TECHNICAL STANDARDS - 2020

NAM-CATS: Part 90 Performance Based Navigation

Document: TS/Part 90/2020

Issue Date: 20th November 2020

1. GENERAL

1.1. Section 227 of the Civil Aviation Act, 2016 (Act no. 6 2016 – hereinafter called "the Act") empowers the Executive Director of Civil Aviation to issue technical standards for civil aviation "on such matters as may be prescribed". Section 227(3) of the Act further empowers the Executive Director of Civil Aviation to incorporate into a technical standard any international aviation standard or anu amendment without publishing the text of such standard or any amendment "by mere reference" to the title, number and year of issue of such standard or amendment or to any other particulars by which such standard or amendment is sufficiently identified.

1.2. By way of Government Notice 293/2018 published in Government Gazette 6763 dated 8th November 2018, NAMCARS (2018) provides for Part 90 – "Performance Based Navigation". This Part 90 provides for the issue of technical standards as document NAM-CATS-PBN 90. The Executive Director of Civil Aviation has, pursuant to the empowerment mentioned above, issued technical standards relating to NAMCAR Part 90 (Performance Based Navigation) to be known as NAM-CATS-PBN 90.

1.3. NAM-CATS-PBN 90 contains the standards, rules, requirements, methods, specifications, characteristics, and procedures which are applicable in respect of Performance Based Navigation (PBN) to be used for all aspects of civil aviation performance based navigation operations.

1.4. To the extent possible, each reference to a technical standard in this document, is a reference to the corresponding regulation in the Namibian Civil Aviation Regulations.

Example: *(1) Technical standard 90.01.3 refers to Regulation 3 of Subpart 01 of Part 90*

1.5. Where there is any perceived disparity of meaning or inconsistency between these technical standards and the regulations, the provisions of the regulations will take precedence.

1.6. Where there is a difference between a standard and procedure prescribed in ICAO documents and the Civil Aviation Technical Standards (CATS), the CATS standard will prevail.

1.7. Said difference will be published in the AIP.

2. GUIDANCE MATERIAL

2.1. Guidelines and recommendations in support of any particular technical standard are contained in schedules or appendices to, and/or compliance notes inserted throughout, the technical standards. These guidelines are intended to provide recommendations and guidance to illustrate a means, but not necessarily the only means of complying with the regulations or technical standards. They may explain certain regulatory requirements by providing interpretive and explanatory materials. It is expected that service providers will document internal actions in their own operational manuals, to put into effect those, or similarly adequate, practices.

3. AMENDMENTS TO THE TECHNICAL STANDARDS

3.1. The NCAA Safety Division Flight Operations (OPS) has responsibility for the technical content of this technical standard.

3.2. This technical standard is issued, and may only be amended under the authority of the Executive Director of Civil Aviation.

3.3. Requests for changes to the content of this technical standard must be forwarded to the Executive Director and may come from:

(a) Technical areas within the NCAA; or
(b) Aviation industry service providers or operators; or
(c) NCAA licence holders.

3.4. The need to change the content of this technical standard may arise for any of the following reasons:

(a) To ensure safety;

(b) To ensure standardisation;

(c) To respond to changed NCAA regulations or standards;

(d) To respond to changes initiated by ICAO;

(e) To accommodate proposed initiatives or new technologies.

3.5. NCAA may approve trials of new procedures or technologies to develop appropriate standards.

4. INTERNATIONAL STANDARDS

4.1. Section 227 of the Civil Aviation Act, 2016 empowers the Executive Director of Civil Aviation to issue technical standards for civil aviation. Section 227 of the Civil Aviation Act, 2016 further empowers the Executive Director of Civil Aviation to incorporate into a technical standard any international aviation standard or any amendment without stating the text of such standard or amendment, by mere reference to the title, number, and year of issue of such standard or amendment, or to any other particulars by which such standard or amendment is sufficiently identified.

