navigation displays and functions are required and must be installed in accordance with AC 20-138( ) or equivalent airworthiness installation advisory material.

E.6.2 Navigation Data Displays. Navigation data, including a TO/FROM indication and a failure indicator, must be displayed on a lateral deviation display (course deviation indicator (CDI), electronic horizontal-situation indicator (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 (e.g., 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).
2. The lateral deviation display scaling must agree with any alerting and annunciation limits.
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; ±2 NM for RNP 2. It is also acceptable for the scaling to be more conservative (e.g., ±1 NM for an RNP 2 route).

4. The display scaling may be set automatically by default logic or 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 the required track-keeping accuracy.
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 flightpath 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). 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.
7. It is not necessary for navigation displays, particularly primary flight displays (PFD), to include an Actual Navigation Performance (ANP) or RNP value. The displays only need to provide an alert if the RNP for the operation cannot be met.

E.6.3 System Capabilities. The following system capabilities are required as a minimum within any RNP 2 equipment:

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) 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). 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. The capability to load from the database into the RNP system the RNP 2 route to be flown if applicable.

Note 1: It is acceptable to manually load en route and terminal waypoints from the database into a flight plan page and manually set the scaling and alerting.

Note 2: 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 capability to automatically set RNP 2 from the onboard navigation database for each leg segment of a RNP 2 route or procedure.
7. For RNP 2 tracks in oceanic/remote continental airspace using flexible (e.g., organized) tracks, a means to enter the unique waypoints required to build a track assigned by the ATS provider. Manual entry or creation of new waypoints is permitted, by manual entry of latitude and longitude.
8. The means to display the following items, either in the pilot's primary FOV, or on a readily accessible display page:
   - The active navigation sensor type,
   - The identification of the active (To) waypoint,
   - The ground speed and time to the active (To) waypoint, and
   - The distance and bearing to the active (To) waypoint.
9. The capability to execute a "direct to" function.
10. The capability to execute a parallel offset (Appendix I, Additional Capabilities).

Note: The system must have the capability to fly parallel tracks at a selected offset distance. When executing a parallel offset (Appendix I), the RNP type and all performance requirements of the original route in the active flight plan must be applicable to the offset route. The system must provide for entry of offset distances in increments of 1 NM, left or right of course. The system must be capable of offsets of at least 20 NM.

11. The capability for automatic leg sequencing with display to the pilots.
12. The capability to automatically execute waypoint transitions and maintain track consistent with the RNP 2 performance requirements with the following Aeronautical Radio, Inc. (ARINC) Specification 424 path terminators:
    - Course to Fix (CF),
    - Direct to Fix (DF), and
    - 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-236( ) and DO-201( ).

13. The capability to display an indication of the RNP 2 system failure in the pilot's primary FOV.
14. The capability to indicate to the crew when the Navigation System Error (NSE) alert limit is exceeded (i.e., the alert provided by the onboard performance monitoring and alerting function).
15. Capability for the crew to create, review and activate a flight plan.

Note: The system must provide the capability for modification (e.g., deletion and addition of fixes and creation of ATRK fixes), review and user acceptance of changes to the flight plans. When this capability is exercised, guidance outputs must not be affected until modification(s) is/are activated. Activation of any flight plan modification must require positive action by the flightcrew after input and verification by the flightcrew.

16. The system must provide data to enable the generation of command signals for AP/FD/CDI, as applicable. In all cases a FTE must be defined at the time of certification, which will meet the requirements of the desired RNP operation in combination with the other system errors.

E.6.4 Database Integrity. The operator must ensure their navigation database supplier possesses a Type 2 Letter of Acceptance (LOA) in accordance with AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases.

E.6.5 Path Terminators. The database supplier should not substitute path terminators in lieu of those specified in the original State AIP data.

E.7 Aircraft Eligibility.

E.7.1 System Eligibility for RNP 2 Operations. Systems meeting the requirements in AC 20-138( ) are eligible for RNP 2 operations.

E.8 Operational Requirements.

E.8.1 Navigation Equipage. To satisfy the higher continuity requirement, all RNP 2 operations in oceanic and remote continental areas must have at least dual independent GPS LRNS.

E.8.2 Configuration. The equipment configuration used to demonstrate the required accuracy must be identical to the configuration, which is specified in the minimum equipment list (MEL).

E.8.2.1 The operator must have an approved GNSS availability prediction program ensuring the requisite availability of the GNSS FDE function. Prior to conducting RNP 2 operations oceanic or remote continental areas, the

operator must use this prediction program prior to dispatch. 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 2 operation, the operator should revise the flight plan (e.g., delay the departure or plan a different route).

E.8.3 Aircraft Qualification Documentation. The aircraft or avionics manufacturers should develop aircraft qualification documentation that shows compliance with the applicable criteria, as appropriate. This is not required for aircraft with an AFM or AFMS which explicitly states that the RNP system is approved for instrument flight rules (IFR) operations with RNP values at least as low as RNP 2 and the equipment meets the performance and reliability guidance of AC 20-138( ).

E.8.3.1 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.

E.9 Operational Considerations.

E.9.1 Pilot Training and Qualification. Operators should ensure pilots are trained and qualified to operate in RNP 2 airspace.

E.9.2 Preflight Planning. The following actions should be completed during preflight:

1. Review maintenance logs and forms to ascertain the condition of equipment required for flight in RNP 2 airspace or on an RNP 2 route, and
2. Ensure that maintenance action has been taken to correct defects to required equipment.

E.9.3 Domestic Operations. 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. Preflight integrity checks and the various capabilities that can be utilized to perform them can be found in Chapter 9, Flight Planning, of this AC.

E.9.4 Oceanic and Remote Continental Operations. RAIM availability prediction should take into account the latest GNSS constellation, Notices to Airmen (NOTAM), and avionics model (when available). The ANSP, avionics manufacturer, or the RNP system may provide this service.

E.9.4.1 In the event of a predicted, continuous loss of an appropriate level of FDE of more than 5 minutes for any part of the RNP 2 operation, the operator should revise the flight plan (e.g., delay the departure or plan a different route).

E.9.4.2 RAIM availability prediction software does not guarantee the service; rather, RAIM prediction tools assess the expected capability to meet the RNP. Because of unplanned failure of some GNSS elements, pilots and ANSPs must realize that RAIM or GNSS navigation may be lost while airborne, and

this may require reversion to an alternative means of navigation. Therefore, pilots should prepare to assess their capability to navigate (potentially to an alternate destination) in case of failure of GNSS navigation.

E.9.5 General In-Flight Considerations. For flexible route structures, manual entry of waypoints (i.e., latitude and longitude), may be permitted provided the potential for entry error by pilots is mitigated by adequate flightcrew procedures. The manual entry or creation of new waypoints, by manual entry of latitude and longitude or rho/theta values for fixed, published routes is not permitted. The pilot may modify the route through the insertion or deletion of specific waypoints in response to ATC clearances. Pilots must not change any database waypoint type from a flyby to a flyover or vice versa.

E.9.5.1 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.

Note: Flightcrew may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3 degrees or less may result from equipment manufacturer's application of magnetic variation and are operationally acceptable.

E.9.5.2 For RNP 2 operations, pilots must use a lateral deviation indicator, FD, or AP in lateral navigation (LNAV) mode. Pilots of aircraft with a lateral deviation display must ensure lateral deviation scaling is suitable for the RNP 2 operation.

E.9.5.3 At least two independent LRNS capable of navigating to the RNP should be operational at the oceanic entry point. If this is not the case, the pilot should consider an alternate routing or divert for repairs.

E.9.5.4 If the navigation system does not automatically retrieve and set RNP 2 from the onboard navigation database for the entirety of the RNP 2 operation, the flightcrew's operating procedures must manually set RNP 2. This ensures proper RNP system monitoring and alerting is available for the RNP 2 operation.

E.9.5.5 Operator in-flight procedures must include verifying the RNP value set in the FMS matches the equipment capability and authorizations as annotated in the flight plan prior to entering oceanic and remote continental airspace.

E.9.5.6 Operator in-flight operating procedures must include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent aircraft from an inadvertent deviation from ATC-cleared routes.

E.9.5.7 Crews must advise ATC of any deterioration or failure of the navigation equipment below the navigation performance requirements or of any deviations required for a contingency procedure.

E.9.5.8 All pilots are expected to maintain centerline, 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, performing a Strategic Lateral Offset Procedure (SLOP), or under emergency conditions. For normal operations, cross-track (XTK) 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 RNP value associated with the procedure (i.e., 1 NM for RNP 2). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the RNP value (i.e., 2 NM for RNP 2), are allowable.

Note: Some aircraft do not display or compute a path during flyby 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. This does not apply to the execution of either fixed radius transition (FRT) or Radius to Fix (RF) procedures.

E.9.5.9 Operational qualification for RNP procedures requires flightcrew monitoring of lateral and, if installed, vertical deviations on the pilot's PFDs 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.

E.9.5.10 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 2 procedure.

E.9.5.11 The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action.

E.9.5.12 Whenever possible, RNP routes should be extracted from the database in their entirety, rather than loading RNP route waypoints from the database into the flight plan individually. Selecting and inserting individual, named fixes from the database is permitted, provided all fixes along the published route to be flown are inserted.

E.9.5.13 Pilots of aircraft with RNP input selection capability should select an RNP value of 2 NM, or smaller. The selection of the RNP value should ensure the RNP system offers appropriate lateral deviation scaling permitting the pilot to monitor lateral deviation and meet the requirements of the RNP 2 operation.

E.9.5.14 Emergency procedures for operations in RNP 2 airspace or on RNP 2 routes are no different than normal oceanic emergency procedures with one exception, crews must be able to recognize and ATC must be advised when the aircraft is no longer able to navigate to its RNP 2 approved capability.

E.9.6 Prior to Commencing the RNP 2 Procedure. In addition to normal operating procedures, prior to commencing the procedure the flightcrew should accomplish the following:

1. For multisensor systems, crew must verify that the correct sensor is being used for position computation; and
2. Where Controller-Pilot Data Link Communication (CPDLC) is used to uplink flight plan changes for routing that is not contained in the navigation database, the flightcrew should confirm the RNP in effect matches the airspace requirement. If not, the flightcrew should manually enter the RNP applicable to the route.

APPENDIX F. QUALIFICATION CRITERIA FOR REQUIRED NAVIGATION PERFORMANCE (RNP) 4 OCEANIC AND REMOTE CONTINENTAL OPERATIONS

F.1 Introduction.

