

Understanding Required Navigation Performance (RNP) and Area Navigation (RNAV) Operations

White Paper

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Executive Summary

This document clarifies the current Required Navigation Performance (RNP) and Area Navigation (RNAV) requirements in the United States, Europe, and other parts of the world. It also discusses how Universal Avionics' Flight Management System (FMS) product line supports approved RNP operations.

Operators may use this information to assist in making future equipment acquisitions and aircraft modification choices necessary to allow them to fly into RNP airspaces or fly RNAV Instrument Approach Procedures (IAP). Failure to address RNP will, as time progresses, force non-RNP approved aircraft into undesirable lower altitudes (greatly increasing fuel burn), or severely limit the capability of a non-RNP aircraft to fly into a desired airport in instrument weather conditions.

The Federal Aviation Administration's (FAA) plan to modernize the National Airspace System (NAS) is through the Next Generation Air Transportation System (NextGen). The goals of NextGen are to increase NAS capacity and efficiency while simultaneously improving safety, reducing environmental impacts, and improving user access to the NAS. It is expected to be implemented through new Performance-Based Navigation (PBN) routes and procedures. This requires avionics that support RNP/RNAV capability.

In addition, the FAA has taken the initial steps toward removing ground based navaids and the supporting IAPs based upon those navaids. RNAV approach capability may become the mandatory method of flying into numerous airports that only support instrument approaches that are RNP/RNAV based.

RNP/RNAV capable systems can also form the basis of a compliant Automatic Dependent Surveillance-Broadcast (ADS-B) Out system. For more information, refer to Universal Avionics White Paper, Doc. No. WHTP-2013-14-05 titled "ADS-B (OUT) Compliance with Universal Avionics Equipment".

Three key terms to know are PBN, RNAV, and RNP.

What is PBN?

Performance-Based Navigation (PBN) is the basis for defining system performance requirements for navigation equipment and installation specifications. These navigation specifications provide specific implementation guidance in order to facilitate global harmonization. The FAA's NextGen solutions are dependent on RNAV and RNP implementation.

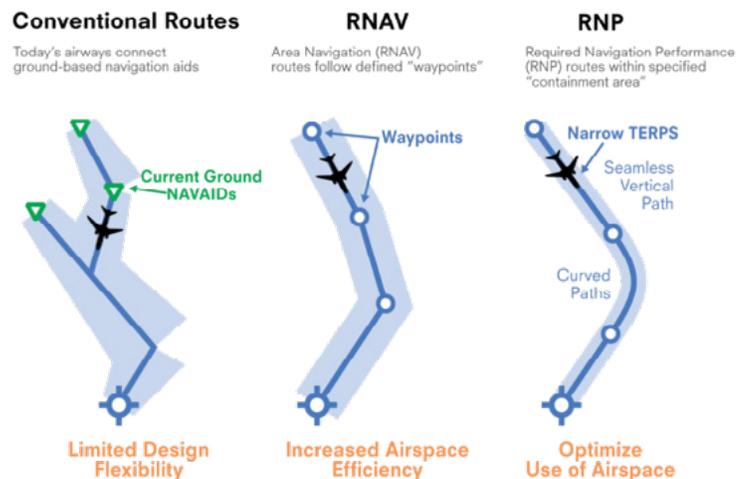
What is RNAV?

Area Navigation (RNAV) enables aircraft to fly on any desired flight path rather than being constrained to an airway. RNAV systems have been available for a number of years and may utilize scanning DME, inertial navigation, GPS, TACAN, or other multi-sensor capability.

What is RNP and what are the benefits?

Required Navigation Performance (RNP) equipment provides onboard navigation capability that allows crews to fly aircraft along a precise flight path with exceptional accuracy, and most importantly, the ability to determine aircraft position with both accuracy and integrity.

Not only does RNP offer safety benefits with precision and accuracy, it reduces the cost of inefficiencies such as multiple step-down non-precision and circling approaches (saving fuel and time).



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The addition of RNP radius to fix arrivals, approaches and departures increases airspace capacity by shortening the approach and departure paths. Finally, precision approach procedures with lower minimums replace non-precision approaches, thus reducing missed approaches.