4.2. The following international standards, recommended practices and procedures, as amended from time to time, are incorporated into the technical standards contained in this document:

(a) ICAO Document 9613 AN/937 Performance Based Navigation (PBN) Manual, 2013 as amended from time to time

(b) ICAO Annex 6 Operation of Aircraft, 2020 as amended from time to time

4.3. Differences from ICAO Standards, Reccommended Practices, and Procedures are published in the AIP.

REINHARD GäRTNER
INTERIM EXECUTIVE DIRECTOR OF CIVIL AVIATION

SCHEDULE

PART 90– PERFORMANCE BASED NAVIGATION TECHNICAL STANDARDS
(NAM-CATS-PBN 90)

CONTENTS

1. OVERVIEW

1.2 Section 227 of the Civil Aviation Act, 2016 empowers the Executive Director of Civil Aviation to issue technical standard for civil aviation. Section 227 of the Act further empowers the Executive Director of Civil Aviation to incorporate into a technical standard any international aviation standard or any amendment without publishing the text of such standard or any amendment by mere reference to the title, number and year of issue of such standard or amendment or to any other particulars by which such standard or amendment is sufficiently identified.

1.3 The Executive Director of Civil Aviation has, pursuant to the empowerment mentioned above, issued technical standards relating to NAMCARs Part 90 (Performance-Based Navigation) to be known as NAM-CATS-PBN.

1.4 NAM-CATS-Performance-Based Navigation comprises the standards, rules, requirements, methods, specifications, characteristics and procedures which are applicable in respect of PBN to be used in all aspects of civil aviation air and ground operations.

1.5 To the extent possible, each reference to a Technical Standard in this document, is a reference to the corresponding regulation in the Namibian Civil Aviation Regulations (NAMCARS).

Example: *(1) Technical standard 90.01.02 refers to regulation 90 of Subpart 01 of the Part 2*
(2) Technical standard 2.02 refers to either the whole, or more than one specific regulation, of Subpart 02 of Part 2.

1.6 Where there is any perceived disparity of meaning or inconsistency between these Technical Standards and the regulations, the provisions of the Regulations will take precedence.

1.7 Where there is a difference between a standard and procedure prescribed in ICAO documents and the Civil Aviation Technical Standards (CATS), the CATS standard will prevail.

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3.2 This Technical Standard is issued, and may only be amended, under the authority of the Executive Director of Civil Aviation.

3.3 Requests for changes to the content of this Technical Standard must be forwarded to the Executive Director and may come from:

(1) technical areas within NCAA; or
(2) aviation industry service providers or operators; or
(3) pilots and ATC staff,

and for it to be dealt with in accordance with the relevant Sub-Part of Part 3 of the NAMCARS.

3.4 The need to change the content of this technical standard may arise for any of the following reasons:

(1) to ensure safety;
(2) to ensure standardisation;
(3) to respond to changed NCAA regulations or standards;
(4) to respond to changes initiated by ICAO; or
(5) to accommodate proposed initiatives or new technologies,

and for it to meet the validity and other requirements set out in accordance with the relevant Sub-Part of Part 3 of the NAMCARS.

3.5 NCAA may approve trials of new procedures or technologies to develop appropriate standards.

4. INTERNATIONAL STANDARDS

4.1 Based on the empowering provisions to the Executive Director in section 227 to incorporate into a technical standard any international aviation standard or any amendment without stating the text of such standard or amendment, by mere reference to the title, number and year of issue of such standard or amendment, or to any other particulars by which such standard or amendment is sufficiently identified the Technical Standards herein provide for the following international standards, recommended practices and procedures, as amended from time to time, are incorporated into the technical standards contained in this document:

(1) ICAO Annex 15 – PBN;

(2) WGS 84 as amended from time to time.

4.2 Differences from ICAO Standards, Recommended Practices and Procedures are published in the AIP.

4.3 Other compliance requirements in documentation integral to PBN are as provided in the CATS.

90.01.3 REQUIREMENTS FOR INDIVIDUAL CATEGORIES OF PBN OPERATIONS

1 Performance Based Navigation

1.1 PBN Concept

The Performance Based Navigation (PBN) concept represents a change from sensor-based navigation to PBN. The PBN concept specifies that aircraft navigation system performance requirements be defined in terms of accuracy, integrity, continuity and functionality required for the proposed operations in the context of a particular airspace concept, when supported by the appropriate NAVAID infrastructure. Compliance with WGS 84 and data quality prescribed in ICAO Annex 15 are integral to PBN.

Performance requirements are identified in the navigation specifications (e.g., the requirements of this Technical Standard), which also identify options in terms of navigation sensors, navigation equipment, operating procedures, and training needs to meet performance requirements.