F.1.1 Performance and Functional Requirements. This appendix provides guidance on the performance and functional requirements for systems used to conduct RNP 4 over oceanic and remote continental airspace. Previous authorizations in accordance with FAA Order 8400.33, Procedures for Obtaining Authorization for Required Navigation Performance 4 (RNP-4) Oceanic and Remote Area Operations, remain valid. This appendix does not address communications or surveillance requirements that may be specified to operate on a particular route or in a particular area. Those requirements are specified in other documents, such as the Aeronautical Information Publications (AIP) and the International Civil Aviation Organization (ICAO) Doc 7030, Regional Supplementary Procedures (SUPPS) and ICAO Doc 4444 PANS ATM, Procedures for Air Navigation Services, Air Traffic Management.

F.2 Aircraft and System Requirements for RNP 4.

F.2.1 Statement of Compliance (SOC). Aircraft with an SOC with RNP 4 criteria in Advisory Circular (AC) 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, in their Airplane Flight Manual (AFM), Airplane Flight Manual Supplement (AFMS), pilot's operating handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this appendix.

F.2.2 Statement from the Manufacturer. Aircraft with a statement from the manufacturer documenting compliance with the RNP 4 criteria in AC 20-138( ) 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.

F.2.3 Navigation Equipment Requirements. Navigation equipage for all RNP 4 operations in oceanic and remote continental areas must have at least dual independent long-range navigation systems (LRNS). Global Navigation Satellite System (GNSS) must be used as either a stand-alone navigation system, as one of the sensors in a multisensor system, or as part of an integrated GNSS/inertial system.

Note: RNP 4 operations are based on Global Positioning System (GPS) positioning. 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.

F.3 System Performance, Monitoring, and Alerting.

F.3.1 Accuracy. The aircraft must comply with Section 2.1.1 of RTCA/DO-236( ). During operations in airspace or on routes designated as RNP 4, the lateral TSE must be within ±4 nautical miles (NM) for at least 95 percent of the total flight time. The along-track (ATRK) error must also be within ±4 NM for at least 95 percent of the total flight time. To satisfy the 95 percent accuracy requirement, the Flight Technical Error (FTE) should not exceed 2 NM.

Note: The use of a lateral deviation indicator with 4 NM full-scale deflection has been found to be an acceptable means of compliance (AMC) integrity.

F.3.2 Integrity. Malfunction of the aircraft navigation equipment that causes the TSE to exceed two times the RNP value is classified as a major failure condition under airworthiness guidance (i.e., 10^{-5} per hour).

F.3.3 Continuity. For RNP 4, loss of navigation equipment function is a major failure condition. The continuity requirement is satisfied by the carriage of dual independent LRNSs (excluding Signal in Space (SIS)).

Note: Operators and pilots are required to use the specified continuity requirements of the governing state or regional authority before conducting flights outside of the U.S. National Airspace System (NAS).

F.3.4 Performance Monitoring and Alerting. The RNP system, or the RNP system and pilot in combination, must provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 2 x RNP (8 NM) is greater than 10^{-5} for RNP 4 operations.

F.3.4.1 Onboard performance monitoring and alerting compliance does not imply an automatic monitor of FTE. The onboard monitoring and alerting function should at least consist of a Navigation System Error (NSE) monitoring and alerting algorithm and a lateral deviation display enabling the crew to monitor the FTE.

F.3.4.2 Path Definition Error (PDE) is considered negligible.

F.3.5 SIS. If using GPS, the aircraft navigation equipment must provide an alert if the probability of SIS errors causing a lateral position error greater than 8 NM exceeds 10^{-7} per hour for RNP 4 operations.

Note: For RNP systems where the architecture is an integrated, multisensor capability and where GNSS integrity is incorporated into a 2 x RNP integrity alert consistent with DO-236( ) where performance cannot be met, a separate GNSS integrity alert is not required.

F.4 Aircraft Eligibility.

F.4.1 Detection Methods. There are two methods to recognize aircraft and system eligibility for RNP 4 operations: 1) RNP certification; and, 2) prior navigation system certification. In both cases, the aircraft must be equipped with at least two independent and serviceable LRNSs; at least one of which must be GNSS.

F.4.2 RNP Certification. RNP certification is typically documented in the AFM/AFMS for aircraft that have been formally certificated and approved for RNP operations and typically is not limited to RNP 4. The AFM/AFMS addresses RNP levels that have been demonstrated to meet the certification criteria and any related provisions applicable to their use (e.g., navigation aid sensor requirements). Operational approval is based upon the performance stated in the AFM/AFMS and pilot qualification. This method also applies in cases where certification is received through a Supplemental Type Certificate (STC) issued to retrofit equipment, such as GNSS receivers, to enable the aircraft to meet RNP 4 performance criteria in oceanic and remote continental area airspace.

F.4.2.1 This method is used to approve aircraft whose level of performance under previous standards equates to the RNP 4 criteria listed in this AC. The AFM/AFMS must indicate the aircraft is equipped with GNSS approved as a LRNS for oceanic and remote continental airspace operations.

F.4.2.2 RNP 4 operations using only GNSS is based upon a predeparture fault detection and exclusion (FDE) availability prediction program. Twenty-five minutes is the maximum allowable time for which FDE capability is projected to be unavailable on any one event. This maximum outage time must be included as a condition of the RNP 4 operational approval. If predictions indicate that the maximum allowable FDE outage will be exceeded, the operation must be rescheduled to a time when FDE is available.

1. Aircraft with Technical Standard Order (TSO)-C129( ) equipment must also document the equipment is approved for oceanic operations according to AC 20-138( ), Appendix 1.
2. TSO-C115b (or later revision) is acceptable for multisensor systems incorporating GNSS sensors.

F.4.2.3 Multisensor systems incorporating an approved inertial navigation sytem (INS)/(Inertial Reference Unit (IRU) can extend the maximum FDE unavailability time based upon the amount of time the system can maintain RNP 4 coasting performance without a position update. The approval must indicate the maximum GNSS FDE unavailability time.

F.4.3 GNSS Eligibility. Aircraft fitted with only GNSS for oceanic and remote continental airspace operations must meet the RNP 4 performance requirements. The acceptable technical standards are:

1. Combination GNSS Navigation Computer/Sensor.
   - TSO-C129a Class A and
   - TSO-C146( ).
2. Flight management system (FMS) (TSO-C115b or later revision) with GNSS sensor.
   - TSO-C129a (Class B or C),
   - TSO-C145( ), and
   - TSO-C196( ).

Note: GNSS equipment approved under TSO-C129a must also meet AC 20-138( ), Appendix 1.

F.4.3.1 For aircraft equipped with GNSS-only, the operator must have an approved GNSS availability prediction program ensuring the requisite availability of the GNSS FDE function. Prior to conducting RNP 4 operations in oceanic or remote continental areas, the operator must use this prediction program prior to dispatch. When using the prediction program, the maximum predicted, allowable time for a loss of FDE is 25 minutes. When the predicted loss of FDE exceeds 25 minutes, then RNP 4 operations are not available, and the operator must reschedule the flight. All RNP 4 operations approvals must document the 25-minute FDE outage limit as a condition of the operational approval.

F.4.4 Integrating Multisensor Systems. Multisensor navigation systems integrating GNSS with INS must be capable of sustaining ±4 NM lateral TSE and ±4 NM ATRK for 95 percent of the total flight time to meet the RNP 4 performance requirements. There is no requirement to use a dispatch FDE availability prediction program when the operator uses an approved multisensor navigation system that includes INS. The INS must be approved in accordance with Title 14 of the Code of Federal Regulations (14 CFR) part 121, Appendix G.

F.4.5 Demonstrations. Demonstration of aircraft performance in accordance with AC 20-138( ) does not constitute operations approval to conduct RNP operations.

F.5 Maintenance Requirements.

F.5.1 LRNS. Aircraft must have established maintenance procedures for all LRNS intended for use in oceanic and remote continental area operations.

F.6 Functional Requirements of Navigation Data Displays.

F.6.1 Installation. The following navigation displays and functions are required and must be installed in accordance with AC 20-138( ) or equivalent airworthiness installation advisory material.

F.6.2 Navigation Data Displays. Navigation data, including a TO/FROM indication and a failure indicator, must be displayed on a lateral deviation display (course deviation indicator (CDI), electronic horizontal-situation indicator (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 (e.g., 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).
2. The lateral deviation display scaling must agree with any alerting and annunciation limits.
3. The lateral deviation display must have a full-scale deflection suitable for the current phase of flight.

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

4. The display scaling may be set automatically by default logic; automatically to a value from a navigation database; or manually by flightcrew procedures. The full-scale deflection value must be known or must be available for display to the pilot commensurate with the required track-keeping accuracy.
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 flightpath 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). 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.
7. It is not necessary for navigation displays, particularly primary flight displays (PFD), to include an Actual Navigation Performance (ANP) or RNP value. The displays only need to provide an alert if the RNP for the operation cannot be met.

F.6.3 System Capabilities. The following system capabilities are required as a minimum within any RNP 4 equipment:

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) 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. A means for the crew to create, review, and activate a flight plan. The system must incorporate a means for the crew to verify flight plan entries or changes before they are activated. The guidance output must not be affected until the flight plan or flight plan changes are activated.
6. The means to display the following items, either in the pilot's primary FOV, or on a readily accessible display page:
   - The active navigation sensor type,
   - The identification of the active (To) waypoint,
   - The ground speed or time to the active (To) waypoint, and
   - The distance and bearing to the active (To) waypoint.
7. The capability to execute a "direct to" function.
8. The system must have the capability to automatically execute leg transitions and maintain tracks consistent with the following Aeronautical Radio, Inc. (ARINC) Specification 424 path terminators:
   - Course to Fix (CF),
   - Direct to Fix (DF), and
   - 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-236( ) and DO-201( ).

9. When executing a parallel offset (Appendix I, Additional Capabilities), the capability to execute parallel tracks at a selected offset distance. When executing a parallel offset (Appendix I), the RNP value and all performance

criteria of the original route in the active flight plan must be applicable to the offset route.

- The system must provide for entry of offset distances in increments of 1 NM, left or right of course. The system must be capable of offsets of at least 20 NM.
- System offset mode operation must be clearly indicated to the pilot. When in offset mode, the system must provide reference parameters (e.g., cross-track (XTK) deviation, distance-to-go, time-to-go) relative to the offset path and offset reference points.
- An offset must not be propagated through route discontinuities, unreasonable path geometries, or beyond the initial approach fix (IAF).
- The system must provide an annunciation prior to the end of the offset path, with sufficient time to return to the original path.
- Once a parallel offset (Appendix I) is activated, the offset must remain active for all flight plan route segments until removed automatically, until the pilot enters a direct-to routing, or until pilot (manual) cancellation.
- The parallel offset (Appendix I) function must be available for en route TF and the geodesic portion of DF leg types.

Note: Systems compliant with parallel offset (Appendix I) requirements in RTCA/DO-229C (or later revision), DO-236C (or later revision) or DO-283A (or later revision) meet the parallel offset criteria for RNP 4.