As ground based nav aids have been removed from service, along with the IAPs they supported, RNAV approaches now outnumber traditional Instrument Landing System (ILS) approaches. This trend will be accelerated as FAA's NextGen rolls out and budgetary issues force the retirement of even more ground-based nav aids. This is also the situation in Europe, where RNP/RNAV approaches are increasing in number and access to airports is limited to only RNP/RNAV capable aircraft.

RNP Level of Performance

Required Navigation Performance refers to the level of performance required for a specific procedure or a specific block of airspace. An RNP of 10 means that a navigation system must be able to calculate its position to within a circle with a radius of 10 Nautical Miles (NM). Similarly, an RNP of 0.3 means the aircraft navigation system must be able to calculate its position to within a circle with a radius of 3 tenths of a NM. The aircraft must have both aircraft and operational approval for RNP and the operator must know the level of monitoring provided. FMS equipment with GPS multi-sensor capability meeting TSO-C146 (SBAS/WAAS GPS) meets basic RNP requirements, when installed in an RNP-compliant aircraft installation. The FMS is a key component of this RNP compliant installation.

The world is relying on PBN for airport access and operational safety. RNP/RNAV approvals are quickly becoming a requirement.

Worldwide Requirements

US Airspace Requirements

The current US RNP requirements are:

- RNP-10 as described in FAA order 8400.12c
- RNP-4 as described in FAA Order 8400.33
- RNAV (RNP AR) approach authorization as defined in Advisory Circular (AC) 90-101a
- Basic RNP capability is achieved through TSO-C146 compliant equipment when installed under AC 20-138().

RNP-10 and RNP-4 procedures are limited primarily to oceanic airspace. RNAV (RNP AR) procedures are available in the US for domestic operations. These procedures require approval, hence the name: Authorization Required (AR), formally known as Special Aircraft & Aircrew Authorization Requirements (SAAAR) procedures.

European Airspace Requirements

There are two existing European RNP requirements:

- Basic-RNAV (B-RNAV), equivalent to RNP-5 (reference FAA AC 90-45A, AC 20-130(), AC 20-138(), and AC 25-15)
- Precision-RNAV (P-RNAV), equivalent to RNP-1. These requirements are defined in European Aviation Safety Agency (EASA) Temporary Guidance Leaflet (TGL)-10, and FAA AC 90-96A. A statement is required in the Aircraft Flight Manual (AFM) or AFM Supplement (AFMS). For European operations, a Letter of Authorization (LOA) for all RNP operations is necessary, as the requirements differ from the FAA requirements.

RNP Benefits

- Greater navigational precision and accuracy
- Reduces step-down and circling approaches
- Saves fuel and time
- Increases airspace capacity
- Reduces missed approaches

Obtaining FAA Certification

Advisory Circular AC 90-100A defines RNAV requirements as outlined by the FAA. A lot of confusion surrounds the RNAV SIDs, STARs, and enroute procedures described in this AC. Note that AC 90-100A describes RNAV procedures, not RNP procedures, and does not require an aircraft to have an RNP certification to fly an RNAV departure, enroute segment, or RNAV arrival. Universal Avionics FMS units with Software Control Number (SCN) 601/701 and later are compliant with the requirements in AC 90-100A. FMS units operating software prior to SCN 601/701 are not compliant to AC 90-100A. Requirements relative to Universal Avionics' FMSs are discussed in Service Letter (SL) No. 2804 (see References). **Currently, the only domestic US RNP procedures are those denoted as RNAV (RNP) approaches.**

Aircraft approved for RNP operations must have equipment that provides onboard navigation containment, performance monitoring and alerting capabilities. An FMS alone cannot be certified for RNP operations. An aircraft is certified to a particular RNP level, which is based on the aircraft's capabilities to meet performance level requirements. In order to receive FAA approval for RNP, an operator must meet both aircraft airworthiness requirements as well as operational requirements.

RNP operations for airspace or operation require an aircraft system certification, typically a Supplemental Type Certificate (STC), of which the FMS is only a part, although an important part.