RNP procedures and routes require the use of RNP systems with on-board performance monitoring and alerting. A critical component of RNP is the requirement for the ability of the aircraft navigation

systems, in combination with the pilot, to monitor its achieved navigation performance, and to identify for the pilot whether the operational requirement is or is not met during an operation.

1.1.1 Operations with RNP systems

RNP operations:

(1) Do not require the pilot to monitor the ground-based navigation aids (NAVAIDs) used for position updating, unless required by the aircraft flight manual (AFM);
(2) Bases obstacle clearance assessments on the associated required system performance;
(3) Relies on conventional compliance with descent profiles and altitude requirements;
Note: Pilots operating aircraft with an approved barometric vertical navigation (baro-VNAV) system can continue using said system while operating on routes SIDs, and STARs. Operators must ensure compliance with all altitude limitations as published in the procedure in reference to the pressure altimeter.
(4) All routes and procedures must be based on the world geodetic system of coordinates (WGS 84); and
(5) The navigation data published for the routes, procedures and supporting NAVAIDs must meet the requirements of Annex 15 to the Convention on International Civil Aviation.

1.2 PBN Operational Approval

1.2.1 Approval Overview

The PBN concept requires that an operator of an aircraft has an operational approval from the State of registry or State of operator as applicable. The aircraft is also required to meet certain airworthiness certification standards, including the necessary navigation system performance and functionality so as to be eligible for a particular application.

A PBN navigation specification operational approval is an approval that authorises an operator to carry out defined PBN operations with specific aircraft in designated airspace. The operational approval for an operator shall be issued when the operator has demonstrated to the regulatory authority that the specific aircraft are in compliance with the relevant airworthiness standard and that the continued airworthiness and flight operations requirements are satisfied.

The airworthiness element ensures that the aircraft meets the aircraft eligibility and safety requirements for the functions and performance defined in the navigation specifications (or other referenced certification standards) and the on-board installation meets the relevant airworthiness standards, e.g. U.S. 14 CFR Part 25/EASA CS-25 and the applicable AC/AMC. The AC/AMC may also include other non-navigation equipment required to conduct the operation such as communications and surveillance equipment.

The continued airworthiness element of the operational approval should be inherent in the aircraft airworthiness approval through the airworthiness requirements, i.e. U.S. 14 CFR 25.1529/EASA CS-25.1529, but the operator is expected to be able to demonstrate that the navigation system will be maintained compliant with the type design. For navigation system installations there are few specific continued airworthiness requirements other than database and configuration management, systems modifications and software revisions, but the element is included for completeness and consistency with other CNS/ATM operational approvals, e.g. RVSM.

The flight operations element considers the operator's infrastructure for conducting PBN operations and flight crew operating procedures, training and competency demonstrations. This element also considers the operator's MEL, operations manual, checklists, instrument flight procedure approval processes, navigation database validation procedures, dispatch procedures, etc.

Compliance is determined against each relevant navigation specification. Compliance with one navigation specification does not automatically imply compliance with another.

1.2.2 Operational Approval

The following factors can influence the Authority's decision to require a formal operational approval process and specific documentation of approval:

(1) The degree of linkage to the basis for aircraft/avionics certification, i.e. whether the aircraft, including its RNAV or RNP navigation system, has an airworthiness approval covering the type of envisaged PBN operations;

(2) The complexity of the PBN operation and the level of associated challenges to operators and regulators;

(3) The maturity of the related operational concept and systems and, specifically, whether the issues are well understood and relatively stable;

(4) The risk associated with improper conduct of operations and operator-specific safety expectations, as well as those of third parties in the air and on the ground;

(5) The availability of appropriate training, and checking standards and procedures for the respective type of PBN operations (mainly for pilots but also for maintenance and dispatcher personnel, as appropriate); and

(6) The promulgation of information from holders of TCs to air operators (e.g. MMEL and training requirements) throughout the life cycle of the aircraft.

Decisions should be based upon balancing the efficient use of available regulatory resources to ensure proper initial operator compliance and to promote ongoing operational safety, while also enabling the use of new technologies and operations in the interest of enhanced safety and efficiency. .

Note: See further guidance to PBN phased approval process in Section 2.2.4 of this Technical Standard.