10. For RNP 4 tracks in oceanic/remote continental airspace using flexible (e.g., organized) tracks, a means to enter the unique waypoints required to build a track assigned by the Air Traffic Service (ATS) provider. Manual entry or creation of new waypoints is permitted, by manual entry of latitude and longitude.
11. The capability for automatic leg sequencing with display to the pilots.
12. The capability to automatically sequence fixes.
13. The capability to display an indication of the RNP 4 system failure in the pilot’s primary FOV.
14. The capability to indicate to the crew when the NSE alert limit is exceeded (i.e., the alert provided by the onboard performance monitoring and alerting function).
15. The system must have the capability to perform flyby transitions:
    - Flyby transitions must be the default when a transition type is not specified,
    - Navigation systems should be designed to keep aircraft within the theoretical transition area, and

- Flyby theoretical transition areas are based upon the following assumptions:
  1. Course changes do not exceed 120 degrees for low altitude transitions (aircraft barometric altitude is less than flight level (FL) 195), and
  2. Course changes do not exceed 70 degrees for high altitude transitions (aircraft barometric altitude is equal to or greater than FL 195).

     Note: Systems compliant with the flyby transition requirements in RTCA/DO-236C (or later revision), or DO-283A (or later revision) meet the flyby transition criteria for RNP 4.

F.6.4 Database Integrity. The operator must ensure their navigation database supplier possesses a Type 2 Letter of Acceptance (LOA) in accordance with AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases.

F.6.5 Path Terminators. The database supplier should not substitute path terminators in lieu of those specified in the original State AIP data.

F.7 Operational Requirements.

F.7.1 Navigation Equipage. All RNP 4 operations in oceanic and remote continental areas must have at least dual independent LRNSs of integrity such that the navigation system does not provide misleading information.

F.7.2 Aircraft Incorporating GPS. Aircraft equipped with GPS avionics by one of the following three methods is acceptable for receiving an RNP 4 operational approval:

1. Federal Aviation Administration (FAA) Aircraft Certification Office (ACO) (or U.S. Military equivalent) letter meeting performance requirements of FAA N 8110.60, GPS as a Primary Means of Navigation for Oceanic/Remote Operations, canceled December 4, 1996.
2. FAA ACO (or U.S. Military equivalent) letter meeting performance requirements of AC 20-138( ).
3. GPS avionics marked with TSO-C129( )/TSO-C145( )/TSO-C146( )/ TSO-C196( ) and installed in accordance with AC 20-138( ).

F.7.2.1 The equipment configuration used to demonstrate the required accuracy must be supportable in RNP 4 oceanic and remote continental airspace. For example, the statistical benefit of estimating position using INS position data filtered with distance measuring equipment (DME) data will not be considered.

F.7.2.2 The equipment configuration used to demonstrate the required accuracy must be identical to the configuration, which is specified in the minimum equipment list (MEL).

F.7.3 Aircraft Qualification Documentation. 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 4 operations, the aircraft or avionics manufacturers should develop RNP 4 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 AFMS which explicitly states that the RNP system is approved for instrument flight rules (IFR) operations with RNP values at least as low as RNP 4 and the equipment meets the performance and reliability guidance of AC 20-138( ).

F.7.3.1 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.

F.8 Operational Considerations.

F.8.1 Pilot Training and Qualification. Operators should ensure pilots are trained and qualified to operate in RNP 4 airspace.

F.8.2 Preflight. The following actions should be completed during preflight:

1. Review maintenance logs and forms to ascertain the condition of equipment required for flight in RNP 4 airspace or on an RNP 4 route, and
2. Ensure that maintenance action has been taken to correct defects to required equipment.

F.8.2.1 At dispatch or during flight planning, the operator must ensure that adequate navigation capability is available en route to enable the aircraft to navigate to RNP 4 and include the availability of FDE, if appropriate for the operation.

Note: When the predicted loss of FDE exceeds 25 minutes, then RNP 4 operations are not available, and the operator must reschedule the flight.

F.8.3 General In-Flight Considerations. For flexible route structures, manual entry of waypoints (i.e., latitude and longitude) may be permitted provided the potential for entry error by pilots is mitigated by adequate flightcrew procedures. The manual entry or creation of new waypoints, by manual entry of latitude and longitude or rho/theta values for fixed, published routes is not permitted. The pilot may modify the route through the insertion or deletion of specific waypoints in response to air traffic control (ATC) clearances. Pilots must not change any database waypoint type from a flyby to a flyover or vice versa.

F.8.3.1 The pilot must confirm the correct route is loaded. 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.

Note: Flightcrew may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3 degrees or less may result from equipment manufacturer's application of magnetic variation and are operationally acceptable.

F.8.3.2 For RNP 4 operations, pilots must use a lateral deviation indicator, flight director (FD), or autopilot (AP) in lateral navigation (LNAV) mode. Pilots of aircraft with a lateral deviation display must ensure lateral deviation scaling is suitable for RNP 4 operations.

F.8.3.3 At least two independent LRNS capable of navigating to the RNP should be operational at the oceanic entry point. If this is not the case, the pilot should consider an alternate routing or divert for repairs.

F.8.3.4 If the navigation system does not automatically retrieve and set RNP 4 from the onboard navigation database for the entirety of the RNP 4 operation, the flightcrew's operating procedures must manually set RNP 4. This ensures proper RNP system monitoring and alerting is available for the RNP 4 operation.

F.8.3.5 Operator in-flight procedures must include verifying the RNP value set in the FMS matches the equipment capability and authorizations as annotated in the flight plan prior to entering oceanic and remote continental airspace.

F.8.3.6 Operator in-flight operating procedures must include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent aircraft from an inadvertent deviation from ATC-cleared routes.

F.8.3.7 Crews must advise ATC of any deterioration or failure of the navigation equipment below the navigation performance requirements or of any deviations required for a contingency procedure.

F.8.3.8 All pilots are expected to maintain centerline, 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 (such as Strategic Lateral Offset Procedure (SLOP)) or under emergency conditions. For normal operations, XTK 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 RNP value associated with the procedure (i.e., 2 NM for RNP 4). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the RNP value (i.e., 4 NM for RNP 4), are allowable.

Note: Some aircraft do not display or compute a path during flyby 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. This does not apply to the execution of fixed radius transition (FRT) procedures.

F.8.3.9 Operational qualification for RNP routes requires flightcrew monitoring of lateral and, if installed, vertical deviations on the pilot's PFDs to ensure the aircraft remains within the bounds defined by the route. The deviation must be monitored, and action taken to minimize errors during all RNP operations.

F.8.3.10 The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action.

F.8.3.11 In addition to normal operating procedures, prior to commencing the procedure the flightcrew should accomplish the following:

1. For multisensor systems, crews must verify that the correct sensor is being used for position computation; and
2. Where Controller-Pilot Data Link Communication (CPDLC) is used to uplink flight plan changes for routing that is not contained in the navigation database, the flightcrew should confirm the RNP in effect matches the airspace requirement. If not, the flightcrew should manually enter the RNP applicable to the route.

F.8.3.12 Emergency procedures for operations in RNP 4 airspace or on RNP 4 routes are no different than normal oceanic emergency procedures with one exception, crews must be able to recognize and ATC must be advised when the aircraft is no longer able to navigate to its RNP 4 approved capability.

APPENDIX G. QUALIFICATION CRITERIA FOR REQUIRED NAVIGATION PERFORMANCE (RNP) 10 OCEANIC AND REMOTE CONTINENTAL OPERATIONS

G.1 Introduction. This appendix provides guidance for operation in remote continental airspace including oceanic and Special Areas of Operation (SAO) and is intended to support 50 nautical miles (NM) lateral and the 50 NM longitudinal distance based separation minima. Previous authorizations in accordance with Federal Aviation Administration (FAA) Order 8400.12C, Required Navigation Performance 10 (RNP 10) Operational Authorization, remain valid. This appendix does not address communications or surveillance requirements that may be specified to operate on a particular route or in a particular area. Those requirements are specified in other documents, such as the Aeronautical Information Publications (AIP) and the International Civil Aviation Organization (ICAO) Doc 7030, Regional Supplementary Procedures (SUPPS) and ICAO Doc. 4444 PANS ATM, Procedures for Air Navigation Services, Air Traffic Management.

Note: Area Navigation (RNAV) 10 is designated and authorized as RNP 10. This document uses the designation of RNP 10.

G.2 Aircraft and System Requirements for RNP 10.

G.2.1 Statement of Compliance (SOC). Aircraft with an SOC with RNP 10 criteria in Advisory Circular (AC) 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, in their Airplane Flight Manual (AFM), Airplane Flight Manual Supplement (AFMS), pilot's operating handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this appendix. RNP compliance is documented in the AFM and is typically not limited to RNP 10. The AFM will address RNP, navigation specifications (Nav Specs) that have been demonstrated and any related provisions applicable to its use (e.g., Navigational Aid (NAVAID) sensor requirements).

G.2.2 Equipment. Aircraft must be equipped with at least dual navigation systems except for operation in the Gulf of Mexico (GOMEX) where Single Long-Range Navigation System (S-LRNS) RNP 10 is authorized.

G.3 System Performance.

G.3.1 Accuracy. During operations in airspace or on routes designated as RNP 10, the lateral Total System Error (TSE) must be within ±10 NM for at least 95 percent of the total flight time. The along-track (ATRK) error must also be within ±10 NM for at least 95 percent of the total flight time.

Note: For RNP 10 approval, navigation positioning error is considered the dominant contributor to cross-track (XTK) and ATRK for aircraft capable of coupling the navigation system to the flight director (FD) or autopilot (AP). Flight Technical Error (FTE), Path Definition Error (PDE), and display error are considered to be insignificant for the purposes of RNP 10 approval (RNP 10 is

intended for oceanic and remote continental areas where aircraft separation minima of 50 NM are applied).

G.3.2 Integrity. Malfunction of the aircraft's long-range navigation (LRN) equipment without annunciation is a major failure condition (i.e., the probability of a malfunction with no annunciation must be less than 10^{-5} per hour).

G.3.3 Continuity. Loss of function of the LRN equipment is a major failure condition for oceanic and remote continental operations. Dual independent long-range navigation system (LRNS) equipage may satisfy the continuity criteria (excluding Signal in Space (SIS) criteria).

G.3.4 SIS. If using Global Navigation Satellite System (GNSS), the aircraft LRN equipment must provide an alert if the probability of SIS errors causing a lateral position error greater than 20 NM exceeds 10^{-7} per hour.

G.4 Aircraft Eligibility.

G.4.1 Prior Navigation System Certification. Aircraft Original Equipment Manufacturers (OEM) and operators may use a prior navigation system certification to recognize an aircraft whose performance under the criteria of another RNP specification equates to or exceeds the RNP 10 performance criteria listed in AC 20-138( ). Aircraft OEMs and operators may also use other Nav Spec standards when they are sufficient to ensure compliance with RNP 10 performance criteria.