Oceanic, Enroute, Terminal, and Approach modes are embodied in TSO-C146 (applicable to WAAS/SBAS capable FMS), "Stand-Alone Airborne Navigation Equipment Using The Global Positioning System Augmented By The Satellite Based Augmentation System." Therefore, FMS equipment claiming TSO-C146 support these modes. Approach modes may be Lateral Navigation (LNAV), LNAV/ Vertical Navigation (VNAV), and Localizer Performance with Vertical Guidance (LPV) levels of service. Universal Avionics' line of WAAS/SBAS-enabled FMSs support all three of these approach levels of service.

Several AC, AMC and Orders specifically state that an RNAV system approved to TSO-C145 () or TSO-C146 () meet the RNP requirements for RNP 2, 1 and 0.3. AC 20-138 () has these statements as well.

TSO-C145 () and TSO-C146 () RNP Types or RNAV Containment Values

RNP Type	Required Accuracy (95 percent Containment)	Description
0.3	± 0.3 NM	Non-precision, LNAV, VNAV, using GPS/WAAS
1	± 1.0 NM	Supports Terminal Operations such as Arrival, Initial/Intermediate Approach, Departure and some Enroute applications
2	± 2.0 NM	Supports ATS routes and airspace

In order to qualify for any RNP operations, the operator must have a compliance statement in the AFMS for the FMS establishing that the aircraft meets the equipment requirements. This can be in the form of a statement in the AFMS that claims compliance with AC 20-138 (). An example of this is:

This installation complies with AC 20-138C for navigation using GPS and WAAS (within the coverage of a Space-Based Augmentation System complying with ICAO Annex 10 for enroute, terminal area, non-precision approach operations (including "GPS", "or GPS", and "RNAV" approaches), approach procedures with vertical guidance (including "LNAV/VNAV" and "LPV"). Navigation information is referenced to the WGS-84 reference system, and should only be used for approach where the Aeronautical Information Publication (including electronic data and aeronautical charts) conform to WGS-84 or equivalent.

The operator must also meet operational requirements in order to receive FAA operational approval. Part 91 operators require an FAA LOA while certificate holders require Operations Specification (Ops Spec) approval.

Operators of Universal Avionics FMS are encouraged to read the guidance material associated with applicable Service Letters to better understand the information as it pertains to the operator's installation. The Service Letters are referenced in the References section at the end of this White Paper.

Obtaining RNP Operational Approval

Obtaining an RNP operational approval requires written aircraft eligibility documentation that states the aircraft is properly certificated, equipped and maintained to perform the required functions for the specific approval that is being sought. This written evidence may take the form of a Type Certificate (TC), STC, AFM, AFMS, or Flight Standardization Board (FSB) Report.

The specific equipment and software called out in the approval may not change. For example, if an STC was used to install dual UNS-1Lw FMSs with SCN 1000.5 to claim compliance with FAA order 8400.12C, (RNP-10), then that specific hardware and software combination must be installed in the aircraft. If SCN 1000.6 was installed in the aircraft and the associated documentation is not updated to show SCN 1000.6, the aircraft will no longer be RNP-10 compliant, even if the 1000.6 software is an improvement on what was originally approved.

RNP operational approvals must be coordinated closely with the regional Flight Standards Airworthiness branch. If the applicant is not able to provide the Flight Standards District Office (FSDO) with specific eligibility from the AFM, AFMS, or the FSB Report, other written equipment eligibility must be provided. Universal Avionics Service Letters may be provided as evidence that the equipment meets the specific RNP requirement. However, this applies only to the Universal Avionics equipment, not the aircraft installation.

If the FSDO is unable to determine equipment eligibility from the approved or other documentation, the FSDO can forward the request and supporting data to its Flight Standards Regional Division Aircraft Evaluation Group (AEG). The AEG will verify that the aircraft and equipment meet the criteria for the specific operations and that the system can safely fly the specified operation. The AEG will provide written documentation to verify the eligibility of that equipment. Refer to information in FAA Order 8900.1 as follows;

Volume 4: AIRCRAFT EQUIPMENT AND OPERATIONAL AUTHORIZATIONS, Chapter 1: AIR NAVIGATION, COMMUNICATIONS, AND SURVEILLANCE, Section 2: Air Navigation Approval Requirements.

