U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Performance-Based Navigation Operations

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This advisory circular (AC) replaces and consolidates several ACs (listed in paragraph 1.4) and provides guidance for operators using Performance-based Navigation (PBN) in the United States, in oceanic airspace, Remote Continental Airspace (RemCon), and in foreign countries that adopt International Civil Aviation Organization (ICAO) PBN standards. This AC provides operator guidance for the following Area Navigation (RNAV) and Required Navigation Performance (RNP) navigation specifications (NavSpecs) or operations:

- RNAV 1 (terminal);
- RNAV 2 (en route);
- RNP 0.3 (en route/terminal), rotorcraft only;
- RNP 1 (terminal);
- RNP 2 (en route, offshore, oceanic, and remote continental);
- RNP 4 (oceanic and remote continental);
- RNP Approach (RNP APCH), including operations to localizer performance with vertical guidance (LPV) minima and Localizer Performance (LP) minima (terminal);
- RNP 10 (RNAV 10) (oceanic and remote continental);
- Advanced Required Navigation Performance (A-RNP) (en route/terminal);
- Use of suitable RNAV systems on conventional routes and procedures; and
- RNP to xLS (e.g., instrument landing system (ILS) and Ground-Based Augmentation System (GBAS) Landing System (GLS)) operations (terminal).

  Note: This AC does not apply to Required Navigation Performance with Authorization Required (RNP AR), as described in AC 90-101( ), Approval Guidance for RNP Procedures with AR.

The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

Lawrence Fields
Acting Executive Director, Flight Standards Service

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CHAPTER 1. GENERAL

1.1 Purpose of This Advisory Circular (AC). This AC provides guidance for all operators to conduct Performance-based Navigation (PBN) operations including Area Navigation (RNAV) operations and Required Navigation Performance (RNP) operations in all phases of flight. Additionally, this document provides an overview of aircraft eligibility, operational guidance, and Federal Aviation Administration (FAA)-recommended training necessary to obtain operational approval for PBN operations. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

Note: When required, the FAA provides operational approval by issuing operations specifications (OpSpecs), management specifications (MSpecs), training specifications (TSpecs), or Letters of Authorization (LOA). For the remainder of this AC, the term "OpSpec" represents all types of authorizations in order to avoid repeating each type of authorization unless it is specifically relevant to the meaning of the sentence. Operators should contact the responsible Flight Standards office for more information on obtaining authorizations to conduct PBN operations.

1.1.1 Alternative Method. This AC provides a method of compliance for authorization to conduct PBN operations in the United States. In lieu of following this method without deviation, operators may elect to follow an alternative method that the FAA reviews and accepts as providing an equivalent or better level of safety as the standards in this AC.

1.1.2 Regulatory Authority and Operational Authorizations. Nothing in this AC countermands any regulation in Title 14 of the Code of Federal Regulations (14 CFR) or the requirements, provisions, and limitations of any operational authorization issued to an aircraft operator. No person should consider anything in this AC as permission to deviate from the regulations or the authorization documents.

1.1.3 AC Format. To provide the information in a format that is helpful to operators, Chapters 4 through 12 are arranged by phase of flight: preflight and departure operations, en route operations, and approach operations. Full airworthiness guidance for PBN operations is documented in AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems. This AC provides only an overview of airworthiness guidance as it relates to specific PBN operations.

1.1.4 Applicable Airspace. The guidance in this AC applies to PBN operations in U.S. airspace, as well as offshore and oceanic airspace administered by the FAA (e.g., the entire Oakland Oceanic Control Area (OCA)/Flight Information Region (FIR)). The information and guidance in this AC should also prepare U.S. operators to conduct PBN operations in the airspace of any State that is an International Civil Aviation Organization (ICAO) signatory. Operators should refer to individual State Aeronautical Information Publications (AIP) to understand PBN requirements in those States' sovereign airspace, as well as in any oceanic airspace administered by those States. For example, operators

should consult the AIP of Canada to understand operational requirements for flying in the Gander OCA/FIR.

Note: See Appendix E, Definitions and Acronyms, for an explanation of the difference between oceanic, remote continental, and offshore airspace.

1.2 Audience. The guidance contained in this AC applies to all operators conducting PBN operations under 14 CFR parts 91, 91 subpart K (part 91K), 121, 125, 129, and 135.

1.3 Where You Can Find This AC. You can find this AC on the FAA's website at https://www.faa.gov/regulations_policies/advisory_circulars and the Dynamic Regulatory System (DRS) at https://drs.faa.gov.

1.4 What This AC Cancels. This AC cancels the following documents:

- AC 90-100A CHG 2, U.S. Terminal and En Route Area Navigation (RNAV) Operations, dated April 14, 2015;
- 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, dated March 7, 2016;
- 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, dated February 11, 2011; and
- AC 90-108 CHG 1, Use of Suitable Area Navigation (RNAV) Systems on Conventional Routes and Procedures, dated April 21, 2015.

Note: Unless otherwise stated, operational approvals issued under the guidance of earlier, now canceled or superseded ACs or FAA orders generally remain valid. No operator needs to obtain a new authorization solely because the FAA issued this new AC. Operators must ensure their operations remain consistent with the performance and functional requirements of this AC. This AC only provides overviews of aircraft eligibility guidance for various PBN 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 OpSpec applicants to ensure compatibility of modifications with type design and airworthiness standards.

1.5 Source Basis and Related 14 CFR Parts.

- Part 61.
- Parts 91 (including part 91K), 95, and 97.
- Parts 121, 125, and 129.
- Parts 133, 135, and 137.

1.6 Definitions. The following key terms are defined as used in this AC. A complete definitions list can be found in Appendix E.

1. Area Navigation (RNAV) System. An installed instrument flight rules (IFR) aircraft navigation system that permits aircraft operation on any desired flightpath within the coverage of ground- or space-based Navigational Aids (NAVAID), within the limits of the capability of self-contained aids, or a combination of these, and is capable of meeting the performance requirements of this AC. Chapter 2, Performance-Based Navigation (PBN) Overview, provides an expanded description of RNAV.
2. Compliance. Means meeting operational and functional performance criteria, actions, or behavior in line with regulatory requirements.
3. Flight Manual. Means the Airplane Flight Manuals (AFM) or Rotorcraft Flight Manuals (RFM), or installed avionics operating manuals, pilot's operating handbook (POH), and appropriate supplements.
4. May. Indicates an option without indicating a recommendation.
5. Must. Specifies a mandatory requirement driven by regulation or required for a system to operate properly during a PBN operation. Any instance of the word "must" in this document is based on a specific regulation that is annotated as a note or is based generally on part 91, § 91.103 and/or § 91.123, or on public airworthiness standards. Additionally, "must" is used to denote compliance as the only means authorized when applying this AC. The use of the term "must" in this AC does not change, add, or delete regulatory requirements or authorize deviations from regulatory requirements.
6. Note. Provides essential information offering clarity in understanding a requirement or function.
7. Operator. Refers to the certificate holder (CH), program manager, company, and/or pilot or to any "person" who "operates" an aircraft as defined in 14 CFR part 1, § 1.1.
8. Performance-Based Navigation (PBN). The use of PBN in this AC denotes RNAV and/or RNP flight operations. Chapter 2 provides an expanded description of PBN.
9. Principal Inspector (PI). Primarily a Principal Operations Inspector (POI), but may be a Principal Avionics Inspector (PAI) or Principal Maintenance Inspector (PMI), as required.
10. Required Navigation Performance (RNP) System. An RNAV system capable of meeting the requirements of a specification for an RNP operation. An RNP system is an installed IFR aircraft navigation system that offers onboard performance monitoring and alerting, and that is approved for the performance and the functional requirements of the RNP operations described in this AC. Chapter 2 provides an expanded description of RNP system capability.
11. Should. The word "should" in this AC is used to indicate a preferred action or system state. This AC does not change, add, or delete regulatory requirements or authorize deviations from regulatory requirements.

1.7 Authorizing Documents and OpSpecs. Documents created and issued by the FAA to authorize an operator to perform an action are collectively referred to as "Authorizing Documents." See Appendix A, Obtaining PBN Operational Approval, for information on the operational approval process. For the purposes of this AC, the use of the term "OpSpec" hereafter refers to one or more of the following authorizing documents:

1. Management Specifications (MSpecs). Normally issued to program managers who conduct fractional ownership operations under part 91K.
2. Operations Specifications (OpSpecs). Normally issued to CHs for part 121, 125, 129, 133, 135, 137, 145, or 147.
3. Training Specification (TSpecs). Normally issued to CHs for parts 91, 91K, 121, 135, 141, and 142.
4. Letters of Authorizations (LOA). Normally issued to operators for parts 91 and 125.

1.8 Use of Parentheses ( ) and Letters With Document References. Most of the document references in this AC are the most current version, as designated by the use of parentheses ( ) placed at the end of the document title. In some cases, a letter will indicate the actual version. Documents without ( ) or a letter after the end of the document title designate that all valid versions apply.

1.9 Related Reading Material. Please refer to the links provided in this paragraph to obtain the latest ACs and/or orders.

1.9.1 ACs. Current ACs are available at https://www.faa.gov/regulations_policies/advisory_circulars/ and on DRS at https://drs.faa.gov.

- 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 90-101( ), Approval Guidance for RNP Procedures with AR.
- AC 90-117( ), Data Link Communications.
- AC 91-70( ), Oceanic and Remote Continental Airspace Operations.
- AC 120-91( ), Airport Obstacle Analysis.
- AC 120-118( ), Criteria for Approval/Authorization of All Weather Operations (AWO) for Takeoff, Landing, and Rollout.

1.9.2 FAA Orders (current editions). FAA orders provide policy and guidance to FAA employees for the performance of specified functions. Operators may find the information in these orders helpful to their broader understanding of the subjects presented in this AC. Current orders are available at https://www.faa.gov/regulations_policies/orders_notices/ and on DRS at https://drs.faa.gov.

- Order JO 7210.632, Air Traffic Organization Occurrence Reporting.
- Order JO 7400.11, Airspace Designations and Reporting Points.
- Order 8260.3, United States Standard for Terminal Instrument Procedures (TERPS).
- Order 8260.19, Flight Procedures and Airspace.
- Order 8260.42, United States Standard for Helicopter Area Navigation (RNAV).
- Order 8260.46, Departure Procedure (DP) Program.
- Order 8260.58, United States Standard for Performance Based Navigation (PBN) Instrument Procedure Design.

1.9.3 FAA Technical Standard Orders (TSO). TSOs are available on DRS at https://drs.faa.gov.

- TSO-C66c, Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960–1215 Megahertz.
- TSO-C106, Air Data Computer.
- TSO-C115d (or later), Required Navigation Performance (RNP) Equipment Using Multi-Sensor Inputs.
- TSO-C129a, Airborne Supplemental Navigation Equipment using the Global Positioning System (GPS).
- TSO-C145d, Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System (SBAS).
- TSO-C145e, Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System (SBAS).
- TSO-C146d, Stand-Alone Airborne Navigation Equipment Using The Global Positioning System Augmented By The Satellite Based Augmentation System (SBAS).
- TSO-C146e, Stand-Alone Airborne Navigation Equipment Using The Global Positioning System Augmented By The Satellite Based Augmentation System (SBAS).
- TSO-C196b, Airborne Supplemental Navigation Sensors for Global Positioning System Equipment using Aircraft-Based Augmentation.

1.9.4 RTCA, Inc. Documents. Copies of the following RTCA, Inc. documents may be obtained from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, or purchased online at https://my.rtca.org/nc__store.

- RTCA/DO-178( ), Software Considerations in Airborne Systems and Equipment Certification.
- RTCA/DO-187( ), Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Multi-Sensor Inputs.
- RTCA/DO-189( ), Minimum Operational Performance Standards for Airborne Distance Measuring Equipment (DME) Operating Within the Radio Frequency Range of 960-1215 MHz.
- RTCA/DO-201( ), User Requirements for Navigation Data.
- 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 Base Augmentation System.
- RTCA/DO-384( ), Minimum Operational Performance Standards (MOPS) for GNSS Aided Inertial Systems.

1.9.5 ICAO Documents. Copies of the following ICAO documents may be obtained from the ICAO Store, 999 Robert Bourassa Blvd., Montreal, Quebec, H3C 5H7, Canada, or online at https://store.icao.int/.

- ICAO Doc 9613, Performance-based Navigation (PBN) Manual.
- ICAO Doc 4444, Procedures for Air Navigation Services - Air Traffic Management (PANS ATM).
- ICAO Doc 7030, Regional Supplementary Procedures.

1.9.6 Other FAA Documents.

- FAA-H-8083-15, Instrument Flying Handbook.
- FAA-H-8083-16, Instrument Procedures Handbook.
- FAA Aeronautical Information Manual (AIM).
- Aeronautical Information Publication (AIP), United States.

1.10 AC Feedback Form. For your convenience, the AC Feedback Form is the last page of this AC. Note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this AC on the Feedback Form.

CHAPTER 2. PERFORMANCE-BASED NAVIGATION (PBN) OVERVIEW

2.1 Performance-Based Navigation (PBN). Under PBN, the aircrew and navigation performance requirements may be defined in terms of the accuracy, integrity, continuity, and functionality needed for a particular operation in a particular airspace (an "airspace concept"). PBN shifts the emphasis from specified navigation aids and equipment to the navigation performance "required" for the desired operation (e.g., instrument departure, approach, and en route procedures). Performance requirements are identified through navigation specifications (NavSpecs), which may also identify the choice of navigation sensors and equipment that operators may use to meet the performance requirements. This chapter will provide guidance on PBN NavSpecs and will identify the navigation sensors and navigation equipment needed to meet PBN performance requirements.

Note: A significant portion of the information presented in this chapter derives from International Civil Aviation Organization (ICAO) Doc 9613, Performance-based Navigation (PBN) Manual. For an expanded description, operators should review that manual. Operators may purchase the PBN Manual through the ICAO website at https://store.icao.int/.

2.2 Area Navigation (RNAV). Area Navigation, whose abbreviation "RNAV" stems from the historical term "random navigation," is a key enabler of PBN. RNAV enables pilots to create and accurately follow a flight route by entering a series of waypoints either manually or by loading waypoints from an integrated navigation database. The navigation system estimates the aircraft position using the navigation sensors and compares the estimation to the defined route. The deviation between the estimated position and the defined flightpath is used to guide the aircraft along the defined route. Unlike conventional navigation, RNAV allows routes to be defined anywhere within the coverage and capabilities of navigation aids, including space-based or self-contained aids.

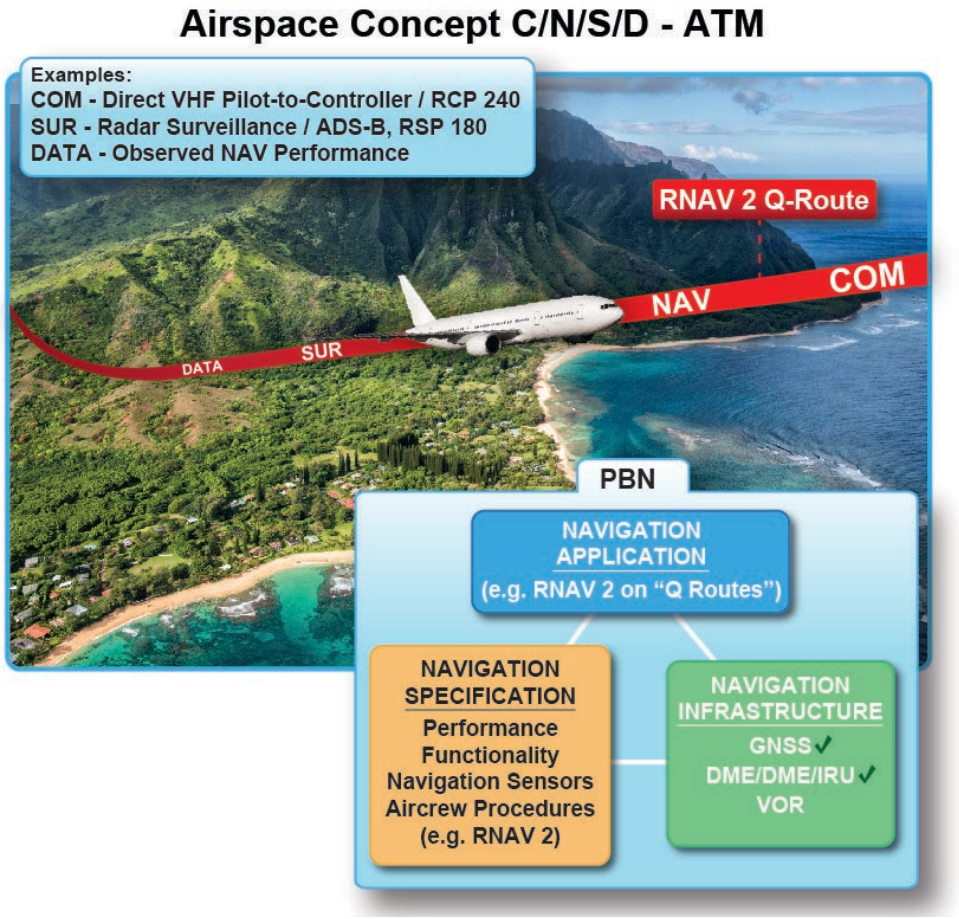
2.3 Airspace Concepts and PBN. The airspace concept is a master plan for a specific airspace design and the PBN operations within it. The concept describes the intended operations within an airspace construct (e.g., oceanic and remote continental operations, or a specific arrival or instrument approach procedure (IAP)) For a more thorough description of the airspace concept, refer to ICAO Doc 9613. Communications (COM), Air Traffic Control Surveillance (SUR), and Air Traffic Management (ATM) systems and requirements in the United States are covered in other guidance such as the Aeronautical Information Manual (AIM), Aeronautical Information Publication (AIP), or other FAA ACs. In Figure 2-1, Airspace Concept as "RNAV 2 Q-Route," the illustrated airspace concept is based on ATM, COM, NAV, and SUR (CNS) and DATA assumptions to satisfy explicit strategic objectives of improved safety, increased air traffic capacity and mitigation of environmental impact. Therefore, the heart of the airspace concept stems from "enablers" of ATM, CNS, and DATA components. Each of these components have certain interdependencies depending on the airspace and operation. For example, PBN requirements will be affected by CNS and ATM services, the Navigational Aid (NAVAID) infrastructure, and the functional and operational capabilities needed to meet the ATM application. PBN requirements also depend on the availability of reversionary, conventional navigation techniques and a required

(e.g., regulatory) amount of redundancy to ensure adequate continuity of functions. PBN consists of:

1. Navigation Application (e.g., use of RNAV 2 on Q-Routes);
2. NAVAID Infrastructure (e.g., Global Navigation Satellite System (GNSS), distance measuring equipment (DME)/DME/Inertial Reference Units (IRU), very high frequency (VHF) omni-directional range (VOR)); and
3. Navigation Specification (e.g., RNAV 2).

Note: These three components of PBN are described in the paragraphs below. The Airspace Concept is a formal method to respond to airspace requirements. As such, the development of the Airspace Concept is a key step in ICAO PBN implementation. The FAA has not yet adopted this "Airspace Concept" terminology, but does employ specific implementation processes for complex airspace solutions with PBN.

Figure 2-1. Airspace Concept as "RNAV 2 Q-Route"



Note: Figure 2-1 illustrates an example that will be used in the next several paragraphs. The airspace concept is a notional en route PBN track. This PBN

track has specified PBN requirements for data communications, voice communications, ATC surveillance, ATC separation, and navigation. The DATA requirement is listed as suitable observed navigation performance. The COM requirement is VHF; the SUR requirement, long-range radar (LRR) and Automatic Dependent Surveillance-Broadcast (ADS-B); and the ATM requirement includes a standard 5 nautical mile (NM) radar separation. The NAV requirement component is the Navigation Application, which is the defined "Q-Route." The NAVAID infrastructure is provided by Global Positioning System (GPS) or DME/DME/IRU, and no reliance on VOR is needed. The NavSpec ensures that the aircraft, the aircraft avionics, and the aircrew meet the navigation performance requirements for RNAV 2. The PBN information is normally available to the pilot in chart notes and legends or is described in the State AIP.

2.3.1 Navigation Application. A navigation application describes applying a NavSpec (and appropriate NAVAID infrastructure) to an airspace concept, thereby enabling PBN operations on a route or procedure. There is a direct relationship between a navigation application and NavSpec (e.g., RNAV 2 en route track using RNAV 2 eligible aircraft equipped with an RNAV 2 system). Other examples include departure procedures (DP) and Instrument Approach Procedures (IAP).

2.3.2 NAVAID Infrastructure. The NAVAID infrastructure relates to ground-based or space-based navigation aids needed to support the navigation capability required by a NavSpec. The unavailability of necessary NAVAIDs may result in insufficient navigation performance to support the NavSpec or the intended operation. For example, if a specific Q-route requires the performance met by the RNAV 2 NavSpec, but there are insufficient DMEs available for DME navigation, then the only way to meet the NavSpec performance requirements is by use of GPS. If GPS is also out of service, then the aircraft's navigation capability is likely insufficient to comply with the RNAV 2 Q-route's requirements.

2.3.3 PBN NavSpec. A NavSpec contains a set of functional and performance requirements for the aircraft, its navigation system(s), and the aircrew that must be met to support a specific PBN implementation within a defined airspace concept (e.g., a specific type of airspace, route or procedure). Each PBN NavSpec defines the aircraft's lateral navigation (LNAV) accuracy and requires the accuracy to be available for 95 percent of the total flight time of the defined PBN operation. There are two types of PBN NavSpecs: RNAV and Required Navigation Performance (RNP).

1. RNAV NavSpec. A NavSpec based on the RNAV lateral navigation accuracy requirement (see Appendix E, Definitions and Acronyms, Paragraph E.1.71, RNAV Value). RNAV NavSpecs use the prefix "RNAV" (e.g., RNAV 1 or RNAV 2). RNAV NavSpecs express the 95 percent lateral navigation accuracy requirement in nautical miles (e.g., RNAV 1 requires 1 NM, 95 percent accuracy). RNAV NavSpecs do not include a requirement for onboard performance monitoring and alerting.

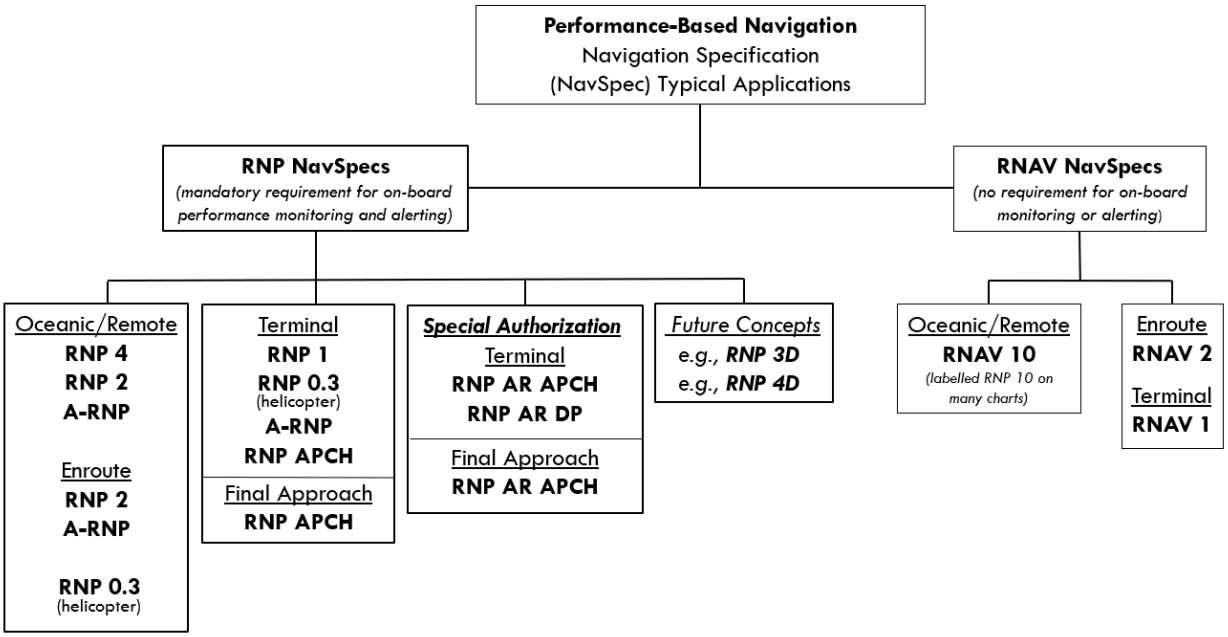
2. RNP NavSpec. A NavSpec based on the RNP lateral navigation accuracy requirement (see Appendix E, Paragraph E.1.75, RNP Value) and requires onboard performance monitoring and alerting. RNP NavSpecs use the prefix "RNP" (e.g., "RNP 1"). RNP NavSpecs express the 95 percent lateral navigation accuracy requirement in nautical miles (e.g., RNP 1 requires 1 NM, 95 percent accuracy). RNP NavSpecs require monitoring the Total System Error (TSE) during the RNP operation. TSE consists of Navigation System Error (NSE), Flight Technical Error (FTE), and Path Definition Error (PDE). RNP NavSpecs require NSE monitoring and alerting, combined with flightcrew or onboard system monitoring of FTE, to achieve confidence in the integrity of the RNP operation.

Note 1: Onboard navigation database requirements for RNP operations (refer to AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases) result in a negligible PDE.

Note 2: ICAO Doc 9613, Volume II, Implementing RNAV and RNP Operations, contains additional information on harmonized, individual NavSpecs.

Note 3: Figure 2-2 below shows the relationships of the PBN NavSpecs to their operational use.

Figure 2-2. PBN NavSpecs



2.3.4 Onboard Performance Monitoring and Alerting. The requirement for onboard performance monitoring and alerting is the primary distinguishing characteristic between an RNAV system and an RNP system. During an RNP operation, the aircraft's RNP

system, or the RNP system in combination with pilot monitoring (e.g., the pilot's instrument cross-check of lateral and vertical deviation), can ensure:

1. The aircraft performance meets the requirements for the RNP route or procedure; and
2. The probability of the aircraft's TSE, expressed in nautical miles (NM), exceeding the "containment limit" of two times the RNP value (2×RNP) without an alert during the operation is less than one in 100,000 (1×10^{-5}) and supports the operation's intended target level of safety (e.g., measurement of risk).

2.3.4.1 RNP Alerting. During an RNP operation, the RNP system shall provide an alert when the RNP system cannot support the operation. An aircraft may implement an RNP system in a number of ways. One aircraft may provide RNP alerting with a requirement that the pilot monitors path deviation. Another aircraft may provide TSE alerting where the system monitors RNP performance and path deviation. Whatever the mechanism, the RNP system continuously monitors the integrity of the navigation solution. The presence of onboard monitoring and alerting of RNP systems permits the aircraft to safely conduct RNP operations to tighter tolerances and therefore provides instrument procedure designers with more routing flexibility and reduced separation from other traffic or terrain than the separation available with RNAV operations.

2.3.5 Lateral Navigation Performance. Lateral navigation accuracy requirements safely separate routes from obstacles, airspace, and other routes. Air Traffic managers consider these requirements, along with path construction, observed navigational error rates, and other factors to establish route spacing. For example, parallel RNAV 2 routes in Class A airspace, with centerlines (CL) laterally spaced 8–16 NM (or more) from each other, could provide air traffic control (ATC) sufficient lateral spacing to meet their separation standards. For oceanic/remote continental, en route, and terminal phases of flight, PBN operations use a specific, fixed-width, lateral navigation performance requirement (i.e., RNP 10 on an oceanic route or RNAV 1 on a PBN Standard Terminal Arrival (STAR)). In contrast, in the approach phase of flight, RNP operations can use multiple RNP values (i.e., RNP Approach (APCH) uses RNP values of 1.00 in initial, intermediate, and missed segments, but 0.30 in the Final Approach Segment (FAS)).

2.3.5.1 Lateral Navigation Accuracy. Lateral navigation accuracy (called "RNP or RNAV values") is applicable to a selected airspace construct to published route, procedure, or procedure segment. The lateral accuracy is typically expressed as a distance in nautical miles from the intended CL of a procedure, route, or path. RNP applications also account for potential Navigation System Errors (NSE) out to twice the required lateral navigation accuracy. For example, both the RNAV 1 and RNP 1 NavSpecs require a lateral navigation accuracy value of 1.00 NM for 95 percent of the total flight time. In this case, the FAA expects both RNAV and RNP eligible aircraft to meet the 1.00 NM, 95 percent performance requirement.

Note 1: RNP routes and procedures identify lateral accuracy requirements as RNP values (e.g., on a chart or in a line of minima). RNP values always use two digits to the right of the decimal (e.g., RNP 0.30 or RNP 1.00) to ensure the operator can distinguish the RNP value from a NavSpec title such as RNP 0.3 or RNP 1.

Note 2: When a NavSpec requires a lateral navigation accuracy for 95 percent of the total flight time, this does not imply anything about the pilot's ability to fly the CL of the route or procedure, or the amount of time the aircraft may be off the route CL. Instead, it pertains to the aircraft's demonstrated capability to navigate by means of the RNAV or RNP system (either the pilot or autopilot flying) and the statistical probability the aircraft meets the required accuracy. There is no 5 percent "grace period" for flying off the selected CL. Pilots should always fly the path CL.

2.3.6 Vertical Performance. RNP APCH and RNP procedures with Authorization Required (AR) APCH NavSpecs include requirements for approved vertical navigation (VNAV) guidance using augmented Global Navigation Satellite System (GNSS) (e.g., Satellite-based Augmentation System (SBAS)) or barometric VNAV (baro-VNAV) in the FAS. Some RNAV and RNP systems may also provide advisory vertical guidance as a pilot aid in the departure, en route climb/descent, arrival, and terminal phases of flight. In the approach phase of flight, baro-VNAV or SBAS-enabled vertical guidance is used as primary flight guidance on vertically guided approaches to LNAV/VNAV lines of minima. SBAS (e.g., wide area augmentation system (WAAS)) is required for localizer performance with vertical guidance (LPV) lines of minima.

Note: All vertical guidance outside the FAS is advisory vertical guidance (refer to AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, for airworthiness standards for performance of vertical guidance).

2.4 Navigation Resiliency. The FAA is committed to ensuring that the National Airspace System (NAS) navigational infrastructure remains secure, sustainable, and resilient. A key component of the navigational infrastructure is a resilient positioning capability independent of GPS that will ensure safety while minimizing the impact of a GPS disruption. To sustain the GPS-independent navigational infrastructure, the FAA will maintain those elements needed for safety, recovery, and continued operations. This is accomplished with a combination of NAVAIDs, including a VHF omni-directional range (VOR) network, a robust DME network in the continental United States (CONUS), and select instrument landing system (ILS) availability. In the event of a GPS outage, and depending on the demonstrated performance of the aircraft's navigation capability, these networks can provide pilots with the opportunity to continue the RNP operation, proceed under RNAV operations, or revert to conventional operations (e.g., VOR and ILS). It is vital that pilots understand the navigation capability available to them, as described in the flight manual for their specific aircraft, in the event of a loss of GPS. During preflight preparations, pilots should consider contingency planning for a loss of GPS, using their flight manual procedures.

2.4.1 VOR Minimum Operational Network (MON). The VOR MON enables pilots, faced with a loss of GPS service, to revert to conventional VOR navigation procedures. The MON establishes a reliable network of VORs geographically sited to provide CONUS coverage at and above 5,000 feet above ground level (AGL). The program also ensures sufficient VOR service volumes at select remaining VORs to ensure adequate signal coverage. The VOR MON allows pilots to proceed via VOR routes to a MON-designated airport where an ILS or VOR approach procedure can be flown without the necessity of GPS, DME, automatic direction finder (ADF), or ATC Surveillance. While any airport with a suitable instrument approach may be used for landing, the VOR MON ensures that at least one MON-designated airport will be within 100 NM of any CONUS flightpath. To learn more about the VOR MON and its capabilities, operators should refer to the AIM or the FAA VOR MON website at https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices.

2.4.2 DME Navigation. The Next Generation Air Transportation System (NextGen) DME program expands CONUS DME coverage in surveilled en route and selected terminal airspace to provide a complementary DME navigation service for continuous use by RNAV and RNP systems. The intent of the network is to ensure availability of RNAV en route and terminal operations during times when GPS is unavailable within the NAS. The FAA ensures DME station service volumes, maximizes DME availability, and intends to avoid "critical DME" designations on routes and procedures. Navigation systems using DME positioning can benefit from this DME network, with or without integration of inertial navigation system(s) (INS), and may retain PBN capability when GPS is not available. Some RNP systems offer DME navigation, and can maintain RNP performance, with or without an INS integration, including the ability to complete an RNP APCH operation after GPS is lost. See Appendix E for the definitions of the terms "DME/DME (D/D) Positioning," "DME/DME/Inertial (D/D/I) Positioning," and "DME Navigation." Also refer to AC 20-138( ), which contains airworthiness guidance for DME navigation where the aircraft uses multiple DME facilities, with or without an INS, to support both RNP and RNAV operations.

2.4.3 Dual Frequency Multi-Constellation (DFMC). Currently in the NAS, civil aviation use of GNSS is based on a single frequency of a single GNSS satellite constellation, GPS L1, which provides the foundation for the global implementation of PBN and Automatic Dependent Surveillance (ADS) in the NAS. The aviation industry is developing equipment standards for systems to use a second GNSS frequency band and/or multiple GNSS constellations, called Dual Frequency Multi-Constellation (DFMC). DFMC will improve the robustness of GNSS positioning and expand the area where the LPV line of minima is available, to areas such as Puerto Rico and the U.S. Virgin Islands. The DFMC operations concept will be fully backward-compatible with existing GPS equipment and published procedures while providing resilience to GNSS vulnerabilities like single frequency interference by using different frequency bands. DFMC enables onboard ionospheric corrections and improved satellite geometries by using additional ranging sources. Industry anticipates fielding the first DFMC RNP system for FAA acceptance in the coming decade.