Note: Qualification through data collection guidance provided in Order 8400.12C is available in a booklet format online. Operators qualifying by the data collection methods should contact their principal operations inspector (POI) and download a copy of the booklet, RNP 10 Qualification through Data Collection from the AFS-470 Web site, Performance Based Flight Systems Branch, Oceanic and Remote Airspace (Special Areas of Operations).

G.4.2 Application Description. RNP 10 is an RNAV operational application supporting 50 NM lateral and 50 NM longitudinal distance-based aircraft separation minima in oceanic or remote continental airspace. As an RNAV application, there is no requirement for onboard performance monitoring and alerting. There are two methods to recognize aircraft and system eligibility for RNP 10 operations: 1) RNP 10 certification; and, 2) prior navigation system certification.

G.4.3 Eligibility Through an RNP 10 Certification. RNP 10 compliance is documented in the AFM and is typically not limited to RNP 10. The AFM/AFMS should document the demonstrated RNP values the aircraft supports along with any limitations (e.g., navigation aid sensor requirements for present position updating).

Note: Aircraft qualified for RNP 4 operations automatically qualify for RNP 10 operations.

G.4.3.1 An aircraft may have an airworthiness approval specific to RNP 10 qualification. The following (or equivalent) is an example of AFM wording when RNP 10 approvals are granted for either a change in, or new demonstration of, the inertial navigation system (INS)/Inertial Reference Unit (IRU)-certified performance:

"The XXX navigation system meets the aircraft qualification criteria of AC 20-138( ), as a primary means of navigation for flights up to XXX hours in duration without present position updating. The determination of flight duration starts when the flightcrew places the long-range navigation system in the inertial navigation mode,"

Note: The "XXX hours" specified in the AFM/AFMS for INS/IRU systems do not include credit for present position updating.

G.4.3.2 For LRNSs capable of updating the aircraft's present position while airborne, the airworthiness approval must address the impact present position updating has on position accuracy and any impact on time limits for RNP 10 operations. The approval should clarify the role of ground-based navigation facilities in present position updating (if any), clarify the role of GNSS present position updating (if equipped), and define any requisite flightcrew procedures necessary to initiate and terminate present position updating. The credit received for present position updating can be applied to the "XXX hours" specified in the AFM/AFMS for INS/IRU systems.

G.4.3.3 Demonstration of aircraft performance in accordance with AC 20-138( ) does not constitute operations approval to conduct RNP operations.

G.4.3.4 The demonstration of inertial performance to FAA Aircraft Certification Service (AIR) forms the basis for the suggested AFM/AFMS wording above, but is only one element of the approval process. Aircraft that have this wording in their flight manual will be eligible for operational approval through issuance of operations specifications (OpSpecs)/management specifications (Mspecs) or an letter of authorization (LOA) (as applicable) when the operator and aircraft meet all other RNP 10 qualification criteria.

G.5 Aircraft Equipped with Two or More INS or IRUs. Inertial systems approved in accordance with Title 14 of the Code of Federal Regulations (14 CFR) part 121, Appendix G are considered to meet RNP 10 requirements for up to 6.2 hours of flight time. This time starts when the system is placed in the inertial navigation mode.

G.5.1 <u>INS/IRU System Updates</u>. If the flightcrew updates the INS/IRU systems en route (through manual or automatic means), the flightcrew must adjust the 6.2 hour RNP 10 time limit to account for the update's accuracy. The flightcrew must base any adjustments to the time limit on the demonstrated capability of the updates stated in the aircraft's airworthiness approval documentation (i.e., the AFM/AFMS).

G.5.1.1 INS/IRU accuracy, reliability, training, and maintenance issues required by an airworthiness approval in compliance with part 121, Appendix G are applicable to an RNP 10 operation, including any associated procedures in oceanic and remote continental airspace. Except as authorized by the FAA Administrator, and in accordance with the applicable section of 14 CFR, RNP 10 operations based solely IRS/IRU requires at least dual equipage (i.e., two or more inertial systems). Refer to 14 CFR part 121, § 121.351, part 125, § 125.203, and part 135, § 135.165.

Note: The long-term inertial drift rate of 2.0 NM/hour (a 95 percent radial position error rate (circular error rate)) is the performance basis for the 6.2 hour time limit. This drift rate is statistically equivalent to an individual 95 percent XTK and an individual 95 percent ATRK position error rates (orthogonal error rates) of 1.6015 NM/hour each; and, a 95 percent XTK and a 95 percent ATRK position error limit of 10 NM each (e.g., 10 NM/1.6015 NM/hour = 6.2 hours).

G.5.1.2 Aircraft approved for North Atlantic Minimum Navigation Performance Specifications (NAT/MNPS) or Australian RNAV operations meet RNP 10 criteria for up to 6.2 hours after the flightcrew places the LRNS in the inertial navigation mode.

G.5.2 Two or More INSs or IRUs – Extended Time Limit. The 6.2 hour time limit is the baseline for RNP 10 inertial systems performance, and the time limit begins when the flightcrew places the LRNS in the inertial navigation mode. However, this time limit may be extended by one of the following methods:

1. Establishing an extended time limit during a formal RNP 10 airworthiness approval process (e.g., a new type certificate (TC), amended TC, or Supplemental Type Certificate (STC) project);
2. An existing airworthiness approval holder requests an extension for the installed inertial navigation system from the appropriate Aircraft Certificate Office (ACO) based on justifying engineering data; or
3. An airworthiness applicant or existing airworthiness approval holder requests an extended time limit by showing how multiple navigation sensors that mix or average navigation position error justifies an extension (e.g., triple-mixed INSs). If the applicant requests an extended time limit based on mixing, then the availability of the mixing capability is a limitation for flight on RNP 10 routes. If the mixing or averaging function is not available, the operator must use a time limit that does not depend on mixing.

G.6 Route Evaluation For RNP 10 Time Limits For Aircraft Equipped Only With INS or IRU. An RNP 10 time limit must be established for aircraft equipped only with INS or IRU. When planning operations in areas where RNP 10 is applied, the operator must establish that the aircraft will comply with the time limitation on the routes that it intends to fly.

G.6.1 Time Limit Considerations. In making this evaluation, the operator must consider the effect of head winds and, for aircraft not capable of coupling the navigation system or FD to the AP, the operator may choose to make this evaluation on a one-time basis or on a per-flight-basis. The operator should consider the points listed in the following subsections in making this evaluation.

1. Route Evaluation. The operator must establish the capability of the aircraft to satisfy the RNP 10 time limit established for dispatch or departure into RNP 10 airspace.
2. Start Point for Calculation. The calculation must start at the point where the system is placed in navigation mode or the last point at which the system is expected to be updated.
3. Stop Point for Calculation. The stop point may be one of the following:
   - The point at which the aircraft will begin to navigate by reference to ICAO standard NAVAIDs (very high frequency omni-directional range (VOR), distance measuring equipment (DME), Non-Directional Beacon (NDB)) and/or comes under Air Traffic Service (ATS) surveillance; or
   - The first point at which the navigation system is expected to be updated.
4. Sources of Wind Component Data. The head wind component to be considered for the route may be obtained from any source found acceptable to the FAA. Acceptable sources for wind data include:
   - The National Weather Service (NWS),
   - Bracknell,
   - Industry sources (e.g., Boeing Winds on World Air Routes), and
   - Historical airline data supplied by the operator.

G.6.2 One-Time Calculation Based on 75 Percent Probability Wind Components. Certain sources of wind data establish the probability of experiencing a given wind component on routes between city pairs on an annual basis. If an operator chooses to make a one-time calculation of RNP 10 time limit compliance, he/she may use the annual 75 percent probability level to calculate the effect of head winds. This level has been found to be a reasonable estimation of wind components.

G.6.3 Calculation of Time Limit for Each Specific Flight. The operator may choose to evaluate each individual flight using flight-planned winds to determine if the aircraft will comply with the specified time limit. If it is determined that the flight will exceed the time limit, then the aircraft must fly an alternate route or delay the flight until it can meet the time limit. This evaluation should be considered a flight planning or dispatch task.

G.7 Two or More GNSS Systems. Aircraft approved to use GNSS for oceanic and remote continental operations without reliance on other LRNSs are considered to meet the RNP 10 requirements without time limitations associated with INS/IRU equipment. However, using GNSS depends upon using a fault detection and exclusion (FDE) availability prediction.

G.7.1 AFM/AFMS Documentation. Dual GNSS installations with a Technical Standard Order Authorization (TSOA) qualify for RNP 10 when the operator uses an approved dispatch GNSS FDE availability prediction. The AFM/AFMS should indicate if a particular GNSS installation meets the appropriate FAA criteria for oceanic and remote continental operations.

G.7.2 Applicable Technical Standard Order. Technical Standard Order (TSO)-C196 and TSO-C145/TSO-C146 Global Positioning System (GPS) equipment are inherently capable of supporting oceanic and remote continental operation when used in conjunction with an approved FDE prediction program.

G.7.3 Additional Required Guidance. TSO-C129( ) GPS equipment is not inherently capable of oceanic and remote continental operations. Additional criteria defining an acceptable means of compliance (AMC) for this equipment to be approved for this operation is located in AC 20-138( ), Appendix 1. The AFM/AFMS should also indicate if a particular TSO-C129( ) GNSS installation meets the AC 20-138( ), Appendix 1 criteria for oceanic and remote continental operations.

G.7.4 Multisensor Systems. Multisensor systems integrating GNSS with FDE approved using the guidance in AC 20-138( ), Appendix 1 can be considered to meet RNP 10 requirements without time limitations.

G.7.5 GNSS Not Integrated with Other Sensors. AC 20-138( ) provides an acceptable means of complying with installation requirements for aircraft using a GPS that is not integrated with other sensors.

G.7.6 FDE Availability. The maximum allowable time for which FDE capability is projected to be unavailable is 34 minutes. The maximum outage time should be included as a condition of the RNP 10 approval.

Note: If predictions indicate that the maximum FDE outage time for the intended RNP 10 operation cannot be met, then the operation must be rescheduled when FDE is available or select another route where predicted FDE capability is available.

G.8 Single INS/IRU and a Single GNSS. Aircraft equipped with a single INS or IRU and a single GNSS meet the RNP 10 requirements without time limitations.

G.8.1 INS or IRU Equipment. The INS or IRU equipment must meet the standards of paragraph G.5 except that only one INS/IRU is required.

G.8.2 GNSS Equipment. GNSS equipment must meet the standards of paragraph G.7, except that only one GNSS is required.

Note: If a GNSS FDE prediction indicates FDE unavailability exceeding 34 minutes, the performance criteria for the intended RNP 10 operation cannot be met using GNSS. The operator must predicate their RNP 10 operations on an INS/IRU for that portion of the flight.