RNP Requirements

The operator should ensure that the aircraft meets the requirements for the specific approval being sought. An operational approval issued by one certification agency will typically be accepted by all, but the operator should ensure that the aircraft meets the requirements for the specific approval being sought or risk denial of access or violation. As an example, there is no specific P-RNAV or RNP-1 requirement in the US, yet there is a requirement specified by TGL-10 for P-RNAV (RNP-1) in EASA airspace. An FAR Part 91 operator would have to obtain an LOA for operations in EASA airspace. There is no operational approval required for basic RNP operations in the US.

RNP AR Procedures: Definition, Approval and Operation

Guidance for RNP AR procedures is defined in AC 90-101A Approval Guidance for RNP Procedures with AR. RNP AR approaches include unique capabilities that require special aircraft and aircrew authorization similar to Category (CAT) II/III ILS operations.

All RNP AR approaches have reduced lateral obstacle evaluation areas and vertical obstacle clearance surfaces predicated on the aircraft and aircrew performance requirements of AC 90-101A. In addition, selected procedures may require the capability to fly an RF leg and/or a missed approach, which requires RNP less than 1.0.

Universal Avionics' customers have received RNP AR approval for various airframes, including the Bombardier Q400 down to RNP 0.1. Operators or airlines that have achieved this goal have attained valuable cost benefits for their operations. Each potential RNP AR applicant should assess the return on the investment required for RNP AR certification.

Obtaining an RNP AR approval is a complex process, but one that could produce significant benefit for the operator. Operators seeking an RNP AR approval should read and fully understand the requirements of AC 90-101A and closely coordinate the effort with their FSDO or Principal Operations Inspector (POI).

Universal Avionics will support RNP AR efforts for those operators desiring this capability.

The following are short checklists extracted from the Advisory Circular (AC) relating to specific equipment, modification, or required training in support of RNP AR approval and operation.

Navigation Database Validation Program

- The operator must have a responsible manager
- The operator must have a documented process
- The operator must validate every RNP AR procedure before flying it in IMC
- The operator must compare the database procedure to the published procedure with every database cycle
- The operator must validate the loaded navigation database for the procedure either in a simulator or in the aircraft, and the entire procedure must be flown. This must be done for every RNP AR procedure to be flown. Note: If there are any changes to a validated procedure the operator must validate the amended procedure.

Aircraft Modifications

- If a system required for RNP AR operations is modified after obtaining an RNP AR approval, the operator is responsible for validation that RNP AR procedures are not affected

Aircraft Equipment Requirements

- SBAS-capable GPS
- IRS
- DME
- VOR
- Terrain Awareness and Warning System (TAWS) (required by AC 20-138D)

Operational Considerations

- Minimum Equipment List (MEL)
- Autopilot Flight Director must be functional
- Dispatch RNP assessment
- Must be able to exclude NAVAIDs
- Must have approved flight procedures for conditions such as:
 - RNP management
 - Approach Procedure Confirmation
 - Track Deviation Monitoring
 - System crosscheck
 - Go around or missed approach
 - Enroute failures
 - Failure on approach

Training

- The operator is responsible for training flight crew for the specific RNP AR operations to be conducted
- The operator must include RNP AR requirements in the AFM or AFMS
- RNP AR specific flight dispatcher training
- Air Traffic Control communication and coordination for use of RNP AR
- RNP AR equipment components, controls, displays and alerts

EASA Approvals Per EASA TGL-10

There are two European RNP requirements, the first being B-RNAV, which is equivalent to RNP-5, (reference FAA AC 90-45A, AC 20-130(), AC 20-138(), and AC 25-15). P-RNAV is the second European RNP requirement, equivalent to RNP-1.

The requirements for P-RNAV are defined in EASA Temporary Guidance Leaflet TGL-10, which references FAA AC 90-96A. As previously mentioned, a statement is required in the AFM or AFMS. For European operations, an LOA for all RNP operations is necessary, differing from FAA requirements.

TGL-10 *“Airworthiness and Operational Approval for Precision RNAV Operations in Designated European Airspace”* outlines the approval of aircraft and operations in the European region where P-RNAV is required.

This guidance references the entire aircraft installation, including the AFMS and operational considerations. Universal Avionics Service Letter No. 2792 addresses the FMS functional compliance, and indicates areas where alternate means of compliance are needed.