Operational approvals must be endorsed in the applicable section of the AOC Operations Specifications document issued to the operator for the specific type of aircraft.

General aviation (GA) operators may not be required to follow the same authorisation model as commercial operators although a letter of authorisation (LOA) must be issued after an evaluation process.

The operational approval assessment must take account of the following:

(1) Aircraft eligibility and airworthiness compliance (any limitations, assumptions or specific procedures considered in the framework of the airworthiness approval must be addressed);

(2) Operating procedures for the navigation systems used;

(3) Control of operating procedures (documented in the operations manual);

(4) Flight crew initial training and competency requirements and continuing competency requirements;

(5) Dispatch training requirements; and

(6) Control of navigation database procedures.

Where a navigation database is required, operators need to have documented procedures for the management of such databases. These procedures will define the sourcing of navigation data from approved suppliers, data validation procedures for navigation databases and the installation of updates to databases into aircraft so that the databases remain current with the AIRAC cycle. (For RNP AR applications, the control of the terrain database used by TAWS must also be addressed.

Note: See further guidance on data validation procedures in Section 2.5 of this Technical Standard.

1.2.3 Aircraft eligibility

An aircraft is eligible for a particular PBN application provided there is clear statement in:

(1) The TC; or

(2) The STC; or

(3) The associated documentation — AFM or equivalent document; or

(4) A compliance statement from the manufacturer, which has been approved by the State of Design and accepted by the State of Registry or the State of the Operator, if different.

The operator must have a configuration list detailing the pertinent hardware and software components and equipment used for the PBN operation.

The TC is the approved standard for the production of a specified type/series of aircraft. The aircraft specification for that type/series, as part of the TC, will generally include a navigation standard. The aircraft documentation for that type/series will define the system use, operational limitations, equipment

fitted and the maintenance practices and procedures. No changes (modifications) are permitted to an aircraft unless the State of Registry either approves such changes through a modification approval process or STC, or accepts technical data defining a design change that has been approved by another State.

An alternate method of achieving the airworthiness approval of the aircraft for PBN operations is for the aircraft to be modified in accordance with approved data (e.g. STC, minor modification).

One means of modifying an aircraft is the approved service bulletin (SB) issued by the aircraft manufacturer. The SB is a document approved by the State of Design to enable changes to the specified aircraft type, and the modification then becomes part of the type design of the aircraft. Its applicability will normally be restricted by airframe serial number.

The SB describes the intention of the change and the work to be done to the aircraft. Any deviations from the SB require a design change approval; any deviations not approved will invalidate the SB approval. The State of Registry accepts the application of an SB and changes to the maintenance programme, while the State of the Operator accepts changes to the maintenance programme and approves changes to the MEL, training programmes and operations specifications. An OEM SB may be obtained for current-production or out-of-production aircraft.

For recently manufactured aircraft, where the PBN capability is approved under the TC, there may be a statement in the AFM limitations section identifying the operations for which the aircraft is approved. There is also usually a statement that the stated approval does not itself constitute an approval for an operator to conduct those operations. .

In many cases for legacy aircraft, while the aircraft is capable of meeting all the airworthiness requirements of a PBN navigation specification, there may be no clear statement in the applicable TC or STC or associated documents (AFM or equivalent document). In such cases, the aircraft manufacturer may elect to issue an SB with an appropriate AFM update or instead may publish a compliance statement in the form of a letter, for simple changes, or a detailed aircraft-type-specific document for more complex changes. The State of Registry may determine that an AFM change is not required if it accepts the OEM documentation.

Note: This Technical Standard contains a number of references to FAA Technical Standard Orders (TSO) and Advisory Circulars (AC) as well as EASA E/TSOs and Acceptable Means of Compliance (AMC). TSO and AC are numbered in the format e.g. TSO-C129(), where the parentheses () indicate the current version of the TSO. eg. TSO-C129C. Applicants for PBN approvals must, where applicable, refer to the current version of the TSO, ETSOs, AC or AMC published by the FAA or EASA as applicable.

1.2.4 PBN Phased Approval Process

Approval process for all the navigation specifications consists of two components to the approval comprising airworthiness and operational. Although the two have different requirements, they must be considered in one single process.

Each process is an orderly method used by the Authority to make sure that the applicants meet the established requirements.