G.9 Single INS/IRU or a Single GNSS. Aircraft equipped with a single INS/IRU or a single GNSS are approved for oceanic and remote continental navigation RNP 10 in the Houston oceanic Control Area/Flight Information Region (CTA/FIR), the GOMEX portion of the Miami Oceanic CTA/FIR, the Monterrey CTA, and Merida High CTA within the Mexico FIR/upper control area (UTA). Aircraft equipped with GNSS meet the RNP 10 requirements without time limitations.

Note: This approval is predicated on the air traffic surveillance provided in the GOMEX. Therefore, RNP 10 authorizations approved in accordance with this paragraph must clearly state that RNP 10 operational approval is limited to the GOMEX.

G.9.1 INS or IRU Equipment. INS or IRU equipment must meet the standards of paragraph G.5, except that only one INS/IRU is required.

G.9.2 GNSS Equipment. GNSS equipment must meet the standards of paragraph G.7, except that only one GNSS is required.

G.10 Operational Approval For RNP 10 Operations.

G.10.1 Aircraft Qualification Documentation. 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 10 operations.

G.10.1.1 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.

G.11 Operational Considerations.

G.11.1 Pilot Training and Qualification. Operators should ensure pilots are trained and qualified to operate in RNP 10 airspace.

G.11.2 Preflight. The following actions should be completed during preflight:

1. Review maintenance logs and forms to ascertain the condition of equipment required for flight in RNP 10 airspace or on an RNP 10 route and
2. Ensure that maintenance action has been taken to correct defects to required equipment.

G.11.2.1 During flight planning, the pilot should pay particular attention to conditions affecting the performance requirements for operations in RNP 10 airspace (or on RNP 10 routes), including:

1. Inertial system performance time limitations (if applicable),
2. GNSS FDE availability (if applicable), and

Note: For GNSS systems, the maximum allowable predicted time for a loss of GNSS FDE capability must be 34 minutes or less.

3. Accounting for any operating restriction related to RNP 10 approval, if required for a specific navigation system.

G.11.3 General In-Flight Considerations.

G.11.3.1 For flexible route structures, manual entry of waypoints (i.e., latitude and longitude), may be permitted provided the potential for entry error by pilots is mitigated by adequate flightcrew procedures. The manual entry or creation of new waypoints, by manual entry of latitude and longitude or rho/theta values for fixed, published routes is not permitted. The pilot may modify the route through the insertion or deletion of specific waypoints in response to air traffic control (ATC) clearances. Pilots must not change any database waypoint type from a flyby to a flyover or vice versa.

G.11.3.2 The pilot must confirm the correct route is loaded. 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.

G.11.3.3 Flightcrew may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3 degrees or less may result from equipment manufacturer's application of magnetic variation and are operationally acceptable.

G.11.3.4 For RNP 10 operations, pilots must use a lateral deviation indicator, FD, or AP in lateral navigation (LNAV) mode. Pilots of aircraft with a lateral deviation display must ensure lateral deviation scaling is suitable for the RNP 10 operations.

G.11.3.5 Operator in-flight procedures must include verifying the RNP value set in the flight management system (FMS) matches the equipment capability and authorizations as annotated in the flight plan prior to entering oceanic and remote continental airspace.

G.11.3.6 All pilots are expected to maintain centerline, 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, XTK 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 RNP value associated with the procedure (i.e., 5 NM for RNP 10). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the RNP value (i.e., 10 NM for RNP 10), are allowable.

Note: Some aircraft do not display or compute a path during flyby 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. This does not apply to the execution of fixed radius transitions (FRT) procedures.

G.11.3.7 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.

G.11.3.8 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 10 procedure.

G.11.3.9 The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action.

G.11.3.10 In addition to normal operating procedures, prior to commencing the procedure the flightcrew should accomplish the following:

1. For multisensor systems, crew must verify that the correct sensor is being used for position computation; and
2. Where Controller-Pilot Data Link Communication (CPDLC) is used to uplink flight plan changes for routing that is not contained in the navigation database, the flightcrew should confirm the RNP in effect matches the airspace requirement. If not, the flightcrew should manually enter the RNP applicable to the route.

G.11.3.11 Emergency procedures for operations in RNP 10 airspace or on RNP 10 routes are no different than normal oceanic emergency procedures with one exception, crews must be able to recognize and ATC must be advised when the aircraft is no longer able to navigate to its RNP 10 approved capability.

APPENDIX H. ADVANCED REQUIRED NAVIGATION PERFORMANCE (A-RNP)

H.1 Introduction.

H.1.1 Performance and Functional Requirements. This appendix provides guidance on the performance and functional requirements for the U.S. A-RNP operational implementation and related operations of:

- Required Navigation Performance (RNP) 2 (domestic or offshore en route),
- RNP 1 instrument departure procedures (DP),
- RNP 1 (RNP Obstacle Departure Procedures (ODP), and Standard Instrument Departures (SID)), and
- RNP 1 Standard Terminal Arrival Routes (STAR).

H.1.2 A-RNP Operations. A-RNP also applies to RNP approaches within the U.S. National Airspace System (NAS) where domestic air traffic control (ATC) procedures are applied. Additionally, this appendix provides guidance for oceanic and remote continental Areas of Operation where RNP 2, RNP 4, or RNP 10 routes may apply.

Note: This appendix does not address all requirements that may be specified for particular operations. These requirements are specified in other documents, such as national operating rules, Aeronautical Information Publications (AIP), and the International Civil Aviation Organization (ICAO) Doc 7030, Regional Supplementary Procedures (SUPPS). Operators and pilots must adhere to the operational requirements of the appropriate state or regional authority before conducting flights outside of the U.S. NAS.

H.2 Applicable Operators. This appendix applies to all operators conducting A-RNP operations under Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 91 subpart K (91K), 121, 125, 129, and 135 within the U.S. NAS or offshore airspace areas.

H.3 Application of A-RNP.

H.3.1 Navigation System Requirements. Navigation systems must have foundational RNP capability (Required Navigation Performance Approach (RNP APCH) to lateral navigation (LNAV), RNP 1, and RNP 2) as a prerequisite to implementing any A-RNP functions.

H.3.2 RNP Functions. Table H-1, RNP Functions, below lists RNP functions beginning with those that are required for the A-RNP qualification in the United States (Scalability, Radius to Fix (RF), and parallel offset). Fix radius transition (FRT) and Time of Arrival Control (TOAC) are optional capabilities that may be included in bundling authorizations discussed in Chapter 12, Bundling Concept, of this advisory circular (AC). Scalability is uniquely an A-RNP function and therefore described in detail in this appendix. The remaining RNP functions are described in Appendix I, Additional Capabilities. It is

necessary to distinguish scalability from the other RNP functions because RF and parallel offset are not uniquely A-RNP functions and are used with other authorizations. Those operators already qualified to perform RF and/or parallel offset are not required to be A-RNP qualified.

H.3.3 Requirement for A-RNP in the United States. The requirement for A-RNP in the United States is to be operationally and functionally capable of performing scalability, RF, and parallel offset.

H.3.4 Qualification. A-RNP qualification per AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, means the aircraft navigation system performs all six A-RNP functions (RF legs, parallel offsets, Area Navigation (RNAV) holding, Scalable RNP, FRTs, and TOAC).

Note: Other States may choose to implement a different subset of functions, or all six functions for their advanced RNP definition.

Table H-1. RNP Functions

RNP Function	Reference	Application	Required/Optional
Scalability	H.5	Appendix A, See Table 5-1	Required for U.S.
Radius to Fix (RF)*	I.2	Appendices: A, C, D	Required for U.S.
Parallel Offset*	I.3	Appendices: E, F	Required for U.S.
Fixed Radius Transition (FRT)	I.5	Currently not used in U.S.	Optional
Time of Arrival Control (TOAC)	I.6	Currently not used in U.S.	Optional
Note 1: In addition to RNP functions, higher continuity may be required where specified. **Note 2:** *Required for A-RNP in the United States.			

H.3.5 Scalable Lateral Navigation. The requirement for scalable lateral navigation accuracy invoked in this AC (optional in the ICAO navigation specification (Nav Spec)) leverages existing aircraft equipage. This functionality, coupled with mandatory RF capability, supports the design of beneficial procedures, especially at locations with high-density traffic or challenging terrain. A-RNP allows for the bundling of approvals across flight phases, improving efficiencies during initial certification and operational use.

H.3.6 Design. A-RNP is designed for operation in oceanic/remote continental airspace, on the domestic or offshore en route structure as well as on arrival, approaches, and DPs.

H.3.7 Multiple Operational Approvals. An A-RNP aircraft qualification may be applied to multiple operational approvals without the need for re-examination of aircraft eligibility. This enables an operator's approved procedures, training, etc. to be common to multiple approvals. The A-RNP aircraft qualification will also facilitate multiple operations specifications (OpSpecs).

H.3.8 Features and Requirements. For A-RNP, some features/requirements may be required in one flight phase and optional or unnecessary in another. No distinctions are made regarding flight phase association in providing a general set of criteria spanning all phases and navigation applications. Where such differences are deemed important or the operational need is for one application, a specific operational approval (e.g., RNP 1), is expected to be used instead.

H.3.9 Area Navigation Capability. The area navigation capability required for A-RNP will encompass the lateral aspects of the desired flightpath. The predictability and performance monitoring and alerting for the lateral flightpath will support a number of applications including closely-spaced procedures/routes and operations in terrain-challenged areas.

H.4 Aircraft and System Requirements for A-RNP.

H.4.1 RNP Capability. Navigation systems must have foundational RNP capability (RNP APCH to LNAV, RNP 1, and RNP 2) as a prerequisite to implementing any A-RNP functions.

Note: The system must allow for a means to become established prior to the final approach fix (FAF) on an instrument landing system (ILS) or Ground Based Augmentation System (GBAS) Landing System (GLS) with minimal overshoot or undershoot.

H.4.2 System Requirements. AC 20-138( ) defines the system requirements for A-RNP functions.

H.5 RNP Scalability.

H.5.1 Definition. RNP scalability refers to the ability of the RNP system to automatically retrieve and set the RNP value for each leg segment of a route or procedures from the onboard navigation database. When a change occurs to a smaller RNP value (e.g., from RNP 1 to RNP 0.3), the change must be completed by the first fix defining the leg with the smaller RNP value requirement. The timing of this change must also consider any latency in alerting from the RNP system.

Note: When the RNP system cannot automatically set the RNP value for each leg segment, operational procedures necessary to manually set the RNP value must be identified.

H.5.2 Usage. Scalable RNP is intended for legs on RNP routes or procedures where ATC, terrain, and/or obstacle considerations provide a benefit on selected legs to using RNP values other than RNP 2 or RNP 1. RTCA/DO-236C, paragraph 3.2.6 provides equipment requirements for assigning an RNP value to a leg and transitions between legs (See Appendix A and Table 5-1).