2.5 Flight Phase Overview. PBN NavSpecs apply to specific operations in certain phases of flight. For example, RNP 4 and RNP 10 apply to the oceanic/remote continental en route environment. Advanced Required Navigation Performance (A-RNP), on the other hand, has broader applicability. Figure 2-3, Phases of a PBN Flight With Associated NavSpecs, provides a visual representation of the phases of flight and the NavSpecs normally associated with those phases. Figure 2-4, Applications of PBN Operations and Associated Lateral Accuracies, provides operators a cross-reference of NavSpec lateral accuracies and their applicability with phases of flight.

Figure 2-3. Phases of a PBN Flight With Associated NavSpecs

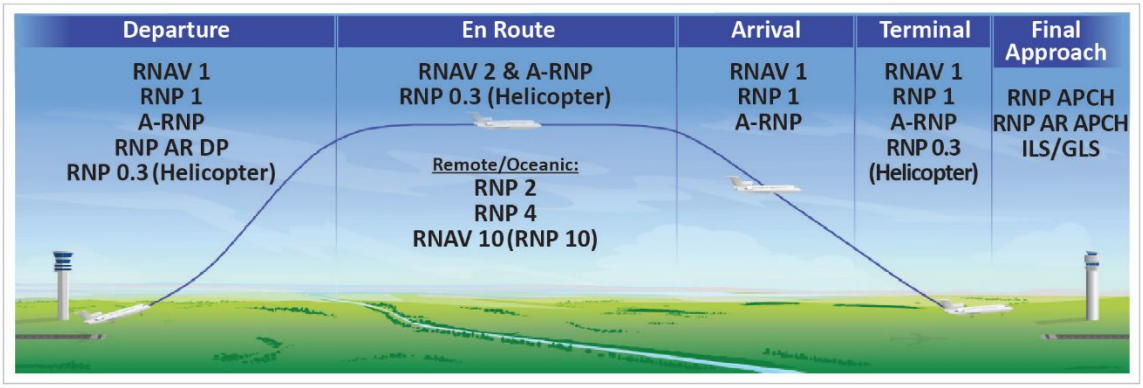
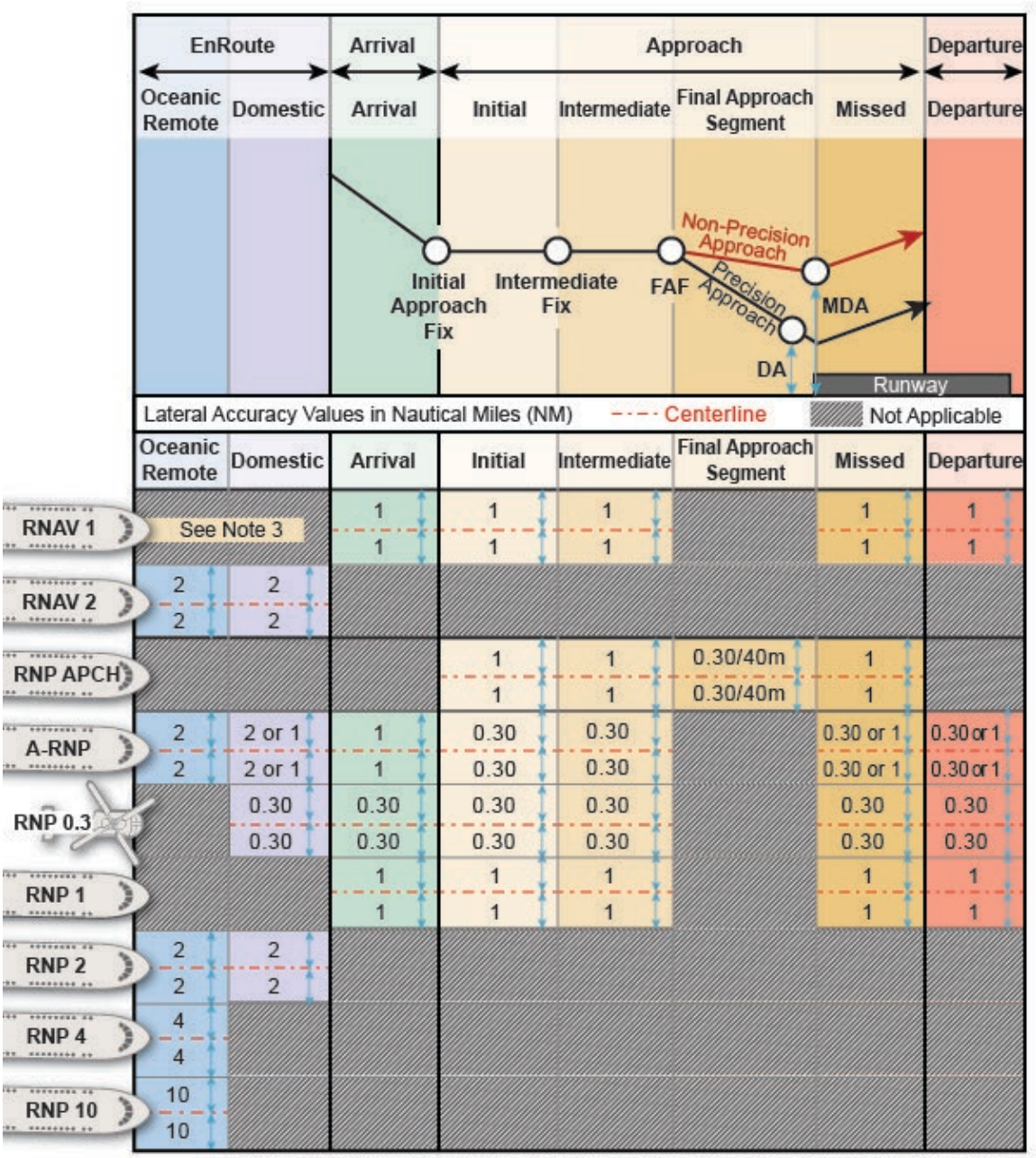


Figure 2-4. Applications of PBN Operations and Associated Lateral Accuracies



Note 1: Procedure designers may use A-RNP, RNP 1, and RNP 0.3 m in lieu of the initial, intermediate, or Missed Approach Segments (MAS) of RNP APCH procedure to join any type of final approach course (e.g., RNP APCH, ILS, Ground-Based Augmentation System (GBAS) Landing System (GLS), VOR, etc.).

Note 2: Domestic RNP 0.3 NavSpec applies only to helicopter and rotorcraft operations.

Note 3: Published en route transition routes from RNAV DPs and to RNAV STARs are RNAV 2, unless otherwise specified.

Note 4: RNAV 1 applies in the approach phase, excluding final approach, when using RNAV as a substitute or alternate means of navigation on a conventional instrument approach (termed RNAV substitution or alternate means). Navigation using published waypoints during an instrument approach operation is inherently an RNP operation.

2.5.1 Alaska Operations and Resiliency. Alaska's unique geography, vast distances between settlements, sparse lines of communication, unforgiving terrain, and Arctic to sub-Arctic climate combine to create a unique and challenging aviation environment. In general, the policy in this AC applies to PBN operations in Alaska. Certain operators and operations may find relief from some provisions in this AC and in 14 CFR with specialized operations specifications (OpSpecs) and/or Special Federal Aviation Regulation (SFAR) 97.

CHAPTER 3. GENERAL GUIDANCE COMMON TO ALL PERFORMANCE-BASED NAVIGATION (PBN) OPERATIONS

3.1 Introduction. This chapter provides information and guidance on the navigation functions and capabilities essential to aircraft eligibility for the PBN operations covered by this AC. This chapter also includes the following:

- General guidance for pilot use of the aircraft's navigation system and its controls and displays in support of PBN operations,
- General operational considerations for pilots when conducting PBN operations, and
- Pilot knowledge, education, and training applicable to PBN operations.

3.1.1 Specific guidance for an Area Navigation (RNAV) or Required Navigation Performance (RNP) operation is in the chapter of this AC covering each PBN operation (see Chapters 4 through 12). All operators and pilots should become familiar with the information in this chapter before proceeding on to the chapters dealing with specific PBN operations (e.g., RNAV routes, RNP 1, etc.). Operators creating PBN training programs for their organization should ensure their programs address the content of this chapter.

3.2 Aircraft Eligibility Overview. Before flying any PBN route or procedure in the National Airspace System (NAS), or indicating on their flight plans a capability to fly a PBN route or procedure, all operators must verify that their aircraft are eligible to perform the planned PBN operations. Operators who are unable to verify their aircraft's eligibility for PBN operations should contact the aircraft Original Equipment Manufacturer (OEM), type certificate (TC) holder, Supplemental Type Certificate (STC) holder, the avionics manufacturer, or the FAA's Flight Standards Service (FS) or Aircraft Certification Service (AIR) office for assistance. For complete, detailed airworthiness guidance supporting an aircraft's eligibility for PBN operations, refer to AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems. Nothing in this AC supersedes the airworthiness criteria in AC 20-138( ).

3.2.1 Statement of Compliance (SOC). The most straightforward way an operator or a pilot may determine aircraft eligibility for a specific PBN operation is through a review of a SOC from the OEM. The OEM may issue a SOC in an Airplane Flight Manual (AFM) or Rotorcraft Flight Manual (RFM), AFM/RFM Supplement (AFMS/RFMS), pilot's operating handbook (POH), FAA-approved flight manual supporting an STC's avionics installation (including limitations in an approved model list (AML)), or similar approved documents.

3.2.2 SOC Format. While operators should be aware there is currently no standard format for an OEM SOC, AIR and FS encourage the use of a simple SOC format (such as a table) to ease operator understanding of equipment capability. Operators should thoroughly read the OEM documents to understand the installed system's capability. Formal, controlled documents, like an AFM, may attest to FAA airworthiness approval and the approved or alternate means of compliance for specific PBN operations through a variety of means.

Typically, a manufacturer's SOC will identify the specific PBN operations the aircraft supports (i.e., "RNP 4 en route operations" or "RNP APCH operations to LPV minimums"), but other formats like charts or diagrams are also used.

3.2.3 How to Obtain a SOC. If the aircraft's documentation does not contain a SOC for the desired PBN operations, an operator should request and obtain a SOC from the entity holding the type design approval for the aircraft. Typically, this authority rests with the aircraft OEM holding the aircraft's TC. However, the authority to make a SOC may rest with an alternative source, such as the holder of a STC supporting installation of PBN-capable avionics or another responsible party (e.g., an FAA-approved avionics installation facility that completed an aircraft modification).

3.2.4 Statement from the Manufacturer. Operators and pilots of aircraft with a formal statement from the aircraft manufacturer or STC holder (i.e., in an RNP Capability Document, airworthiness compliance document, Service Bulletin (SB), or another form of formal communication) documenting compliance with AC 20-138( ) for specific PBN operations may assume the aircraft is operationally eligible for those specific PBN operations. Equipment capability statements from an avionics OEM that do not address performance as installed in a specific aircraft are insufficient. Further, informal communications, such as an email message, are not sufficient. The manufacturer may choose to communicate eligibility through a SOC on their website. When using their website to declare a SOC, the manufacturer should include details on when they gained an airworthiness approval for PBN operations. Since operators are responsible to the FAA for confirming aircraft eligibility for PBN operations, they should consult with their FS office if they have any doubt or questions about the adequacy of manufacturer SOCs.

3.2.5 Documentation OEMs Should Provide to Operators. Operators may need to provide relevant documentation to the FAA to establish that their aircraft is eligible for PBN operations. Accordingly, AIR recommends that aircraft or avionics OEMs provide a SOC that conforms to the guidance in AC 20-138( ) and include:

1. A description of the aircraft and avionics configuration achieving eligibility for a specific navigation specification (NavSpec) (e.g., eligibility for RNP Approach (RNP APCH) NavSpec for an "RNAV (GPS)" or "GPS-based" approach procedure), including hardware modification level and software version(s);
2. Any recommended standard operating procedures (SOP) or checklists the pilot should use when conducting a specific PBN operation;
3. Any other functional capability or equipment the aircraft requires to be eligible for a specific NavSpec (e.g., "optional" add-on settings for the avionics software or navigation database);
4. Confirmation of requirements for additional operational approval when the navigation operation requires specific authorization (e.g., "This eligibility does not constitute an operational approval");

5. Any required operational mitigations when the aircraft does not directly support a specific NavSpec (e.g., a requirement for the pilot to manually set the RNP value when the aircraft lacks scalable RNP);
6. Any recommended maintenance procedures or instructions for continued airworthiness (ICA) to ensure the aircraft remains eligible for PBN operations (e.g., a schedule and means to update the aircraft's magnetic variation tables, software version, or navigation database);
7. A description of the pilot's requirements to use the aircraft's monitoring and alerting annunciations and displays in support of specific NavSpecs (e.g., recommended SOP or flight manual procedure for reaction to an "UNABLE RNP" or "Loss of Integrity" alert during an RNP operation);
8. The means to control the aircraft during any specific PBN operation (e.g., a requirement to conduct the operation with the aircraft's autopilot (AP) coupled to the lateral guidance from the RNP system, when applicable); and
9. Normal and abnormal pilot operating procedures for specific PBN operations (e.g., the means by which a pilot may abandon an RNP APCH operation in response to an alert or excessive deviation from path).

3.2.6 Eligibility Not Based on the Flight Manual or Supplement (Special Approval). The operator may not be able to determine eligibility from the flight manual or other FAA-approved documentation. In such a case, operators flying under parts 91K, 121, 125, 129, and 135 should request the responsible Flight Standards office make this eligibility assessment. The operator should provide their principal inspectors (PI) with the RNP system's make, model, and part number, any evidence of instrument flight rules (IFR) navigation system approval, and pertinent information from pilot operating procedures. If the inspectors are unable to verify eligibility, they will consult with the Flight Technologies and Procedures Division's Flight Operations Group, the Aircraft Evaluation Group (AEG), and AIR, as needed, to ensure the aircraft and RNP system meet the criteria for the various NavSpecs. Further, a determination should be made for Satellite-based Augmentation System (SBAS) and/or barometric vertical navigation (baro-VNAV) capability, as applicable, that the system can safely fly specified vertical navigation (VNAV) paths associated with instrument approach procedures (IAP) applying a decision altitude (DA) rather than a minimum descent altitude (MDA). In all cases, the approved evaluations will provide written documentation (i.e., amended Flight Standardization Board Report (FSBR) or other official documentation) to verify the eligibility of that aircraft installation.

3.2.6.1 FAA Approval Process for Part 91 Operators. If the FAA determines that the navigation system is eligible, the responsible Flight Standards office will provide documentation approving the system's eligibility for NavSpecs for use in en route, terminal, or approach operations, to include the appropriate lines of minima (including for SBAS (wide area augmentation system (WAAS)) or baro-VNAV RNP APCH operations to a published DA, if authorized).

3.2.6.2 FAA Approval Process for Parts 91K, 121, 125, 129, 133, and 135 Operators. The FAA will attempt to establish system eligibility and ensure the operator's training and operations manuals contain adequate operating policies (such as those in this AC). Once these steps are successfully completed, the operator may begin using the system for the eligible NavSpecs to fly en route or terminal operations requiring the NavSpec, including approach operations to specified lines of minima (e.g., SBAS (WAAS) or baro-VNAV RNP APCH operations to a published DA, if authorized).

3.2.7 RNAV Visual Flight Procedures (RVFP). An RVFP is an FAA-accepted, special, charted, visual flight maneuver (depicting a specific flightpath with recommended altitudes) that is contained in the aircraft's database and provides the pilot with lateral and vertical guidance, typically to a runway not served by an IAP. RVFPs are not IAPs and are flown only under a procedure-specific visual approach clearance. All operators, including part 91 operators, must have the appropriate operations specifications (OpSpec)/management specifications (MSpec)/Letter of Authorization (LOA) to accept an RVFP clearance and conduct RVFP operations. Refer to FAA Order 8260.60, Special Procedures, for more information on RVFPs.

3.2.8 Special Use—Not for Navigation. A special approval category for Global Navigation Satellite System (GNSS) equipment is "Special Use—Not for Navigation." Systems that are installed for special use (e.g., agriculture, aerial attack and firefighting, search and rescue, etc.) that will not be used for aircraft positioning or navigation under IFR can be approved on a non-interference basis using less strict airworthiness approval methods.

3.2.8.1 Field Approvals for Special-Use Equipment. Field approvals are normally acceptable for special-use GNSS mission equipment. Inspectors should ensure that the flight evaluation includes maneuvers that will normally take place while the GNSS equipment is in use and the equipment does not interfere with any required systems on the aircraft. AC 20-168( ), Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems & Equipment (CS&E), and AC 20-169( ), Guidance for Certification of Military and Special Mission Modifications and Equipment for Commercial Derivative Aircraft (CDA), provide additional guidance on miscellaneous, non-required equipment installations.

3.3 Navigation Database.

3.3.1 Database Suppliers. For PBN operations, all operators need to ensure their aircraft is equipped with a navigation database obtained from a navigation database supplier holding an FAA-issued Type 2 Letter of Acceptance in accordance with AC 20-153( ), Acceptance of Aeronautical Data Processes and Associated Databases. Type 2 Letters of Acceptance ensure compatibility of the database with the aircraft's installed navigation system. Operators need not possess a copy of the supplier's Letter of Acceptance, but it is reasonable to expect suppliers to "document" holding the Letter of Acceptance on their website or similar public medium.

3.3.2 Database Currency. Aeronautical Information Regulation and Control (AIRAC) information updates every 28 days, and always on a Thursday. During system initialization in preparation for IFR flight, pilots are to confirm the aircraft's navigation database is current and valid for the duration of the flight. If the AIRAC cycle changes during flight, aircraft that carry two database products may automatically load the new, current database on the changeover date and time. Other aircraft may necessitate that the pilot select the new database product. When this feature is not available, it will be necessary for operators and pilots to establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the routes and procedures for flight. The operator may accomplish this by verifying electronic data for each procedure or route with current published charts. Once the flight is complete, the operator should load a current database for subsequent IFR flight.

3.3.3 Operator Database Management. Commercial operators (i.e., those flying under parts 91K, 121, 125, 129, and 135) should establish a database management program (refer to AC 20-153) that:

1. Identifies within their procedures the responsible manager or position for the navigation database updating process;
2. Documents a process for accepting, verifying, and installing a navigation database, including periodic and ad hoc database updates; and
3. Places the documentation supporting their database management processes under configuration control.

Note 1: The importance of aircraft flying IFR with a current navigation database cannot be overstated; hence, the FAA's recommendation that commercial operators have in place a formal process for database management, to include installation of updates in their aircraft. Operators should keep their written procedures current and known to pilots and maintenance personnel.

Note 2: For the PBN operations addressed in this AC, "verification" of the database refers to the process by which the operator confirms the database received is applicable to the operator's aircraft, and for the correct database AIRAC cycle.

Note 3: The aircraft and avionics OEMs work with the providers of the aircraft's navigation database to ensure the database does not contain, or permit selection of, routes or procedures the aircraft is not eligible to use. However, this process is not foolproof, and operators or pilots should report any discrepancies to their database provider.

3.3.4 Path Terminators. The operator or pilot cannot direct a navigation database supplier to alter or substitute the path terminators specified for a PBN route or procedure in the original State Aeronautical Information Publication (AIP) data. Altering the content of the navigation database by substituting one type of path terminator for another may

compromise the aircraft's ability to comply with a PBN route or procedure and therefore affect the safety of the operation.

3.4 Performance Monitoring and Alerting. The aircraft's onboard performance monitoring and alerting characteristics distinguish an RNP system from an RNAV system. RNAV systems usually offer no monitoring or alerting for the pilot during RNAV operations. In contrast, during an RNP operation, the aircraft's RNP system, or the RNP system in combination with pilot monitoring (e.g., the pilot's instrument cross-check of lateral and vertical deviation), can ensure that:

1. The aircraft performance meets the requirements for the RNP route or procedure; and
2. The probability of the aircraft's Total System Error (TSE), expressed in nautical miles (NM), exceeding two times the RNP value (2×RNP) with an undetected error during the operation, is less than one in 100,000 (1×10^{-5}) and supports the operation's intended target level of safety.

Note: This TSE performance requirement is the foundation for the aircraft's airworthiness eligibility for RNP operations. When the pilot operates the aircraft in compliance with the flight manual during an RNP operation, the aircraft and the pilot can achieve the performance an RNP operation requires.

3.5 Airworthiness Demonstrations. Airworthiness demonstrations of compliance with the criteria of AC 20-138( ) do not constitute operational approval to conduct PBN operations. Operators and pilots should ensure they comply with the specific operational approval basis for each PBN operation.

3.5.1 Radius to Fix (RF) Eligibility. RF turns may only be used with RNP NavSpecs during terminal area operations (arrival, departure, or instrument approach). RF is not used in the en route flight phase. Operational eligibility to conduct RNP procedures with RF segments should be clearly documented in the flight manual. RF capability is mandatory for Advanced Required Navigation Performance (A-RNP) or Required Navigation Performance Authorization Required (RNP AR) operations. If the flight manual does not include the appropriate SOCs, the minimum requirements for RF eligibility include:

1. A flight director (FD) or an autopilot (AP) capable of coupling to the RNP system's lateral guidance output;
2. An electronic navigation display in the pilot's primary field of view (FOV) capable of displaying the aircraft's position relative to the RNP system's desired path, including display of any RF segments;
3. The operator's procedures requiring the pilot to couple the FD and/or AP to the RNP system's lateral guidance output when conducting any RNP procedure with RF segments when the RNP value is less than 1 NM ("RNP < 1.00"); and
4. RNP systems with approved RF capability may fly published RF segments during RNP APCH, RNP 0.3 (helicopter), and RNP 1 operations as documented in the flight manual. RF eligibility is mandatory for A-RNP operations.

Note: The use of AP or FD is required to execute RF transitions with RNP values less than 1.00. Certain exceptions exist for 14 CFR part 23, Levels 1, 2, and 3 aircraft, for which no type rating is required, and that are performing RNP 1 or RNP APCH operations at speeds of 200 knots or less. These aircraft should be equipped with an appropriately scaled course deviation indicator (CDI) and a navigation display depicting the curved path.

3.5.1.1 Operators of aircraft with no SOC in the flight manual should follow guidance in paragraph 3.2.6 to obtain suitable documentation to confirm RF eligibility.

3.6 Operator Guidance. The following foundational operating guidance applies to the performance of all PBN operations this AC covers.

3.6.1 Aircraft Minimum Equipment List (MEL). The FAA must approve any MEL revisions necessary to address aircraft eligibility for PBN operations (refer to part 91, § 91.213).

3.6.1.1 Required Dispatch Conditions for PBN Operations Versus the MEL. If an approval for a specific PBN operation requires the operator ensure certain equipment or capability be available to begin that operation, the operator should modify their dispatch procedures to ensure that equipment or capability is available for the intended operation.

Note: The operator should not confuse a list of required equipment needed for a PBN operation with the aircraft's formal MEL (refer to § 91.213). When the aircraft's equipment does not meet the specific minimum list for a PBN operation, the aircraft simply does not meet the performance requirements to conduct that PBN operation. The basic operation of the aircraft remains safe.

3.6.2 PBN Replication of Conventional Procedures. Modern RNAV and RNP systems often contain PBN-coded representations of routes and procedures designed for use with conventional navigation aids (e.g., a route or procedure design based on very high frequency (VHF) omni-directional range (VOR) courses or radials and distance measuring equipment (DME) fixes). Some navigation systems may also provide an automated means to auto-tune ground-based navigation aids and make procedural course changes. Further, many systems can seamlessly provide guidance to join conventional and PBN routes and procedures. These capabilities exist to assist the pilot with the fundamental responsibility to adhere to their IFR clearance routing. Because the path terminators used in procedure coding for navigation databases attempt to replicate the conventional procedure's path referenced to a ground-based Navigational Aid (NAVAID), the resulting navigation guidance only approximates the charted flightpath. Even when using the convenience of the navigation system, it remains the pilot's responsibility to adhere to the clearance. This may require the pilot to simultaneously display the lateral guidance from the navigation system and the lateral guidance from the conventional, ground-based NAVAID. See Chapter 11 for more guidance on use of the aircraft's RNAV or RNP system as a substitute or alternate to the ground-based navigation aid.

Note: It is critical that pilots carefully monitor their flightpath when using RNAV or RNP systems as an alternate or substitute means of navigation on conventional routes and procedures. RNAV and RNP systems are not verified against a standard for their performance in this role and may not fly the same path evaluated for obstacles as the path designated by the ground-based navigation aid signal.

3.6.3 Fly Only Authorized Routes and Procedures. Operators and pilots should ensure they only request and execute PBN routes or procedures they and their aircraft are eligible to use. This includes the responsibility of the pilot to ensure they are eligible for the PBN route or procedure they select and extract from the aircraft's navigation database before executing the route or procedure. During any PBN operation, if air traffic control (ATC) issues a clearance to fly a route/procedure the pilot or the aircraft is not eligible to use, pilots should inform ATC they are unable to accept that clearance and request an alternate clearance.

3.6.4 Flight Plan Equipment Suffix and PBN Capability Codes. When filing an IFR flight plan intending to conduct PBN operations, operators and pilots should ensure the flight plan coding (depicted in the Aeronautical Information Manual (AIM), or as updated on the FAA Flight Plan Filing website at https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/air_traffic_services/flight_plan_filing) reflects the correct PBN eligibility of the aircraft.

3.6.5 Use of DME as a Navigation Sensor. The FAA publishes PBN routes and procedures for use by eligible aircraft including aircraft using DME/DME (D/D), DME/DME/Inertial (D/D/I), or Global Positioning System (GPS) positioning. Operators and pilots should check the PBN route and procedure chart notes, annotations, and the U.S. AIP to confirm the operation supports use of D/D or D/D/I positioning. A PBN Requirements Box entry (see paragraph 3.6.9) permitting use of D/D or D/D/I positioning sensors confirms sufficient DME facility availability along the RNAV procedural path. Operators and pilots intending to use D/D or D/D/I RNAV positioning on RNAV routes or procedures must check Notices to Air Missions (NOTAM) to verify the status of any published critical DMEs (e.g., on RNAV departure or arrival procedures). Sole use of D/D or D/D/I positioning is not authorized to initiate any IAP.

Note 1: Some aircraft include flight manual limitations that prohibit use of DME/DME for RNAV operations under IFR. Pilots should adhere to flight manual limitations for their aircraft's navigation capability.

Note 2: Some aircraft with multisensor RNP systems include airworthiness approval for DME navigation and can support RNAV and RNP operations. AC 20-138( ) contains detailed and complete airworthiness guidance for aircraft eligibility using DME sensor(s), with or without integrating an inertial navigation system(s) (INS), in support of PBN operations.

3.6.6 Complex PBN Procedures. PBN arrival, departure, and approach procedures may contain multiple transitions. The aircraft and its navigation system may not be eligible to use

every transition. For example, an aircraft may not be eligible for an A-RNP segment applying a lateral navigation (LNAV) accuracy (RNP value) of RNP 0.30 with an RF turn, but eligible for other transitions on the same procedure. Typically, the database provider will attempt to screen and remove transitions (or entire procedures) that the aircraft cannot support. However, this process is not foolproof, may not be practical for all approved database types, and most importantly, does not guarantee a pilot can fly any procedure or transition that appears in the aircraft database. Ultimately, the operator and pilot remain responsible for determining their eligibility for any PBN procedural transition ATC assigns. If ATC assigns a PBN procedure, transition, or segment that either the pilot or the aircraft is not eligible to use, the pilot should refuse the clearance and request an alternate clearance.

Note: When a pilot discovers a selectable PBN procedure, transition, or segment in the navigation database that the aircraft is ineligible to use, the pilot should identify the discrepancy to the database provider.

3.6.7 Use Current Navigation Database. The navigation database needs to be current during the intended PBN operation, and pilots should ensure that the database contains the route and terminal airspace procedures they intend to complete during the flight prior to departure. If the AIRAC cycle will change during a flight, operators and pilots should ensure, before conducting the flight that the intended routes and procedures did not change with the AIRAC cycle. These procedures should include a review of the State's AIPs and published amendments to confirm whether any changes or updates alter the planned, desired, or expected routes or procedures. These operator procedures should also compare the aircraft's loaded navigation database content against the new paper charts or Electronic Flight Bag (EFB) content. This can help the pilot confirm whether any of the amendments affect the actual route and procedural path compliance.

3.6.7.1 Compare the New Versus Current Aeronautical Charts. One acceptable means to conduct this process is to compare the new charts against the expiring aeronautical charts to verify navigation fixes, courses, and route/procedural constraints (e.g., procedural barometric altitudes and airspeed constraints) prior to departure. If the new, amended charts contain any new data for the intended route or procedure affecting the definition of the route or procedural path, then the pilot should treat this situation as if the loaded navigation database lacks the new route or procedure. Pilots should plan to use other, unchanged routes or procedures available in the loaded onboard navigation database.

3.6.7.2 Procedure Amendment Effective Date. On U.S. IAPs only, pilots may use the chart's "Procedure Amendment Effective Date" 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 expiration date, pilots are not to fly the procedure using the out-of-date database.

3.6.7.3 Check Currency of Onboard Navigation Database and Verify Present Position (When Applicable). After applying power to the aircraft's

navigation system during preflight, pilots should confirm that the navigation database is current and contains the planned routes and procedures. After loading the navigation system's flight plan, pilots should verify that the displayed aircraft "present position" represents the correct current position.

3.6.7.4 **Extract Procedures by Name.** To support the concept that a pilot should see, hear, and read matching procedure names (what a pilot hears on the radio from ATC, what they see on the RNP system selection menus, and what they read on the procedure chart should all match), pilots should extract PBN procedures by name from the onboard navigation database and ensure the extracted procedures match the charted procedures.

3.6.7.4.1 Due to equipment variability and changes to naming conventions over time, the name used in the onboard equipment and the NAVAID symbols shown on the flight displays may not exactly match the charted procedure. Refer to manufacturer's documentation on correlating charted procedure names with equipment naming and flight display conventions.

3.6.7.4.2 Pilots are also cautioned that some procedures, even if extracted by name from the database, may not contain every segment, turn point, or conditional waypoint, or may contain "computer navigation fixes (CNF)" not shown on the procedure. It is always the pilot's responsibility to ensure that the aircraft's flightpath conforms to the ATC clearance.

3.6.7.5 **Extract PBN Routes in Their Entirety.** Pilots should extract the PBN routes from the navigation database rather than loading the route by stringing individual fixes defining the route in sequence.

3.6.7.5.1 Pilots operating a legacy RNAV or GPS navigation system that cannot auto-load a PBN route may manually load a PBN route fix-by-fix. This is done by extracting the individual, defined fixes defining the route from the onboard navigation database. When this is necessary, pilots should verify that the resulting flight plan route entries match the charted routes before executing the flight plan.

3.6.7.6 **Unusable Route Segments.** Routes or route segments designated as "unusable" by chart notation or NOTAM are unusable by any user. Pilots should not file for, and ATC should not use, the unusable route's title or name in the IFR clearance. This does not preclude the use of unusable routes' waypoints in a "direct to" or "random RNAV" route clearance.

3.6.7.7 **Prohibition on Creating or Altering Published Waypoints.** For any published (i.e., charted) PBN routes or procedures, pilots may only use waypoints downloaded from the aircraft navigation database. Pilots may not manually create waypoints defining a published PBN route or procedure (e.g., by using latitude/longitude coordinates, place/bearing, or any other means). Pilots also may not change any parameters of waypoints downloaded

from the navigation database (e.g., changing a flyover waypoint to a flyby waypoint).

Note: Onboard navigation databases with an FAA Letter of Acceptance in accordance with AC 20-153( ) do not provide a means for a pilot to modify the content of the onboard navigation database.

3.6.7.7.1 Pilots may file flight plans based on a random RNAV route through use of published fixes, latitude/longitude coordinates, place/bearing, or any other means consistent with the State's AIP requirements and their aircraft's RNAV performance capabilities and limitations.

3.6.7.8 **Cross-Check Flight Plan with ATC Clearance.** Pilots must cross-check the routes and procedures extracted from the aircraft's onboard navigation database in the navigation system's flight plan against current aeronautical charts to ensure compliance with their ATC clearance (refer to part 91, § 91.123). Both the flight plan's textual display and the aircraft's navigation display (when available) can aid in this cross-check. If at any time during this cross-check a pilot doubts the validity of the route or procedure in the navigation system flight plan, the pilot should not attempt to execute the route or procedure.

3.6.7.8.1 Pilots may notice a slight difference between the RNAV or RNP track portrayed on the chart versus the representation of the track on the primary flight and navigation displays. A variation of up to 3 degrees between charted track and navigation system displayed track on the route or procedure is acceptable.

3.6.8 Confirming Aircraft Eligibility to Perform a Route or Procedure. When confirming that the PBN route or procedure from the aircraft's onboard navigation database matches the charted route or procedure, the pilot should also confirm the route or procedure is consistent with the eligibility of the aircraft and its navigation system. For example, if the pilot selects an approach procedure that contains only a Localizer Performance (LP) line of minima, and the aircraft is not eligible to use RNP APCH procedures to LP minima, then the pilot should delete the approach from the RNP system's flight plan and select another suitable approach.

Note: When a pilot discovers a PBN route or procedure in the navigation database that the aircraft is ineligible to use, the pilot should identify the discrepancy to the database provider.