Operating in the International RNP Environment with ICAO

Once approved for operating in the RNP environment, the appropriate ICAO equipment code(s) may be used when filing a flight plan. Since 2012, the FAA has required the use of ICAO equipment codes when filing a flight plan for ATC. The code identifies the operator’s RNAV/RNP capabilities, and is based upon the equipment installed in the aircraft and the operational approvals for that specific aircraft as specified in the AFM or AFMS. Before filing an ICAO flight plan, it is strongly recommended that operators become familiar with the FAA ICAO Flight Planning Interface Reference Guide Version 2.1. Specifically, Section 4.5 of the FAA ICAO Flight Planning Interface Reference Guide describes PBN.

Reference: www.faa.gov/about/office_org/headquarters_offices/ato/service_units/enroute/flight_plan_filing/references/

An example equipment/capability code for a flight entering US airspace is: **PBN/A1C4D1 NAV/RNVD1E2A1**. This code is entered into item 18 on the ICAO form. The code is identified as follows:

Performance Based Navigation (PBN) Codes:	Area Navigation (RNAV) Codes:
A1=RNP-10	D1=Departure 1 NM
C4=RNAV-2	E2=Enroute 2 NM
D1=RNAV-1	A1=Arrival 1 NM

Autopilot Limitations

Although not clearly defined in FAA guidance or regulatory material, certain approach procedures have a turn six degrees or greater between the Final Approach Fix (FAF) and End of Approach (EOA) and have been defined as “advanced” in Universal Avionics’ equipment. A Radius to a Fix (RF) leg between the FAF and the EOA also qualifies as an advanced approach. Due to the turning maneuvers involved in an advanced approach, they cannot be flown accurately in an aircraft that uses autopilot deviation steering only. Aircraft flying advanced approaches must use autopilot roll steering, or required Flight Technical Error (FTE) margins cannot be maintained.

These approach types are hidden in the navigation database in SCN 802 and later. There is an FMS configuration option that enables these approach types when the aircraft is properly equipped. It is very important that the operator and installer understand the aircraft integration and limitations before enabling this feature.

Summary

There is more to an RNP/RNAV certification and operational approval than the FMS installation alone. Other aircraft systems are involved in achieving operational approval for growing number of RNP/RNAV operations and airspaces.

Universal Avionics releases this technical white paper as a guide to some of the necessary considerations for operators to consider in order to ensure continuous aircraft operations without limits to airspace or airports, as well as an overview for gaining operational approvals. Please contact Universal Avionics' Customer Support for additional information for your specific installation or concern.

Reference List

- FAA order 8400.12C, Required Navigation Performance 10 (RNP 10) Operational Authorization
- JAA AMJ20X2, Leaflet 2, Revision 1, European B-RNAV operations
- FAA, AC 20-138(), Airworthiness Approval of Positioning and Navigation Systems
- FAA, AC 25-15, Approval of Flight Management Systems in Transport Category Airplanes
- FAA Order 8400.33, Procedures for Obtaining Authorization for Rnp-4 Oceanic and Remote Area Operations
- FAA Order 8900.1 Flight Standards Information Management System
- FAA AC 90-101A, Approval Guidance for RNP Procedures with AR
- EASA TGL-10 AIRWORTHINESS AND OPERATIONAL APPROVAL FOR PRECISION RNAV OPERATIONS IN DESIGNATED EUROPEAN AIRSPACE
- Universal Avionics Service Letter No. 2758, RNP-10 Operations in the North and Central Pacific
- Universal Avionics Service Letter No. 2814, Compliance Summary for RNP-4 Operations (FAA Order 8400.33)
- Universal Avionics Service Letter No. 2804, UASC FMS Compliance with FAA Advisory Circular 90-100A
- Universal Avionics Service Letter No. 2753, Basic RNAV (BRNAV)/RNP-5 Operation in European Airspace
- Universal Avionics Service Letter No. 2792, JAA PRNAV UASC Compliance Evaluation Summary

About Universal Avionics

Universal Avionics, an Elbit Systems Company, is a leading manufacturer of innovative commercial avionics systems offered as retrofit and forward-fit solutions for the largest diversification of aircraft types in the industry. To learn more, visit uasc.com.

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