H.5.3 When Entering into the RNP Navigation System. The RNP scaling, monitoring, and alerting value for scalable legs must be entered into the RNP navigation system automatically from the database. RTCA/DO-236C provides an order of precedence for entering leg RNP values.

Note: Manually entered RNP values for legs are allowed, provided the equipment also changes the scaling, monitoring, and alerting consistent with the RNP value.

H.5.4 Displaying and Entering Values. The RNP system must provide the ability to display and enter RNP values in tenths of a nautical mile (NM) between 0.3 and 2.0.

H.5.5 Small RNP Values. It is acceptable to have a smaller RNP value entered in the RNP navigation system than the leg requires. As an example only to illustrate the point, it is acceptable to have the RNP system set to RNP 1 for a leg that requires RNP 2.

H.5.6 Path Steering Performance. The Original Equipment Manufacturer (OEM) must identify any conditions or constraints on path steering performance (e.g., autopilot (AP)-engaged, flight director (FD) with map display, and/or course deviation indicator (CDI)/map scaling criteria). This is particularly true for RNP values less than RNP 1.

H.5.7 Alerts Prior to an Upcoming Waypoint. The RNP navigation system must provide an alert prior to an upcoming waypoint when the system cannot support the next RNP value.

H.5.8 Deviation Guidance Cues. The deviation guidance cues must be scaled to the RNP value.

H.5.9 Alerts for Failure Modes. The RNP navigation system must provide an alert for any failure mode that potentially affects the navigation performance relative to the selected RNP value. Failure modes may include loss of electrical power, loss of signal reception, and RNP equipment failure, including navigation performance degradation, 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 (FOV) when loss of navigation capability and/or loss of integrity are experienced.

H.6 Operational Approval for A-RNP Operations.

H.6.1 Certification and Recognition. Airworthiness certification and recognition of A-RNP aircraft qualification alone does not authorize A-RNP operations. Operational approval is also required to confirm the operator has acceptable normal and contingency procedures for A-RNP operations.

H.6.2 Aircraft Qualification Documents. The aircraft or avionics manufacturers should develop aircraft qualification documentation that shows compliance with the applicable criteria.

H.6.3 Performance Requirements Review. 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.

H.7 FAA Acceptance of Documentation.

H.7.1 New Aircraft/Equipment. The aircraft/equipment qualification documentation can be approved as part of an aircraft certification project and reflected in the Airplane Flight Manual (AFM) and related documents.

H.7.2 Existing Aircraft/Equipment. For installations/equipment not previously approved to conduct A-RNP procedures, the aircraft or avionics manufacturer should submit the A-RNP documentation in accordance with AC 20-138( ). The operator will submit the RNP operational application package (if required) to the Federal Aviation Administration (FAA).

H.8 Operational Considerations.

H.8.1 RNP Operations within the U.S. NAS. For systems with receiver autonomous integrity monitoring (RAIM)-based integrity, a 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. Preflight integrity checks and the various capabilities that can be utilized to perform them can be found in Chapter 9, Flight Planning, of this AC.

H.8.2 RNP Operations in Oceanic and Remote Continental Areas. The operator must have an approved Global Navigation Satellite System (GNSS) availability prediction program ensuring the requisite availability of the GNSS fault detection and exclusion (FDE) function. Prior to conducting RNP operations in oceanic or remote continental areas, the operator must use this prediction program prior to dispatch.

H.8.3 General In-Flight Considerations. At system initialization, pilots must confirm the navigation database is current and verify that the aircraft position has been entered correctly. Pilots must not fly an RNP procedure unless it is retrievable by name from the onboard navigation database and conforms to the chart. An RNP route, RNP SID, RNP STAR, or RNP APCH should not be used if doubt exists as to the validity of the procedure in the navigation database.

Note 1: For flexible route structures, manual entry of waypoints (i.e., latitude and longitude), may be permitted provided the potential for entry error by pilots is mitigated by adequate flightcrew procedures. The manual entry or creation of new waypoints, by manual entry of latitude and longitude or rho/theta values for fixed, published routes is not permitted. The pilot may modify the route through the insertion or deletion of specific waypoints in response to ATC clearances. Pilots must not change any database waypoint type from a flyby to a flyover or vice versa.

Note 2: Flightcrew may notice a slight difference between the navigation information portrayed on the chart and their primary navigation display. Differences of 3 degrees or less may result from equipment manufacturer's application of magnetic variation and are operationally acceptable.

H.8.3.1 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.

H.8.3.2 Determine cross-track (XTK) error/deviation. More specifically, the maximum deviations allowed to support A-RNP must be understood and respected.

H.8.3.3 It is important to maintain the published path and maximum airspeeds while performing A-RNP operations with RF legs or FRTs.

H.8.3.4 For A-RNP procedures, pilots must use a lateral deviation indicator, FD, or AP in LNAV mode. Pilots of aircraft with a lateral deviation display must ensure lateral deviation scaling is suitable for the RNP value associated with the procedure.

H.8.3.5 The pilot must be able to use RNP equipment to follow flight guidance for LNAV no later than 500 feet above the airport elevation.

H.8.3.6 Some aircraft do not display or compute a path during flyby 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. This does not apply to the execution of either FRT or RF procedures.

H.8.3.7 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.

H.8.3.8 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 A-RNP procedure.

H.8.3.9 The flightcrew must be able to assess the impact of equipment failure on the anticipated RNP operation and take appropriate action.

H.8.3.10 Whenever possible, RNP routes should be extracted from the database in their entirety, rather than loading RNP route waypoints from the database into the flight plan individually. Selecting and inserting individual, named fixes from the database is permitted, provided all fixes along the published route to be flown are inserted. Expanded coordinates of named fixes extracted from the database should be verified.

H.8.3.11 Pilots of aircraft with RNP input selection capability should select the smallest RNP value for the route or procedure that ensures the RNP system offers appropriate lateral deviation scaling permitting the pilot to monitor lateral deviation and meet the requirements of the A-RNP operation.

H.8.3.12 If the navigation system does not automatically retrieve and set the RNP value from the onboard navigation database for each leg segment of a route or procedure, the flightcrew's operating procedures should verify the appropriate RNP value for the route or procedure is manually entered into the RNP system.

H.8.4 Prior to Commencing the A-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. 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 multisensor systems, crew must verify that the correct sensor is being used for position computation.

H.8.5 Contingency Procedures. The pilot must notify ATC of any loss of the RNP capability (integrity alerts or loss of navigation), together with the proposed course of action. If unable to comply with the requirements of an RNP procedure, pilots must advise ATC as soon as possible. The loss of RNP capability includes any failure or event causing the aircraft to no longer satisfy the RNP requirements of the route.

H.8.6 Scalability Considerations. The RNP system should automatically retrieve and set the RNP value for each leg segment of a route or procedure from the onboard navigation database. When a change occurs to a smaller RNP value, (e.g., from RNP 1 to RNP 0.3), the change must be complete by the first fix defining the leg with the smaller RNP value requirement. The timing of this change must also consider any latency in alerting from the RNP system. When the RNP system cannot automatically set the RNP value for each leg segment, any operational procedures necessary to accomplish this must be identified.

Note: RNP scalability is an FAA requirement for A-RNP operators.

H.8.6.1 One acceptable means to meet this requirement may be to require the flightcrew to manually set the smallest RNP value the route or procedure uses before commencing the route or procedure (i.e., prior to the initial approach fix (IAF)).

H.8.6.2 If the RNP value for the RNP system has been set manually by the flightcrew and following an RNP system change to the RNP value required (e.g., the next

flightpath segment contains a different RNP value), the RNP system should provide an alert to the flightcrew.

Note: One means by which this can be achieved is as described in RTCA, Inc., Minimum Operational Performance Standards (MOPS), DO-283A. Another means is to develop lateral deviation displays and alerting as per RTCA, Inc./European Organization for Civil Aviation Equipment (EUROCAE) Minimum Aviation System Performance Standard (MASPS) DO-236C/ED-75.

H.8.6.3 The RNP system must provide lateral deviation displays and alerting appropriate to the selected RNP value and application.

H.8.6.4 It is recognized that aircraft and equipment based upon Global Positioning System (GPS) standards such as RTCA DO-208 and DO-229( ) have RNP capabilities for lateral deviation and alerting that are generally associated with navigation accuracies of 0.3, 1.0, and 2.0 NM only. Such capability exists in a large portion of the aircraft fleet, but may not be extended to other navigation accuracies or the means of compliance specified herein. Additionally, some of this fleet does provide the capability to select other navigation accuracies. Therefore, before a manufacturer implements or an operator applies this functional capability, it is recommended that they determine the effects of the resolution of a number of issues including:

1. How their aircraft and systems will be affected or accommodated operationally when different navigation accuracy requirements are needed,
2. Is there a basis for implementing improved functionality or operating procedures, and
3. How such systems will need to be qualified, used by the flightcrew and operationally approved.

H.9 A-RNP Aircrew Training. A-RNP training should include the following:

1. Demonstrate continuity of RNP systems as part of contingency procedures,
2. Retrieve and fly a RF procedure,
3. Retrieve and fly a parallel offset, and
4. Demonstrate RNP scalability (The RNP system must be capable of manual or automatic entry and display of RNP value requirements).

APPENDIX I. ADDITIONAL CAPABILITIES

I.1 Introduction.

I.1.1 Guidance. This appendix provides guidance on the performance, functional and additional operational requirements for Required Navigation Performance (RNP) systems containing additional capabilities.

I.1.2 Applicability. This appendix applies to all operators conducting RNP operations under Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 91 subpart K (91K), 121, 125, 129, and 135 within the U.S. National Airspace System (NAS) or offshore airspace areas.

I.2 Radius to Fix (RF).

I.2.1 Description of RF Legs.

I.2.1.1 RF legs are an optional capability for use with:

- Required Navigation Performance Approach (RNP APCH) (Appendix A, Qualification Criteria for Required Navigation Performance Approach (RNP APCH) Operations;
- RNP 1, (Appendix C, Qualification Criteria for Required Navigation Performance (RNP) 1 (Terminal) Operations); and
- RNP 0.3 (Appendix D, Qualification Criteria for Required Navigation Performance (RNP) 0.3 (Rotorcraft) Operations).

I.2.1.2 This functionality can be used in the following:

- Initial and intermediate approach segments;
- Final phase of the missed approach;
- Standard Instrument Departures (SID); and
- Standard Terminal Arrival Routes (STAR).

I.2.1.3 The application of RF legs in the final approach, initial or intermediate phases of the missed approach is prohibited. Such procedure segments wishing to apply RF would have to use the Required Navigation Performance Authorization Required (RNP AR) specification (Refer to Advisory Circular (AC) 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, and AC 90-101( ), Approval Guidance for RNP Procedures with AR).