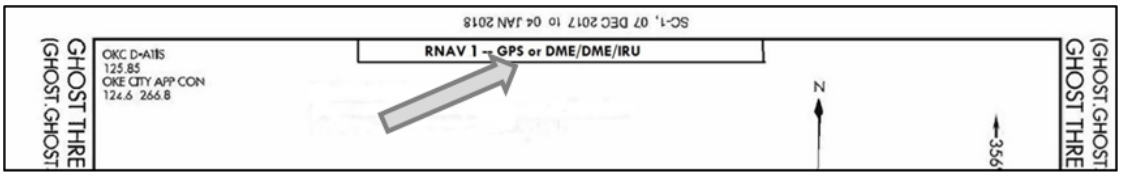
3.6.9 PBN Requirements and Capabilities. In the United States, any procedure with a PBN segment will prominently display the RNAV or RNP requirements in a separate PBN Requirements Box. These include: the NavSpec(s); any specific sensors or infrastructure required for the navigation solution; any optional or functional requirements not included in the core NavSpec; minimum RNP value for any segment (if required); and any

necessary plain language remarks. The format for the "PBN Requirements Box" is standardized as:

[NAVSPEC – SENSOR(s), FUNCTION(s), Min RNP x, Remarks]

3.6.9.1 Since all the elements listed in this PBN Requirements Box are required, the word "required" will not normally be published in the PBN Requirements Box. In Figure 3-1, PBN Requirements Box Example on STAR, the PBN Requirements Box lists "RNAV 1 – GPS or DME/DME/IRU" on an RNAV Standard Terminal Arrival (STAR). The pilot should interpret this to mean the aircraft and pilot must be eligible for RNAV 1 operations, and the avionics must be capable of using GPS and/or D/D/I sensors to maintain RNAV 1 performance for the arrival. It also means that the route has been assessed for D/D coverage, and since the Inertial Reference Unit (IRU) or GPS is listed as required, D/D navigation alone is insufficient to maintain the navigation accuracy required by ATC on the procedure. A "RADAR Required" annotation denotes ATC's use of surveillance as an additional safety measure for aircraft not using GPS.

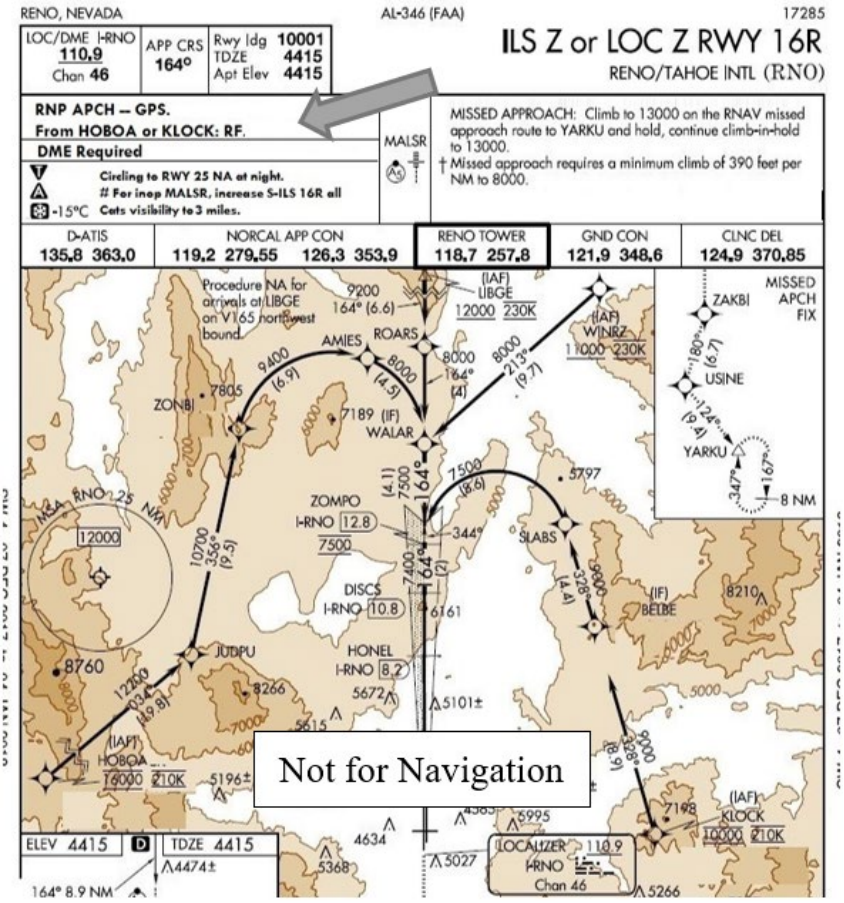
Figure 3-1. PBN Requirements Box Example on STAR



3.6.10 RNP to xLS Operations. Figure 3-2, PBN Requirements Box on "RNP to xLS" Instrument Approach, shows a charted instrument landing system (ILS) final approach course with four PBN initial approach fixes (IAF): WINRZ, LIBGE, HOBOA, and KLOCK. Since there is no "RADAR Required" placard, the only navigation method to the final approach course is via one of these PBN tracks. HOBOA and KLOCK require RF turns and have plan view speed restrictions of 210 knots, while WINRZ and LIBGE require only Track to Fix (TF) turns. All four waypoints are IAFs and will be recallable from the RNP system's database. This is an RNP APCH NavSpec application of PBN to an ILS final approach course, or an "RNP to xLS" operation. The PBN Requirements Box reads: "RNP APCH – GPS. From HOBOA or KLOCK: RF." This indicates to the pilot that RNP APCH eligible avionics, using GPS as the navigation source, are required to begin the approach from any of the four IAFs. To choose HOBOA or KLOCK as the IAF, the aircraft must be RF turn eligible and, from the plan view notes at HOBOA and KLOCK, the pilot must fly 210 knots indicated airspeed (KIAS) or slower for Terminal Instrument Procedures (TERPS) obstacle avoidance and flightpath compliance in the RF turn. The pilot of a non-RF capable aircraft should be unable to select HOBOA or KLOCK as IAFs from the RNP system's database when loading the approach. Some database providers will disable or remove selection of ineligible segments of the approach, or alternatively will disable/remove the entire procedure from the database for aircraft ineligible to fly the PBN segment. To complete the approach, the pilot would

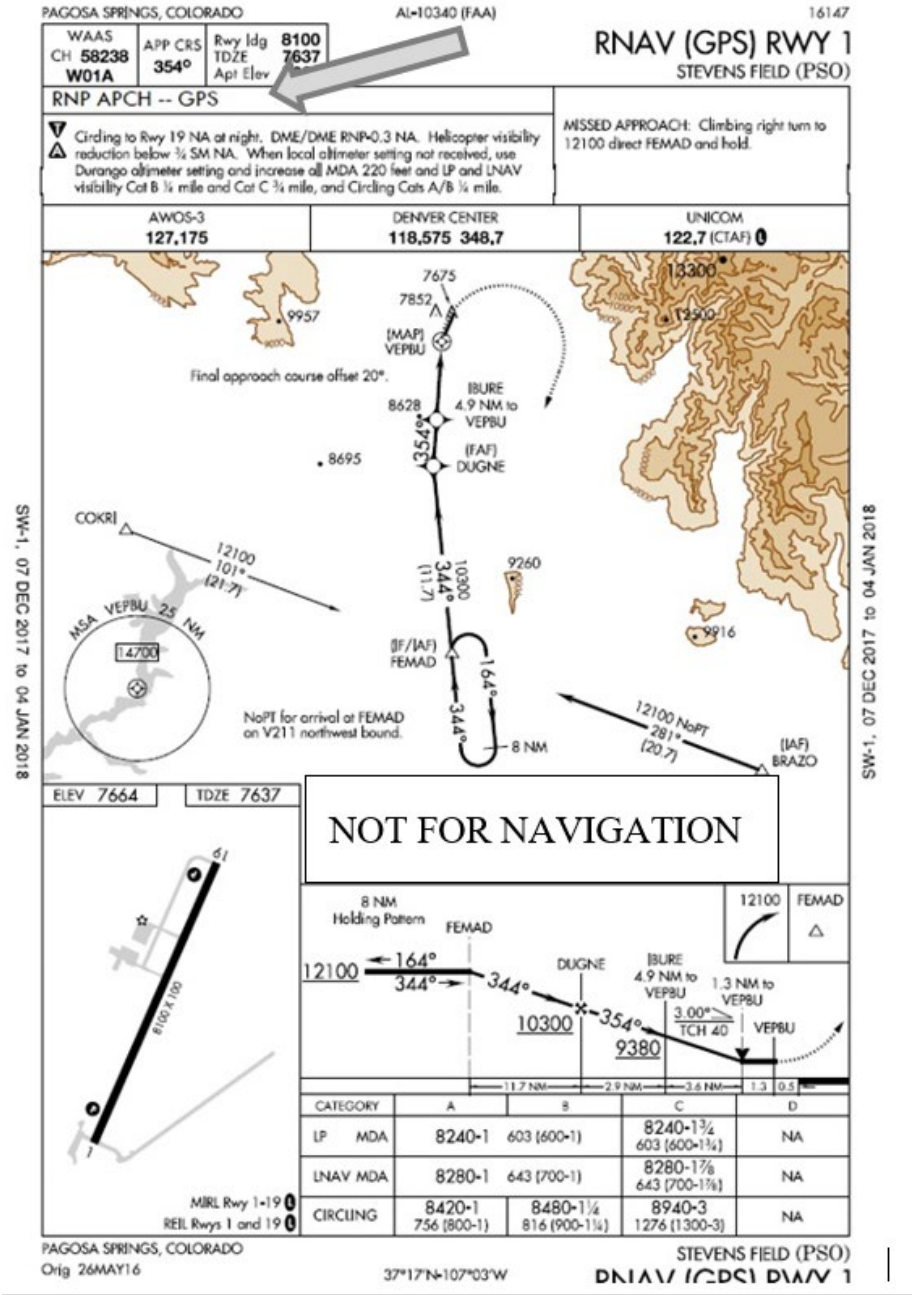
switch to ILS navigation once established on final approach course inside the ILS service volume (e.g., ZOMPO fix).

Figure 3-2. PBN Requirements Box on "RNP to xLS" Instrument Approach



3.6.11 SBAS (WAAS)-Enabled PBN Instrument Approach. In Figure 3-3, RNAV (GPS) Instrument Approach PBN Requirements Box, a WAAS-enabled PBN instrument approach titled "RNAV (GPS) RWY 1," shows a PBN Requirements Box containing the NavSpec RNP APCH and mandatory sensor GPS. From the PBN Requirements Box, the pilot sees that an RNP APCH eligible RNP system is required along with GPS availability to begin the approach. If the pilot chooses to fly to the LP line of minima, then WAAS must also be available—the RNP system will annunciate the level of service (LP or LNAV) no later than 2 NM from the final approach fix (FAF) in this case.

Figure 3-3. RNAV (GPS) Instrument Approach PBN Requirements Box



Note: PBN Requirements Boxes are being added onto procedures as they are developed and amended based on the procedure's biannual review. Often the PBN Requirements Box information will be combined with other chart notes until all procedures are amended. More information on the PBN Requirements Box can be found in the AIM and in the Terminal Procedures Publication (TPP) legend.

3.6.12 Check Lateral Deviation and Appropriate Scaling. For RNP operations, pilots should ensure the aircraft's navigation system, FD, and AP are in the appropriate LNAV mode consistent with the aircraft's PBN eligibility. When conducting these operations, the pilot

should ensure the lateral deviation scaling is consistent with any recommendations from the aircraft and/or avionics manufacturer. If the pilot must manually set the deviation scaling, manufacturers or operators should provide pilots with procedures to do so.

3.6.13 Verify Lateral Deviation Scaling During PBN En Route Operations. For en route operations, pilots should ensure the lateral deviation scaling settings or system default settings and annunciations support the route's PBN requirements. Pilots should know how to monitor lateral deviation given the aircraft's automatic or default deviation scaling to comply with the performance required of the operation (e.g., maintain flight technical error within one-half the RNAV accuracy the route requires).

Note 1: Some aircraft navigation systems use default accuracy values by phase of flight. Typically, these systems switch between Terminal and En Route phases of flight when 30 NM from the departing/arriving airport reference point. For many of these system installations, the en route default deviation scaling is set to 5 NM. This is acceptable when the pilot actively monitors deviation from centerline (CL) in accordance with the route's required accuracy (e.g., 2 NM for a RNAV 2 Q-route).

Note 2: Aircraft with scalable RNP capability automatically set the deviation scaling based on the RNAV value or the RNP value the route or procedure requires.

3.6.14 Routine Cross-Check of Navigation. Pilots should make use of all available resources to routinely cross-check their navigation to help identify any navigation errors in sufficient time to prevent deviations from their ATC clearance. This cross-check can be as simple as ensuring the aircraft's heading is consistent with desired path and wind conditions, while also ensuring the aircraft will meet any required estimated time of arrival (ETA) along the flightpath. Operators should establish cross-check SOP to include verification of position and next waypoint, time-and-distance checks, fuel remaining, etc.

3.6.15 Verify ATC Clearances. Some revised ATC clearances, like a revised airspeed constraint, can degrade the ability of the aircraft to stay within the design assumptions of the PBN route or procedure. Pilots should always use discretion when accepting ATC clearances that modify PBN routes or procedures. Specifically, pilots should:

1. Verify proper entry of their clearance upon initial receipt and upon any subsequent change of the clearance, before executing the PBN operation;
2. Ensure the waypoint sequence depicted by their navigation system matches the charted route or procedure and corresponds to their ATC clearance before executing the PBN route or procedure; and
3. Confirm the reasonableness of track angles and distances, courses, segment types, procedural barometric altitudes, airspeed constraints, and any other parameters available on the navigations system's flight plan display. If the pilot alters any attribute in the loaded flight plan in response to an acceptable, revised ATC clearance (e.g., a revision to a barometric altitude constraint at a fix or a new airspeed

constraint), the pilot should verify accurate entry of the new, revised ATC clearance before executing the revised segments of the PBN route or procedure.

3.6.16 Pre-Departure Cross-Check of Aircraft Position With Navigation Displays. Prior to takeoff, pilots of aircraft with a navigation map display depicting the aircraft's position should select a map scale to enable verification of the aircraft's position relative to their assigned takeoff runway. The pilot should also verify the map displays the intended PBN procedure and route. The map display should be consistent with any external visual cues as well as chart depiction of the procedure and route. During flight, the pilot should use the map displays in concert with textual displays to maintain position and situation awareness and to verify the path of the aircraft matches the intended route or procedure.

3.6.17 Maintain CL. In accordance with § 91.181, pilots must always maintain the CLs of PBN routes or procedures. Pilots should limit lateral deviation from the flightpath to no more than one-half of the navigation accuracy required of the PBN route or procedure while maintaining CL. A pilot's failure to maintain path CL may lead to a gross navigation error, violate their ATC clearance, and may compromise safe separation from other aircraft, terrain, and obstacles.

Note: When using Strategic Lateral Offset Procedures (SLOP) in oceanic airspace to establish offset flightpaths, the CL guidance is for the offset flightpath.

3.6.17.1 Aircraft Without Continuous Display or Computation of Flight Guidance to Path (During a Turn). Some aircraft navigation systems do not display or compute continuous flight guidance to path CL during flyby turns at a waypoint. When these aircraft begin a turn, the deviation display or CDI may depict full-scale deviation as the aircraft's LNAV guidance transitions to the new track (i.e., the next segment of the route or procedure). This is an acceptable system display; however, pilots need to ensure, whether through manual or automatic means, the aircraft rejoins the route or procedure CL without delay.

3.6.17.2 Turning Performance. As the aircraft completes a turn and the navigation system captures a new track, brief, small deviations from CL (e.g., overshoots or undershoots) can also occur, and these too are operationally acceptable. When this occurs, pilots should continue to ensure the aircraft expeditiously completes turns and does not prolong capture of a new track CL.

Note: If necessary when conducting AP-coupled operations, the pilot should manually intervene, disconnect coupled AP steering, and steer the aircraft to the track CL.

3.6.17.3 Manufacturer-Recommended Procedures. The pilot should also follow the aircraft manufacturer's recommended procedures for maintaining path CL and comply with the manufacturer's requirements and limitations for ensuring path compliance. For example, some manufacturers require the pilot to couple

the FD and/or AP to the flight guidance output of the RNP system when an RNP procedure contains RF segments.

3.6.18 Considerations When Vectored Off a PBN Route or Procedure. If ATC issues a radar vector or direct clearance taking the aircraft off a PBN route or procedure, the pilot should not modify the PBN route or procedure in the navigation system's flight plan until ATC issues a revised clearance.

Note: When the pilot complies with an ATC instruction and the aircraft is no longer on a published PBN route or procedure, the associated navigation accuracy, monitoring, and alerting requirements no longer operationally apply.

3.6.18.1 If in Doubt, Request a New Clearance. ATC may ask the pilot to rejoin the PBN route or procedure, but the pilot may refuse to rejoin the route or procedure when they are unsure of the ability to comply with the remainder of the route or procedure. If this occurs, the pilot should request a new clearance.

3.6.19 Avoid Bank-Limiting Functions. Pilots should not select a flight guidance system (FGS) bank-limiting function during PBN operations. Use of the bank-limiting function may compromise the aircraft's ability to maintain the desired track (DTK) and, in some instances, can result in an ATC violation for deviation from the path. This is especially true when use of a bank-limiting function results in the aircraft starting turns too early, outside the lateral protection of the PBN route or procedure design.

Note 1: Do not interpret avoiding bank-limiting functions as a requirement to deviate from flight manual limitations associated with flying the aircraft, especially during the en route phase of flight. Rather, pilots should limit the selection of a bank-limiting function within the aircraft's accepted operational limits and procedures. This includes complying with the aircraft manufacturer's recommended SOP for PBN routes and procedures, while adhering to aircraft performance limitations in the flight manual.

Note 2: A few aircraft include a bank-limiting function solely for passenger comfort, rather than for compliance with any aircraft aerodynamic limitations. Pilots of these aircraft should not use the bank-limiting function during PBN operations.

3.6.20 Use of Default RNP Values During RNP Operations. To enable eligibility for some RNP operations, many aircraft use default RNP values set for the aircraft's phase of flight. These default settings may change through a variety of means other than the general phase of flight, including through the coding of the aircraft's navigation database for the RNP routes and procedures the aircraft eligibility supports. Pilots should not modify the manufacturer's default RNP values unless the manufacturer requires the pilot to do so for a specific RNP operation. When there is a need to change an RNP value for a specific RNP operation, the operators' procedures should be consistent with any recommendations from the aircraft and/or avionics manufacturer.

Note: Many aircraft manufacturers allow the operator to select from a variety of "default RNP values." The operator should ensure they select default values that are consistent with the desired RNP operations and are in line with the pilot training and procedures provided for those operations.

3.6.21 Notify ATC of Any Loss of PBN Capability. If there is any loss of the aircraft's PBN capability in flight, pilots must notify ATC (§ 91.187). If unable to comply with the requirements of a PBN procedure, pilots are to advise ATC as soon as practical. The loss of PBN capability includes any alert, failure, or event resulting in the aircraft being unable to satisfy the performance requirements for the PBN procedure or route (e.g., an "UNABLE RNP" alert or loss of GPS).

3.6.22 Comply With Published Altitude Constraints. Pilots operating aircraft with approved vertical guidance for use during approach operations (i.e., VNAV through either baro-VNAV or SBAS) must comply with all procedural barometric altitude constraints by reference to the primary barometric altimeter. If following the VNAV vertical guidance will result in descending below a procedural altitude constraint at a fix before crossing the fix, the pilot must ignore the vertical guidance and manually control the descent to ensure compliance with the procedural barometric altitude constraint.

3.6.22.1 During the Final Approach Segment (FAS) only, pilots flying approved vertical guidance to localizer performance with vertical guidance (LPV) minima or LNAV/VNAV minima (through either baro-VNAV or SBAS) may ignore FAS step-down fix altitude constraints.

3.6.22.2 Pilots may apply the aircraft's automated temperature compensation function to gain relief from procedural temperature limitations and use approved baro-VNAV to LNAV/VNAV minima. See Appendix C, Operations in Nonstandard Temperature Conditions.

3.6.23 Maintenance Program. Parts 91K, 121, 125, 129, and 135 operators should have an approved maintenance program tailored for the intended RNAV and RNP operations.

3.7 Training.

3.7.1 Pilots conducting any of the PBN operations addressed in this AC should be knowledgeable on all the operating guidance presented in this chapter, in addition to that listed in the chapters or appendices applying to specific PBN operations (e.g., Chapter 12 covering RNP APCH specifications and Chapter 8 covering specifications for RNP 4).

3.7.2 In addition to that operating guidance, all PBN training plans, programs, syllabi, personal programs, etc., should cover the common training subject matter below. The FAA also recommends part 91 operators include PBN operations as part of their recurring instrument flying regimen. Those pilots should also include PBN operations as elements of the pilot proficiency check required by part 61, § 61.58 and/or the instrument proficiency check (IPC) required by § 61.57(d).

Note 1: Commercial operators do not require a distinct PBN training program when they integrate PBN training into their current approved training program. However, applicants for operational approvals should identify the PBN training elements from this AC within their existing training program.

Note 2: The FAA maintains and promotes a program that provides training courses on a variety of topics as a means to enhance safety. The Pilot Proficiency Program (WINGS) is based on the premise that pilots who maintain currency and proficiency will enjoy a safer and more stress-free flying experience. Pilots who complete a phase of WINGS may count the completion as a flight review. Refer to the FAA WINGS website at https://www.faasafety.gov/wings/pub/learn_more.aspx for more information.

3.7.3 Any pilot conducting PBN operations should be knowledgeable on the following PBN subject matter:

1. The meaning and proper use of applicable aircraft flight planning codes (e.g., coding used on FAA Form 7233-4, Pre-Flight Pilot Checklist and International Flight Plan) as described in the AIM.
2. The aircraft eligibility and capability that each PBN route or procedure may uniquely require (e.g., PBN Requirements Boxes or chart notes).
3. The unique characteristics of PBN procedures and routes as depicted graphically on charts and in textual descriptions. This information can include, but is not limited to, the depiction of waypoint types (flyover and flyby), required capability (e.g., GNSS, D/D/I), and ATC-pilot phraseology (e.g., "descend via").
4. When and how to obtain a receiver autonomous integrity monitoring (RAIM) prediction and/or a fault detection and exclusion (FDE) prediction.

   Note 1: Operators and pilots may use approved, third-party prediction services during U.S. PBN operations.

   Note 2: Pilots of aircraft equipped with SBAS need not perform an availability prediction for U.S. PBN operations, provided they check the availability of the U.S. WAAS for the geographic region in which they intend to operate by checking flight data center (FDC) NOTAMs for WAAS service outages.

5. The aircraft navigation system's capabilities, to include the means to couple the system to an FGS, navigation mode annunciations (including failure modes), changes, alerts, reversion capabilities, and any other information essential to the safe conduct of a PBN operation.
6. The operational conditions used to support PBN operations (e.g., appropriate selection of CDI scaling (lateral deviation display scaling)).
7. Navigation system functional integration with other aircraft systems.

8. The meaning and appropriateness of route discontinuities, as well as related pilot procedures.
9. Monitoring procedures for each phase of flight (e.g., monitoring the Progress (PROG) or LEGS pages of a multipurpose control and display unit (MCDU)).
10. The navigation sensors/sources the navigation system uses during PBN operations (e.g., GNSS, DME, IRU) to include the system's hierarchy of sensor selection, and any limitations as they relate to aircraft eligibility requirements for a given PBN operation.
11. Depiction of path terminators, associated aircraft flightpaths, altitude, and speed constraints on the navigations system's flight plan pages and on the map displays (when available).
12. Automatic and/or manual setting of the required RNP value.
13. The importance of maintaining the CL of the published path and observing maximum airspeeds while flying RNP procedures with RF segments.
14. Turn anticipation, with consideration to speed and altitude effects.
15. Interpretation of electronic displays and symbols, including display of conventional NAVAIDs as RNAV waypoints (e.g., VOR/DME, Tactical Air Navigation System (TACAN), and DME facilities).
16. How to verify currency of navigation data.
17. How to verify successful completion of navigation system self-tests.
18. How to initialize navigation system position.
19. How to retrieve and fly any authorized procedure or route covered by this AC.
20. Understanding speed and/or altitude constraints associated with a PBN procedure.
21. How to make a runway change associated with a PBN procedure.
22. How to verify waypoints and flight plan programming.
23. How to perform takeoff planning function updates due to change in runway assignment or takeoff point, including manual or automatic position updates.
24. How to fly direct to a waypoint, fly a course/track to a waypoint, intercept a course/track, or insert or delete a holding pattern.
25. How to rejoin a procedure following a vector taking the aircraft off the procedure.
26. How to determine cross-track (XTK) error/deviation.
27. How to insert and delete/clear route discontinuity.
28. How to deselect navigation sensor inputs, including DME facilities reported out of service via NOTAM.
29. How to insert and delete a lateral offset.
30. How to change the arrival airport and alternate airport.

31. Communications phraseology for PBN operations.
32. Requirements to couple the AP/FD to the navigation system's lateral guidance on applicable PBN procedures.
33. Operator-recommended levels of automation for phase of flight and workload, including methods to minimize XTK error to maintain procedure CL.
34. How to remove and reselect navigation sensor inputs consistent with the PBN route or procedure's requirements and the aircraft's eligibility.
35. How to confirm exclusion of a specific conventional NAVAID or type of conventional NAVAID (e.g., VOR) during a PBN operation.
36. How to conduct a parallel lateral offset path assigned by ATC through either manual or automated means during PBN operations.
37. How to verify the RNP value set in the RNP system to ensure a match with the aircraft eligibility and any operational authorization in support of any PBN operation, as communicated by the filed IFR flight plan codes.
38. Contingency procedures for any aircraft or system failures affecting the ability to continue and complete PBN routes or procedures.

CHAPTER 4. DEPARTURES, TERMINAL AIRSPACE, AND EN ROUTE USING RNAV 1 AND RNAV 2

4.1 Introduction. This chapter provides operational guidance for flying U.S. terminal and en route phases of flight, including Area Navigation (RNAV) routes, departure procedures (DP), Standard Terminal Arrivals (STAR), Terminal Arrival Areas (TAA), and feeder routes for instrument procedures. Operators and pilots should use this guidance to determine their eligibility for these U.S. RNAV routes and procedures. The information in this chapter supplements that provided in Chapter 3, General Guidance Common to All Performance-Based Navigation (PBN) Operations.

4.1.1 Applicability. This information is generally consistent with information in International Civil Aviation Organization (ICAO) Doc 9613, Performance-based Navigation (PBN) Manual, and Doc 7030, Regional Supplementary Procedures. However, operators flying PBN routes and procedures outside the United States may face other requirements. Operators should review the applicable State's Aeronautical Information Publication (AIP) for more information. Instrument flight rules (IFR) en route charts normally identify any specific capability requirements for RNAV routes in U.S. airspace. Similarly, departure and arrival charts contained in U.S. Terminal Procedures Publication (TPP) should indicate the capability requirements for PBN procedures. In addition, certain routes lying within international airspace, but under FAA air traffic control (ATC), have different requirements. Pilots should review available online international notices at https://www.faa.gov/air_traffic/publications/internationalnotices/.

Note: Aircraft eligible for RNAV 1 and 2 under the guidance of this AC are eligible for RNAV 5 routes (including routes labeled as "P-RNAV" and "B-RNAV") without any additional documentation. Such eligibility does not constitute an operational approval.

4.1.2 General Characteristics of RNAV Routes and Procedures. If a nonstandard navigation specification (NavSpec) or special feature is used, those specific requirements will be published for pilot awareness in the procedure's PBN Requirements Box ("PBN Box") or in appropriate chart notes or legends. In the United States, the following standards apply:

1. RNAV 1 is for RNAV terminal procedures, including:
   - RNAV STARs;
   - RNAV DPs including Obstacle Departure Procedure (ODP), and Standard Instrument Departure (SID) procedures; and
   - TAA/feeder routes of instrument approach procedures (IAP).
2. RNAV 2 is applied to RNAV DP/STAR published en route transitions or applies to the published DP/STAR procedure outside of 30 nautical miles (NM) from the airport reference point (ARP) if no en route transitions are published.
3. RNAV 2 is applied to Air Traffic Service (ATS) RNAV routes such as Q-, Y-, and T-routes.

4. U.S. RNAV routes, DPs, and STARs may identify minimum segment altitude requirements.
5. RNAV DPs will publish obstacle gradients only when higher than standard. ATC climb rates between published altitude constraints are not normally published.
6. RNAV STARs assume normal descent profiles.
7. Pilots flying on U.S. RNAV routes, DPs, and STARs do not need to monitor ground-based Navigational Aids (NAVAID) used in position updating unless required by the flight manual.
8. Pilots should not attempt to navigate a PBN route or procedure that includes a fix based on a conventional NAVAID using course guidance derived from that NAVAID. Pilots should use their installed, approved RNAV system to navigate on U.S. RNAV routes and procedures.
9. The FAA assesses the distance measuring equipment (DME) facility infrastructure supporting the design of RNAV routes or procedures and identifies critical DMEs associated with U.S. DPs and STARs on the FAA's Critical DMEs web page at https://www.faa.gov/air_traffic/flight_info/aeronav/criticaldme. Pilots flying RNAV systems that rely on the DME sensor on DPs or STARs should check the operational status of critical DMEs as part of their preflight duties.
10. The FAA will monitor the navigation infrastructure and issue timely warnings of outages, normally via Notice to Air Missions (NOTAM).
11. FAA ATC will likely not issue a routine IFR clearance for non-Global Navigation Satellite System (GNSS) aircraft on a random RNAV route, DP, or STAR in areas where ATC surveillance or radio communications are unavailable.
12. Special navigation requirements may apply to certain operations in Alaska. Use of Special Federal Aviation Regulation (SFAR) 97 as an acceptable means of compliance may provide regulatory relief to some operators.

4.2 Aircraft Eligibility Overview. AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems, and Chapter 3 of this AC provide aircraft eligibility guidance for operations on RNAV routes, DPs, and STARs. In general, aircraft with a statement of compliance (SOC) to the RNAV 1 and RNAV 2 NavSpecs in their flight manual meet the eligibility requirements for flying RNAV routes, DPs, and STARs. Aircraft for which the manufacturer provides a statement (i.e., other than in the flight manual) documenting compliance with this AC also meet the eligibility requirements for flying RNAV routes, DPs, and STARs.

Note: Aircraft and systems demonstrating compliance to A-RNP (or RNP 1 and RNP 2) in accordance with AC 20-138 are also eligible for RNAV 1 and RNAV 2 operations; no further documentation or evaluation is necessary.

4.2.1 Capability Needed for RNAV Routes, DPs, and STARs. In order to meet ATC navigation accuracy requirements, and thereby assure safe operations, operators intending to fly U.S. RNAV routes, DPs, and STARs should ensure their aircraft capability meets or exceeds

the minimum required navigation accuracy with any required sensors. Some routes and procedures may specifically require dual systems, or Satellite-based Augmentation System (SBAS)-enabled (wide area augmentation system (WAAS)) systems, or Global Positioning System (GPS) as the sensor, while others may permit use of DME-based RNAV (e.g., (D/D or D/D/I). Operators and pilots should look for these requirements on charts, in notes, NOTAMs, the U.S. AIP, and in the RNAV procedure's PBN Requirements Box.

4.3 Operational Guidance. Chapter 3 provides pilot operational guidance applicable to all PBN operations. Operators and pilots should ensure their operations manuals and checklists address the information and operating practices detailed in this AC. The appropriate manuals should contain navigation operating instructions and contingency procedures where specified.

4.3.1 Preflight Considerations. Operators and pilots should not file or request RNAV routes or procedures unless they meet the eligibility criteria provided in this AC. Likewise, pilots should not accept a clearance to fly an RNAV route or procedure if ineligible. Pilots should be familiar with the operational guidance contained in this chapter as well as the "common guidance" provided in Chapter 3 prior to flying RNAV routes, DPs, and STARs.

4.3.1.1 Understanding Pre-Departure Clearance (PDC) and Printed Routings. It is essential that pilots using PDC and printed routings understand their assigned clearance and recognize direct routings, assigned altitudes, revised clearances, SIDs, and en route transitions. Pilots need to understand their operator's PDC notation, and if any doubt exists about their clearance, they should request clarification from ATC.

Note: For data link PDC and Controller-Pilot Data Link Communication Departure Clearance (CPDLC-DCL) guidance, refer to AC 90-117( ), Data Link Communications, and https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs400/afs410/datacomm/.

4.3.1.2 Route Verification. Pilots should ensure they understand the assigned route and have correctly entered the departure transition into their navigation system. It is recommended pilots review any published Attention All Users Pages (AAUP) when preparing to fly the associated RNAV DP.

4.3.1.3 DPs. Pilots need to confirm that they have selected and loaded the correct runway and DP, including any applicable en route transition. In the event pilots receive a change of runway, procedure, or transition, it is essential that they verify the appropriate changes are entered and available for navigation prior to takeoff. Shortly before takeoff, pilots should confirm they have entered the correct runway, at least the first fix on the DP (especially if departing during parallel runway operations) and reviewed the route depiction on the navigation display.

4.3.1.4 STARs. Likewise, pilots should double-check their navigation system to ensure it displays the assigned STAR, transition, and expected runway.

4.4 Flight Considerations.

4.4.1 Lateral Navigation (LNAV) Mode. To ensure adherence to course centerline (CL) in accordance with part 91, § 91.181 on RNAV 1 or 2 routes and procedures, pilots are to use a course deviation indicator (CDI) (or equivalent navigation map display), flight director (FD), and/or autopilot (AP) in LNAV (steering) mode. Pilots of aircraft with a scalable navigation mode need to ensure that the pilot's CDI scaling (full-scale deflection) is suitable for the navigation accuracy associated with the route/procedure (i.e., ±1 NM for RNAV 1, ± 2.0 NM for RNAV 2, etc.). Pilots of aircraft without scaled CDI indications may be able to use the annunciations of their avionics system to ensure that the system is in the correct mode for the phase of flight (e.g., "ENR" for en route, "TERM" for terminal operations, etc.). Pilots should check their system technical documentation to ensure that the annunciations are consistent with the minimum NavSpec for the phase of flight. While there is no technical requirement for the values to match exactly, the values should be sufficient in scale to ensure the pilot can maintain course CL.