The approval process is made up by the following phases:

(1) Phase one: Pre-application

(2) Phase two: Formal application

(3) Phase three: Documentation evaluation

(4) Phase four: Inspection and demonstration

(5) Phase five: Approval

Phase One - Pre-application: the Authority calls the applicant or operator to a pre-application meeting. At this meeting, the Authority informs the applicant or operator of all the operational and airworthiness requirements that it must meet during the approval process, including the following:

(1) The contents of the formal application;

(2) The review and evaluation of the application by the Authority;

(3) The limitations (if any) applicable to the approval; and

(4) Conditions under which the navigation specification(s) applied for could be cancelled.

Phase Two – Formal Application: the applicant or operator submits the formal application along with all the relevant documentation.

Phase Three – Documentation evaluation: the Authority evaluates all the documentation and the navigation system to determine their eligibility and the approval method to be followed in connection with the aircraft. As a result of this analysis and evaluation, the Authority may accept or reject the formal application along with the documentation.

Phase Four – Inspection and demonstration: the operator will provide training to its personnel and will carry out the validation flight, if required.

Phase Five – Approval: the Authority issues the operations specifications for the applicable navigation specification after the operator has met the airworthiness and operational requirements. For Part 121, 127 and 135 AOC holders the Authority issues an amended OpSpecs for the particular aircraft type. For Part 91 and Part 93 operators a letter of authorisation (LOA) is issued.

2 Navigation Database Validation Programme

2.1 Introduction

The information stored in the navigation database defines the lateral and longitudinal guidance of the aircraft for the applicable PBN operations. Navigation database updates are carried out every 28 days by means of the AIRAC cycle. The navigation data used in each update are critical to the integrity of every applicable RNAV/RNP procedure and route. This sub-section provides guidance on operator procedures to validate the navigation data associated with the applicable operations.

2.2 Data Processing

The operator will identify in its procedures the person responsible for the navigation data updating process.

The operator must document a process for accepting, verifying, and loading navigation data into the aircraft.

The operator must place its documented data process under configuration control.

2.3 Initial Data Validation

The operator must validate every applicable RNAV/RNP procedure and route, before flying under instrument meteorological conditions (IMC) to ensure compatibility with the aircraft and to ensure that the resulting paths are consistent with the published procedures. As a minimum, the operator must:

(a) Compare the navigation data of the RNAV/RNP procedures and routes to be loaded into the FMS with valid charts and maps containing the published procedures;

(b) Validate the navigation data loaded for RNAV/RNP procedures and routes, either on the flight simulator or on the aircraft, under visual meteorological conditions (VMC). The procedures and routes outlined on a map display must be compared to the published procedures and routes. The procedures and routes must be flown in order to ensure that the paths can be used, that they have no apparent lateral or longitudinal discrepancies, and that they are consistent with the published routes; and

(c) Once the RNAV/RNP procedures and routes are validated, a copy of the validated navigation data must be kept and maintained in order to compare them with subsequent data updates.

2.4 Data Updating

Upon receiving a navigation data update and before using such data on the aircraft, the operator must compare the update with the validated procedures and routes. This comparison must identify and resolve any discrepancy in the navigation data. Where there are significant changes (any change affecting the

path or the performance of the procedures or routes) and where those changes are verified through the initial data, the operator must validate the amended route in accordance with the initial validation data.

2.5 Navigation Data Suppliers

Navigation data suppliers must have a letter of acceptance (LOA) in order to process these data (*e.g.*, FAA AC 20-153 or the document on the conditions for the issuance of letters of acceptance to navigation data suppliers by the European Aviation Safety Agency – EASA (EASA IR 21 Subpart G) or equivalent documents). A LOA recognises the data supplier as one whose data quality, integrity and quality management practices are consistent with the criteria of DO-200A/ED-76. The database supplier of an operator must have a Type 2 LOA and its respective suppliers must have a Type 1 or 2 LOA. The Authority may accept an LOA issued to navigation data suppliers or issue its own LOA.

2.6 Aircraft Modifications (Database Update)

If an aircraft system necessary for PBN operations is modified (*e.g.*, change of software), the operator is responsible for validating the RNAV/RNP procedures and routes with the navigation database and the modified system. This can be done without any direct assessment if the manufacturer confirms that the modification has no effect on the navigation database or on path calculation. If there is no such confirmation by the manufacturer, the operator must perform an initial validation of the navigation data with the modified system.