I.2.2 Path Definition. The RNP lateral accuracy requirement is evaluated around the path defined by the published procedure and RTCA, Inc.'s document, RTCA/DO-236( ).

Note: Industry standards for paths can be found in RTCA/DO-236C( ).

I.2.3 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. There is no requirement for the aircraft to include a redundant navigation capability to perform RF legs should a loss of navigation occur during the RF leg. However, type certificate (TC) or Supplemental Type Certificate (STC) applicants for RNP approval that include RF legs are encouraged to provide a redundant navigation capability on the aircraft that can maintain the RF leg track.

I.2.3.1 The Airplane Flight Manual (AFM)/Rotorcraft Flight Manual (RFM) or aircraft qualification guidance should document limitations if:

1. The aircraft cannot proceed "Direct-To" the initial fix defining an RF leg segment.
2. The aircraft cannot accept a radar vector (a heading assigned by air traffic control (ATC)) to the middle of an RF leg segment for intercepting and completing the RF leg segment from that point while sustaining the desired level of performance.

I.2.4 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 (AP) and/or flight director (FD) mode requested. If documenting FTE values other than those listed in RTCA/DO-283A, the documentation must show demonstration in accordance with AC 120-29( ), Criteria for Approval of Category I and Category II Weather Minima for Approach, or AC 20-138( ).

I.2.5 Interface to Flight Guidance System (FGS). An acceptable AP and/or FD response to an RNP system failure or loss must be verified in each AP and FD mode, as applicable.

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

I.2.6 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 (FOV) when loss of navigation capability and/or loss of integrity are experienced.

I.2.7 Functional Requirements. RNP procedures with RF legs require the use of an AP or FD with at least "roll-steering" capability that is driven by the RNP system. The AP/FD must operate with suitable accuracy to track the lateral and, as appropriate vertical paths required by a specific RNP procedure.

I.2.7.1 The aircraft must have an electronic map display depicting the RNP-computed path of the selected procedure.

I.2.7.2 The flight management computer (FMC), the FD system, and the AP must be capable of commanding a bank angle up to 30 degrees above 400 feet above ground level (AGL).

I.2.7.3 The specified bank angles comply with RTCA/DO-236C and are consistent with a common procedure design criteria that accommodates all aircraft categories; including those with the highest approach speeds. Aircraft with lower approach speeds will typically not achieve these bank angles in normal operations.

I.2.8 Maintaining Lateral Navigation (LNAV) in Missed Approach. If abandoning a procedure while on an RF leg or initiating a go-around or missed approach (through activation of takeoff/go-around (TOGA) or other means), the flight guidance mode should remain in LNAV to enable display of deviation and positive course guidance during an RF leg, including the missed approach segment. If the aircraft does not provide this capability, crew procedures must be used that assure the aircraft will adhere to the specified flightpath during the RF leg segment.

Note: For missed approaches with a RF leg, the flightcrew must be able to couple the AP or FD to the RNP system (engage LNAV) by 500 feet AGL.

I.2.9 Crew Workload Analysis. Analyze the crew workload and determine acceptability when flying and monitoring track adherence in association with RF legs during all phases of flight, including those non-normal procedures that can be evaluated in-flight.

I.2.10 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., AP-engaged, FD with map display, including lateral and vertical modes, and/or course deviation indicator (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 includes:
   - Acceptable normal and non-normal procedures,
   - Demonstrated configurations,

- Type of facilities used, and
- Any constraints or limitations necessary for safe operation should be identified.

I.3 Parallel Offset.

I.3.1 Description of Parallel Offset. Parallel offsets provide a capability to fly offset from the parent track, as defined by the series of waypoints. Parallel offset capability is required for an A-RNP qualification and mandatory for oceanic/remote continental RNP 2 (Appendix E) and RNP 4 (Appendix F) operations. The turn defined for the parent track (flyby or fixed radius transitions (FRT)) must be applied in the offset track. Parallel offsets are applicable only for en route segments and are not foreseen to be applied on SIDs, STARs, or approach procedures. The activation of an offset must be clearly displayed to the flightcrew with the cross-track (XTK) deviation indication to the offset track.

I.3.2 Usage of Parallel Offset. Parallel offsets can be used on route segments in en route and terminal areas, and are intended to replicate all of the centerline route characteristics at the desired offset to the left or right of the centerline route. Parallel offsets are not intended for approach segments, arrivals, or departures. RTCA/DO-236C, paragraphs 3.2.4.3 and 3.7.2.2.4 provide detailed requirements for implementing parallel offsets in RNP equipment.

I.3.3 Parallel Offset Considerations. The system should be capable of flying tracks offset by up to 20 nautical miles (NM) from the parent track. The presence of an offset should be continuously indicated. Tracks offset from the parent track must be continued for all Air Traffic Service (ATS) route segments and turns until either removed by the crew or automatically cancelled by:

1. Amendment of the active flight plan by executing a “Direct-To,”
2. Commencement of an approach procedure, or
3. Where a course change exceeds 90 degrees. The navigation system can be expected to terminate the offset no later than the fix where the course change occurs. The offset may also be terminated if the route segment ends at a hold fix.

I.3.4 Lateral Offset Activation. When a lateral offset is activated in the Area Navigation (RNAV) or RNP system, the aircraft will leave the defined route and typically intercept the offset at an angle of 45 degrees or less. When the offset is cancelled, the aircraft returns to the defined route in a similar manner.

I.4 RNAV Holding.

I.4.1 Usage of RNAV Holding. RNAV holding is intended to give aircraft the ability to fly either ATC-defined ad hoc or published holding patterns with the performance, monitoring, and alerting abilities associated with RNP. RTCA/DO-236C,

paragraph 3.2.4.1 defines equipment requirements for RNP holding. RNP holding implemented per RTCA/DO-236C is acceptable for meeting RNAV holding.

I.4.2 Implementation of RNAV Holding. Aircraft implementing RNAV holding capability should have an electronic map display capable of depicting all segments of an RNAV holding procedure. A map display depicting the RNAV holding segments enhances situation awareness.

I.5 **FRT.** FRTs are waypoint transitions between en route legs using a defined radius. The intent is to define waypoint transitions along airways where separation between parallel routes is required and flyby transitions are not compatible with the separation criteria. RTCA/DO-236C, Change 1, paragraph 3.2.5.4.2 defines equipment requirements for FRTs.

I.6 **Time of Arrival Control (TOAC).** This section will be updated at a future revision once system requirements are defined for RTCA/DO-236C.

I.7 **Operational and Functional Considerations.**

I.7.1 RF Legs. Requirements for RF legs will be indicated on the charts, in the notes section, or at the applicable initial approach fix (IAF) 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.

I.7.1.1 Pilots must not exceed maximum airspeeds where published, while performing RNP operations containing RF legs.

I.7.1.2 When the dispatch of a flight is predicated on flying a RNP APCH with a RF leg at the destination and/or alternate, the operational control personnel/pilot must determine that the AP/FD is installed and operational.

I.7.1.3 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).

I.7.2 Parallel Offset. The cross track offset distance should be manually entered into the RNP system to a resolution of 1 NM or better.

I.7.2.1 The lateral track-keeping requirement of RNP must be maintained referenced to the offset track where parallel offsets are applied.

I.7.2.2 Where FRTs are applied, the offset track must be parallel to the parent track (i.e., a smaller turn radius for offsets to the inside of the turn, and a larger turn radius for offsets to the outside of the turn).

I.7.3 Direct-To Function. The navigation system must have a "Direct-To" function the flightcrew can activate at any time. This function must be available to any fix except initial waypoint of an RF segment.

I.7.3.1 The navigation system must also be capable of generating a geodesic path to the designated "To" fix, without "S-turning" and without undue delay.

APPENDIX J. ADMINISTRATIVE INFORMATION

J.1 Terminology.

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

Air Traffic Control (ATC) Service:

1. Area Control Service,
2. Approach Control Service, and
3. Airport Control Service.

Air Traffic Service (ATS) − A generic term meaning:

1. Flight Information Services (FIS),
2. Alerting Service, and
3. Air Traffic Advisory Service.

Air Traffic Service (ATS) Routes. The term “ATS Route” is a generic term that includes “VOR Federal airways,” “colored Federal airways,” “jet routes,” and “RNAV routes.” The term “ATS route” does not replace these more familiar route names, but serves only as an overall title when listing the types of routes that comprise the United States route structure.

Area Navigation (RNAV). A method of navigation which permits aircraft operation on any desired flightpath 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. RNAV includes Performance-based Navigation (PBN) as well as other operations that do not meet the definition of PBN.

Area Navigation (RNAV) System. A navigation system which permits aircraft operation on any desired flightpath 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).

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. Airworthiness approval criteria is found in Advisory Circular (AC) 20-138 ( ), Airworthiness Approval of Positioning and Navigation Systems.

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.

Discontinuity. A discontinuity is an interruption in the sequence of waypoints within the active onboard flight plan (primary flight plan loaded into FMS).

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

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.

Estimate of Position Uncertainty (EPU). A measure based on a defined scale in nautical miles (NM), 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.

Fault Detection and Exclusion (FDE). A RAIM algorithm that can automatically detect and exclude a faulty satellite from the position solution when a sufficient number of redundant satellite measurements are available.

Fixed Radius Transition (FRT). An arc at a constant (specified) radius that is tangent to both the inbound and outbound en route path segments at an en route fix.

Flight Guidance System (FGS). A system primarily intended to assist the flightcrew in the basic control and tactical guidance of the airplane. Typically referred to as an autopilot (AP)/flight director (FD)/autothrust system, it may consist of sensors, computers, power supplies, servo-motors/actuators, and indications and controllers necessary for the pilot to manage and supervise the system. For rotorcraft, it can include a FD with a stability augmentation system and/or AP.

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 (AFCS).

Flight Technical Error (FTE) or Path Steering Error (PSE). 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.

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 (RNP) for the actual phase of operation.

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.

Lateral Navigation (LNAV). The function of RNAV systems that computes, displays, and provides lateral guidance to a profile or path. Sometimes referred to as managed navigation.

Long-Range Navigation System (LRNS). An electronic navigation unit that is approved for use under instrument flight rules (IFR) as a primary means of navigation, and has at least one source of navigational input, such as inertial navigation system (INS) and/or GPS.

Navigational Aid (NAVAID) Infrastructure. NAVAID infrastructure refers to space-based and or ground-based NAVAIDs available to meet the requirements in the navigation specification (Nav Spec).

Navigation Application. This is defined as the application of a Nav Spec and the supporting NAVAID infrastructure, to routes, procedures, and/or defined airspace volume, in accordance with the intended airspace concept.