4.4.2 Vertical Navigation (VNAV) Systems Approved for Climb/Descent Functionality. Pilots operating aircraft with an SBAS or barometric vertical navigation (baro-VNAV) system incorporating an approved VNAV function may use that capability in conjunction with the primary barometric altimeter reference when executing PBN ODPs, SIDs, and STARs.

4.4.3 Legacy GPS and GPS/SBAS Receivers. By default settings, some legacy GPS and GPS/SBAS systems automatically scale to ±2.0 NM or ±5.0 NM beyond 30 NM from the ARP. This is acceptable when pilot procedures require maintaining CL and monitoring deviation from CL consistent with deviation scaling of 2.0 or 5.0 NM.

4.4.4 RNAV DP Engagement Altitudes and Climb Gradients. Some RNAV DPs have nonstandard minimum climb gradients (higher than 200 ft/NM) to ensure that all aircraft have the ability to engage their RNAV systems and so the pilot may begin following the system's lateral guidance as soon as practical (i.e., at and above 500 ft above ground level (AGL)). During these RNAV DPs, the pilot is responsible for complying with the nonstandard climb gradient as described, and with following the procedure-defined path, which may begin less than 2 NM from the departure end of the takeoff runway. For indepth information on climb gradients, refer to the Aeronautical Information Manual (AIM); FAA-H-8083-16, the Instrument Procedures Handbook (IPH); and FAA Information for Operators (InFO) 18014.

4.4.5 Navigation Position Check Prior to Takeoff. Pilots should follow their system-specific procedures to ensure a valid position of their aircraft prior to taking the runway for departure. When relying on GPS to conduct an RNAV DP, pilots must confirm GPS is available and being used by the aircraft's RNAV system before the takeoff roll commences.

4.4.6 Radar Required. PBN, by definition, does not require ATC radar services as a basis for operations. Neither radar nor surveillance is a PBN navigation sensor and should not appear in a PBN Requirements Box denoting PBN requirements for a procedure. The chart annotation "RADAR REQUIRED" on many U.S. RNAV DPs and STARs is a statement attesting to the use of surveillance by ATC as a supplemental traffic deconfliction and flightpath compliance safety measure, or assures the pilot of the availability of radar vectors. In the unlikely event of an ATC surveillance outage or if ATC reports the aircraft is not in radar contact, pilots with non-GNSS RNAV systems should confirm their clearance with ATC if assigned a DP or STAR charted with the notation "RADAR REQUIRED."

Note: Some aircraft using DME-based RNAV navigation may not be eligible for RNAV 1 and 2 in nonsurveilled airspace. AC 20-138( ) contains detailed and complete airworthiness guidance for aircraft eligibility using D/D sensors, with or without an Inertial Reference Unit (IRU).

4.4.7 Random RNAV Routes. Random or impromptu RNAV routes are direct routes between fixes or waypoints, rather than on a prescribed or charted route. In the United States, operators and pilots may conduct operations on random RNAV routes in aircraft eligible for RNAV 1 or 2, in accordance with paragraph 4.2. When flying random RNAV routes, pilots may define waypoints by latitude/longitude coordinates, degree-distance fixes, or offset paths from established routes at a specified distance and direction. Operation on a random RNAV route in an aircraft without a GNSS navigation capability requires radar monitoring by ATC (refer to the AIM, Chapter 5, Air Traffic Procedures).

Note: Pilots should not expect ATC to issue a routine IFR clearance for non-GNSS aircraft on an RNAV STAR or RNAV DP, or random RNAV route, in areas where ATC surveillance or radio communications are unavailable.

4.4.8 Random RNAV Routes With GNSS-Enabled RNAV Systems. Although pilots of any aircraft eligible for RNAV 1 or 2 operations may flight plan for a random RNAV route, only pilots of GNSS-equipped aircraft should expect to receive IFR clearance through areas outside ATC surveillance coverage. In general, pilots have no practical means to determine, during flight planning, the availability of ATC surveillance coverage throughout their intended route of flight. Accordingly, to preclude rerouting around areas lacking radar coverage, pilots with GNSS sensors in the RNAV system should define their random route using NAVAIDs, waypoints, fixes, or airports, all of which are recallable from their aircraft's navigation database. The distance between points should not exceed 500 NM. Defining the route using other than points in the navigation database will likely result in a change of routing should ATC surveillance become unavailable. For more information on filing and flying a random RNAV route in the U.S. National Airspace System (NAS), refer to the IPH.

4.5 Training.

4.5.1 Parts 91K, 121, 125, 129, and 135 operators should have a training program addressing the operational practices, procedures, and training items identified in Chapter 3 (e.g., initial, upgrade, or recurrent training for pilots and dispatchers).

4.5.2 All pilots flying RNAV 1 and 2 routes and procedures should be very familiar with the applicable information in Chapter 3, which provides subject matter applicable to all PBN operations. Approved training programs should provide comprehensive training on the aircraft's RNAV system such that the pilots are able to correctly utilize the RNAV system (in both normal and abnormal situations) and its various functions to assure safe navigation throughout the flight. Training programs for parts 91K, 121, 125, 129, and 135 should address the knowledge items listed in Chapter 3.

4.6 Operational Authorizations. Commercial operators obtain authorization to fly RNAV routes, DPs, and STARs through their operations specifications (OpSpecs). (Part 125 operators authorized to operate under part 91 regulations, via Letter of Deviation Authority (LODA), receive a Letter of Authorization (LOA).)

4.6.1 Bundling and Additional Authorizations.

4.6.1.1 In accordance with the "bundling" concept described in Appendix A, Obtaining PBN Operational Approval, operators should discuss with their principal inspectors (PI) the possibility of adding, to the appropriate OpSpec, all the NavSpecs for which they are eligible. For example, the following bundling hierarchy is available for the NavSpecs in OpSpec C063, Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations, which authorizes commercial operators to fly RNAV 1 DPs and STARs:

1. A-RNP, RNP 1, Tailored Arrivals (TA), RNAV 1.
2. RNP 1, Radius to Fix (RF), TA, RNAV 1.
3. RNP 1, RF, RNAV 1.
4. RNP 1, TA, RNAV 1.
5. RNP 1, RNAV 1.
6. RNAV 1.

4.6.1.2 Another bundling example is the following from OpSpec B035, Class I Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems, which authorizes commercial operators to fly RNAV 2 routes:

1. A-RNP, RNP 2, RNAV 2.
2. RNP 2, RNAV 2.
3. RNAV 2.

CHAPTER 5. DEPARTURES AND TERMINAL AIRSPACE OPERATIONS USING REQUIRED NAVIGATION PERFORMANCE (RNP) 1

5.1 Introduction. In the interest of improving the overall safety and efficiency of operations, the FAA has found it advantageous to apply the RNP 1 NavSpec to certain procedures. Since RF segments require RNP, the chart for a DP, SID, or STAR that requires an RF turn for the best ground track would designate the RNP 1 NavSpec and RF functionality in the PBN Requirements Box (e.g., "RNP 1 – GPS, RF"). Similarly, a charted feeder to a conventional IAF may apply RNP 1 due to close-proximity terrain or airspace constraints. The information and guidance on RNP 1 in this chapter supplements that provided in Chapter 3. Operators may find the RNP 1 NavSpec most commonly applied on the following procedure types:

- Obstacle Departure Procedures (ODP),
- Standard Instrument Departures (SID),
- Standard Terminal Arrival (STAR), and
- Certain instrument approach operations (e.g., charted "RNP to xLS" flightpaths prior to an IAF).

5.2 Aircraft Eligibility Overview. This overview addresses aircraft eligibility for RNP 1 operations. See Chapter 3 for common aircraft eligibility for RNP operations. Operators should refer to AC 20-138( ) for complete airworthiness guidance. RNP 1 operations require an RNP system that uses GPS as a primary navigation sensor; however, some systems can continue RNP operations even with a loss of GPS (for any reason). Pilots should refer to the PBN Requirements Box of RNP 1 procedures for any required sensors. Additionally, RNP APCH eligible aircraft with RF functionality will also meet the performance and functional requirements for RNP 1 with RF (see Chapter 12).

5.2.1 System Capability. In addition to the navigation system capabilities in Chapter 3, the following are capabilities applicable to RNP 1:

1. The capability of setting RNP 1.00 from the navigation database for each segment of an RNP 1 route or procedure (e.g., within 30 NM of the ARP).
2. For paths defined by a course (e.g., Course to Fix (CF) and Fix to an Altitude (FA) path terminators), the navigation system should use the magnetic variation value for the procedure or suitable RTCA DO-236( ) compliant magnetic variation hierarchy.

5.3 Operational Guidance. Operators should read Chapter 3 along with the RNP 1 specific guidance provided in this chapter.

5.3.1 Flight Considerations.

5.3.1.1 RF Turns. RNP 1 procedures may contain RF turns. As RF is an optional capability for RNP 1, if used in a procedure, the RF turn requirement will be annotated in the PBN Requirements Box for pilot awareness. Operators and pilots need to know if their aircraft are capable of and eligible for RF turns,

and as applicable, pilots should be trained to fly RF turns. Operators may find more information on RF turn requirements in Chapter 10.

5.3.1.2 Manually Setting Lateral Navigation Accuracy or RNP Value. If the navigation system does not retrieve and set or display RNP 1.00 (or its equivalent) from the onboard navigation database for the entirety of the RNP 1 operation, the manufacturer should provide pilot operating procedures for manually setting RNP 1.00 NM.

5.3.1.3 Use of a CDI, FD, or AP. For RNP 1 operations, pilots are to use a CDI, FD, or AP in LNAV (steering) mode. Pilots of aircraft with a scalable lateral deviation display are to ensure lateral deviation scaling is suitable for the RNP value associated with the procedure. Pilots of aircraft without scaled CDI indications may be able to use the annunciations of their avionics system to ensure that the system is in the correct mode for the phase of flight (e.g., "ENR" for en route, "TERM" for terminal operations, etc.). Pilots should check their system technical documentation to ensure the annunciations are consistent with the minimum NavSpec for the phase of flight.

Note: If the RNP 1 operation extends beyond (or begins farther than) 30 NM from the ARP, pilots should ensure the RNP system full-scale deviation display scaling does not exceed 1 NM, or adjusts to a scale that enables the pilot to maintain course CL. In these situations, pilots may manually set an appropriate RNP value.

5.3.1.4 VNAV Systems Approved for Climb/Descent Functionality. Pilots operating aircraft with an SBAS or baro-VNAV system incorporating a VNAV function may use that capability, with reference to the primary barometric altimeter, when executing RNP 1 ODPs, SIDs, and STARs.

5.3.1.5 Prior to Commencing the RNP 1 Procedure. In addition to normal operating procedures, prior to commencing an RNP 1 procedure, the pilot must verify GPS is available and being used by the aircraft's RNP system for position estimation. Pilots should follow the aircraft and/or avionics OEM's guidance on how to confirm GPS is indeed being used for positioning. Pilots can normally find the required sensor identified in the procedure's PBN Requirements Box.

5.4 Training.

5.4.1 Parts 91K, 121, 125, 129, and 135 operators should have a training program addressing the operational practices, procedures, and training items identified in Chapter 3 (e.g., initial, upgrade, or recurrent training for pilots and dispatchers).

5.4.2 All pilots flying RNP 1 routes and procedures should be very familiar with the applicable information in Chapter 3, which provides subject matter applicable to all PBN operations. Training programs should provide comprehensive training on the aircraft's RNP system

such that the pilots are able to correctly utilize the RNP system (in both normal and abnormal situations) and its various functions to assure safe navigation throughout the flight. Training programs for parts 91K, 121, 125, 129, and 135 should address the knowledge items listed in Chapter 3.

5.5 Bundling of Operational Authorizations. As discussed in Appendix A, Obtaining PBN Operational Approval, bundling is a packaging of multiple PBN capabilities (i.e., NavSpecs) according to a hierarchy, in a single operational authorization application.

5.5.1 Commercial Operators Require Authorization to Fly RNP DPs and STARs. The FAA issues authorization through appropriate OpSpecs for RNAV and RNP terminal operations. (Part 125 operators authorized to operate under part 91 regulations, via LODA, receive an LOA instead of an OpSpec.)

5.5.2 Bundling Example: OpSpec C063. Commercial operators would normally receive authorization to fly the procedures addressed in this chapter via OpSpec C063. Bundling allows the operator to apply for, and the FAA inspector to authorize, all the terminal PBN capabilities (NavSpecs) for which the operator is eligible, according to a hierarchy. The RNP 1 inclusive bundling hierarchy options available for OpSpec C063 include the following:

1. A-RNP, RNP 1, RF, TA, RNAV 1.
2. RNP 1, RF, TA, RNAV 1.
3. RNP 1, RF, RNAV 1.
4. RNP 1, TA, RNAV 1.
5. RNP 1, RNAV 1.

CHAPTER 6. REQUIRED NAVIGATION PERFORMANCE (RNP) 0.3 FOR ROTORCRAFT OPERATIONS

6.1 Introduction. This chapter provides guidance on the operational requirements for rotorcraft to conduct RNP 0.3 operations during DPs, en route operations on defined routes, terminal arrival procedures and during the initial, intermediate, and MASs of an RNP APCH procedure (or a suitable conventional final approach course). RNP 0.3 operations require the rotorcraft use an RNP value of RNP 0.30 throughout these operations (except for the FAS). The information contained in this chapter supplements the guidance in Chapter 3 and lists only those additional items applicable to RNP 0.3 rotorcraft operations.

Note 1: The term "RNP 0.3" refers to the NavSpec. A specific LNAV accuracy, or minimum RNP value, should have two decimal places published (e.g., "RNP 1.00" or "RNP 0.30") to differentiate that value from the title of the RNP 1 or RNP 0.3 NavSpec. In practice, if a route or procedure utilizes a NavSpec, then the navigation accuracy required by the NavSpec applies to the entire procedure or route. Operators will see the NavSpec label "RNP 0.3" applied to the TK-route on en route charts or in the PBN Requirements Box of the procedure.

Note 2: The RNP 0.3 NavSpec is only applicable to rotorcraft.

6.1.1 Benefits. The FAA applies the RNP 0.3 NavSpec to provide rotorcraft operators improved efficiency and safety in the following ways:

1. Safer low-level routes in obstacle-rich environments, thereby reducing exposure to icing by reducing the size of the required obstacle-protection area on an RNP 0.3 route.
2. Seamless transition from en route to terminal procedure.
3. More efficient routing in obstacle-rich or noise-sensitive terminal environments, specifically in consideration of helicopter air ambulance (HAA) services in IFR operations between hospitals.
4. More efficient and lower rotorcraft instrument procedure segments (prior to the FAS and after the missed approach point (MAP)), including rotorcraft departure operations.

6.1.2 Applicability. The FAA applies the RNP 0.3 NavSpec to en route operations, terminal arrival and departure routes, and RNP APCH (or suitable conventional) approaches (prior to the FAS and after the MAP).

Note: Rotorcraft RNP 0.3 eligibility and qualification is separate and distinct from RNP AR APCH or A-RNP, and does not convey eligibility, qualification, or authorization for either RNP AR operations or A-RNP.

6.2 Rotorcraft Eligibility Overview. See Chapter 3 for common rotorcraft eligibility for RNP operations. For complete airworthiness guidance, refer to AC 20-138( ). Rotorcraft operators should reference their flight manual, or appropriate updated supplement, for documentation sufficient to support a SOC with RNP 0.3 operations.

Note: Airworthiness certification and recognition of RNP 0.3 rotorcraft eligibility alone does not provide commercial operators authority to conduct RNP 0.3 operations. Commercial operators should apply for the appropriate OpSpec (e.g., OpSpec H123, Class I Navigation Using Area or Long-Range Navigation Systems with WAAS for Rotorcraft RNP 0.3 En Route and Terminal Operations) for operational authorization to conduct RNP 0.3 operations.

6.2.1 RNP Capability. In the United States, the RNP 0.3 NavSpec requires the rotorcraft to include an SBAS sensor augmenting GPS for all RNP 0.3 operations. The rotorcraft OEM or avionics manufacturer should provide supplemental documentation in the flight manual that includes the RNP capability resulting from the installation or upgrade of the rotorcraft's avionics. This should include the recommended operations, maintenance, and any continued airworthiness procedures, as well as the procedures for pilots to confirm WAAS or SBAS availability and select or verify the rotorcraft's avionics en route and terminal RNP 0.3 capability.

Note: A helicopter equipped with a navigation system compliant with TSO-C115d (or later) using a GPS sensor compliant with TSO-C129a or TSO-C196a, with documented compliance to the A-RNP requirements in RTCA DO-283B as a Type A RNP system, is also eligible for RNP 0.3 operations without further airworthiness evaluation. Other helicopter RNP system installations require further evaluation for RNP 0.3 operations.

6.2.2 Rotorcraft Qualification Documentation. Operators of rotorcraft without a flight manual or supplement statement from the manufacturer documenting RNP 0.3 compliance need to show how their rotorcraft complies with the RNP airworthiness criteria described in AC 20-138( ). Operators may follow the procedures in Chapter 3 of this AC and develop RNP 0.3 eligibility documentation showing compliance with appropriate airworthiness guidance. The documentation should also define the recommended operations, maintenance, and any continued airworthiness procedures.

6.3 Operational Guidance. Operators should comply with operational guidance in Chapter 3 along with the RNP 0.3 specific guidance provided in this chapter. Operators should tailor their operating manuals such that they include navigation system operating instructions and contingency procedures applicable to RNP 0.3 operations.

6.3.1 Charting Differences. Procedures requiring RNP 0.3 may have slightly different PBN requirements shown in the chart's PBN Requirements Box, or on the en route chart. For a

hybrid instrument approach with RNP 0.3 routing to the FAS, expect only the individual route to show the RNP 0.3 requirement. For example:

1. An ILS approach with PBN routes to final for fixed-wing aircraft, and a single charted RNP 0.3 helicopter route from waypoint "NOLAN" to the FAS, should show the minimum route altitude on the plan view, while the PBN Requirements Box would show: [RNP APCH – GPS. From NOLAN: RNP 0.3 – GPS.].
2. On an RNP 0.3 DP, since SBAS is required from the initial departure fix (IDF) on the departure, the procedure's PBN Requirements Box would show [RNP 0.3 – GPS.].
3. For a hybrid RNAV 1 departure with a designated rotorcraft RNP 0.3 flightpath from the waypoint "MWEBB," the PBN Requirements Box would state: [RNAV 1 – GPS. From MWEBB: RNP 0.3 – GPS.].
4. En route, the RNP 0.3 route will simply have "RNP 0.3" charted near the route name: "TK-502 RNP 0.3". The chart legend will annotate the GPS requirement for RNP 0.3 routes.

6.3.2 Preflight Considerations. RNP 0.3 operations require SBAS augmentation of GPS. In the United States, SBAS is provided by WAAS. Pilots are to confirm the availability of SBAS/WAAS by checking WAAS NOTAMs prior to flight (see Appendix B, Flight Planning).

6.3.2.1 **Normal and Contingency Procedures.** All operators should include normal and contingency RNP 0.3 procedures for their particular equipment installation. The operator should establish contingency procedures for typical system failures such as loss of GPS or SBAS (e.g., "In the case of loss of navigation capability the pilot will climb on course at maximum climb rate to next highest minimum IFR altitude."). The pilot must notify ATC of any loss of RNP capability or if unable to comply with the requirements of the RNP route or procedure. This loss of RNP capability includes any failure or event causing the rotorcraft to no longer satisfy the RNP 0.3 requirements of the route or procedure.

6.3.2.2 **Configuration List.** The operator should comply with a list of minimum equipment their rotorcraft requires to conduct RNP 0.3 operations that is consistent with the rotorcraft airworthiness eligibility requirements (refer to AC 20-138( )) and representative of the operational requirements of this AC.

Note: This list of minimum equipment does not replace the helicopter's MEL according to part 91, § 91.213.

6.3.2.3 **FGS Equipment Requirement.** All rotorcraft RNP 0.3 operations require an operational stability augmentation system and the use of an AP coupled directly to the guidance output of the rotorcraft's RNP system. Any alternate means of controlling FTE requires a rotorcraft-specific FTE demonstration of the alternate means of control, an airworthiness approval, and FS acceptance.

6.3.3 Flight Considerations. In addition to the general in-flight considerations provided in Chapter 3, rotorcraft operators should consider the following when conducting RNP 0.3 operations.

6.3.3.1 Departure Procedure (DP). Prior to commencing takeoff, the pilot should verify the following:

1. Rotorcraft RNP system is operational with SBAS available;
2. Correct airport/heliport and departure data are loaded;
3. The rotorcraft position is properly depicted on the flight deck navigation display; and
4. The RNP value is set to 0.30 NM and should stay at 0.30 NM to the end of the RNP 0.3 procedure.

6.3.3.2 Engagement of FGS After Takeoff. The pilot must engage the FGS (i.e., couple the RNP LNAV system to the AP) prior to reaching the first waypoint defining an RNP 0.3 procedure or route.

6.3.3.3 Change in Departure Clearance. A pilot assigned an RNP 0.3 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, and which represent the beginning or end of an RF segment.

6.3.3.4 En Route Operations on RNP 0.3 TK-Routes. Pilots should verify the TK-route is loaded correctly from the onboard navigation database. On systems that do not load entire routes from database memory, the pilot may load the route manually, waypoint by waypoint, from the waypoint list stored in the navigation database. When doing so, the pilot should verify the individually loaded waypoints match the clearance and the paper or electronic chart.

6.3.3.5 Standard Terminal Arrival (STAR). Prior to the arrival phase, the pilot should verify the following:

1. Loading of the correct arrival procedure and check the active flight plan by comparing the charts (paper or electronic) with the map display (or equivalent).
2. Confirmation of the waypoint sequence, reasonableness of track angles and distances, and any altitude or speed constraints. Where possible, pilots should identify which waypoints are flyby and which are flyover, and which represent the beginning or end of a RF segment.

3. Correct terminal routing and instrument approach are loaded, along with correct airport/heliport and arrival data.
4. Display scaling is set to 0.30 NM.

6.3.3.6 AP Use. The operator's standard procedures should ensure pilots fly RNP 0.3 routes and procedures with the AP engaged and coupled to the RNP system's LNAV mode before the first waypoint of the RNP 0.3 route or procedure segment.

6.4 Training. Parts 91K, 121, 125, 129, and 135 operators should have a training program addressing the operational practices, procedures, and training items identified in Chapter 3 (e.g., initial, upgrade, or recurrent training for pilots and dispatchers).

6.4.1 Pilot Knowledge and Training. All pilots flying RNP 0.3 routes and procedures should be very familiar with the information in Chapter 3, which provides subject matter applicable to all PBN operations. Approved training programs should provide comprehensive training on the aircraft's RNP system such that the pilots are able to correctly utilize the RNP system (in both normal and abnormal situations) and its various functions to assure safe navigation throughout the flight. Training programs for parts 91K, 121, 125, 129, and 135 should address the knowledge items listed in Chapter 3 and this chapter.

6.4.2 RNP 0.3 Knowledge. The training program should provide sufficient training (e.g., simulator, training device, or rotorcraft) to the extent that the pilot is also familiar with the following, as applicable to the rotorcraft RNP system:

1. Required navigation equipment and MEL (or equivalent) for operation on RNP 0.3 routes and procedures. Understanding of the rotorcraft configuration and operational conditions required to support RNP 0.3 operations (e.g., how to verify SBAS availability, and how to ensure RNP 0.30 is set and what the deviation display scaling is when RNP 0.30 is the RNP value in use).
2. Impact of pilot-selectable bank limitations on rotorcraft ability to achieve the track-keeping on the planned RNP 3.0 route or procedure.
3. Selecting the appropriate STAR or SID for the active runway/heliport/helipad in use and being familiar with procedures required to respond to a runway/heliport/helipad change.
4. Understanding the XTK deviation limits applicable to RNP 0.3 operations and how to recognize the limit on the deviation display.
5. Performing a parallel offset function (see Chapter 10), either manually or automatically, if the function is available in the rotorcraft's RNP system.

6.5 Authorizing Documents. Operators are expected to show compliance documentation from their manuals and checklists as part of the application process for operational approval.

6.5.1 Commercial Operators. Commercial operators are required to obtain appropriate OpSpec authorizing documents prior to flying RNP 0.3 rotorcraft operations (e.g., OpSpec H123).

6.5.2 Part 91 Operators. Part 91 operators should be familiar with the requirements of Chapters 3 and 6 of this AC prior to conducting RNP 0.3 rotorcraft operations. Special emphasis should be placed on the preflight considerations in this chapter.

6.6 Bundling of Operational Authorizations. As discussed in Appendix A, Obtaining PBN Operational Approval, bundling is a packaging of multiple PBN capabilities (i.e., NavSpecs) according to a hierarchy, in a single operational authorization application.

6.6.1 Bundling Example: OpSpec H123. This authorizes rotorcraft operators to conduct Class I navigation using an RNP system augmented by SBAS, for RNP 0.3 operations applied to en route and terminal operations. The bundling hierarchy options are the following:

1. A-RNP/RNP 0.3.
2. RNP 0.3/RF.
3. RNP 0.3.

CHAPTER 7. REQUIRED NAVIGATION PERFORMANCE (RNP) 2 FOR EN ROUTE OPERATIONS

7.1 Introduction. This chapter provides operators with information and guidance that is specific to RNP 2 operations. The information in this chapter supplements that provided in Chapter 3.

7.1.1 Domestic and Oceanic/Remote Continental Applications. In accordance with ICAO Doc 9613, the RNP 2 NavSpec serves both an en route domestic application, as well as oceanic and remote continental applications. The major difference in the applications involves navigation capability redundancy.

7.1.2 Implementation of RNP 2 in the NAS. This AC provides guidance on NavSpec compliance for RNP 2 routes in the NAS. When established, RNP 2 routes may include additional onboard aircraft communications or surveillance capability to meet minimum airspace requirements. Pilots can expect to find such requirements published on charts or in NOTAMs and in the U.S. AIP.

7.1.3 RNP 2 for Oceanic and Remote Continental Applications. RNP 2 is not yet required in any oceanic airspace or Remote Continental Airspace (RemCon). Currently, Australia implements RNP 2 within portions of its oceanic and domestic en route airspace. In planning overseas flights, U.S. operators should always consult the AIP for each State they will traverse. Those AIPs may specify an RNP 2 requirement.

7.1.4 Additional Reference Documents. In addition to the State AIPs, U.S. operators should be familiar with the following documents for any overseas flight:

- AC 90-117( ), Data Link Communications;
- AC 91-70( ), Oceanic and Remote Continental Airspace Operations; and
- ICAO Doc 7030, Regional Supplementary Procedures.

7.2 Aircraft Eligibility Overview. This overview addresses aircraft eligibility for RNP 2 operations. Operators should see Chapter 3 for common aircraft eligibility for PBN operations. For complete airworthiness guidance, refer to AC 20-138( ). RNP 2 requires the operator's navigation system(s) receive position inputs from GNSS. The FAA recommends that all operators have a contingency navigation capability (that does not rely on ground navigation aids) for the GNSS-based LRNS during RNP 2 operations.

7.2.1 GNSS System Requirements for Domestic and Oceanic/Remote Continental Operations. RNP 2 applications solely within domestic U.S. airspace require only a single RNP system receiving GNSS inputs. RNP 2 operations in oceanic or remote continental applications require dual independent RNP systems capable of long-range navigation (i.e., without reliance on ground navigation aids), both of which receive position input from GNSS. Independent systems are those in which no single point of failure could disable all capability to navigate to RNP specifications. Dual independent, RNP systems

with separate receivers and antennas, interfaced with separate flight management computers (FMC), is one example of the capability needed for oceanic RNP 2 operations.

7.2.2 GPS Receiver Autonomous Integrity Monitoring (RAIM). Operators intending to conduct RNP 2 operations through use of GPS in domestic airspace may need to perform a GPS RAIM prediction (or a suitable RNP prediction) during flight planning to ensure availability of GPS RAIM throughout the RNP 2 operation. This check does not apply to RNP systems using SBAS to augment GPS when the operator verifies WAAS is available for the intended RNP 2 route. For RNP 2 oceanic or remote continental operations, the aircraft GNSS system needs to incorporate the FDE function. This function detects faulty navigation data from a satellite and subsequently removes that data from the navigation solution. Since the FDE function depends on a certain number of GNSS satellites being "visible" to the aircraft at any time, operators intending to fly using RNP 2 on oceanic or remote continental routes need to perform an FDE prediction during the flight planning process. Operators are not to file for RNP 2 operations if there is a predicted loss of FDE function exceeding 5 minutes at any time on a route where the pilots intend to utilize RNP 2 navigation. Operators can receive information on how to obtain an FDE prediction from their aircraft avionics manufacturer.

7.2.3 Parallel Offset. For RNP 2, the aircraft navigation system needs to be capable of designating parallel tracks at a pilot-selectable offset distance. Pilots should be able to select an offset track in at least 1 NM increments out to at least 20 NM from the assigned track. Operators should ensure their pilots know how to activate and deactivate a parallel offset, along with the associated operational requirements and restrictions. For example, the operator/pilot may need to manage the exit/capture angle from the route to within operationally acceptable limits (e.g., 30 degrees).

7.2.4 Operational Guidance. Operators should read Chapter 3, along with the RNP 2 specific guidance provided in this chapter. Flightcrew operating manuals and checklists should address information on the SOPs detailed in this AC.

7.2.5 Dispatch Requirements. Operators authorized to fly using an MEL should ensure their MEL identifies the required aircraft equipment configuration for RNP 2. The MEL should reflect the navigation configuration used to obtain operational approval (i.e., OpSpec) for RNP 2.

7.3 Training. Parts 91K, 121, 125, 129, and 135 operators should have a training program addressing the operational practices, procedures, and training items identified in Chapter 3 (e.g., initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel).

7.3.1 Pilot Knowledge and Training. In addition to the general RNP training topics provided in Chapter 3, operators should ensure pilots understand the specific navigation equipment requirements for RNP 2, as well as procedures for setting up a parallel offset, whether as part of the SLOP or as otherwise necessary.

7.4 Bundling of Operational Authorizations. Once worldwide RNP 2 concepts of operations are published, and States begin utilizing RNP 2 routes in their domestic or oceanic airspace, operators may obtain authorization to fly RNP 2 en route operations via appropriate authorizing documents. As discussed in Appendix A, bundling is a packaging of multiple PBN capabilities (i.e., NavSpecs) according to a hierarchy, in a single operational authorization application. All operators need to receive the appropriate OpSpec to conduct RNP 2 operations in oceanic airspace (e.g., OpSpec B036, Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (M-LRNS)).

7.4.1 Bundling Example: OpSpec B036. The following bundling hierarchy options may be applicable to RNP 2:

1. A-RNP, RNP 2, RNP 4, and RNP 10.
2. RNP 2, RNP 4, and RNP 10.
3. RNP 4 and RNP 10.
4. RNP 10.

CHAPTER 8. EN ROUTE REQUIRED NAVIGATION PERFORMANCE (RNP) 4 FOR OCEANIC AND REMOTE CONTINENTAL AIRSPACE OPERATIONS

8.1 Introduction. The information in this chapter on RNP 4 operations supplements that provided in Chapter 3. There is no implementation of RNP 4 outside of oceanic or Remote Continental Airspace. Operators are likely to see a requirement for RNP 4 only in specifically designated oceanic airspace (i.e., oceanic control areas (OCA)).

8.1.1 Planning Overseas Flights. In planning overseas flights, U.S. operators should always consult the AIP for each State they will traverse. Those State AIPs may specify an RNP 4 requirement in any oceanic airspace they control or in any sovereign airspace considered "remote continental."

8.1.2 Additional Reference Documents. In addition to the State AIPs, U.S. operators should be familiar with the following documents for any overseas flight:

- AC 90-117( ), Data Link Communications;
- AC 91-70( ), Oceanic and Remote Continental Airspace Operations; and
- ICAO Doc 7030, Regional Supplementary Procedures.

8.2 Aircraft Eligibility Overview. This overview addresses aircraft eligibility for RNP 4 operations. Operators should see Chapter 3 for common aircraft eligibility for PBN operations. Eligibility for RNP 4 normally conveys eligibility for RNP 10 without further examination. For complete airworthiness guidance, refer to AC 20-138( ). RNP 4 operations require the aircraft's RNP system to use an approved GNSS sensor for position estimation. While dual independent LRNS and dual GNSS sensors are normally required to ensure continuity when flying on extended overwater profiles, operators should have a long-range navigation capability that does not rely on ground navigation aids for contingency operations when GNSS is lost (for any reason) during RNP 4 operations.

8.2.1 Navigation Equipment Requirements. RNP 4 operations require two independent RNP systems capable of long-range navigation (i.e., without reliance on ground navigation aids), at least one of which receives position input from GNSS. Independent navigation systems are those in which no single point of failure could disable all capability to navigate to RNP 4 specifications. In the case of RNP 4 operations, the aircraft must be equipped, for example, with dual operable FMCs, and if relying on GNSS for navigation, dual GNSS receivers and antennas.

8.2.2 Fault Detection and Exclusion (FDE). For RNP 4, the aircraft GNSS system needs to incorporate an FDE function to detect faulty navigation data from a satellite and subsequently remove that data from the navigation solution. Since the FDE function depends on a certain number of GNSS satellites being "visible" to the aircraft at any time, operators intending to fly using RNP 4 need to ensure an FDE prediction is included during the flight planning process. Operators are not to file for RNP 4 operations if there is a predicted loss of FDE function exceeding 25 minutes at any time on a route where

the pilot intends RNP 4 navigation. Operators can receive information on how to obtain an FDE prediction from their aircraft avionics manufacturer.

8.3 Operational Guidance. Operators should read Chapter 3, along with the RNP 4 specific guidance provided in this chapter. Flightcrew operating manuals and checklists should address information on the SOPs detailed in this AC.

8.3.1 RNP 4 Flight Planning. In order to enter airspace requiring RNP 4 or indicate RNP 4 capability on their flight plan, all operators will need to hold OpSpec B036 indicating eligibility for RNP 4.