3. ATC Flight Plan

Where an ATC flight plan is filed, the flight plan must include the PBN capabilities of the aircraft. The applicable fields of the flight plan form must be completed as follows.

Item 10 EQUIPMENT. This field must include the entry ‘R’ to indicate the aircraft equipment is approved for PBN.

Item 18. This field must include a description of the type of approved PBN equipment carried. The entry PBN/ must be inserted followed by the applicable entry as given in the following list.

Note: Not all of the listed specifications are approved for Namibian operators. The full list specified by ICAO is given for completeness.

RNAV Specifications		RNP Specifications	
A1	RNAV 10 (RNP 10)	L1	RNP 4
B1	RNAV 5 all permitted sensors	O1	Basic RNP 1 all permitted sensors

B2	RNAV 5 GNSS	O2	Basic RNP 1 GNSS
B3	RNAV 5 DME/DME	O3	Basic RNP 1 DME/DME
B4	RNAV 5 VOR/DME	O4	Basic RNP 1 DME/DME/IRU
B5	RNAV 5 INS or IRS	S1	RNP APCH
B6	RNAV 5 LORANC	S2	RNP APCH with BARO-VNAV
C1	RNAV 2 all permitted sensors	T1	RNP AR APCH with RF (special authorisation required)
C2	RNAV 2 GNSS	T2	RNP AR APCH without RF (special authorisation required)
C3	RNAV 2 DME/DME		
C4	RNAV 2 DME/DME/IRU		
D1	RNAV 1 all permitted sensors		
D2	RNAV 1 GNSS		
D3	RNAV 1 DME/DME		
D4	RNAV 1 DME/DME/IRU		

NAVIGATION SPECIFICATIONS

4. RNAV 10 (RNP 10)

4.1 General considerations

4.1.1 Navigation performance specification

RNAV 10 (RNP 10) does not require performance monitoring and alerting on-board the aircraft. However, the term RNP 10 is being retained as the navigation specification in certain airspace areas because it is in common use worldwide. Therefore, operators of aircraft in airspace where the minimum performance specification is published as RNP 10 are required to hold operational approval for RNAV 10.

4.1.2 Namibian airspace

The navigation specification RNAV 10 is not applicable to Namibian airspace.

4.1.3 Source document

This Technical Standard for RNAV 10 is based upon FAA Order 8400.12C Required Navigation Performance 10 (RNP 10) Operational Authorisation, adapted for the purposes of the Namibian civil aviation environment.

4.2 Airworthiness and operational approval

In order to receive an RNAV 10 approval, the operator must comply with two types of approval, airworthiness approval and operational approval. Compliance with airworthiness requirements by themselves does not constitute the operational approval.

4.2.1 Part 91 and 93 operators

The Executive Director issues a Letter of Approval (LOA) once it has determined that the aircraft meets all applicable requirements for RNAV 10 operations.

4.2.2 Part 121, 127 and 135 operators

The approval must be included in the Ops Specs.

4.3 Airworthiness approval

4.3.1 Eligibility of aircraft and navigation systems

To be eligible for airworthiness approval, many aircraft and navigation system types currently in use in oceanic or remote area operations qualify for RNAV 10 based on one or more provisions of existing certification criteria. Thus, additional aircraft certification action may not be necessary for the majority of RNAV 10 approvals. In these instances, additional aircraft certification will only be necessary where the operator chooses to claim additional performance beyond that originally certified or stated in the Aircraft Flight Manual (AFM).

4.3.2 RNAV 10 system requirements

4.3.2.1 Cross-Track and Along-Track Error.

All aircraft conducting RNAV 10 operations shall have a 95 percent cross-track error (XTK) of less than 10 NM. This includes positioning error, Flight Technical Error (FTE), path definition error, and display error. All aircraft shall also have a 95 percent along-track positioning error of less than 10 NM.

Note: For RNAV 10 approval, navigation positioning error is considered the dominant contributor to cross-track and along-track error. FTE, path definition error, and display error are considered to be insignificant for the purposes of RNAV 10 approval. (RNAV 10 is intended for oceanic and remote areas where aircraft separation minima on the order of 50 NM are applied.)