Navigation Specification (Nav Spec). A set of aircraft and aircrew requirements needed to support PBN operations within a defined airspace. There are two kinds of Nav Spec:

1. **RNAV specification.** A Nav Spec based on RNAV that does not include the requirement for onboard performance monitoring and alerting, designated by the prefix RNAV (e.g., RNAV 5, RNAV 1).
2. **RNP specification.** A Nav Spec based on RNAV that includes the requirement for onboard performance monitoring and alerting, designated by the prefix RNP (e.g., RNP 4, RNP APCH).

Navigation System Error (NSE). NSE or Position Estimation Error (PEE) is the difference between the true position and estimated position.

Oceanic. Oceanic airspace is defined as international airspace over oceans where separation and procedures are in accordance with the International Civil Aviation Organization (ICAO). Responsibility for the provision of ATC service in this airspace is delegated to various countries.

Offshore. Offshore airspace is defined by Title 14 of the Code of Federal Regulations (14 CFR) part 71, §§ 71.31 and 71.71. It is designated in international airspace within areas of domestic radio navigational signal or ATC radar coverage, and within which domestic ATC procedures are applied.

Path Definition Error (PDE). The difference between defined path and desired path at a specific point.

Path Steering Error (PSE) or Flight Technical Error (FTE). The difference between the estimated position and the abeam point on the system-defined path.

Performance-Based Navigation (PBN). RNAV-based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure (IAP), or in a designated airspace.

Position Estimation Error (PEE). PEE or NSE is the difference between true position and estimated position.

Primary Flight Display (PFD). A display that provides increased situational awareness to the pilot by replacing the traditional six instruments used for instrument flight with an easy-to-scan display that provides the horizon, airspeed, altitude, Vertical Speed (VS), trend, trim, and rate of turn among other key relevant indications.

Primary Optimum Field of View (FOV). The vertical and horizontal visual fields relative to the design eye reference point that can be viewed with eye rotation only using foveal or central vision. The values for the horizontal (relative to the normal line of sight) are +/-15 degrees optimum, with +/-35 degrees maximum. The values for the vertical (relative to normal line of sight) are +/-15 degrees optimum, with + 40 degrees up and -20 degrees down maximum (Refer to AC 25-11( ), Electronic Flight Displays). The primary FOV definition should be broad enough to include the center radio stack on 14 CFR part 23 airplanes with “classic”, analog basic ‘T’ instrumentation. For rotorcraft, reference the visibility requirements defined in AC 27-1( ), Certification of Normal Category Rotorcraft, and AC 29-2( ), Certification of Transport Category Rotorcraft.

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

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

Remote Continental. Remote continental airspace is defined as airspace above terrain where line-of-sight communications, independent surveillance and reliable ground-based NAVAIDs is not available. Controllers provide ATSs utilizing procedural control and procedural separation.

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 onboard 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.

RNAV. See Area Navigation (RNAV) above.

RNP/RNAV Procedure. An RNP/RNAV Procedure includes instrument departure procedures (DP), standard terminal arrivals (STAR), and instrument approaches based on PBN.

RNP Value. The RNP value designates the 95 percent LNAV performance (in NM) and the related monitoring and alerting requirements associated with an RNP instrument flight operation or a particular segment of that instrument flight.

RNP System. An RNAV system which supports onboard performance monitoring and alerting. For the purposes of this AC, RNP systems comply with Appendices A-I, as appropriate.

Total System Error (TSE). The difference between the true position and the desired position and is equal to the vector sum of the FTE, PDE, and NSE.

Waypoints. A waypoint is a predetermined geographical position that is defined in terms of latitude/longitude coordinates. Waypoints may be a simple named point in space or associated with existing NAVAIDs, intersections, or fixes. A waypoint is most often used to indicate a change in direction, speed, or altitude along the desired path. RNAV procedures make use of both flyover and flyby waypoints.

1. **Flyby Waypoints.** Flyby waypoints are used when an aircraft should begin a turn to the next course prior to reaching the waypoint separating the two route segments. This is known as turn anticipation.
2. **Flyover Waypoints.** Flyover waypoints are used when the aircraft must fly over the point prior to starting a turn.

J.2 Acronyms.

Table J-1. Acronyms

Acronym	Meaning
14 CFR	Title 14 of the Code of Federal Regulations
91K	Part 91 Subpart K (14 CFR)
ABAS	Aircraft-Based Augmentation System
AC	Advisory Circular
ACO	Aircraft Certification Office (FAA)
AEG	Aircraft Evaluation Group
AFCS	Automatic Flight Control System
A/FD	Airport/Facility Directory
AFM	Airplane Flight Manual
AFMS	Airplane Flight Manual Supplement
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AIR	Aircraft Certification Service
AIRAC	Aeronautical Information Regulation and Control
AMC	Acceptable Means of Compliance
ANP	Actual Navigation Performance
ANSP	Air Navigation Service Provider
AP	Autopilot
ARINC	Aeronautical Radio Incorporated
A-RNP	Advanced Required Navigation Performance
ATC	Air Traffic Control
ATRK	Along-Track
ATS	Air Traffic Service
baro-VNAV	Barometric Vertical Navigation
CA	Course to Altitude (path terminator per ARINC Specification 424)
CDI	Course Deviation Indicator
CF	Course to Fix (path terminator per ARINC Specification 424)
CHDO	Certificate-Holding District Office
CMO	Certificate Management Office
CPDLC	Controller-Pilot Data Link Communications
CTA	Control Area
CTA/FIR	Control Area/Flight Information Region
D/D	DME/DME
D/D/I	DME/DME/Inertial
DA	Decision Altitude
DF	Direct to Fix
DME	Distance Measuring Equipment
DOD	Department of Defense
DP	Departure Procedure
DTK	Desired Track
EFB	Electronic Flight Bag
EHSI	Electronic Horizontal Situation Indicator

Acronym	Meaning
EPE	Estimate of Position Error
EPU	Estimate of Position Uncertainty
ETA	Estimated Time of Arrival
EUROCAE	European Organization for Civil Aviation Equipment
FA	Fix to an Altitude (path terminator per ARINC Specification 424)
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAS	Final Approach Segment
FD	Flight Director
FDE	Fault Detection and Exclusion
FGS	Flight Guidance System
FIR	Flight Information Region
FIS	Flight Information Services
FL	Flight Level
FLIP	U.S. Flight Information Publication
FM	Fix to Manual Termination (path terminator per ARINC Specification 424)
FMC	Flight Management Computer
FMS	Flight Management System
FOV	Field of View
FRT	Fixed Radius Transition
FSDO	Flight Standards District Office
FTE	Flight Technical Error
GBAS	Ground Based Augmentation System
GLONASS	Global Orbiting Navigation Satellite System
GLS	Ground Based Augmentation System (GBAS) Landing System
GNSS	Global Navigation Satellite System
GOMEX	Gulf of Mexico
GPS	Global Positioning System
HEMS	Helicopter Emergency Medical Service
HSpec	Helicopter Specification
IAF	Initial Approach Fix
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
IF	Initial Fix (path terminator per ARINC Specification 424)
IFP	Instrument Flight Procedure
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INS	Inertial Navigation System
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
LAAS	Local Area Augmentation System
LNAV	Lateral Navigation
LOA	Letter of Acceptance
LOA	Letter of Authorization

Acronym	Meaning
LP	Localizer Performance without Vertical Guidance
LPV	Localizer Performance with Vertical Guidance
LRN	Long-Range Navigation
LRNS	Long-Range Navigation System
MAP	Missed Approach Procedure
MASPS	Minimum Aviation System Performance Standard
MCDU	Multipurpose Control Display Unit
MDA	Minimum Descent Altitude
MEL	Minimum Equipment List
MNPS	minimum navigation performance specification
MOPS	Minimum Operational Performance Standards
MSpec	Management Specification
NANU	Notice Advisory to Navstar Users
NAS	U.S. National Airspace System
NAT/MNPS	North Atlantic Minimum Navigation Performance Specifications
NAVAID	Navigational Aid
Nav Spec	Navigation Specification
NDB	Non-Directional Beacon
NM	Nautical Mile
NOTAM	Notice to Airmen
NPA	Nonprecision Approach
NSE	Navigation System Error
NWS	National Weather Service
ODP	Obstacle Departure Procedure
OEM	Original Equipment Manufacturer
OpSpec	Operation Specification
PBN	Performance-Based Navigation
PDE	Path Definition Error
PEE	Position Estimation Error
PF	Pilot Flying
PFD	Primary Flight Display
PinS	Point in Space
PNF	Pilot-Not-Flying (Pilot Monitoring)
POH	Pilot’s Operating Handbook
POI	Principal Operations Inspector
P-RNAV	Precision Area Navigation (European)
PSE	Path Steering Error
RAIM	Receiver Autonomous Integrity Monitoring
RF	Radius to Fix (path terminator per ARINC Specification 424)
RFM	Rotorcraft Flight Manual
RFMS	Rotorcraft Flight Manual Supplement
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP APCH	Required Navigation Performance Approach
RNP AR	Required Navigation Performance Authorization Required
RNP AR APCH	Required Navigation Performance Authorization Required Approach

Acronym	Meaning
R/T	Receiver/Transmitter
SAO	Special Areas of Operation
SAPT	Service Availability Prediction Tool
SB	Service Bulletin
SBAS	Satellite-Based Augmentation System
SFAR	Special Federal Aviation Regulation
SID	Standard Instrument Departure
SIS	Signal in Space
SL	Service Letter
SLOP	Strategic Lateral Offset Procedure
S-LRNS	Signal Long-Range Navigation System
SOC	Statement of Compliance
STAR	Standard Terminal Arrival
STAR	Standard Terminal Arrival Route
STC	Supplemental Type Certificate
SUPPS	Regional Supplementary Procedures
TC	Type Certificate
TF	Track to Fix (path terminator per ARINC Specification 424)
TOAC	Time of Arrival Control
TOGA	Takeoff/Go-Around
TSE	Total System Error
TSO	Technical Standard Order
TSOA	Technical Standard Order Authorization
VA	Heading to Altitude (path terminator per ARINC Specification 424)
VI	Heading to Intercept (path terminator per ARINC Specification 424)
VM	Heading to Manual (path terminator per ARINC Specification 424)
VNAV	Vertical Navigation
VOR	Very High Frequency Omni-Directional Range
VS	Vertical Speed
WAAS	Wide Area Augmentation System
XTK	Cross-Track

Advisory Circular Feedback Form

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by contacting the Flight Technologies and Procedures Division (AFS-400) or the Flight Standards Directives Management Officer.

Subject: AC 90-105A, Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System and in Oceanic and Remote Continental Airspace

Date: _____

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph _____

on page _____.

☐ Recommend paragraph _____ on page _____ be changed as follows:

_____

_____

☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

_____

_____

☐ Other comments:

_____

_____

☐ I would like to discuss the above. Please contact me.

Submitted by: _____ Date: _____