Note: Previous authorizations issued under the guidelines of canceled FAA Order 8400.33, Procedures for Obtaining Authorization for Required Navigation Performance 4 (RNP-4) Oceanic and Remote Area Operations, remain valid.

8.3.2 Dispatch Requirements. Operators authorized to fly using an MEL should ensure their MEL identifies the required aircraft equipment configuration for RNP 4 operations. The MEL should reflect the navigation configuration used to obtain operational approval (i.e., OpSpec B036) for RNP 4.

8.3.3 Prior to Entering RNP 4 Airspace. In addition to standard oceanic operating procedures (e.g., as outlined in AC 91-70( )), pilots should accomplish the following prior to entering airspace requiring RNP 4:

1. For multisensor systems, verify that the aircraft's RNP system is using GNSS for position estimation; and
2. Where RNP 4 operations rely on CPDLC to uplink new ATC clearances and routing (that is not contained in the onboard navigation database), confirm the RNP value in use is RNP 4.0. If executing the uplink does not automatically set the RNP value, the pilot should manually enter the RNP 4.0 in the RNP system.

8.4 Training. Parts 91K, 121, 125, 129, and 135 operators should have a training program addressing the operational practices, procedures, and training items identified in Chapter 3 (e.g., initial, upgrade, or recurrent training for pilots, dispatchers, or maintenance personnel).

8.4.1 Pilot Knowledge and Training. In addition to the general RNP training topics provided in Chapter 3, operators should ensure pilots understand the specific aircraft equipment requirements for RNP 4.

8.5 Bundling of Operational Authorizations. As discussed in Appendix A, bundling is the packaging of multiple PBN capabilities (i.e., NavSpecs) according to a hierarchy, in a single operational authorization application.

8.5.1 Bundling Example: OpSpec B036. The following bundling hierarchy options are applicable to RNP 4:

1. A-RNP, RNP 2, RNP 4, and RNP 10.
2. RNP 2, RNP 4, and RNP 10.
3. RNP 4 and RNP 10.

CHAPTER 9. EN ROUTE REQUIRED NAVIGATION PERFORMANCE (RNP) 10 FOR OCEANIC AND REMOTE CONTINENTAL AIRSPACE OPERATIONS

9.1 Introduction. The information in this chapter on RNP 10 operations supplements that provided in Chapter 3.

9.1.1 Oceanic and Remote Continental. In accordance with ICAO Doc 9613, the RNP 10 NavSpec provides a means to offer RNAV operations in oceanic and remote continental applications. There is no implementation of RNP 10 outside of oceanic airspace or Remote Continental Airspace (RemCon). In fact, operators are only likely to see a requirement for RNP 10 in specifically designated oceanic airspace (i.e., oceanic control areas (OCA)).

Note: With respect to both ICAO and FAA applications of the RNP 10 NavSpec, the specification is misnamed such that the terms RNP 10 and RNAV 10 are synonymous. For consistency within this AC and the airspace and operational authorization designations, the guidance is titled "RNP 10" while the NavSpec application will be RNAV 10. Readers interested in learning more about these terms can find that information in ICAO Doc 9613.

9.1.2 Aeronautical Information Publication (AIP). In planning overseas flights, U.S. operators should always consult the AIP for each State they will traverse. Those State AIPs may specify an RNP 10 requirement in any oceanic airspace they control or in any sovereign airspace considered "remote continental."

9.1.3 Additional Reference Documents. In addition to the State AIPs, U.S. operators should be familiar with the following documents for any overseas flight:

- AC 90-117( ), Data Link Communications;
- AC 91-70( ), Oceanic and Remote Continental Airspace Operations; and
- ICAO Doc 7030, Regional Supplementary Procedures.

9.2 Aircraft Eligibility Overview. This overview addresses aircraft eligibility for RNP 10. Operators should see Chapter 3 for common aircraft eligibility for PBN operations. For complete airworthiness guidance, refer to AC 20-138( ).

9.2.1 RNP 10 Through Data Collection. On rare occasions, typically involving much older aircraft, neither manufacturer SOCs nor other documented means are available to prove aircraft eligibility for RNP 10. Aircraft eligibility for RNP 10 through data collection remains an option, though it is complex and labor intensive. Operators may find a booklet, RNP 10 Through Data Collection, describing the data collection process on the Flight Technologies and Procedures Division's Performance Based Navigation (PBN) Guidance and Approval web page at https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs400/afs410/pbn/.

9.2.2 Navigation Equipment Requirements. RNP 10 operations require the use of RNAV or RNP systems that do not rely on ground-based navigation aids. Despite the "RNP 10"

label, RNP 10 operations are RNAV operations, and there is no requirement for the onboard performance monitoring and alerting capability that is required for RNP operations. RNP 10 requires two independent RNAV or RNP systems (capable of long-range navigation (i.e., without reliance on ground navigation aids)) that receive position inputs from GNSS and/or incorporate navigation information provided by aircraft inertial navigation systems (INS). Independent systems are those in which no single point of failure could disable all capability to navigate to RNP 10 specifications. In the case of RNP 10 operations, the aircraft needs to be equipped, for example, with dual FMCs, and if relying on GNSS for navigation, dual GNSS receivers and antennas. Navigation systems relying on inertial inputs will need to have two of every component necessary for inertial navigation. The FAA further recommends that all operators have a contingency navigation capability (that does not rely on ground navigation aids) for the GNSS-based LRNS when flying extended overwater flight segments.

Note: The FAA may authorize (via OpSpec) operators to conduct RNP 10 operations when equipped with only a single RNAV or RNP system, limited to defined geographic areas.

9.2.3 Fault Detection and Exclusion (FDE). For RNP 10 operations, the aircraft GNSS system needs to incorporate an FDE function to detect faulty navigation data from a satellite and subsequently remove that data from the navigation solution. Since the FDE function depends on a certain number of GNSS satellites being "visible" to the aircraft at any time, operators intending to fly using RNP 10 need to ensure an FDE prediction is included during the flight planning process. Operators are not to file for RNP 10 operations if there is a predicted loss of FDE function exceeding 34 minutes at any time on a route where the pilot intends RNP 10 navigation. Operators can receive information on how to obtain an FDE prediction from their aircraft avionics manufacturer.

9.2.4 Inertial Navigation Systems (INS). Aircraft using only INSs (i.e., do not have GNSS) have a limitation on the amount of time they can fly under RNP 10 standards between navigation system position updates.

9.2.4.1 Maximum Time Between Updates. Inertial systems approved in accordance with part 121 appendix G meet RNP 10 requirements for up to 6.2 hours of flight time, between any in-flight updating. This 6.2-hour time limit begins when the pilot places the INS in the navigation mode or when the system is properly updated in flight. This time limit establishes the point beyond which the pilot may not operate if either RNP 10 is required or if ATC applies separation from other aircraft based on RNP 10 capability (e.g., oceanic/remote continental airspace). If a pilot determines a flight will exceed the RNP 10 time limit and remain in oceanic/remote continental airspace, the pilot is to inform ATC that their aircraft will no longer be RNP 10 capable beyond the point determined by the time limit. ATC may need to adjust that aircraft's separation from others in the oceanic/remote continental airspace.

Note: The 6.2-hour time limit is the baseline limit for RNP 10 operations using INSs. Manufacturer-prepared documentation used as the basis for the aircraft's airworthiness approval should state if, and under what circumstances and procedures, the aircraft is capable of more than 6.2 hours of RNP 10 flight using inertial navigation.

9.3 Operational Guidance. Operators should read Chapter 3, along with the RNP 10 specific guidance provided in this chapter. Flightcrew operating manuals and checklists should address information on the SOPs detailed in this AC.

9.3.1 Determining Inertial Navigation Time Limits. During the flight planning process, operators flying non-GNSS aircraft and intending to conduct RNP 10 operations, will need to determine that their time in oceanic/remote continental airspace will not exceed the time limit specified in their operational authorization.

9.3.1.1 Bounding the Time Calculation. Operators should start the calculations based on the time when the pilot places the navigation system in the navigation mode (or the last point at which they expect to update the system). The operator should determine the stop point for calculations based on when the pilot can reasonably expect a ground NAVAID fix, when the aircraft comes under Air Traffic Service (ATS) surveillance, or when the pilot can reasonably expect to be able to update the navigation system in accordance with established procedures.

9.3.1.2 Wind Estimates. Winds used in the calculations should be the worst-case winds from sources used in the operator's normal (and, if applicable, approved) flight planning process.

9.3.1.3 Pilot Procedures. The flight manual should specify whether and how the pilot may update INS position in flight, and what effect that updating has on the RNP 10 time limit.

9.3.2 Dispatch Requirements. Operators authorized to fly using an MEL should ensure their MEL identifies the required navigation configuration for RNP. The MEL should reflect the navigation configuration used to obtain operational approval (i.e., OpSpec B036) for RNP 10.

9.3.3 RNP 10 Flight Planning. In order to enter airspace requiring RNP 10 or to indicate RNP 10 capability on their flight plan, all operators need to hold appropriate OpSpecs. Previous authorizations issued under the guidelines of canceled FAA Order 8400.12, Required Navigation Performance 10 (RNP 10) Operational Authorization, remain valid.

Note: Operators eligible for RNP 4 are also eligible for RNP 10.

9.4 Training. Parts 91K, 121, 125, 129, and 135 operators should have a training program addressing the operational practices, procedures, and training items identified in Chapter 3 (e.g., initial, upgrade, or recurrent training for pilots, dispatchers, or maintenance personnel).

9.4.1 Pilot Knowledge and Training. In addition to the general RNP training topics provided in Chapter 3, operators should ensure pilots understand the specific navigation equipment requirements for RNP 10.

9.5 Bundling of Operational Authorizations. As discussed in Appendix A, bundling is the packaging of multiple PBN capabilities (i.e., NavSpecs) according to a hierarchy in a single operational authorization application.

9.5.1 Bundling Example: OpSpec B036. The following bundling hierarchy options are applicable to RNP 10:

1. A-RNP, RNP 2, RNP 4, and RNP 10.
2. RNP 2, RNP 4, and RNP 10.
3. RNP 4 and RNP 10.
4. RNP 10 only.

CHAPTER 10. ADVANCED REQUIRED NAVIGATION PERFORMANCE (A-RNP) FUNCTIONS AND OPERATIONS

10.1 Introduction. A-RNP is unique among PBN NavSpecs. A-RNP mandates the ability of the RNP system to navigate with multiple RNP values as well as the ability to perform specific functions (see Table 10-1, A-RNP Functions). A-RNP recognizes and takes advantage of the multiple flight phase capabilities of the advanced functionality and performance of modern production aircraft. A-RNP offers distinct flexibility in application of navigation performance and the aircraft's available RNP functions. This chapter provides guidance on the performance, operational, and training requirements for the U.S. A-RNP operations and applies to all A-RNP operations conducted by any operator in the United States under 14 CFR.

10.1.1 A-RNP Overview. A-RNP operations will provide environmental, capacity, and efficiency benefits to en route, oceanic/remote, continental, terminal and approach phases of flight, excluding the final approach. Instrument procedures incorporating any A-RNP function require the aircraft and pilot be eligible for and capable of performing that function during the procedure. The application of an A-RNP function to a procedure drives an A-RNP requirement for that segment, or if applied to any common segment, the entire procedure. For example, an instrument approach may implement one A-RNP Initial Fix (IF) with a PBN segment requiring RNP 0.30 and an RF turn to an ILS/GLS or RNP APCH final approach course. Another implementation may require an RNP value change from 1.00 NM to 0.30 NM on an A-RNP STAR or SID. Any such procedure will prominently display the A-RNP NavSpec requirement in the procedure's PBN Requirements Box or chart note.

10.1.2 A-RNP Use Cases. Public RNP procedures may use A-RNP functions where the aviation infrastructure, obstacle/terrain environment, traffic density and aircraft separation, and runway access do not require RNP AR operations. SIDs/STARs and IAPs may use A-RNP when direct pilot to ATC (voice) communications are available. These procedures may require the ATS surveillance service to assist in contingency procedures (e.g., loss of GPS), to mitigate the effect of pilot blunder errors, and to reduce route spacing. When the use of A-RNP relies on the use of ATS surveillance services, the service provider should ensure the routes lie within the ATC surveillance and communications service volumes (e.g., in Class A, Class B, Class C, and the terminal radar service area (TRSA)). Also, where ATS surveillance and aircraft navigation require use of GPS for A-RNP, the service provider should consider the risk of loss of GPS which results in the loss of both navigation performance and ADS-B surveillance capability.

10.1.3 U.S. A-RNP Implementation. In the United States, the FAA intends to implement A-RNP initially in the terminal environment. SIDs and STARs using A-RNP will increase capacity, efficiency, and safety. For example, A-RNP parallel departures from closely spaced runways may use RNP 0.30 and opposite-direction RF turns to offer reliable and repeatable ground tracks, which expedite increased aircraft separation. On approach procedures, use of RNP 0.30 through A-RNP reduces TERPS obstacle evaluation areas, which should increase traffic capacity, and throughput and airspace efficiency, without

reducing safety. Other possible implementations include replacing some RNP AR Approach (APCH) procedure ground tracks using A-RNP criteria to join an RNP APCH final approach course with LNAV/VNAV or LPV FAS, or even to an ILS/GLS FAS. This offers the advantage of increased availability of the approach procedure to any A-RNP eligible aircraft and pilot without the need for the specific authorization that RNP AR operations require. In all cases, the PBN Requirements Box will annotate the A-RNP requirements.

10.2 Airworthiness Eligibility for A-RNP Operations. RTCA DO-283( ) contains the public standards for all of the A-RNP functions. AC 20-138( ) contains the approved means of compliance for airworthiness eligibility for A-RNP operations.

10.3 A-RNP Capabilities for U.S. and Optional Operations. Table 10-1 below lists the A-RNP functions and whether they are required or optional for U.S. A-RNP operations.

Table 10-1. A-RNP Functions

Function	Reference	U.S. A-RNP
Radius to Fix (RF)	10.3.1	Required
Parallel Offset	10.3.2	Required
RNP Holding	10.3.3	Required
Scalable RNP	10.3.4	Required
Fixed Radius Transition (FRT)	10.4.1	Optional
Time of Arrival Control (TOAC)	10.4.2	Optional

Note: The United States may require the use of FRT and TOAC in the future.

10.3.1 RF Turns. RF turns may be published on instrument procedure segments (initial, intermediate, and missed approach) and on SIDs/STARs.

10.3.2 Parallel Offset. Parallel offsets provide a capability to fly offset from the flight plan track. ATC normally assigns parallel offset during en route operations.

Note 1: Future airspace evolution to Trajectory Based Operations (TBO) may include the use of parallel offset as a procedural method of aircraft separation.

Note 2: SLOP routinely uses parallel offset in oceanic airspace, following internationally accepted procedures and limitations. Operators can find detailed information on SLOP in the U.S. AIP, ICAO Doc 4444, and AC 91-70( ).

10.3.3 RNP Holding. Aircraft eligibility for A-RNP requires RNP holding. The Air Traffic Organization (ATO) will use RNP holding when there is an operational need to aid airspace management and traffic flow. The State AIP should specify RNP holding on charts and procedures. As airspace developers implement RNP holding, operators will see RNP holding on appropriate routes and procedures.

10.3.3.1 The public standards for RNP holding are found in RTCA DO-236( ) and DO-283( ), and European Organization for Civil Aviation Equipment (EUROCAE) ED-75( ), MASPS Required Navigation Performance for Area Navigation. Refer to AC 20-138( ) for the airworthiness means of compliance for the RNP holding function.

10.3.3.2 Many aircraft navigation systems have a holding function supporting RNAV and conventional holding patterns. Until the United States refines the implementation of RNP holding, pilots may use these existing holding functions to comply with a U.S. operational requirement for RNP holding.

10.3.3.3 When using the aircraft's holding function, the pilot remains responsible to ensure the aircraft remains within the holding pattern protected airspace. The pilot should use the holding pattern techniques in the AIM to help ensure flight path compliance.

10.3.4 Scalable RNP. Scalable RNP refers to the ability of the RNP system to automatically retrieve and set the RNP scaling, monitoring, and alerting consistent with the RNP value for each leg segment of a route or procedure from the onboard navigation database without the need for pilot input. RTCA DO-236( ) and DO-283( ) contain the public standards for scalable RNP.

10.3.4.1 When the installed RNP system does not support scalable RNP, an operator may claim A-RNP eligibility if the RNP system provides a means for the pilot to set the RNP value an A-RNP operation requires. For U.S. A-RNP operations, the RNP system should support the ability to, automatically or manually, set RNP 0.30, RNP 1.00, and RNP 2.00.

10.3.4.2 When the A-RNP operation is complete, the pilot should remove a manually set RNP value. This restores the RNP system's automatic or default setting of the RNP value.

10.4 Optional A-RNP Capabilities. The following en route capabilities are optional for A-RNP operations in the United States. If any of these capabilities are incorporated into a procedure's design, pilots will be informed of the requirement by chart note or PBN Requirements Box annotation.

10.4.1 Fixed Radius Transitions (FRT). FRTs are RNP system computed curved path transitions between en route legs using a defined radius. The intent is to define transitions along airways where separation between parallel routes is required and flyby transitions are not compatible with the separation criteria. The FAA does not plan to implement FRTs within the NAS.

10.4.2 Time of Arrival Control (TOAC). The FAA anticipates that TOAC will be used in conjunction with other cockpit technologies and ATC procedures to aid in the separation and orderly flow of traffic on en route "direct" clearances to specific arrival waypoints serving major airports. This section will be revised once requirements and criteria are developed for TOAC implementation in the United States.

10.5 Aircraft Eligibility Overview. See Chapter 3 for the foundation for aircraft eligibility for RNP operations. As a prerequisite for A-RNP, the aircraft and its RNP system must be eligible for RNP APCH. Further, the U.S. implementation requires the functions of RF, parallel offset, scalable RNP, and RNP holding. For complete airworthiness guidance and acceptable means of compliance (AMOC), refer to AC 20-138( ).

10.5.1 Additional Required Information. The flight manual should contain a statement indicating the aircraft meets the requirements for RNP operations with A-RNP capabilities of RF, parallel offset, scalable RNP, and RNP holding. This documentation should describe the A-RNP capabilities in the context of:

- Applicable phases of flight;
- Required FGS modes (e.g., FD/AP coupled or uncoupled);
- Applicable lateral and vertical modes;
- Minimum demonstrated RNP value of 0.30;
- Any sensor limitations; and
- Supplementary operational guidance.

10.6 A-RNP Operational Approval. Commercial operators require an A-RNP authorization through OpSpecs on verification of pilot competency and aircraft eligibility. Part 91 operators do not require specific authorization to conduct A-RNP operations. Part 91 operators need only ensure that their aircraft is eligible for A-RNP operations and the pilot is knowledgeable on how to conduct the A-RNP operations.

10.6.1 Authorizations. Although there is no specific, separate A-RNP OpSpec at this time, commercial operators may bundle A-RNP authorization to a number of en route and terminal OpSpecs for operator convenience. Operators should consult with their PIs before conducting any A-RNP operations to ensure that they have the proper eligibility and authorizations.

10.6.2 Credit for Existing RNP AR APCH Approvals. When the flight manual includes a statement of eligibility for RNP AR APCH operations, the flight manual need not include a statement of eligibility for A-RNP terminal operations. Operators with a current RNP AR APCH authorization may assume their aircraft meets the requirements for all A-RNP terminal operations described in this AC. RNP AR APCH eligible aircraft without a separate statement of A-RNP en route eligibility in their flight manual may require additional evaluation for en route A-RNP operations in accordance with AC 20-138( ). Commercial operators should consult with their PI to confirm eligibility requirements for adding A-RNP to their en route OpSpecs (e.g., B035).

10.7 Training. Parts 91K, 121, 125, 129, and 135 operators should have a training program addressing the operational practices, procedures and training items in Chapter 3 (e.g., initial, upgrade or recurrent training for pilots, dispatchers or maintenance personnel) and the specific A-RNP training items below.

Note: To ensure pilot competency, pilots operating under part 91 should be knowledgeable of the PBN subject areas that Chapter 3 outlines, along with the additional subjects below before conducting operations requiring A-RNP.

10.7.1 Specific A-RNP Training. A-RNP training should include the following:

1. RF segment identification and use, including all necessary flight manual path compliance measures;
2. Use of parallel offset;
3. Use of the RNP system to conduct RNP holding; and
4. Use of scalable RNP, including verification of the scalable RNP function or, when the scalable RNP function is not available, the flight manual procedures for manually setting the procedure or route's RNP value.

CHAPTER 11. USE OF SUITABLE RNAV SYSTEMS ON CONVENTIONAL ROUTES AND PROCEDURES

11.1 Introduction. Operators may use suitable RNAV systems on certain conventional routes and procedures in the U.S. NAS, in place of conventional NAVAIDs and systems. To conduct such operations, the operator should ensure the navigation system meets the capability criteria and the pilots are knowledgeable on the relevant RNAV subject matter listed in Chapter 3. Pilots should operate their navigation systems in accordance with the guidance in Chapter 3, to include the use of the onboard navigation database.

Note: No guidance in this AC can countermand any regulation in 14 CFR, and operators should not construe any guidance in this chapter as authorization to deviate from any regulation specifying navigation equipment requirements.

11.1.1 Definitions. This chapter describes use of suitable navigation systems as a substitute means of navigation or an alternate means of navigation on conventional routes and procedures. The following definitions support the objectives of this chapter:

11.1.1.1 Alternate Means of Navigation. The pilot's use of a suitable navigation system to navigate on a conventional route or procedure without monitoring the operational NAVAID(s) defining the route or procedure. "Alternate means" applies to a situation where the pilot has options, or a choice, and uses the suitable navigation system primarily for convenience.

11.1.1.2 Substitute Means of Navigation. The pilot's use of a suitable navigation system to navigate on a conventional route or procedure in an aircraft with inoperative or not-installed conventional navigation equipment and/or when conventional NAVAIDs are out of service. "Substitution" applies to a situation where the NAVAID or the aircraft equipment are inoperative or unavailable (i.e., the pilot cannot use or monitor the conventional NAVAID).

11.1.1.3 "Suitable RNAV System." In accordance with § 1.1, navigation systems having the following characteristics are suitable for the purpose of serving as a substitute means, or alternate means, of navigating a conventional route or procedure as described in this AC. A system's suitability is dependent upon the availability of ground and/or satellite NAVAIDs needed to navigate along the route to be flown. The suitable navigation system must:

- Be installed and approved for use under IFR;
- Offer an equivalent level of capability for the type of operation (e.g., Instrument Flight Procedure (IFP) or Federal Airway); and
- Meet the performance standards (e.g., accuracy) established for the route or procedure (e.g., oceanic, instrument approach, etc.).

Note: The use of substitution or alternate means is subject to NOTAM, Chart Note, or flight manual limitations.

11.2 Aircraft Eligibility Overview. For substitution or alternate means of use of the aircraft's installed navigation system, when GPS and/or WAAS is available, systems meeting the standards of TSO-C115, TSO-C129, or TSO-C145/C146 or TSO-C196 for terminal and approach operations under IFR are eligible. Non-GPS, multisensor navigation systems (i.e., TSO-C115 equipment) meeting the operational eligibility standards for RNAV 1 and 2 terminal and en route operations under IFR in Chapter 4 of this AC are also eligible.

Note: When the flight manual contains airworthiness approval solely for RNAV en route operations under IFR, the pilot should limit the use of the navigation system to the en route phase of flight.

11.3 Operational Risks.

11.3.1 Importance of Flying Route CL. While § 91.181 requires pilots to fly the route CL (regardless of the navigation system), flying the CL is particularly important when using RNAV substitution or alternate means navigation techniques on conventional routes or procedures. The FAA uses different obstacle evaluation criteria for PBN routes and procedures versus conventional routes and procedures using ground-based NAVAIDs. Therefore, remaining on the route or procedure's CL is essential to minimize the risk of the aircraft being outside the obstacle-protected area.

11.3.2 Contingency Navigation Capability. In accordance with regulations, aircraft flown under parts 91K, 121, 125, 129, and 135 require at least one other independent navigation capability in addition to the suitable navigation system used as substitute or alternate means of navigation on conventional routes and procedures. This additional navigation capability enables the pilot, in the event of loss of navigation of the suitable navigation system, to proceed safely under IFR to a suitable airport and complete an instrument approach using the other independent navigation capability. Private operators should consider the effects of the loss of their suitable navigation system in flight planning to minimize the risk of loss of navigation.

11.4 Operational Guidance.

11.4.1 Use of a Non-GPS RNAV System as a Substitute Means of Navigation. Operators may use suitable navigation systems, approved for use under IFR, that do not use GPS as a position sensor as a substitute means of navigation on conventional routes or procedures only when specifically authorized by a NOTAM or other FAA guidance. For example, a NOTAM or chart note may authorize the use of D/D/I or D/D RNAV for a specific route or procedure. The NOTAM or chart note will also identify any required DME facilities (based on an assessment of the DME infrastructure).

11.4.2 Use of Non-GPS RNAV System as an Alternate Means of Navigation. Operators may use suitable navigation systems, approved for use under IFR, that do not use GPS as a position sensor as an alternate means of navigation on conventional routes or procedures without restriction when continuous RNAV is available. To ensure continuous navigation guidance, pilots should cross-check the conventional NAVAIDs the procedure or route

requires. If any doubt arises as to the suitability of the RNAV guidance, pilots should revert to using conventional NAVAIDs.

11.4.3 Use of GPS or WAAS as an Alternate Means of Navigation. Operators may use suitable navigation systems, approved for use under IFR, using GPS or WAAS as an alternate means of navigation on conventional routes and procedures without restriction.

11.4.4 Flight Manual Limitations. Pilots should observe flight manual limitations on the use of the navigation system when using the system for substitute or alternate means of navigation.

11.4.4.1 If a flight manual limitation requires the aircraft to have other equipment appropriate to the route or procedure being flown, then the pilot may use the aircraft's suitable navigation system in the NAS as a substitute means of navigation for an out-of-service NAVAID, but not to substitute for inoperable or not-installed aircraft equipment.

11.4.4.2 If a flight manual limitation requires the pilot to monitor the underlying conventional NAVAID for the route or procedure being flown, then the navigation system is not suitable for use as an alternate means of navigation.

11.4.4.3 If a flight manual limitation requires the pilot to monitor the underlying conventional NAVAID, and the required NAVAID is out of service, then the use of the navigation system as a substitute means is prohibited.

11.4.4.4 For multisensor navigation systems, if a flight manual limitation states that the aircraft's D/D/I or D/D navigation capability is not approved for use under IFR, then use of the navigation system as a substitute or alternate means is prohibited when GPS or WAAS is not available.

11.4.5 Preflight Considerations. Pilots should consider the following during preflight activity.

11.4.5.1 **Areas of GPS Unreliability.** Operators should not plan to use GPS or WAAS as a substitute or alternate means of navigation in areas affected by a GPS or WAAS NOTAMs as "unreliable" or "may not be available." If flight in such areas is unavoidable or cannot be delayed, operators should ensure a different means of navigation is available (refer to § 91.205) for the desired route or procedure.

11.4.5.2 **Preflight GPS Performance Prediction.** Use of GPS or SBAS (WAAS) navigation systems as a substitute means of navigation requires confirmation of WAAS availability or a RAIM prediction. See Appendix B, Flight Planning, for guidance on RAIM predictions and WAAS availability.

11.4.5.3 **Applicability for Using Alternate Means of Navigation for Dispatch.** Operators may not use a suitable navigation system as an alternate means of navigation in lieu of 14 CFR-required capability dispatch requirements.

11.4.5.4 Applicability for Using Substitute Means of Navigation for Dispatch. Use of a suitable navigation system as a substitute means of navigation should only be used for dispatch with inoperative conventional navigation capability when consistent with the aircraft's Master Minimum Equipment List (MMEL).

11.4.6 Authorized Uses of Suitable Navigation Systems. Operators may use a suitable navigation system to determine position relative to fixes that define a usable conventional procedure or usable ATS route (departure, airway, arrival, or approach) and to navigate any leg of a conventional procedure or route, except as the sole means of navigation along the FAS or along the FAS of a final approach course defined by a Localizer (LOC). Specifically, the following are authorized uses of a suitable navigation system:

1. Determine aircraft position relative to or distance from a conventional NAVAID, DME fix, or named fix based on a conventional NAVAID.
2. Navigate to or from any conventional NAVAID or fix, via direct or a defined course.
3. Hold over any conventional NAVAID or DME fix.
4. Fly a published arc based upon DME.
5. Fly a published route or instrument procedure, comprised of charted airways, fixes, and/or NAVAIDs.
6. Navigate to the FAS of a conventional IAP.
7. Navigate the lateral course of the FAS on an IAP based on a VOR, Tactical Air Navigation System (TACAN), or Non-Directional Beacon (NDB) signal. The aircraft equipment and the NAVAID must be operational and monitored (e.g., as with a horizontal situation indicator (HSI) or radio magnetic indicator (RMI) bearing pointer or a separate CDI) to ensure continuous FAS alignment. The NAVAID remains the primary source of navigation for the FAS and must be used for course alignment if the navigation system track differs from the NAVAID course.

Note: These acceptable uses also apply to situations where a conventional procedure chart contains a note requiring a particular type of conventional NAVAID (e.g., "Note: ADF Required"). Pilots may still use the suitable navigation system on the procedure, to the limits described in this list of authorized uses.

11.4.7 Unauthorized Uses of Navigation Systems. Operators may NOT use a suitable navigation system:

11.4.7.1 On Unusable or Not Authorized (NA) Procedures. Pilots may not fly any portion of a conventional route or procedure identified (by chart annotation or NOTAM) as unusable or not authorized ("NA").

Note: Pilots should take particular care when loading routes by name or title, especially routes defined solely by conventional NAVAIDs. Conventional routes designated as "unusable" by chart notation or

NOTAM are unusable by any user. Pilots should not file for, and ATC should not use, the unusable route title or name in the IFR clearance. This does not preclude the use of direct clearances to usable waypoints or fixes along or across a charted route designated as "unusable."

11.4.7.2 As Sole Means of Navigation on Conventional FAS. Pilots may not use the navigation system as the sole means to fly the final approach course on a conventional instrument approach.

11.4.7.3 To Navigate an LOC Final Approach Course. Pilots may not use the navigation system to fly a FAS defined by an LOC signal.

11.4.7.4 Contrary to Flight Manual Restriction. Pilots may not use the navigation system on any procedure for which the flight manual mandates the pilot monitor the underlying NAVAID, unless the pilot actually monitors that NAVAID.

11.5 Contingency Responses. Operators should maintain procedures for pilots to handle unexpected contingencies during RNAV substitution or alternate means of navigation operations, such as:

11.5.1 Degraded System. Pilots should discontinue the use of the navigation system as a substitute or alternate means of navigation on conventional routes and procedures when experiencing a loss or degradation of the suitable navigation system's performance (e.g., RAIM alert, "UNABLE RNP" annunciation, etc.). Pilots should not use the systems for any of the operations authorized in this chapter if they doubt the capability or suitability of the systems to navigate to the degree of accuracy required for those operations.

11.5.2 Alerting for Loss of GPS. Some aircraft navigation systems using GPS do not automatically alert for a loss of GPS. Operators of this type of installed navigation system should provide their pilots with procedures to monitor and confirm GPS operation before conducting the operations this chapter authorizes.

11.6 Operational Approval. In accordance with 14 CFR, the FAA issues an OpSpec to commercial operators and operators of non-commercial large private aircraft to authorize specific operations discussed in this chapter. Part 91 operators do not require separate authorization to conduct these operations.

11.7 Training. Parts 91K, 121, 125, 129, and 135 training programs should address the operational practices, procedures, and training items identified in Chapter 3 (e.g., initial, upgrade, or recurrent training for pilots, dispatchers, or maintenance personnel).

Note: Pilots operating under part 91 should have knowledge of the training requirements noted in this AC and be competent in the use of their aircraft's suitable navigation system as a substitute or alternate means of navigation prior to flight.

CHAPTER 12. PBN INSTRUMENT APPROACH OPERATIONS USING REQUIRED NAVIGATION PERFORMANCE APPROACH (RNP APCH)

12.1 Introduction. In the United States, the navigation specification (NavSpec) RNP APCH applies to all instrument approach operations that require Performance-based Navigation (PBN) for a segment of the instrument approach procedure (IAP). RNP instrument approach operations have strict airworthiness and operational requirements to maintain predictable, repeatable flightpath compliance, database standards, and ultimately, flight safety. Operators should review Chapter 3 for general aircraft eligibility criteria, operational considerations, and pilot training guidance common to all PBN operations. The information contained in this chapter supplements the guidance in Chapter 3 and lists only those additional items applicable to RNP APCH operations. This chapter provides guidance for operators to conduct 14 CFR part 97 IAPs applying the RNP APCH NavSpec. This guidance applies to the following procedures:

1. IAPs titled "RNAV (GPS)" or with "or GPS" in the title (ICAO: "RNP RWY xx").
2. Any other IAP with RNP segments. For example, a "non-PBN" approach (e.g., very high frequency (VHF) omni-directional range (VOR), Ground-Based Augmentation System (GBAS) Landing System (GLS), instrument landing system (ILS), Localizer (LOC), Non-Directional Beacon (NDB), Tactical Air Navigation System (TACAN), etc.) with a charted PBN initial approach fix (IAF) and intermediate segment to join the final approach course, or a non-PBN approach with a PBN Missed Approach Segment (MAS).

Note 1: Users will know an IAP has an RNP segment by the presence of charted waypoints on a segment of the procedure and/or by the presence of a PBN Requirements Box or specific chart notes.

Note 2: This AC does not apply to Required Navigation Performance Authorization Required Approach (RNP AR APCH) approaches, titled "RNAV (RNP)" (ICAO: "RNP RWY xx (AR)"). Guidance for RNP AR operations is in AC 90-101( ), Approval Guidance for RNP Procedures with AR.

12.2 Aircraft Eligibility. Operators should refer to Chapter 3 for aircraft eligibility guidance applicable to all PBN operations. PBN IAPs applying the RNP APCH NavSpec require specific lateral navigation (LNAV) accuracies (or RNP values) for each segment of the procedure: initial (1.00 nautical mile (NM)), intermediate (1.00 NM), final approach (0.30 NM), and missed approach (1.00 NM). The operator's aircraft manuals, as described in Chapter 3, should explicitly confirm aircraft eligibility for RNP APCH operations, as well as all eligible lines of minima (i.e., LNAV, LP, LNAV/vertical navigation (VNAV), and LPV). Aircraft with documented eligibility (e.g., flight manual statements of compliance (SOC)) meet the performance and functional requirements in this AC for RNP APCH procedures. Operators who are unable to verify their aircraft's eligibility for RNP APCH operations should contact the aircraft Original Equipment Manufacturer (OEM) or type certificate (TC) holder; the avionics manufacturer or the Supplemental Type Certificate (STC) holder; or the responsible Flight Standards office or

Aircraft Certification Service office for assistance. For complete airworthiness guidance, refer to AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems.

Note: Aircraft eligibility for RNP APCH with Radius to Fix (RF) segments require specific airworthiness approval and is optional. See paragraph 12.3.5.

12.2.1 Part 91 Operator Confirmation of Aircraft Eligibility. Prior to flying RNP APCH procedures, part 91 operators need to confirm their aircraft is eligible for the desired PBN operation to include the specific RNP APCH line(s) of minima. The aircraft eligibility documentation cited in Chapter 3 is the only effective way to confirm eligibility. Operators should ensure all pilots are knowledgeable on all aspects of RNP APCH operations for which their aircraft are eligible. Manufacturers typically provide operating manuals to aid in use of their aircraft and its avionics. Pilots should use this material (and RNP APCH-specific educational materials) hand in hand with the guidance in Chapter 3. The FAA recommends part 91 pilots fly RNP APCH procedures as part of their part 61, § 61.56 flight review.

12.3 RNP APCH Overview. In the United States, RNP APCH applies to all approach applications based on Global Positioning System (GPS), normally titled "RNAV (GPS)" or with "or GPS" in the title. In the future, RNP APCH procedures in the United States may be titled "RNP Rwy XX" as global charting specifications are harmonized. RNP APCH procedures provide operators one or more lines of minima (e.g., LNAV, LNAV/VNAV, LPV, or LP) based on the procedure design, obstacle environment, and the eligibility of the aircraft and RNP system. The RNP APCH NavSpec encompasses all segments of the terminal approach operation: initial, intermediate, final, and missed approach. Procedure designers may use features of other RNP NavSpecs in the initial, intermediate, or missed approach segments but not in the Final Approach Segment (FAS) when that segment relies on RNP APCH. Charts for RNP APCH procedures will prominently display a standardized PBN Requirements Box containing the procedure's performance and functional requirements (e.g., RF legs) including NavSpec(s), required sensors, and any minimum RNP value required (outside the FAS) for the procedure, and any applicable remarks.

12.3.1 Relationship of RNP APCH to Traditional Approach Types. In accordance with part 1, § 1.1, the United States defines two types of instrument approach operations: Nonprecision Approach (NPA) and Precision Approach (PA). An RNP APCH procedure may offer lines of minima to support both PA and NPA operations. Depending on the line of minima the pilot uses, the RNP APCH operation may be either an NPA or a PA.

12.3.1.1 NPA Operations. These two dimensional (2D) operations use GPS-based lateral guidance from the RNP system. The procedure provides obstruction clearance when pilots adhere to the published, procedural minimum altitudes along the approach track, by reference to the primary barometric altimeter. These 2D procedures typically offer an LNAV or Localizer Performance (LP) line of minima to a minimum descent altitude (MDA).

12.3.1.2 PA Operations. These three dimensional (3D) operations can use ground-based Navigational Aids (NAVAID), GPS, Satellite-based Augmentation System (SBAS), and electronic, approved vertical guidance to enable PA operations to a published decision altitude (DA)/decision height (DH), usually below 250 feet above ground level (AGL). Typically, these 3D procedures offer LNAV/VNAV, LPV, ILS, and GLS DA/DH lines of minima.

Note 1: "Electronic" vertical guidance includes barometric vertical navigation (baro-VNAV) and SBAS vertical guidance a pilot may use to fly the procedure's glidepath during a PA operation.

Note 2: Some approach procedures contain both precision and nonprecision attributes internationally designated as "Approaches with Vertical Guidance (APV)." These "APV" operations use GPS or SBAS to generate lateral guidance and SBAS or baro-VNAV to generate electronic, approved vertical guidance in a 3D PA operation. These RNP APCH procedures typically offer LNAV/VNAV lines of minima to a DA as low as 250 feet AGL.

Note 3: In the United States, all RNP APCH procedures offering an SBAS LPV DA (regardless of height above touchdown (HAT)) are 3D PA operations.

12.3.2 Use of Advanced Required Navigation Performance (A-RNP) or RNP 0.3 NavSpecs During an RNP APCH Operation. When necessary, an RNP APCH procedure may use the additional capabilities of the A-RNP or RNP 0.3 NavSpecs on the initial, intermediate, and/or missed approach segment. To identify the use of these additional NavSpec(s), the PBN Requirements Box will show the required NavSpec(s) and functions for that procedure. The additional NavSpec (e.g., A-RNP) may apply to an individual alternate IAF or Intermediate Fix (IF). For example, to avoid an airspace conflict, the procedure designer may apply an A-RNP function of RNP 0.30 on an RF turn to a specific approach transition beginning at an IAF. In another example, the designer may apply the helicopter RNP 0.3 NavSpec to the procedural path to the RNP APCH final approach fix (FAF) to achieve lower procedural altitudes. In this case, the PBN Requirements Box would describe the requirement for the helicopter to use the RNP 0.3 NavSpec on the track to the FAF. Compliance with the requirements of the PBN Requirements Box is essential for safe operations.

12.3.3 Baro-VNAV Approved for LNAV/VNAV in the RNP APCH FAS. Aircraft with airworthiness approval may use baro-VNAV vertical guidance from the RNP system as approved VNAV capability in the FAS. Baro-VNAV enables a 3D operation defined by vertical angles or altitudes at waypoints along the RNP APCH procedural path. Temperature and pressure deviations from International Standard Atmosphere (ISA) affect baro-VNAV vertical guidance resulting in procedural temperature constraints. The pilot must adhere to these temperature constraints unless applying temperature compensation described in Appendix C, Nonstandard Temperature Operations. Aircraft

with airworthiness approval for baro-VNAV vertical guidance in the FAS may conduct the RNP APCH operation to the LNAV/VNAV line of minima.

12.3.4 SBAS Approved Vertical Guidance in RNP APCH FAS. GPS augmentation through SBAS improves the accuracy, integrity, availability, and continuity of the GPS-based positioning. The U.S. National Airspace System (NAS) provides SBAS through the wide area augmentation system (WAAS). Augmentation with WAAS can provide advisory and/or approved vertical guidance without a need for use of any ground-based NAVAIDs. Temperature and pressure deviations from ISA do not affect WAAS vertical guidance, unlike the vertical guidance operators obtain from baro-VNAV. In the absence of any aircraft airworthiness limitations/restrictions, WAAS guidance supports aircraft navigation during all phases of flight from takeoff through 2D or 3D vertically guided approaches, including missed approach. When in approach mode, the SBAS sensor will display the best level of service available from WAAS. WAAS guidance can support 2D operations to LNAV or LP lines of minima using advisory vertical guidance and 3D operations to LNAV/VNAV and LPV lines of minima using approved vertical guidance. When the pilot conducts an RNP APCH operation to circling minima, the SBAS sensor may provide LNAV, LNAV/VNAV, LP, or LPV guidance to the circling MDA.

12.3.5 Optional RF Capability. See RF eligibility in Chapter 3. RNP APCH procedure developers may employ RF turns in the initial, intermediate, or missed approach segments of the procedure. When the RNP APCH procedure requires an RF leg(s), the PBN Requirements Box will prominently note "RF", and the RNP value on the turn will be 1.00. The procedure may publish a speed constraint for the RF turn segment. Operators need to ensure their pilots know whether their aircraft are eligible to fly RF turns. Aircraft or avionics manufacturers should provide documentation on aircraft eligibility, limitations, and procedural requirements for the conduct of RF turns. The operator should find a description of RF functionality in the avionics supplement or flight manual. This documentation should include additional operational requirements for pilot use during the RF turn, such as use of an autopilot (AP) and/or flight director (FD) and navigation map display. RNP APCH eligible aircraft with such RF functionality also meet the performance and functional requirements for RNP 1 with RF.

12.3.5.1 If the aircraft is not eligible to fly RF turns, the RNP system may not be able to provide flight guidance along the RF turn. The aircraft's Type 2 Letter of Approval navigation database shall not contain procedures or procedure segments that the aircraft cannot support. As a result, some data providers will strip or hide procedure segments (or even entire procedures) in databases of aircraft ineligible for RF turns. Pilots should not select an RNP APCH segment containing an RF turn unless the aircraft is eligible to fly them. If a pilot discovers an RNP route, transition, or procedure in the navigation database that the aircraft is ineligible to use, the pilot should notify their navigation database provider of the discrepancy.

12.3.6 RNP to xLS Approach Designs. The FAA can implement approach procedure designs incorporating the use of RNP systems where the FAS is not based on RNP (see also

Chapter 3 for RNP to xLS information). These designs may use RNP APCH for initial or intermediate approach segments joining a localizer performance with vertical guidance (LPV), ILS, GLS FAS, or in the MAS. These procedures may employ RF and/or Track to Fix (TF) segments to connect the RNP path with the FAS. These IAPs require the aircraft to have RNP APCH eligibility since the operation is dependent on the RNP APCH performance to the FAS or the missed approach. Some complex RNP APCH or RNP to xLS procedures may employ A-RNP functions (e.g., RF turn with RNP 0.30) and the PBN Requirements Box will annotate these additional requirements. Other designs include the use of RNAV or RNP in the MAS of a "conventional" ILS approach, which enables procedure designers to avoid obstacles, comply with airspace constraints, or replace decommissioned NAVAIDs with waypoints. In such cases, the procedure will have a PBN Requirements Box delineating the requirements.

Note: RNP to xLS operations are not examples of the use of "Area Navigation (RNAV) substitution or alternate means." When using the navigation system for a substitution or alternate means operation, the operator is choosing to use the system in place of conventional means during the IAP (see Chapter 11).

12.3.7 Navigation Inputs for RNP APCH. GPS is the primary navigation source for RNP APCH procedures in the NAS. Operators should confirm GPS and requisite RNP is available prior to initiating an RNP APCH procedure. RNP based on DME/DME or VOR/DME positioning is not acceptable to initiate an RNP APCH operation. Operators of aircraft with multisensor RNP systems demonstrating RNP APCH capability through DME navigation or DME-inertial RNP may continue RNP in the event of a loss of GPS provided that their flight manual confirms this capability.

Note: The MAS of an RNP APCH procedure may rely on conventional NAVAID or pilot procedures (e.g., a heading to a prescribed altitude). On such procedures the MAS does not require RNP.

12.3.8 RNP APCH Resiliency. Operators of aircraft whose RNP APCH capability is based on GPS and/or WAAS through single or dual RNP systems should understand the ramifications of any GPS or WAAS service interruptions. Operators should perform contingency planning for loss of GPS or WAAS, including when Notices to Air Missions (NOTAM) describe areas of reduced GPS or WAAS availability. Operators of aircraft with multisensor RNP capability should plan contingency operations consistent with their flight manual description of the aircraft's resilient RNP capability. Operators of aircraft lacking multisensor RNP capability should plan contingency operations based on the aircraft's remaining instrument flight rules (IFR) capability (e.g., use of conventional VOR navigation). All operators should maintain resilient IFR navigation capability to ensure safe flight operations (e.g., additional IFR approach capability such as ILS). See also paragraph 12.4.2.

12.3.9 Advisory Vertical Guidance. Many RNP APCH procedures contain LNAV and LP lines of minima. During these laterally guided procedures, the aircraft can offer advisory vertical guidance to enable a stabilized continuous descent final approach (CDFA). In this situation, the displayed vertical guidance is advisory only. Pilots may use the

displayed advisory vertical guidance to fly to the MDA provided the pilot complies with any procedural altitude constraints (e.g., step-down fix minimum altitudes) by reference to the primary barometric altimeter. (See Table 12-1, "Advisory Vertical Guidance" column.)

Table 12-1. Lines of Minima and FAS Vertical Guidance

Line of Minima	Approved Vertical Guidance	Advisory Vertical Guidance
LNAV MDA		✓
LP MDA		✓
LNAV/VNAV DA	✓	
LPV DA	✓	

Note: This table addresses use of vertical guidance in the FAS. All vertical guidance outside the FAS is advisory only.

12.3.10 RNP APCH Approach Minima. RNP APCH procedures may list multiple lines of minima on the same chart. RNP APCH can offer 3D precision operations to LPV or LNAV/VNAV DAs and 2D nonprecision operations to LP, LNAV, or circling MDAs. However, the aircraft's RNP system may not offer eligibility to all lines of minima. Pilot knowledge of their aircraft's capabilities and limitations is necessary to obtain the full benefit of RNP APCH operations. The pilot makes an operational choice to fly a specific line of minima based on the aircraft eligibility, the RNP system's available level of service (e.g., LPV or LNAV), standard operating procedures (SOP), weather conditions, and other factors.

12.3.11 LPV Line of Minima. Operators need SBAS augmentation to fly RNP APCH to a line of minima labeled LPV. RNP APCH FASs with LPV minima incorporate SBAS-enabled 3D angular lateral and vertical guidance with increasing CDI sensitivity as an aircraft gets closer to the runway. The navigation display guidance and course deviation indications are nearly identical to those of an ILS at similar distances. This intentional design permits a pilot to demonstrate and maintain 3D PA flying skills and currency by flying RNP APCH operations to an LPV or LNAV/VNAV DA.

12.3.12 LNAV/VNAV Line of Minima. Operators need baro-VNAV or SBAS augmentation to fly an RNP APCH to the 3D line of minima labeled LNAV/VNAV. The flight manual (see Chapter 3) will indicate whether the aircraft uses baro-VNAV or SBAS to fly to the 3D LNAV/VNAV DA. Some aircraft installations use GPS-only to provide lateral path guidance and approved baro-VNAV to provide Vertical Path (VPATH) guidance to a LNAV/VNAV DA.

12.3.13 LP Line of Minima. Operators need SBAS augmentation to fly RNP APCH to a 2D line of minima labeled LP. When terrain or obstacles near the runway prevent designing a 3D procedure to an LPV DA, an RNP APCH procedure can offer a 2D LP line of minima. LP FAS uses angular lateral guidance similar to a LOC-only operation. Use of the LP minima requires a specific SBAS airworthiness approval. Like an LPV operation, the SBAS installation will indicate when the LP level of service is available. Most SBAS installations offer advisory vertical guidance when flying an RNP APCH to LP minima. In such cases, the primary barometric altimeter remains the pilot's altitude reference for complying with all procedural altitude constraints.

12.3.13.1 Some RNP APCH procedures offer only an LP line of minima without an accompanying LNAV line of minima. This occurs when terrain or obstacles in the FAS require the use of SBAS angular lateral guidance to enable a straight-in approach operation.

12.3.13.2 SBAS sensor installations do not offer a "fail-down" mode from the LPV level of service to the LP level of service. SBAS installations can support fail-down from LPV to LNAV when the LNAV line of minima is available on the RNP APCH procedure.

12.3.14 LNAV and Circling Line of Minima. Operators need only GPS to fly RNP APCH to a 2D line of minima labeled LNAV or Circling. Some aircraft RNP systems may offer advisory vertical guidance when flying an RNP APCH to LNAV minima. In such cases, barometric altimeter information remains the primary altitude reference for complying with all altitude restrictions.

12.4 Operational Guidance. Operators and pilots should also review and comply with the guidance in the Aeronautical Information Manual (AIM), the State Aeronautical Information Publication (AIP), and their approved SOP.

12.4.1 Preflight. The following are preflight considerations for RNP APCH operations.

12.4.1.1 Confirm the Availability of GPS and SBAS (WAAS). Since RNP APCH procedures require GPS, operators need to confirm the availability of GPS (and WAAS, if applicable) as part of preflight planning. Operators need to confirm the availability of GPS for the planned time of the RNP APCH procedure. For some operators, this requires receiver autonomous integrity monitoring (RAIM) prediction. WAAS-equipped operators need not perform a RAIM prediction, but still need to confirm WAAS availability through a check of WAAS NOTAMs. Operators should consider the possible impact of large area military GPS testing on their planned use of GPS for en route navigation and terminal operations. During preflight, operators of aircraft equipped only with GPS should make contingency plans to navigate to a safe landing if they experience unreliable GPS, especially if intending to penetrate instrument meteorological conditions (IMC). See Appendix B, Flight Planning, and the AIM.

12.4.1.2 Confirm Navigation Database Currency. Pilots should confirm their navigation database is current.

12.4.1.3 Alternate Weather Minima. Operators of RNP APCH eligible aircraft have some flexibility when it comes to selecting an alternate airfield. Operators of WAAS-enabled aircraft have even greater flexibility owing to the improved accuracy, availability, and reliability of GPS navigation with WAAS. Operators of both GPS and WAAS RNP systems do face some requirements and limitations when evaluating potential alternate airfields. Operators must comply with part 91, § 91.169, and should review the front matter of the Terminal Procedures Publication (TPP), the Alternate Minimums section, for flight planning limits on use of procedures based on GPS and WAAS at an alternate airport. In addition, the AIM, Chapters 1 and 5, contains guidance on qualifying and using the alternate requirements in more detail. Operators should also refer to these sources to understand FAA policy regarding use of GPS and WAAS to meet part 91 alternate airport weather minima.
Non-part 91 operators need to follow the provisions and limitations contained in their applicable operations specifications (OpSpecs). In general, the policy can be summarized as follows:

12.4.1.3.1 An Alternate With GPS. Assuming no NOTAMs to the contrary, operators whose GPS-based RNP systems have fault detection and exclusion (FDE) capability, who perform a preflight RAIM prediction for the airports, may qualify either a destination airport or an alternate airport with a GPS-based IAP, but not both. The pilot must plan for applicable alternate airport weather minima using the nonprecision (2D) LNAV or circling MDA. If the above conditions cannot be met, any required alternate airport must have an approved IAP (other than GPS-based IAP) that is anticipated to be operational and available at the ETA, and for which the aircraft is equipped and able to fly.

12.4.1.3.2 A Destination or Alternate (with WAAS). Assuming no NOTAMs to the contrary, operators with WAAS-enabled RNP systems may qualify both the destination and alternate with a GPS-based IAP but are restricted to planning for the nonprecision (2D) LNAV or circling line of minima at the alternate. Upon arrival at an alternate, if the WAAS-enabled RNP system indicates that LNAV/VNAV or LPV service is available, then the pilot may use the vertical guidance to complete the approach using the displayed level of service.

12.4.2 Contingency Planning. Operators should develop contingency procedures for loss of GPS and/or WAAS during an RNP APCH operation. Such procedures should enable pilots to continue the flight to a safe landing following the loss of GPS or WAAS capability (see examples in paragraphs 12.4.2.1–12.4.2.3 below). Pilots should be thoroughly familiar with how their GPS- or WAAS-enabled RNP system operates, particularly its fail-down capability. Pilots should know how system failures will display and what options remain after loss of GPS occurs (for any reason). Pilots should notify air traffic control (ATC) of

any loss of PBN navigation capability. The controller will likely request the pilot's intentions in place of the RNP APCH procedure.

12.4.2.1 VOR Minimum Operational Network (MON). The VOR MON program provides contingency capability for "loss-of-GPS/WAAS." This resiliency offers pilots the ability to amend their ATC clearance, revert to conventional operations using VOR and continue to the destination or divert to a VOR MON airport served by an ILS or VOR approach procedure. See Chapter 1.

12.4.2.2 Example 1.

Situation: LPV or LP lines of minima not available due to reduced WAAS service.

Aircraft position: Any point prior to the FAF:

- The LNAV or LNAV/VNAV line of minima may still be available depending on the nature of the reduced service.
- Pilots may elect to continue the approach to the LNAV or LNAV/VNAV line of minima.
- Alternatively, pilots may select a different approach using a ground-based NAVAID or fly to an alternate airport.

Aircraft position: After the FAF. An SBAS system failure alert may indicate a loss of LP or LPV service and offer a fail-down to LNAV-only operations:

- Pilots can continue to descend (using advisory vertical guidance, if presented) to the LNAV minima if the aircraft is above the MDA and any step-down fix altitude constraints.
- Pilots should immediately initiate a missed approach if below the LNAV MDA and unable to continue visually.

12.4.2.3 Example 2.

Situation: No WAAS service (this situation is comparable to flying with unaugmented GPS equipment).

Aircraft position: Any point prior to the FAF:

- If there is no instrument flag or other integrity alert, a pilot may complete the approach using the LNAV line of minima (or LNAV/VNAV if suitably equipped with baro-VNAV vertical guidance capability).
- If a pilot sees an instrument flag or integrity alert, the pilot should abandon the approach and request clearance to do one of the following:

- Enter holding (fuel permitting) until the GPS/WAAS is available, or fuel state requires a divert to an alternate;
- Fly an available approach using ground-based NAVAIDs; or
- Proceed to an alternate airport.

Aircraft position: After the FAF. After the aircraft passes the FAF, if the avionics provide an instrument flag or integrity alert, and unable to continue visually, the pilot should immediately begin a go-around and then perform the missed approach procedure.

12.4.2.4 Example 3.

Situation: With loss of GPS (for any reason), the pilot would need to obtain a new ATC clearance to fly a conventional ground-based or RADAR instrument approach (refer to the front matter of the TPP) at either the destination or a suitable alternate airport.

12.4.3 Temperature Compensation During RNP APCH Operations. RNP APCH procedures with an LNAV/VNAV line of minima may have a published temperature limitation range (e.g., "For uncompensated baro-VNAV systems, LNAV/VNAV NA below -25 °C (-13 °F) or above 45 °C (114 °F)"). The temperature limitation is due to the effects of nonstandard temperature(s) on an aircraft's barometric altimetry system and baro-VNAV guidance. When the actual airport temperature is below or above the charted temperature limitations and the aircraft provides baro-VNAV guidance, pilots may not fly to the LNAV/VNAV DA, without use of temperature compensation. All pilots should follow the flight manual procedures for use of the RNP system's temperature compensation function (for both high and low temperatures, if available) as a normal part of the pre-landing checks. The published temperature limitation range does not apply to aircraft with SBAS-based RNP APCH capability to LPV or LP or LNAV/VNAV lines of minima. See Appendix C.

12.4.3.1 Cold Temperature Airports (CTA). The FAA designates certain airports in the United States as CTAs. A snowflake icon on the airport's FAA approach chart will identify a CTA and indicate a limiting temperature in Celsius. When the forecasted temperature is equal to or colder than the CTA temperature, pilots should follow the CTA guidance in chapter 7 of the AIM. See also Appendix C, and also refer to the FAA's list of CTAs at https://aeronav.faa.gov/d-tpp/Cold_Temp_Airports.pdf.

12.4.4 Barometric Altimeter Cross-Check. When using baro-VNAV vertical guidance to conduct an RNP APCH operation to the LNAV/VNAV line of minima, the pilots should complete an altimetry cross-check ensuring that both pilots' altimeters agree within ±100 feet not later than the FAF after receiving the current local altimeter setting at the airport of intended landing. If the difference exceeds 100 feet, pilots should revert to an

LNAV-only operation and comply with any published step-down fix altitude or discontinue the approach.

Note 1: This cross-check is not necessary when using SBAS vertical guidance.

Note 2: This operational cross-check is not necessary when the aircraft includes an avionics function to automatically monitor and compare the primary barometric altimeters during an RNP APCH operation and issues an alert in the primary field of view (FOV) when the difference between the altimeters exceeds 100 feet.

12.4.5 Verify VNAV Path Mode Selection**.** Pilots should select and arm the appropriate vertical guidance mode during RNP APCH operations, in accordance with flight manual guidance. Some vertical guidance modes, such as Vertical Speed (VS), are unsuitable and incompatible with an LNAV/VNAV or LPV final approach operation.

12.4.6 Approach Operation and Monitoring. To ensure flightpath compliance on the RNP APCH final approach course, pilots must maintain course centerline (CL) per § 91.181 and monitor:

1. Cross-track (XTK) deviation to ensure it never exceeds one-half of the lateral navigation accuracy (RNP value) for each segment of the RNP APCH procedure (i.e., 0.50 NM for the initial and intermediate segments, 0.15 NM for the FAS, and 0.50 NM for the MAS). If the XTK exceeds these values on straight segments, the pilot should abandon the approach and request a new clearance.
2. Appropriate flight guidance mode changes for the intended approach. Pilots should ensure correct navigation and deviation display scaling for the approach, and if the flight guidance is ever in doubt, abandon the approach and request a new clearance.

Note: FAA Airmen Certification Standards (ACS) for Instrument rating allow up to 3/4-scale deflection of the CDI on an approach procedure for new instrument rating applicants (and 1/4-scale for airline transport pilot (ATP) applicants).

12.4.6.1 Use FD and/or AP. While conducting RNP APCH operations, pilots are encouraged to use FD and/or AP. Some aircraft and helicopters may have flight manual limitations that require use of AP for specific RNP operations (e.g., for use on RNP APCH procedure using A-RNP or an RF segment). See Chapter 3 for more information on aircraft eligibility and required equipment.

Note: Pilots are encouraged to use the aircraft's Head-Up Display (HUD) and/or Enhanced Vision System (EVS) during an RNP APCH operation.

12.4.6.2 Verify Altimeter Setting. The pilot must observe any flight manual or procedural limitations for the source of the destination altimeter setting and set the barometric altimeter prior to reaching the FAF. Pilots shall not use a

remote altimeter setting if intending to use baro-VNAV to an LNAV/VNAV DA.

12.4.6.3 Verify Annunciations. Pilots should verify the RNP system displays the correct mode or level of service (i.e., "LNAV", "LPV", "TERM", "APPR", etc.) for the desired approach operation at the appropriate time, in accordance with the flight manual. For example, if the RNP system annunciates "LPV", the pilot may fly to the published LPV, LNAV/VNAV, LNAV, or circling minima on the approach chart. If the RNP system annunciates only the availability of "LNAV" on the same procedure, the pilot may use only the LNAV or circling minima.

12.4.6.4 Verify Lateral Deviation Scaling. Pilots should verify the appropriate lateral deviation scaling (i.e., full-scale deflection) during the various segments of the RNP APCH procedure. Most aircraft provide automatic or default scaling during the RNP APCH using ±1.0 NM for the initial and intermediate segments, ±0.3 NM for the FAS, and ±1.0 NM for the MAS. For aircraft without automatic or default scaling, pilots may use flight manual guidance and limitations to set RNP 0.30 manually prior to beginning an RNP APCH.

Note 1: Some aircraft have airworthiness approval for the RNP system to provide angular lateral and vertical deviation scaling in the FAS of an RNP APCH flown to LNAV/VNAV or LNAV minima.

Note 2: The approach mode annunciations in some aircraft provide a means for the pilot to verify proper lateral deviation scaling during the approach (e.g., "APPR", "LNAV", "LNAV/VNAV", etc.).

12.4.6.5 Verify Intermediate Segment Minimum Altitudes. Pilots are to comply with all charted procedure altitudes, including those in the intermediate segment, even if using the LPV, LNAV/VNAV, or ILS/GLS glidepath prior to the FAF. Large temperature differences from ISA will affect the RNP system's altitude computations and ability to capture the glidepath. Therefore, flying appropriate temperature-corrected altitudes in the intermediate segment is critical to maintaining a smooth flightpath into the glidepath capture window or to setting up a stabilized CDFA technique for the descent to minima.

12.4.6.6 Verify Step-Down Fix Altitudes in the Final Segment. During an RNP APCH operation, obstacles in the FAS may necessitate publishing step-down fix altitudes. Pilots should observe these limits when flying the 2D path to the MDA. Properly flying the 3D LPV or LNAV/VNAV glidepath, like the ILS/GLS glidepath, to DA, will keep the aircraft safe from obstacles and terrain. Pilots may ignore published minimum step-down fix altitudes in the final segment between the FAF and the DA when established on the:

- ILS/GLS/LPV glidepath.
- LNAV/VNAV glidepath when using SBAS VNAV guidance.
- LNAV/VNAV glidepath when using baro-VNAV when the airport temperature is within the procedural temperature limits or when the pilot uses appropriate temperature correction as described in Appendix C.

12.4.6.7 Monitor Deviations. During an RNP APCH operation, monitor the lateral and, if installed, vertical track deviations on the pilot's primary flight display (PFD) to ensure that the aircraft remains within the bounds defined by the RNP APCH procedure.

12.4.6.8 Lateral Deviation. 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 one-half of the RNP value specified for each segment of the approach. Normally, during RNP APCH procedures pilots should maintain CL and limit deviations to one-half of the standard RNP values of 1.0 NM on the initial and intermediate segments, 0.30 NM on the final segment, and 1.0 NM on the MAS. However, A-RNP or RNP 0.3 NavSpecs may apply to the initial, intermediate, or missed approach segment of an RNP APCH procedure. When the RNP APCH procedure uses these NavSpecs, leg segments may apply a "Min RNP" of 0.30 NM. Pilots should verify the deviation scaling and monitor deviation appropriately.

12.4.6.9 Vertical Deviations. When using SBAS vertical guidance to fly to LNAV/VNAV minima during the FAS, pilots should ensure vertical deviations do not exceed 1/2-scale. When using approved baro-VNAV vertical guidance to fly to the LNAV/VNAV minima during the FAS, pilots should ensure displayed vertical deviations do not exceed ±75 feet (or smaller value published in the flight manual).

Note: For aircraft approved under previous AC guidance addressing baro-VNAV and LNAV/VNAV minima, the legacy vertical deviation limits of +100/-50 feet remain valid.

12.4.7 Final Approach Fix (FAF). Pilots flying an RNPAPCH procedure using CDFA techniques are likely to be more successful in maintaining a stabilized approach to the selected minima (refer to AC 120-108( ), Continuous Descent Final Approach). Approaching the FAF (or glidepath intercept), pilots should:

12.4.7.1 Verify Transition from Terminal to Approach. Pilots should verify level of service and line of minima they intend to use, and that the RNP system properly transitioned from terminal mode to approach mode when the aircraft is within 2 NM of the FAF.

12.4.7.2 Verify Transition to xLS Course Guidance. When an RNP APCH procedure path includes transitions to an xLS FAS (e.g., GLS, ILS, or LPV),

pilots need to verify the transition to the appropriate final approach guidance in accordance with the flight manual procedures.

12.4.8 Minima. The pilot should arrive at minima prepared to transition to the visual segment or execute the missed approach. Pilots should fly a stabilized approach and descend the aircraft along the CL of the published lateral and vertical path using available vertical guidance. Best practices include computing or following a stabilized rate of descent on final, to arrive at a derived DA, just above the MDA, consistent with CDFA techniques. In all cases, execute the missed approach upon reaching the missed approach point (MAP or DA), unless the appropriate visual references for continuing the approach to a landing are present (per OpSpec or as specified in §§ 91.175 and 91.176).

12.4.9 Discontinue the Approach. Unless the weather conditions permit a visual approach to the runway of intended landing, the pilot must discontinue an RNP APCH procedure if lateral or vertical deviations exceed the limits specified in the flight manual (or other documentation) or any of the following examples of RNP system-related alerts occur:

1. The navigation display or PFD flags invalid (e.g., "OFF" flags on HSI/CDI or "ABORT APPROACH" annunciations);
2. A loss of integrity alert occurs (e.g., "INTEG" or "UNABLE RNP" annunciations);
3. Any integrity alert activates before passing the FAF (e.g., a "RAIM", "APR MODE INHIBITED", or "APPR NOT AVAILABLE" alert); or
4. Any loss of GPS (for any reason) where the flight manual requires discontinuing the RNP APCH procedure.

12.4.10 Missed Approach. The pilot should execute the published missed approach procedure, or alternate instructions issued by ATC, in accordance with flight manual procedures.

12.4.10.1 Verify Missed Approach Navigation Source. The pilot may need to manually activate the published missed approach procedure (e.g., close an RNP system flight plan discontinuity) when continuous LNAV is not available. The pilot should also ensure the selection of the correct navigation source and guidance mode for the missed approach procedural path.

Note: This is particularly important if executing a missed approach from a hybrid ILS (that requires RNP guidance to join final or fly the missed approach) or a GLS approach where the missed approach requires use of the RNP system to navigate to a waypoint.

12.5 Basic Guidance for Point in Space (PinS) Procedures. This paragraph provides additional information pertinent to RNP APCH operations to a PinS followed by a visual segment.

12.5.1 PinS Location. When used, rotary- and fixed-wing PinS locations are selected to provide the pilot maximum time to align the aircraft with the runway, complete any final configuration checks, and continue a stabilized approach to landing in visual conditions.

Rotary-wing PinS criteria presents the optimum PinS location as 0.65 NM from the heliport. This provides an adequate distance to decelerate and land from an approach speed of 70 knots indicated airspeed (KIAS). This distance also permits optimal blending of obstacle clearance criteria with non-instrument heliport ingress areas.

12.5.2 PinS Approach Operations. PinS operations may include a longer-than-usual visual segment beginning after the charted FAF. In most cases, the charted MAP will remain the runway end ID waypoint, although some procedures may be coded differently. Higher-than-normal visual minima are normally attached to the procedure, and the visual segment may include navigational guidance to the runway end waypoint. Pilots are expected to observe any constraints noted on the procedure, and navigate the visual segment as charted (including using guidance provided by the RNP system, if provided) to position the airplane or helicopter for a normal landing. Differences in RNP system behavior necessitate pilot familiarity with the procedure.

12.6 RNP APCH Operations With an Extended Visual Segment.

12.6.1 Unique RNP APCH Operation. Where operationally necessary, and traffic flow constraints do not permit a straight-in approach procedure, the FAA may publish a unique RNP APCH operation to improve traffic flow to the landing runway. To support the traffic flow, the aircraft's navigation database may contain a continuous path definition from the RNP APCH's IAF to the missed approach holding waypoint, including path definition of the visual segment. This enables the aircraft to support a CDFA operation to the procedure's LNAV MDA and then provide a continuous 3D flightpath through the visual segment to the landing runway.

12.6.2 Multiple Turns in the Visual Segment. The visual segment for these RNP APCH procedures may include multiple turns defined by named waypoints with recommended altitudes. This permits the pilot to conduct a CDFA operation during the visual segment by using the RNP system's advisory lateral and vertical guidance to fly the desired vertical profile and ground track to the landing runway.

Note: When the operator's aircraft are eligible for RF turns, the operator's navigation database provider may define the visual segment's turns using a continuous, uninterrupted path definition through use of RF legs in lieu of TF legs. In this case, the visual segment ground track defined by RF legs must overlay the procedure's ground track defined by TF legs.

12.6.3 Go-Around Procedure. During these unique RNP APCH operations, upon arrival at the visual guidance fix (VGF) and maintaining the LNAV MDA, the pilot verifies the required visual references are available and continues to follow the advisory lateral and vertical guidance during the visual segment to the threshold. If the pilot determines a need to go-around, the pilot should stop the descent, notify ATC, and continue to follow the defined lateral path to the runway threshold waypoint and commencing the published missed approach procedure. The pilot should expect ATC to issue a new clearance shortly after contact (e.g., radar vectors).

12.6.4 RNP APCH with Extended Visual Segment Example. An example of this type of RNP APCH procedure is the "RNAV (GPS) Z 13L" approach at John F. Kennedy Airport (KJFK). The procedure's relatively high ceiling and visibility requirements ensure the pilot will obtain the required visual references no later than the beginning of the visual segment. During the approach, the pilot completes a CDFA operation to the LNAV MDA, confirms visual references, and follows the defined ground track, which includes two turns for runway alignment.

12.7 Training. In addition to the general training subjects presented in Chapter 3, pilots need to be very familiar with all aspects of an RNP APCH procedure. While RNP APCH procedures share many similarities with conventional NAVAID IAPs, and the same instrument flying skills are used, there are significant differences in RNP APCH operations. Pilots should review the relevant sections of their flight manual for information on use of GPS/WAAS and PBN. The operating guidance provided in your flight manual, avionics supplements, AIM, Instrument Flying Handbook (IFH), Instrument Procedures Handbook (IPH), including the comprehensive descriptions of approach procedures and charts, and this AC should serve as the foundation for any RNP APCH training plan or program. Operators should consider all that information important to adequate pilot preparation for an RNP APCH procedure. The FAA encourages all pilots to make RNP APCH procedures a part of their flight review.

12.7.1 Training Program. Parts 91K, 121, 125, 129, and 135 operators should have an initial, upgrade, and recurrent RNP APCH training program addressing the operational practices, procedures, and training items identified in Chapter 3 and below. Part 91 pilots are encouraged to use the FAA Pilot Proficiency Program (WINGS) to maintain and document training and proficiency.

12.7.2 Ground Training. Pilots should be familiar with the common training topics listed in Chapter 3. The FAA recommends emphasis on any changes to operator programs, aircraft equipment, or procedures with a review of any occurrences or incidents that may be relevant. This training should include a refamiliarization with topics such as mode annunciations for failure conditions or other information that pilots may not routinely see during normal operations. Training time need not be dedicated solely to normal RNP APCH training and may incorporate aircraft performance and weight limit information to ensure safe obstacle clearance for "all engine," or "engine inoperative" missed approach, or rejected landing, as well as loss of navigation contingencies.

12.7.3 Initial and Recurrent Flight Training. Pilots should review the applicable reference information for RNP APCH approaches, as well as RNAV departures and arrivals. Recurrent flight training should sample the applicable low-visibility landing procedures to be used by the operator. The training should emphasize any rare or critical procedures used by that operator not otherwise routinely flown or the pilots may not have flown recently. Training should include any critical non-normal procedures (e.g., parallel operations, precision runway monitor (PRM) operations, engine inoperative, or system failure cases), and any special emphasis procedures or items found to require attention due to in-service feedback by the operator (e.g., excessively high descent rates near the surface, or loss of navigation capability on approach).

12.7.4 Minimum Training Items. Training for RNP APCH instrument approach operations to all lines of minima should include the items listed under this paragraph. Pilots need to be familiar with how to use their avionics in compliance with the aircraft and/or avionics manufacturer's operating manuals. All operators should take advantage of applicable manufacturer's training tutorials. In the absence of a training program, operators should use this guidance provided in this chapter to develop their training curriculum and document the training as outlined below. Parts 91K, 121, 125, 129, 135, and 137 operators should ensure their program addresses these minimum items. Pilots should be able to:

1. Interpret RNP APCH procedure characteristics (including, but not limited to, temperature and altimeter source limitations for baro-VNAV operations, or airspeed constraints) as determined from IAP chart depictions and textual descriptions.
2. Identify and interpret RNP APCH functional requirements from the procedure's PBN Requirements Box, such as use of A-RNP, RNP 0.3, or RF turns or minimum RNP values.
3. Determine the required navigation capability for RNP APCH operations (e.g., GPS and/or SBAS) and FAS operations (ILS/GLS/LPV) and any operational restrictions/limitations, as outlined in the flight manual, SOP, or OpSpec.
4. Select approaches (procedure name, channel number, etc.) and confirm correct approach ID or Runway Path Identifier (RPI).
5. Define GLS and ILS approach attributes (e.g., approach service volumes) and how to set up and enable appropriate approach flight guidance modes for transition from RNP to the final approach guidance.
6. Identify procedure-specific requirements of parallel approach operations and/or PRM, as appropriate.
7. Recognize and understand RNP system annunciations and alerts (e.g., "UNABLE RNP" or "GPS LOI") including contingency planning (see paragraph 12.4.2) for transition to different levels of service available during the RNP APCH operation.
8. Apply pilot contingency procedures for a loss of GPS and/or WAAS capability.
9. Understand the effects of nonstandard temperature (see Appendix C) and pressure on true altitude relative to ISA and the primary barometric altimeter's indicated altitude.
10. Confirm appropriate altimeter setting and, when required, accomplish barometric altimeter cross-check procedures.
11. Understand and apply CTA operations procedures and temperature compensation functions (as applicable) (see Appendix C).
12. Understand the aircraft limitations associated with baro-VNAV approach operations.
13. Recognize and resolve possible aircraft performance issues with procedure requirements (e.g., airspeed constraints and descent angles).

14. Verify and, if necessary, set appropriate lateral and vertical scaling settings for the RNP APCH operation (e.g., manually set RNP 0.30).
15. Understand the aircraft's LNAV/VNAV capability and limits when the RNP system provides vertical guidance using GPS/SBAS or baro-VNAV during the FAS.
16. Determine how and when to use or resolve RNP system flight plan discontinuities.
17. Interpret and understand which failures and performance parameters require discontinuing the approach.
18. Execute go-around and missed approach procedures, including re-engaging LNAV or use of the required flight guidance mode (e.g., "HDG" mode).
19. Understand alternate airport requirements and options available based on the situation and § 91.169 or OpSpec requirements.

12.7.5 Training Documentation. Parts 91K, 121, 125, 129, 133, 135, and 137 operators' applications for operational approval for RNP APCH operations should be specific their aircraft's RNP APCH eligibility and available lines of minima, including use of SBAS/WAAS without restrictions or limitations to LPV or LP operations. Part 91 operators are encouraged to document events supporting pilot currency and proficiency for RNP APCH operations through a training log. Part 91 pilots may benefit from use of the FAA WINGS program as an aid to maintain a currency and proficiency in RNP APCH operations. Refer to AC 61-91( ), WINGS—Pilot Proficiency Program, for guidance on the FAA WINGS program.

12.8 Operational Approval.

12.8.1 All Operators. No separate or special individual pilot qualification documentation is necessary for RNP APCH operations, including:

- SBAS augmented approach operations (e.g., WAAS enabled approved vertical guidance);
- RNP to xLS operations using RNP APCH (e.g., LPV, ILS, or GLS); or
- RNP APCH operations using RF turns.

12.8.2 Authorizing Documents (OpSpecs). Parts 91K, 121, 125, 129, 135, and 137 operators receive approval to fly RNP APCH operations to appropriate lines of minima via appropriate OpSpec. Consult your certificate management office (CMO) or principal inspector (PI) for more information or to begin the authorization process. Part 91 operators may apply for any desired Letters of Authorization (LOA) (for operations outside of U.S. airspace and when required by host State regulations) and should contact their responsible Flight Standards office to begin the process. See Appendix A, Obtaining PBN Operational Approval.

12.9 Bundling of Operational Authorizations. As discussed in Appendix A, bundling is the packaging of multiple PBN capabilities (i.e., NavSpecs), according to a hierarchy, in a single application for operational authorization. The approach phase does not normally support bundling a hierarchy of capabilities. Instead, the aircraft's RNP APCH capabilities are generally approved and authorized through the flight manual documentation of eligible lines of minima. For example, the flight manual must contain specific eligibility and pilot procedures for LPV and LP lines of minima to authorize their operational use.

APPENDIX A. OBTAINING PBN OPERATIONAL APPROVAL

A.1 Introduction. The FAA issues operational approval (also sometimes referred to as operational "authorization") via authorizing documents termed operations specifications (OpSpecs), management specifications (MSpecs), training specification (TSpecs), and Letters of Authorization (LOA). For the purposes of this AC, all authorizing documents are included in the term "OpSpecs." All commercial operators (those operating under parts 91K, 121, 125, 129, and 135) require operational approval for the PBN operations described in this AC. (Part 129 operators do not require the same OpSpecs as parts 121, 125, and 135 operators.) Any operator planning a flight overseas should carefully review the AIP of every country whose airspace they will traverse, in order to determine what authorizing documents they may need to present to aviation authorities. Table D-2, PBN Operations Specifications, contains a list of current OpSpecs with some applicability to PBN operations.

Note: Unless otherwise stated, operational approvals issued under the guidance of earlier, now cancelled or superseded, ACs or FAA orders generally remain valid. No operator needs to obtain a new authorization solely because the FAA issued this new AC. Operators must ensure their operations remain consistent with the performance and functional requirements of this AC.

A.1.1 Part 91 Operator Responsibilities. While part 91 operators do not require operational approval for most PBN operations, those operators are nevertheless responsible for ensuring their aircraft meet all the aircraft eligibility criteria for any PBN operation they fly. Similarly, they need to ensure they and/or their pilots are adequately trained and equipped (i.e., with sufficient detailed operating procedures) to fly any intended PBN operation. Part 91 operators who fly overseas and internationally may be required to show authorizing documents to host-nation regulatory authorities. Such operators should apply for the appropriate LOA from their Flight Standards District Office (FSDO).

A.2 General Information on Operational Approvals. The FAA assigns each specific type of operational authorization a unique number. For example, OpSpec B036 issues approval to conduct RNP 2, 4, and 10 operations in oceanic airspace and Remote Continental Airspace (RemCon). OpSpec C063 authorizes commercial operators to fly PBN DPs and STARs. Generally, the "A" series OpSpecs deal with technical or special programs, "B" series apply to en route operations, "C" series apply to terminal and approach operations, and "H" series are specific to helicopter operations.

A.2.1 Application Guides or Application Preparation Tools. In some circumstances, particularly for complicated authorizations, the FAA may develop "application guides" or "application preparation tools" to guide operators through the process of building a complete application package. The guides or tools help operators gather all the documentation they need to meet application requirements and build an application package in a way that makes it quicker for an inspector to review. For more information, see your primary inspector at the FS office, and refer to the Flight Technologies and Procedures Division website at https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs400/afs410.

A.2.2 Digital Application Submissions. The FAA also provides operators with the means to build and submit applications digitally, as well as the means to track processing of their application. Your FS inspector can show you how to use the application tracking system.

A.2.3 Adding Performance-Based Navigation (PBN) Authorizations and Bundling. Operators may consult with their principal inspector (PI) to combine or bundle a hierarchy of multiple PBN capabilities in one application. Operators are encouraged to apply for every PBN authorization for which they are eligible under each phase of flight. Operators should supply appropriate documentation confirming that the aircraft and operator meet the airworthiness and operational requirements of the proposed PBN operation(s). Operators should include references to other dependencies (such as communications, surveillance, and datalink) when applying for OpSpec "bundles." The FAA instructs PIs to reference the other dependencies when evaluating the application.

A.2.4 Example of Bundling. The following is a bundling example using OpSpec B035, Class I Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems. OpSpec B035 authorizes an operator to conduct Class I navigation in Class A airspace using an area or long-range navigation system (LRNS). The bundling hierarchy options appear as:

- A-RNP (FRT, TOAC), RNP 2, RNAV 2 [Most capability]
- RNP 2 and RNAV 2 [Additional capability]
- RNAV 2 [Basic capability]

Note: Where appropriate, specific bundling examples are included with some of the chapters of this AC.

A.3 General Contents of an Application Package. Just as each OpSpec authorizes a unique operation, the contents of the application packages for those authorizations are also unique, to a degree. However, all application packages generally require the applicant to show the following:

- Proof of aircraft eligibility for the intended operation;
- How the applicant changed or added to flightcrew (and operational control personnel, where applicable) operating procedures to address the operation;
- How the applicant is training pilots (and operational control personnel, where applicable) to perform the operation; and
- Documentation of any new maintenance procedures and/or changes to the MEL to ensure the aircraft is adequately equipped for the operation.

A.4 General Considerations for All Applications. Operators should keep the following points in mind when seeking operational approval:

A.4.1 Start Early. Do not wait until a few weeks before you need the approval to start the application process. The process for some complex operations involves validation testing

in the final stage. In addition, the inspector's workload drives their ability to process an application in a timely manner. Typically, inspectors work applications in the order received. Ideally, operators should submit applications at least 180 days before they intend to perform the operation.

A.4.2 Make Sure Your Aircraft Is Eligible for the Desired Operation. There is no point in preparing an application if your aircraft is not eligible for the operation. Follow the aircraft eligibility guidance in Chapter 3.

A.4.3 Contact Your FS Office (i.e., FSDO, CMO, International Field Office (IFO), etc.) Before You Start on an Application. Arrange a preapplication meeting with your inspector so you know exactly what you need to do.

A.4.4 Be Thorough and Follow Directions. An incomplete application package will only delay receipt of your operational approval.

A.4.5 Use the Guidance in Chapter 3 of This AC as the Foundation for Your PBN Training and Pilot Operating Procedures. Your application package should show how you have adapted the guidance in Chapter 3 to your particular operation and related training program. Your application should also show how you have adapted the guidance in the chapters applicable to the desired operational approval (e.g., Chapter 5 for approval to conduct RNP 1 departures) to your operation. Those applications that show, clearly and succinctly, that the operator's training and procedures address all of the guidance in those chapters of this AC, are applications which make it through the review process generally unimpeded.

APPENDIX B. FLIGHT PLANNING

B.1 Introduction. In accordance with § 91.103, each pilot in command (PIC) "shall, before beginning a flight, become familiar with all available information concerning that flight." The flight planning process for the RNAV and RNP operations covered by this AC assumes that the aircraft and pilots are eligible for and competent in the intended operation, in accordance with either the guidance in this AC or alternative means acceptable to the FAA.

B.1.1 Notices to Air Missions (NOTAM). Reviewing NOTAMs applicable to your route of flight, including departure, destination, and alternate airports, is a fundamental step in flight planning. NOTAMs serve as one official source of current information concerning your flight. Pilots should not consider flight planning complete without looking for and reviewing NOTAMs pertinent to the intended flight.

B.1.2 GPS/WAAS Availability. Operators intending to fly PBN operations that mandate use of GPS need to confirm the availability of that system for their flight. The FAA publishes NOTAMs when operators might expect interference to GPS in certain areas, or where the system may be otherwise unreliable/unavailable. The FAA also provides specific NOTAMs if WAAS operations may be unavailable in a specific area.

B.1.3 AIM Guidance. The AIM provides comprehensive information on NOTAMs in general, and on GPS and WAAS NOTAMs. All operators/pilots of GPS-equipped aircraft should be familiar with how to find, comprehend, and apply the information found in GPS and WAAS NOTAMs.

B.1.4 Weather Information. AC 91-92( ), Pilot's Guide to a Preflight Briefing, details specifics on the sources and methods pilots may use to obtain flight planning weather information.

B.2 Receiver Autonomous Integrity Monitoring (RAIM). RAIM is a critical function of aircraft GNSS equipment that ensures the reliability of navigation using GNSS. Except when using SBAS or GBAS, the pilot has no assurance of GPS position integrity without RAIM. With very few exceptions, one being use of WAAS equipment for navigation in U.S. airspace, operators/pilots planning IFR navigation by GPS, including departures and approaches, need to confirm the availability of RAIM along their intended route of flight. A predicted loss of RAIM in excess of 5 minutes along the planned route of flight requires operators to change their plans. Operators can find a comprehensive discussion on RAIM, as well as information on how to obtain predictions of the availability of RAIM for their flight, by reading appropriate sections of the AIM.

B.2.1 Fault Detection and Exclusion (FDE). FDE is an additional RAIM function available in certain GNSS equipment. The FDE function allows the GNSS receiver to identify data from a faulty satellite and exclude that data from the aircraft navigation solution. In essence, FDE protects the aircraft's navigation system from the influence of a bad satellite. Like RAIM, FDE requires a certain number of satellites be visible to the aircraft GNSS system. Like RAIM, there is an ability to predict FDE availability along the route of flight.

B.2.2 RNP 2, RNP 4, and RNP 10. Operators planning flights in the oceanic or remote continental environment under RNP 2, 4, or 10 need to perform a preflight FDE prediction whenever the navigation system relies on GNSS. Operators can find additional specific information on FDE in the chapters of this AC addressing operations under RNP 2, 4, and 10. Operators may find FDE prediction information in their flight manual or otherwise consult with their navigation system manufacturer for guidance.

B.3 Flight Plan Filing. Operators/pilots need to make sure their flight plan accurately reflects the navigation, communication, and surveillance equipment operating in their aircraft, as well as any associated aircraft/pilot capabilities and authorizations. Operators need to ensure that the flight plan providers they use have the latest equipment codes for their aircraft. Failure to update the flight plan provider with the latest flight plan codes due to an equipment upgrade or aircraft purchase may result in sending the wrong aircraft eligibility codes to air traffic control (ATC), and result in ATC clearances the aircraft is incapable of flying. Items 10 and 18 of the international flight plan (FAA Form 7233-4, Pre-Flight Pilot Checklist and International Flight Plan, and ICAO equivalent) provide the avenue for those declarations of equipage and capability. ATC assigns clearances based on the equipment and capabilities declared on the flight plan form. Pilots will likely not receive a clearance that matches their requested (filed) route and flight profile if the information in items 10 and 18 does not support that request. Pilots may also miss opportunities for a more efficient route or profile if the flight plan does not accurately reflect all the flight's capabilities. The AIM provides a detailed description of flight plan codes, particularly for items 10 and 18. In addition, the FAA provides more comprehensive information on the FAA Flight Planning Information web page at https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/air_traffic_services/flight_plan_filing/.

B.4 RNP APCH at Alternate Airports. In general, operators face some flight planning limitations (see Chapter 12, paragraph 12.4.1.3) on the use of GPS or SBAS to support RNP APCH operations when § 91.169 or OpSpecs require an alternate airport. The limitations may vary with the type of RNP system in the aircraft. See Chapter 12. Also, chapters 1 and 5 of the AIM explain those limitations, as well as the conditions under which operators may plan to use an RNP APCH procedure at an alternate. Operators should ensure, through training programs and the preparation of pilot guides, that pilots and dispatchers correctly understand when and how they can plan for an RNP APCH IAP at an alternate.

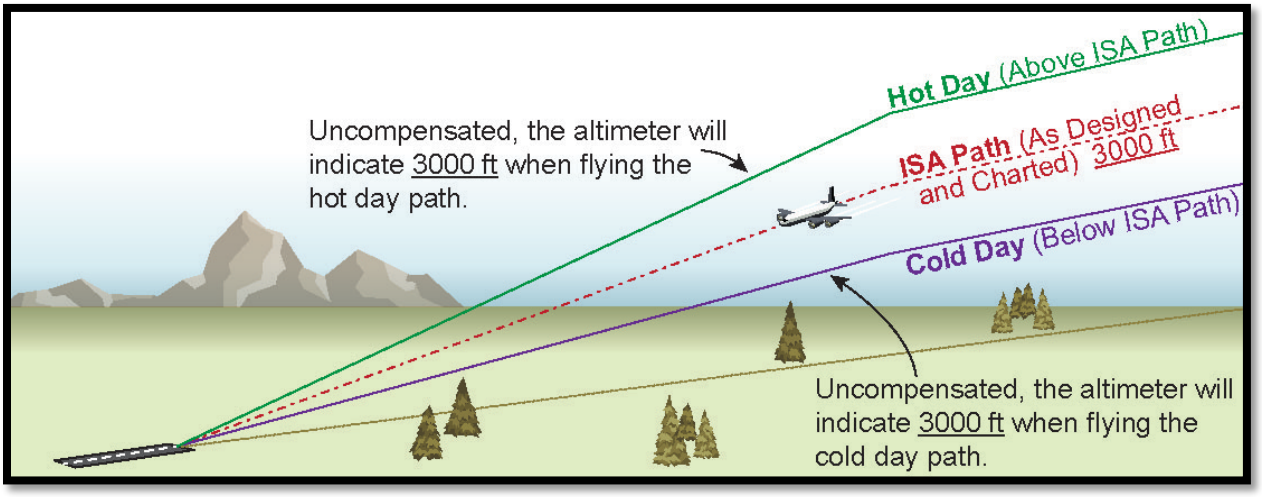
APPENDIX C. OPERATIONS IN NONSTANDARD TEMPERATURE CONDITIONS

C.1 Introduction. Temperature has an effect on the accuracy of barometric altimeters, indicated altitude, and true altitude. The International Standard Atmosphere (ISA) establishes a standard temperature at sea level of 15 °C (59 °F). The standard temperature gradient from sea level is -2 °C (3.6 °F) per 1,000 feet (i.e., at 5,000 feet above sea level, the ambient temperature on a standard day would be 5 °C). When the ambient (at altitude) temperature is colder than standard, the aircraft's true altitude is lower than the indicated barometric altitude. When the ambient temperature is warmer than the standard day, the aircraft's true altitude is higher than the indicated barometric altitude. Two types of temperature limits may be published on IAPs: a temperature range for the use of baro-VNAV or a CTA single temperature, or both. The paragraphs below will discuss the two temperature restrictions and how each should be used.

C.1.1 Temperatures Below ISA. Because the aircraft's actual altitude is lower than the indicated barometric altitude, pilots who operate aircraft in nonstandard cold temperatures may need to make an altitude correction to ensure obstacle or terrain clearance on segments of a published procedure. Glidepath angles on some approaches may also be shallower than published.

C.1.2 Temperatures Above ISA. Because the aircraft's actual altitude is higher than the indicated barometric altitude, pilots who operate aircraft in hot temperatures, particularly at higher elevation airports, may experience a steeper-than-normal final approach path angle. These steeper angles may create an unstable final approach with excessive descent rates. These operations may need alternate aircraft configurations (i.e., flap settings) with associated higher minimum maneuvering airspeeds, creating additional difficulties.

Figure C-1. Temperature and Descent Paths



C.2 Baro-VNAV. Baro-VNAV provides VPATH information that can be defined by vertical angles, or by altitudes at fixes, in PBN approaches. This is accomplished by systems using barometric altitude and RNP information defining the vertical flightpath. The glidepath angle is specified in the RNP system navigation database. Nonstandard temperatures can result in a change to effective VPATHs and actual descent rates when using aircraft baro-VNAV equipment for vertical guidance on FASs.

C.2.1 Effects of Temperature on Baro-VNAV Vertical Guidance. A lower-than-standard temperature will result in a shallower descent angle and require a reduced descent rate. Conversely, a higher-than-standard temperature will result in a steeper angle and require an increased descent rate. Pilots should consider potential consequences of these effects on approach minima, power settings, sight picture, visual cues, etc., especially for high-altitude or terrain-challenged locations and during low-visibility conditions.

C.2.2 RNAV (GPS) Titled Approach Procedure Temperature Restrictions. The procedure notes, "For uncompensated baro-VNAV systems, LNAV/VNAV NA below -XX °C (-XX °F) or above XX °C (XXX °F)," and "For uncompensated baro-VNAV systems, procedure NA below -XX °C (-XX °F) or above XX °C (XXX °F)," apply to baro-VNAV-equipped aircraft. These notes provide a high and low temperature range in which a baro-VNAV-equipped aircraft may operate without a temperature compensating system.

Note: The uncompensated baro-VNAV chart note and temperature range on an RNAV (GPS) approach is applicable only to the LNAV/VNAV line of minima. Baro-VNAV-equipped aircraft without a temperature compensating system may not use the LNAV/VNAV line of minima when the actual temperature is above or below the charted temperature range.

C.2.3 Cold Temperature Airport (CTA). The FAA has determined that operating in very cold temperatures has placed some IAPs in the NAS at risk for loss of required obstacle clearance. An airport that is determined to be at risk can be identified in the Terminal Procedures Publication (TPP).

C.2.3.1 CTA Identification in TPP. A CTA is identified by a "snowflake" () and temperature limit, in Celsius, on the IAP. CTA procedures may be found in the AIM.

C.2.3.2 Approach at a CTA With ILS, GLS, or LPV. When executing a 3D PA operation with vertical guidance at a CTA, pilots are reminded to intercept the glidepath at the corrected intermediate altitude and follow the published glidepath to the corrected minima. The ILS, GLS, and LPV glidepaths are unaffected by hot or cold temperatures and provide vertical guidance to the corrected DA. Begin descent on the glidepath when directed by aircraft instrumentation (i.e., in response to an "on glidepath" indication). The point at which the aircraft intercepts the glidepath on these approaches is called the Precise Final Approach Fix (PFAF). The PFAF is displaced from the FAF waypoint as a function of temperature.

C.2.3.3 Baro-VNAV Temperature Range versus CTA Temperature. The baro-VNAV and CTA temperatures are independent and do not follow the same correction or reporting procedures. However, there are times when both procedures, each according to its associated temperature, should be accomplished on the approach.

C.3 Compensating for Nonstandard Temperatures. Operators and pilots should use appropriate temperature compensation techniques and procedures on all PBN procedures. Operators should advise air traffic control (ATC) when using temperature compensation during instrument approach operations. Also refer to the AIM, 7-3-1 for more operational information on barometric altimeter errors, altimeter setting procedures, and CTAs.

C.3.1 Altimeter Is Never Adjusted for Temperature Compensation. **PILOTS MUST NOT MAKE AN ALTIMETER CHANGE** to accomplish an altitude correction. Pilots must ensure that the altimeter is set to the current altimeter setting provided by ATC in accordance with § 91.121.

C.3.2 Aircraft Temperature Compensation Function. An aircraft's RNP system can provide a temperature compensation function to correct procedural barometric altitude constraints on the instrument approach to compensate for the effects of nonstandard temperature (both hot and cold). Follow the flight manual or system operating manual for applying temperature compensation. The RNP system may offer the option to correct all leg segments from the IAF up to the Missed Approach Holding Point (MAHP); or, the pilot may choose to use temperature compensation on individual leg segment(s) of the approach (e.g., those legs segments impacted by CTA). However, it is a best practice to apply temperature compensation to the entirety of the approach procedure to realize the intent of the procedure design and avoid large "steps" between the realized altitude constraints for compensated leg segments and uncompensated leg segments.

C.3.2.1 When using the temperature compensation function, pilots should ensure the temperature compensation function is on and active prior to the IAF and remains active throughout the entire approach. Pilots should inform ATC when using temperature compensated altitudes on an instrument procedure.

Note: Pilots should be familiar with their RNP system's temperature compensation function and any limitations. Some systems only offer cold temperature compensation while others offer both hot and cold compensation. Some only compensate the approach but do not compensate the missed approach segment.

APPENDIX D. QUICK REFERENCE

Table D-1. PBN Quick Reference Chart

Performance Based Navigation (PBN)

	Nav Specs	Flight Phase: En Route – Oceanic Remote	En Route – Continental	Arrival (STAR)	Terminal Area	Approach – Initial	Approach – Intermediate	Approach – Final	Approach – Missed	Departure (DP)	Supporting Navigation Sensor Capability	Function	Naming Convention and Sample PBN Box Nomenclature (NavSpec - Sensor, Function, Remarks)	Remarks
RNAV Operations	RNAV 10 (RNP 10) (AC 90-119)	10									Dual LRNS IRU, GPS, SBAS			RNP 10 or RNAV 10 Eligibility & Ops approval (airspace labeled "RNP 10" or "RNAV 10" applies the RNAV 10 NavSpec).
	RNAV 2 (AC 90-119)		2	2						2	GPS DME / DME DME / DME / IRU			RNAV SID / STAR (En Route transitions) and Q / Y / T Routes. RNAV 2 Eligibility & Ops approval.
	RNAV 1 (AC 90-119)			1	1	RSAM*	RSAM*	Conventional (e.g. ILS or GLS)	RSAM*	1	GPS DME / DME DME / DME / IRU		FORKK TWO (RNAV) DP [RNAV 1 -- GPS or D/D/I]	RNAV SID / STAR RNAV 1 Eligibility & Ops approval (incl. RSAM*).
RNP Operations	RNP 4 (AC 90-119)	4									GPS DME / DME / IRU Dual LRNS			RNP 4 Eligibility & Ops approval (Aircraft eligible for RNP 4 are automatically eligible for RNP 10).
	RNP 2 (AC 90-119)	2	2								GPS DME / DME DME / DME / IRU			For Oceanic Ops: Dual LRNS RNP 2 Eligibility & Ops approval.
	RNP 1 (AC 90-119)			1	1	RSAM*	RSAM*	Conventional (e.g. ILS or GLS)	RSAM*	1	GPS	RF (option)	KNIFE TWO (RNAV) [RNP 1 -- GPS, BARRK transition: RF]	RNAV SID / STAR RNP 1 Eligibility & Ops approval (incl. RSAM*). RF requires specific Radius-to-Fix capability.
	RNP 0.3 (AC 90-119) (Rotorcraft)		0.30	0.30	0.30	0.30	0.30	RNP APCH	0.30	0.30	GPS + SBAS	RF (option)	Copter RNAV (GPS) RWY 18 [RNP 0.3 - GPS]	Check use on TK Routes & Copter & RNP APCH procedures. RNP 0.3 Eligibility & Ops approval (Rotorcraft only). Requires Autopilot. RF requires specific Radius-to-Fix capability. Flight Plan Code - To Be Determined.
	RNP APCH (AC 90-119)					1	1	Conventional or 0.30 or 40m (w/SBAS)	1		GPS + SBAS (For LP and LPV)	RF (option)	ILS Z RWY 18 (w/PBN Segment) or RNAV (GPS) RWY 15 [RNP APCH - GPS] ICAO Naming: RNAV (GNSS) RWY 15 or RNP RWY 15 (LPV, LNAV, LNAV/VNAV Only)	Conventional ILS / GLS with PBN-required segments RNAV (GPS) approach to LP, LPV, LNAV, LNAV / VNAV. RNP APCH Eligibility & Ops approval. RF requires specific Radius-to-Fix capability. (RF is NA after FAF).
	Advanced RNP (A-RNP) (AC 90-119)		2 or 1	1 or 0.30	1 or 0.30	0.30	0.30	RNP APCH or Conventional	1 or 0.30	1 or 0.30	GPS	RNP APCH, RF, Parallel Offset, RNP Hold	[A-RNP -- GPS. Min RNP 0.30, AP]	A-RNP includes RNP APCH as a pre-requisite. A-RNP Eligibility & Ops approval. A-RNP Ops at 0.30 RNP requires AP/FD.
RNP AR Operations	RNP AR APCH (AC 90-101)					1-0.10	1-0.10	0.30-0.10	0.10-1		GPS + IRU	RF, Scalable RNP	RNAV (RNP) RWY 15 [RNP AR APCH - GPS, Authorization Required] ICAO Naming: RNP RWY 15 (AR)	RNAV (RNP) to DA. RNP AR APCH Eligibility & Ops approval. OpSpec C384.
	RNP AR DP (AC 90-101)									0.30-1	GPS + IRU	RF, Scalable RNP	EELEY TWO (RNP) [RNP AR DP - GPS, Authorization Required]	RNAV (RNP) DP. RNP AR APCH and RNP AR DP Eligibility & Ops approval. OpSpec C384.

*RSAM = RNAV Substitution or RNAV Alternate Means (of Navigation).
"Eligibility" is a statement of aircraft capability to comply with the performance requirement.
"Ops approval" is authorization for the pilot to accomplish the procedure.

Table D-2. PBN Operations Specifications

Legend: A – Available R – Required

OpSpec	Title/Subject	91	91K	121	125	129	135	Other
A014	Special En Route IFR Operations in Class G Airspace		**A**	**A**	**A**		**A**	
A034	Advanced Qualification Program		**A**	**A**			**A**	
B030	IFR Navigation Using GPS/WAAS RNAV Systems		**A**	**A**	**A**		**A**	
B032	En Route Limitations and Provisions			**R**	**R**		**A**	
B034	IFR Class I Terminal and En Route Navigation Using Area Navigation Systems		**A**	**A**	**A**		**A**	
B035	Class I Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems		**A**	**A**	**A**	**A**	**A**	
B036	Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (M-LRNS)	**A**	**A**	**A**	**A**		**A**	
B037	Operations in Central East Pacific (CEP) Airspace		**A**	**A**	**A**		**A**	
B038	Operations in North Pacific (NOPAC) Airspace		**A**	**A**	**A**		**A**	
B039	Operations in North Atlantic High Level Airspace (NAT HLA)	**A**	**A**	**A**	**A**		**A**	
B040	Operations in Areas of Magnetic Unreliability		**A**	**A**	**A**		**A**	
B050	Authorized Areas of En Route Operations, Limitations, and Provisions	**A**	**R**	**R**	**R**		**R**	**141, 145**
B054	Oceanic and Remote Airspace Navigation Using a Single Long-Range Navigation System	**A**	**A**	**A**	**A**		**A**	
C052	Straight-in Non-Precision, APV, and Category I Precision Approach and Landing Minima—All Airports	**A**	**A**	**R**	**R**	**A**	**A**	
C055	Alternate Airport IFR Weather Minimums		**A**	**A**	**A**	**A**	**A**	
C063	Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations	**A**	**A**	**A**	**A**	**A**	**A**	

OpSpec	Title/Subject	91	91K	121	125	129	135	Other
C073	Vertical Navigation (VNAV) Instrument Approach Procedures (IAP) Using Minimum Descent Altitude (MDA) as a Decision Altitude (DA)/Decision Height (DH)	**A**	**A**	**A**	**A**		**A**	
C081	Special Instrument and RNAV Visual Flight Procedures	**A**	**A**	**A**	**A**		**A**	
C085	14 CFR Part 97 NDB, NDB/DME, VOR, VOR/DME, and TACAN Instrument Approach Procedures Using Substitute Means of Navigation			**A**			**A**	
C358	Special Restrictions for "RNP-like" Foreign RNAV Terminal Instrument Procedures with RNP Lines of Minima	**A**	**A**	**A**	**A**		**A**	
C384	Required Navigation Performance (RNP) Procedures With Authorization Required (AR)	**A**	**A**	**A**	**A**	**A**	**A**	
C390	Terminal RNP Instrument Approach Operations Using Non-Part 97 Obstacle Assessments			**A**				
H102	Basic Instrument Approach Procedure Authorizations—All Airports		**A**	**A**		**A**	**A**	
H105	Alternate Airport IFR Weather Minimums		**A**	**A**		**A**	**A**	
H112	Instrument Approach Operations Using an Area Navigation System		**A**	**A**			**A**	
H122	Special Instrument Procedures for Rotorcraft Operations	**A**	**A**	**A**		**A**	**A**	
H123	Class I Navigation Using Area or Long-Range Navigation Systems with WAAS for Rotorcraft RNP 0.3 En Route and Terminal Operations		**A**	**A**			**A**	

APPENDIX E. DEFINITIONS AND ACRONYMS

E.1 Definitions.

E.1.1 Actual Navigation Performance (ANP). The ANP represents a statistical level of confidence in the aircraft's position expressed in nautical miles (NM) and is not an estimate of actual navigation error. Also known as estimate of position uncertainty (EPU) in certain aircraft.

E.1.2 Advisory Vertical Guidance. Vertical Path (VPATH) deviation guidance indications generated by any means, but for no operational credit. Aircraft may offer advisory vertical guidance as an aid to help pilots meet barometric altitude restrictions and they typically use either Global Navigation Satellite System (GNSS) vertical guidance or barometric vertical navigation (baro-VNAV) vertical guidance to do so. Advisory vertical guidance is an optional capability implemented at the manufacturer's discretion, not a requirement for positioning and navigation equipment. When using advisory vertical guidance, it is the pilot's responsibility to use the primary barometric altimeter to ensure compliance with all procedural altitude constraints. Advisory vertical guidance is not "approved vertical guidance" like the glidepath guidance provided in the Final Approach Segment (FAS) of instrument approach procedures (IAP) reflected in the lines of minima, such as lateral navigation (LNAV)/vertical navigation (VNAV), localizer performance with vertical guidance (LPV), or instrument landing system (ILS).

E.1.3 Aircraft-Based Augmentation System (ABAS). A system augmenting and/or integrating information obtained from other GNSS elements with information onboard the aircraft. The most common form of ABAS is Global Positioning System (GPS) receiver autonomous integrity monitoring (RAIM).

E.1.4 Air Traffic Control (ATC) Service:

- Area Control Service,
- Approach Control Service, and
- Airport Control Service.

E.1.5 Air Traffic Service (ATS). A generic term meaning Flight Information Services (FIS), Alerting Service, and Air Traffic Advisory Service.

E.1.6 ATS Routes. The term "ATS route" is a generic term that includes very high frequency omni-directional range (VOR) Federal airways, colored Federal airways, jet routes, Area Navigation (RNAV) routes, and arrival and departure routes, per 14 CFR part 1, § 1.1. 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 U.S. route structure.

E.1.7 Approved Vertical Guidance. Approved vertical guidance provides VPATH deviation guidance through a means subject to an explicit airworthiness approval to provide the VPATH guidance during the FAS of an IAP for operational credit. The aircraft's integration of approved vertical guidance should not be confused with advisory vertical

guidance. Approved vertical guidance provides operational credit by offering a means for the aircraft to complete U.S. Standard for Terminal Instrument Procedures (TERPS) with a protected glidepath in the FAS, expressed through the procedure's line of minima (e.g., approaches with LNAV/VNAV, LPV, or ILS/GBAS Landing System (GLS) lines of minima).

E.1.8 Area Navigation (RNAV). A method of navigation (formerly known as "Random 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.

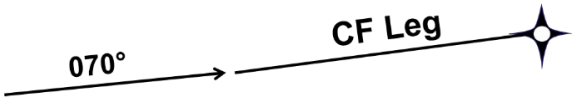
E.1.9 Barometric Aiding (baro-Aiding). A method of augmenting the GPS integrity solution in RAIM by using a barometric altitude input source. Baro-aiding needs four satellites and a barometric altimeter to detect an integrity anomaly (the current altimeter setting may need to be entered into the receiver, as described in the operating manual). Baro-aiding enables RAIM in lieu of a fifth satellite.

E.1.10 Barometric Vertical Navigation (baro-VNAV). A function of RNAV and Required Navigation Performance (RNP) systems offering vertical path guidance to the pilot. Baro-VNAV presents computed vertical guidance based on barometric altimeter information and usually referenced to a desired, defined VPATH. Baro-VNAV can offer both advisory vertical guidance and approved vertical guidance during a Required Navigation Performance Approach (RNP APCH) procedure by offering the ability to use the LNAV/VNAV line of minima when this specific baro-VNAV airworthiness approval is documented in the flight manual. Baro-VNAV airworthiness requires the pilot use the primary barometric altimeter to confirm compliance with all procedural barometric altitude constraints (usually documented in the flight manual). Airworthiness approval criteria for baro-VNAV is found in AC 20-138( ), Airworthiness Approval of Positioning and Navigation Systems.

E.1.11 Commercial Derivative Aircraft (CDA). CDA are aircraft that have been modified with specialized equipment to perform military and other non-civil missions. CDA are operated by, or under the operational control of, governmental entities. With certain limited exceptions, they are operated as public aircraft.

E.1.12 Compliance. Meeting operational and functional performance criteria or meeting regulatory requirements.

E.1.13 Course to Fix (CF). A segment defining a specified course to a specific database fix.

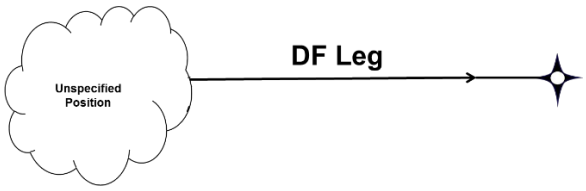


E.1.14 Critical Distance Measuring Equipment (DME). A DME facility that, when unavailable, results in insufficient support for DME/DME (D/D) or DME/DME/Inertial (D/D/I) RNAV operations along a specific route or procedure.

E.1.15 Decision Altitude (DA). In an approach with vertical guidance, DA is a specified altitude expressed in feet above mean sea level (MSL) at which a missed approach is to be initiated if the visual references to continue the approach have not been established.

E.1.16 Departure Procedure (DP). A preplanned instrument flight rules (IFR) procedure for pilot use charted in textual or graphic form. DPs are either an Obstacle Departure Procedure (ODP) or a Standard Instrument Departure (SID).

E.1.17 Direct to Fix (DF). A segment defining an unspecified track starting from an undefined position to a specified fix.



E.1.18 Discontinuity. An interruption in the sequence of waypoints within the active onboard flight plan (primary flight plan loaded into FMS).

E.1.19 DME/DME (D/D) Positioning. Refers to using an aircraft's DME sensor to support D/D RNAV operations through use of DME ranging from at least two DME facilities. D/D RNAV can support RNAV 1 and RNAV 2 operations when under ATC surveillance and specific DME facility availability (e.g., physical geometry and range) ensures continuous D/D position updating.

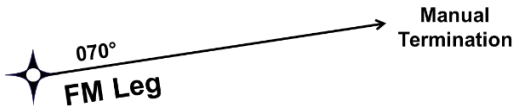
E.1.20 DME/DME/Inertial (D/D/I) Positioning. Refers to use of DME/DME positioning augmented by integration with an aircraft's inertial navigation system(s) (INS) to support RNAV or RNP operations. D/D/I can provide more flexibility and continuity than D/D positioning supporting continuous RNAV operations where gaps in DME facility availability exist or when GPS is lost (for any reason). Aircraft with advanced multisensor RNP capability often include a higher level of D/D/I capability through use of multiple DME facilities, integration with multiple INSs and complex filtering (e.g., Kalman filtering). These aircraft can support continuous RNAV and RNP operations when GPS is lost (for any reason).

E.1.21 DME Navigation. Refers to using an aircraft's multisensor RNP system to support Performance-based Navigation (PBN) operations through use of the system's DME sensor's ability to scan for and use multiple DME facilities simultaneously to provide positioning for RNAV and RNP operations. Advanced multisensor aircraft apply reasonableness checks during DME navigation to achieve a fault detection and exclusion function (with respect to use of DME facilities) ensuring navigation integrity during RNP operations, including when GPS is lost (for any reason).

E.1.22 Estimate of Position Uncertainty (EPU). The EPU represents a statistical level of confidence in the aircraft's position expressed in NM and is not an estimate of actual navigation error. Also known as Actual Navigation Performance (ANP) in certain aircraft.

E.1.23 Fault Detection and Exclusion (FDE). A software algorithm a GNSS sensor requires that automatically detects and excludes a faulty satellite from the GNSS position solution when a sufficient number of satellites are available.

E.1.24 Fix to Manual Termination (FM). A segment defining a specified track over ground from a database fix until manual termination of the segment.



E.1.25 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. FRTs apply during en route operations on published RNP routes and serve to provide aircraft a means to connect from one route to a new route at a transition fix via a published FRT. Like radius to fix (RF) turns, FRTs may offer reliable, repeatable paths for all aircraft.

E.1.26 Flight Guidance System (FGS). A system primarily intended to assist the pilot in the basic control and 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 an FD with a stability augmentation system and/or AP.

E.1.27 Flight Management System (FMS). An integrated system that may be just an RNAV system or, when meeting appropriate airworthiness requirements, can be an RNP system. The FMS typically consists of inputs from airborne sensors and serves as a computer for navigation guidance and aircraft performance. The FMS supports outputs to displays and annunciations that PBN operations require and is often directly coupled to the aircraft's FGS.

E.1.28 Flight Manual. The term "flight manual" in this AC means the Airplane Flight Manuals (AFM), Rotorcraft Flight Manuals (RFM), avionics manuals, Flight Crew Operating Manual (FCOM), or pilot's operating handbook (POH), or appropriate FAA-approved or FAA-accepted supplements. The AFM or RFM, and AFM/RFM Supplements (AFMS/RFMS) are controlled airworthiness documents that contain the aircraft's limitations and may contain statements of operational eligibility for PBN operations and navigation specifications (NavSpecs). A few manufacturers also publish the aircraft's normal and abnormal operating procedures in the AFM(S)/RFM(S).

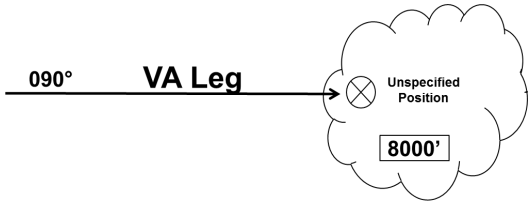
E.1.29 Flight Technical Error (FTE) or Path Steering Error (PSE). The distance from the aircraft's estimated position to the defined path. FTE is often called "Path Steering Error (PSE)" in manufacturer's documentation. FTE is also often called "pilot error," as the pilot is ultimately responsible for monitoring and controlling FTE within the operational FTE limits for a given PBN operation.

E.1.30 Global Navigation Satellite System (GNSS). GNSS is a generic term to denote a global satellite positioning and time determination system, which includes one or more satellite constellations, aircraft receivers, and system integrity monitoring.

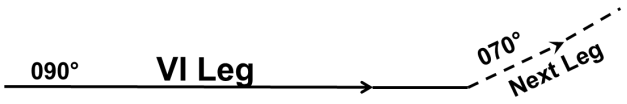
E.1.31 Global Positioning System (GPS). GPS is a U.S. satellite-based radio navigation system that provides a positioning service anywhere in the world. The service provided by GPS for civil use is defined in the GPS Standard Positioning System Signal Specification. GPS is the U.S. core GNSS satellite constellation providing space-based positioning, velocity, and time. GPS is composed of space, control, and user elements.

E.1.32 Ground-Based Augmentation System (GBAS). GBAS is a system that provides GPS differential corrections and integrity monitoring. In the National Airspace System (NAS), GBAS provides GLS Precision Approach (PA) service in the vicinity of the host airport.

E.1.33 Heading to Altitude (VA) Termination. A segment defining a specific altitude termination at an unspecified position.



E.1.34 Heading to Intercept (VI). A segment specified by a heading to intercept the subsequent segment leg at an unspecified position.



E.1.35 Heading to Manual (VM) Termination. A segment defining a specified heading until a manual termination.

E.1.36 Inertial Reference Unit (IRU). IRUs are self-contained systems comprised of gyros and accelerometers that provide aircraft attitude (pitch, roll, and heading), position, and velocity information in response to signals resulting from inertial effects on system components. Once aligned with a known position, IRUs continuously calculate position and velocity. IRU position accuracy degrades with time. This degradation is known as "drift."

E.1.37 Initial Approach Fix (IAF). The point where the initial segment of an instrument approach begins.

E.1.38 Instructions for Continued Airworthiness (ICA). ICA are required airworthiness instructions, usually documented in the flight manual, describing the aircraft operator's required recurring inspections or maintenance actions that ensure the continued airworthiness of the aircraft or aircraft's equipment. Avionics manufacturers may also define ICA for their equipment integrity. Integrity is a measure of the trust that can be placed in the correctness of the information supplied by the total system. Integrity includes the ability of a system to provide timely and valid warnings to the user (alerts).

E.1.39 Lateral Navigation (LNAV). LNAV is a function of RNAV and RNP systems providing lateral navigation guidance to the desired path selected and defined in the system's flight plan. The RNAV and RNP system outputs LNAV guidance to the aircraft's FGS and displays for pilot reference and use during PBN operations.

E.1.40 Lateral Navigation/Vertical Navigation (LNAV/VNAV). LNAV/VNAV is an aircraft flight guidance mode where the aircraft is using the system's lateral guidance and approved vertical guidance for an RNP APCH operation. "LNAV/VNAV" is also a line of minima on an RNP APCH procedure and requires approved vertical guidance from either baro-VNAV or Satellite-based Augmentation System (SBAS)-based guidance for aircraft eligibility.

E.1.41 Localizer Performance (LP). An RNP APCH two dimensional (2D) line of minima, supported by SBAS, published at locations where terrain and obstacles penetrate the sloping LPV obstacle clearance surface preventing publication of LPV minima. LP can provide significant operational benefit due to the LP angular lateral guidance in the FAS, which often enables offering a straight-in approach procedure to the lowest practical minima. The aircraft's RNP system may also provide advisory vertical guidance during the FAS of an LP approach operation.

E.1.42 Localizer Performance with Vertical Guidance (LPV). An RNP APCH line of minima function that requires SBAS to compute, display, and provide 3D horizontal and approved vertical approach navigation to precision minima.

E.1.43 Long-Range Navigation System (LRNS). An electronic navigation unit that is approved for use under IFR as a primary means of navigation, and has at least one source of navigational input, such as an INS and/or GPS.

E.1.44 May. An option without indicating a recommendation.

E.1.45 Minimum Descent Altitude (MDA). A specified minimum altitude expressed in feet above MSL.

E.1.46 Must. Specifies a mandatory requirement driven by regulation or required for a system to operate properly during a PBN operation. Any instance of the word "must" in this document is based on a specific regulation that is annotated as a note or is based generally on 14 CFR part 91, §§ 91.13 and/or 91.123, or on public airworthiness standards. Additionally, "must" is used to denote a method or mechanism required for a system to operate properly. Finally, "must" is used to denote compliance as the only means authorized when applying this AC. The use of the term "must" in this AC does not

change, add, or delete regulatory requirements or authorize deviations from regulatory requirements.

E.1.47 Navigation Application. The application of a navigation specification (NavSpec) and the supporting Navigational Aid (NAVAID) infrastructure to routes, procedures, and/or defined airspace volume, in accordance with the intended airspace concept.

E.1.48 Navigation Specification (NavSpec). A set of aircraft and pilot requirements needed to support Performance-based Navigation (PBN) operations within a defined airspace.

E.1.49 Navigation System Error (NSE). NSE (or Position Estimation Error (PEE)) is the difference between the true position and estimated position. NSE provides essential information offering clarity in understanding a requirement or function.

E.1.50 Navigational Aid (NAVAID) Infrastructure. NAVAID infrastructure refers to space-based and ground-based NAVAIDs available to meet the requirements of a NavSpec.

E.1.51 Note. Provides essential information offering clarity in understanding a requirement or function.

E.1.52 Obstacle Departure Procedure (ODP). A preplanned IFR departure procedure (DP) printed for pilot use in textual or graphic form to provide obstruction clearance via the least onerous route from the terminal area to the appropriate en route structure.

E.1.53 Oceanic Airspace. Airspace over the high seas. Generally, "oceanic" is included in the airspace designation (e.g., oceanic control area (OCA)), and direct controller-pilot very high frequency (VHF) voice communications are not available. ATC is provided using at least some elements of procedural control in accordance with the International Civil Aviation Organization (ICAO).

E.1.54 Offshore Airspace. Offshore airspace is defined by 14 CFR part 71, §§ 71.31 and 71.71. It is designated in international airspace within areas of domestic radio navigational signal or ATC surveillance coverage, and within which domestic ATC procedures are applied. The U.S. offshore airspace may be labeled, for example, as Atlantic High, Gulf of Mexico High, and South Atlantic Low on U.S. IFR en route charts. For more details, refer to FAA Order JO 7400.11, Airspace Designations and Reporting Points.

E.1.55 Operator. Refers to the certificate holder (CH), program manager, company, and/or pilot or to any "person" who "operates" an aircraft as defined in § 1.1.

E.1.56 Path Definition Error (PDE). The difference between the PBN operation's defined path and the aircraft navigation system's desired path at a specific point. PDE is usually considered negligible when aircraft demonstrate Total System Error (TSE).

E.1.57 Path Steering Error (PSE) or Flight Technical Error (FTE). PSE is another term analogous to FTE. See paragraph E.1.29 in this Appendix for the definition of FTE.

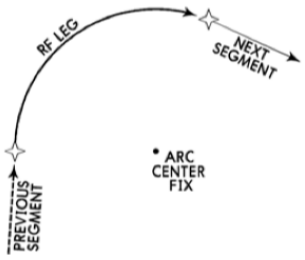
E.1.58 Performance-Based Navigation (PBN). A means to define the performance and functional requirements an aircraft must meet to be eligible for area navigation operations along an ATS route, a terminal departure or arrival procedure, or on an RNP IAP. RNAV requirements are expressed in NavSpecs (an RNAV specification or an RNP specification) in terms of accuracy, integrity, continuity, and functionality the operation needs to provide desired benefits in the context of a particular airspace concept.

E.1.59 Position Estimation Error (PEE). PEE or NSE is the difference between true position and estimated position.

E.1.60 Primary 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, refer to AC 27-1( ), Certification of Normal Category Rotorcraft, and AC 29-2( ), Certification of Transport Category Rotorcraft, for visibility specifications.

E.1.61 Principal Inspector (PI). May be a Principal Operations Inspector (POI), Principal Avionics Inspector (PAI), or Principal Maintenance Inspector (PMI).

E.1.62 Radius to Fix (RF). An RF leg is a constant-radius, circular, repeatable path about a defined turn center that begins and terminates at a fix on an RNP procedure. The beginning of an RF leg is defined by the termination fix and the end of the previous leg, which also lies on the arc representing the RF leg.



E.1.63 Receiver Autonomous Integrity Monitoring (RAIM). A software algorithm in a GPS sensor that verifies the integrity of the sensor's position output using GPS measurements, or GPS measurements and barometric aiding.

E.1.64 Remote Continental Airspace (RemCon). Airspace over land (or over water within 50 NM of shore) where VHF voice communications, ATC surveillance (via radar or Automatic Dependent Surveillance-Broadcast (ADS-B)), and reliable ground-based NAVAIDs are not available. ATC is provided using procedural control and procedural separation, with long-range communication systems (LRCS). Refer to AC 91-70( ), Oceanic and Remote Continental Airspace Operations.

E.1.65 Required Navigation Performance (RNP). A statement of the navigation accuracy necessary for operations in an area, on a route, or on a procedure. An RNP establishes a navigation accuracy in the horizontal plane that is expressed through both lateral and longitudinal position fixing. The RNP for a given operation is identified by a navigation accuracy value expressed in nautical miles, referred to as the "RNP value." Each RNP operation's NavSpecs bring additional requirements beyond accuracy, but all RNP operations require the aircraft include onboard performance monitoring and alerting to notify the pilot when the RNP for the operation is not being met.

E.1.66 Required Navigation Performance Approach (RNP APCH). RNP APCH is a NavSpec for the approach phase of flight based on RNP that includes features to notify the pilot when the RNP is not being met. RNP APCH also includes additional functional, performance and operational requirements to help enable the safe conduct of the approach procedure.

E.1.67 RNAV. See paragraph E.1.8, Area Navigation (RNAV). RNAV is an abbreviation whose context depends on its usage. RNAV is used for the concept of area navigation (using either RNAV or RNP) and is also the abbreviation signifying area navigation in a procedure title (e.g., WIZZI TWO (RNAV) Departure) or as used to denote a specific RNAV NavSpec (e.g., RNAV 1).

E.1.68 RNAV Route. An RNAV route (e.g., Q-, T-, TK-, or Y-routes), within the high or low altitude structure, requiring a specified navigation performance and that may include specified navigation sensor requirements such as GNSS and/or D/D/I or D/D.

E.1.69 RNAV Specification. A NavSpec for RNAV that does not include the requirement for onboard performance monitoring and alerting, designated by the prefix "RNAV" (e.g., RNAV 2).

E.1.70 RNAV System. A navigation system which permits aircraft operation on any desired flightpath within the coverage of ground- or space-based NAVAIDs or within the limits of the capability of self-contained aids, or a combination of these. An RNAV system may be included as part of an FMS.

E.1.71 RNAV Value. The RNAV value designates the 95 percent navigation accuracy (in NM) associated with an RNAV instrument flight operation.

E.1.72 RNP Specification. A NavSpec for a PBN operation that includes the requirement for onboard performance monitoring and alerting, along with many other additional requirements, designated by the prefix "RNP" (e.g., RNP 4, RNP APCH).

E.1.73 RNP System. A navigation system installed in an aircraft supporting onboard performance monitoring and alerting along with the other requirements of the public standards for RNP found in RTCA DO-236( ), DO-283( ), or DO-229( ). An installed RNP system may support a myriad of RNAV and RNP NavSpecs, provided the installed aircraft equipment meets all the requirements for each individual NavSpec.

E.1.74 RNP to xLS. An RNP operation where the procedure uses PBN intermediate segments to connect with an ILS, GLS, or LPV precision FAS. RNP-to-xLS operations may require

Track to Fix (TF) or RF legs to join the procedure's final approach guidance at, or prior to, the glideslope or glidepath intercept point.

E.1.75 RNP Value. The RNP value, defined in NM, establishes the navigation accuracy an RNP NavSpec requires to define the intended operational performance the NavSpec offers and to define the related monitoring and alerting requirements. All RNP NavSpecs define the navigation accuracy requirement in a horizontal plane as ± the RNP value for 95 percent of the total flight time and also defines the FTE limitation, usually not to exceed 1 × the RNP value. The RNP value helps establish other requirements the RNP NavSpec requires, such the aircraft's deviation display scaling, usually set such that full-scale deviation equals 1 × the RNP value.

E.1.76 Satellite-Based Augmentation System (SBAS). SBAS is a wide area coverage augmentation system. The user receives GPS constellation augmentation information from a geostationary satellite-based transmitter. SBAS complements the core GPS satellite constellation by increasing navigation accuracy, integrity, continuity, and availability provided within a service area. The U.S. SBAS is the wide area augmentation system (WAAS).

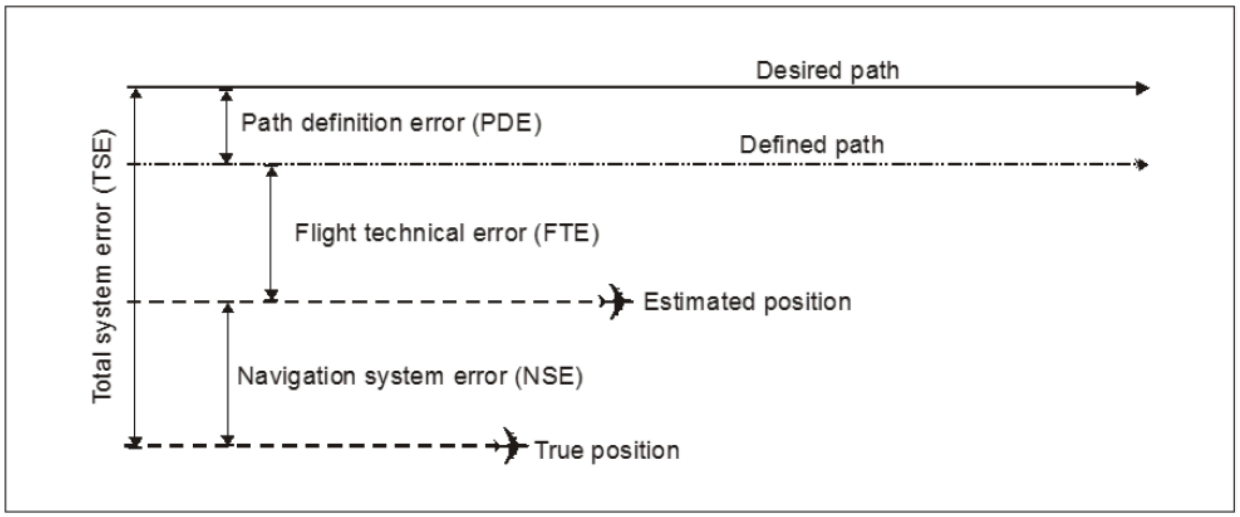
E.1.77 Should. Indicates a recommendation.

E.1.78 Standard Instrument Departure (SID). A published IFR DP providing obstacle clearance and a transition from the terminal area to the en route structure. SIDs are primarily designed for air traffic system enhancement to expedite traffic flow and to reduce pilot/controller workload.

E.1.79 Standard Terminal Arrival (STAR). A published IFR arrival procedure that provides a transition from the en route structure to the terminal area, airport, or runway. STARs may include one or more en route transitions from the en route structure to a common segment, then further transitions to an airport, or a standard IAP or a point in space (PinS) from which ATC surveillance vectors are provided.

E.1.80 Track to Fix (TF). A segment defined by a great circle track over the ground between two known database fixes.

E.1.81 Total System Error (TSE). The difference (expressed as distance in NM) between the aircraft's true position and the desired position and is comprised of PDE, FTE, and NSE.



E.1.82 Waypoints. A waypoint is a predetermined geographical position that is defined in terms of latitude/longitude coordinates. Waypoints may be a simple named PinS (latitude/longitude) or associated with existing NAVAIDs, intersections, or fixes. PBN procedures make use of both flyover and flyby waypoints.

E.1.82.1 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.

E.1.82.2 Flyover Waypoints. Flyover waypoints are used when the aircraft is to fly over the point prior to starting a turn.

E.2 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
ADS-B	Automatic Dependent Surveillance-Broadcast
ADF	Automatic Direction Finder
AEG	Aircraft Evaluation Group
AFCS	Automatic Flight Control System
AFM	Airplane Flight Manual
AFMS	Airplane Flight Manual Supplement

Acronym	Meaning
AGL	Above Ground Level
AIM	Aeronautical Information Manual
AIP	Aeronautical Information Publication
AIR	Aircraft Certification Service
AIRAC	Aeronautical Information Regulation and Control
AMOC	Acceptable Means of Compliance/Alternate Means of Compliance
ANP	Actual Navigation Performance
AP	Autopilot
A-RNP	Advanced Required Navigation Performance
ARP	Airport Reference Point
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Service
baro-VNAV	Barometric Vertical Navigation
B-RNAV	Basic Area Navigation
CA	Course to Altitude (path terminator per ARINC Specification 424)
CAT	Category
CDA	Commercial Derivative Aircraft
CDFA	Continuous Descent Final Approach
CDI	Course Deviation Indicator
CF	Course to Fix (path terminator per ARINC Specification 424)
CFR	Code of Federal Regulations
CH	Certificate Holder
CL	Centerline
CMO	Certificate Management Office
CNF	Computer Navigation Fix
CONUS	Continental United States
CPDLC	Controller-Pilot Data Link Communication
CPDLC-DCL	CPDLC Departure Clearance
CTA	Cold Temperature Airport
CTA/FIR	Control Area/Flight Information Region
DA	Decision Altitude
D/D	DME/DME

Acronym	Meaning
D/D/I	DME/DME/Inertial
DF	Direct to Fix
DFMC	Dual Frequency Multi-Constellation
DH	Decision Height
DME	Distance Measuring Equipment
DP	Departure Procedure
DTK	Desired Track
EFB	Electronic Flight Bag
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
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
FS	Flight Standards Service
FSBR	Flight Standardization Board Report
FSDO	Flight Standards District Office
FTE	Flight Technical Error
GBAS	Ground-Based Augmentation System
GLS	Ground-Based Augmentation System (GBAS) Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

Acronym	Meaning
HAA	Helicopter Air Ambulance
HAT	Height Above Touchdown
HSI	Horizontal Situation Indicator
HUD	Head-Up Display
IAF	Initial Approach Fix
IAP	Instrument Approach Procedure
ICA	Instructions for Continued Airworthiness
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
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
IPC	Instrument Proficiency Check
IPH	Instrument Procedures Handbook
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
KIAS	Knots Indicated Airspeed
LAAS	Local Area Augmentation System (see GBAS)
LNAV	Lateral Navigation
LOA	Letter of Authorization
LOC	Localizer
LODA	Letter of Deviation Authority
LP	Localizer Performance
LPV	Localizer Performance with Vertical Guidance
LRNS	Long-Range Navigation System
LRR	Long-Range Radar
MAHP	Missed Approach Holding Point
MAP	Missed Approach Point
MAS	Missed Approach Segment
MAWP	Missed Approach Waypoint

Acronym	Meaning
MCDU	Multipurpose Control and Display Unit
MDA	Minimum Descent Altitude
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
MOPS	Minimum Operational Performance Standards
MSL	Mean Sea Level
MSpec	Management Specification
NAS	National Airspace System (U.S.)
NAVAID	Navigational Aid
NavSpec	Navigation Specification
NDB	Non-Directional Beacon
NextGen	Next Generation Air Transportation System
NM	Nautical Mile
NOTAM	Notice to Air Missions
NPA	Nonprecision Approach
NSE	Navigation System Error
OCA	Oceanic Control Area
ODP	Obstacle Departure Procedure
OEM	Original Equipment Manufacturer
OpSpec	Operations Specification
PA	Precision Approach
PAI	Principal Avionics Inspector
PBN	Performance-based Navigation
PDC	Pre-Departure Clearance
PDE	Path Definition Error
PEE	Position Estimation Error
PFAF	Precise Final Approach Fix
PI	Principal Inspector
PIC	Pilot in Command
PinS	Point in Space
PMI	Principal Maintenance Inspector
POH	Pilot's Operating Handbook
POI	Principal Operations Inspector

Acronym	Meaning
PRM	Precision Runway Monitor
P-RNAV	Precision Area Navigation (European)
PSE	Path Steering Error
RAIM	Receiver Autonomous Integrity Monitoring
RemCon	Remote Continental Airspace
RF	Radius to Fix (path terminator per ARINC Specification 424)
RFM	Rotorcraft Flight Manual
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
RPI	Runway Path Identifier
SB	Service Bulletin
SBAS	Satellite-Based Augmentation System
SFAR	Special Federal Aviation Regulation
SID	Standard Instrument Departure
SLOP	Strategic Lateral Offset Procedure
SOC	Statement of Compliance
SOP	Standard Operating Procedure
STAR	Standard Terminal Arrival
STC	Supplemental Type Certificate
TA	Tailored Arrival
TAA	Terminal Arrival Area
TACAN	Tactical Air Navigation System
TBO	Trajectory Based Operation
TC	Type Certificate
TERPS	Terminal Instrument Procedures
TF	Track to Fix (path terminator per ARINC Specification 424)
TOAC	Time of Arrival Control
TPP	Terminal Procedures Publication
TSE	Total System Error
TSO	Technical Standard Order

Acronym	Meaning
TSpec	Training Specification
VA	Heading to Altitude (path terminator per ARINC Specification 424)
VGF	Visual Guidance Fix
VHF	Very High Frequency
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
VOR MON	VOR Minimum Operational Network
VPATH	Vertical Path
VS	Vertical Speed
WAAS	Wide Area Augmentation System (see SBAS)
XTK	Cross-Track