4.3.3 Error Types

The following error types are considered.

4.3.3.1 Flight Technical Error (FTE)

The FTE is the accuracy with which the aircraft is controlled, as measured by the indicated aircraft position with respect to the indicated command or desired position. It does not include blunder errors.

4.3.3.2 Path Definition Error (PDE)

This is the difference between the defined path and the desired path at a specific point and time.

4.3.3.3 Display Errors (Display System Error).

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

For systems in which charts are incorporated as integral parts of the display, the display system error necessarily includes charting errors to the extent that they actually result in errors in controlling the position of the aircraft relative to a desired path over the ground. To be consistent, in the case of symbolic displays not employing integral charts, any errors in waypoint definition directly attributable to errors in the reference chart used in determining waypoint positions should be included as a component of this error. This type of error is virtually impossible to handle; in general practice, highly accurate, published waypoint locations are used to the greatest extent possible in setting up such systems to avoid such errors and reduce workload.

4.3.3.4 Navigation System Error (NSE)

This is the root sum square of the ground station error contribution, the airborne receiver error, and the display system contribution.

4.3.3.5 Total System Error (TSE)

This is system use error. The formula for determining TSE is:

$$TSE = \sqrt{(NSE)^2 + (FTE)^2}$$

4.3.3.6 Position Estimation Error

This is the difference between true position and estimated position.

4.3.4 RNAV 10 baseline time limit

The baseline RNAV 10 time limit for INS and IRU systems to meet the system requirements after the system is placed in the navigation mode is 6.2 hours. This time limit may be extended when RNAV is integrated into the aircraft navigation system through a formal certification process. Such extended time limit must be specified in the AFM or equivalent certification documentation.

4.3.5 RNAV 10 Operation in Oceanic and Remote Areas

Aircraft must be equipped with at least dual navigation systems except where use of a single navigation system is specified for the airspace.

4.3.5 Determining aircraft eligibility

LRNSs may be considered eligible for RNAV 10 operations according to two groups of criteria:

(1) Aircraft Eligibility through RNP Certification (Eligibility Group 1); or
(2) Aircraft Eligibility through Prior Navigation System Certification (Eligibility Group 2).

4.3.5.1 Aircraft Eligibility through RNP Certification (Eligibility Group 1)

Group 1 aircraft are those which have obtained certification for RNP integration into aircraft navigation systems.

RNP compliance is documented in the AFM and is typically not limited to RNAV 10. The AFM will address RNP Navigation Specifications that have been demonstrated and any related provisions applicable to its use (e.g., Navigational Aid (NAVAID) sensor requirements). Operational approval of Group 1 aircraft is based upon the performance stated in the AFM.

An airworthiness approval specifically addressing RNAV 10 performance may be obtained. The following is an example of wording for use in AFMs when RNAV 10 approvals are granted for a change in the INS/IRU certified performance:

(1) "The XXX navigation system has been demonstrated to meet criteria of FAA Order 8400.12, current edition, as a primary means of navigation for flights up to XXX hours in duration without updating. The determination of flight duration starts when the system is placed in the navigation mode."
(2) "For flights which include airborne updating of navigation position, the operator must address the effect that updating has on position accuracy, and any associated time limits for RNP operations, pertinent to the updating NAVAID facilities use, and the area, routes, or procedures to be flown."
(3) "Demonstration of performance in accordance with provisions of FAA Order 8400.12 does not constitute approval to conduct RNP operations."

Note: The above wording in an AFM is based upon performance approval by the FAA. Similar wording may be published in the AFM for other certification authorities. Aircraft that have had this wording entered into their flight manual will be eligible for operational approval only if all other criteria are met. The "XXX hours" specified in the AFM for INS and IRU systems does not include updating. When the operator proposes a credit for updating, the proposal must address the effect the updating has on position accuracy, and any associated time limits for RNP operations pertinent to the updating NAVAID facilities' use, and the area, routes, or procedures to be flown.

4.3.5.2 Aircraft Eligibility through Prior Navigation System Certification (Eligibility Group 2).

Group 2 aircraft are those that can equate their certified level of performance, under previous standards, to the RNAV 10 criteria. The standards listed in this subparagraphs can be used to qualify an aircraft under Group 2. Other recognised standards may also be used if they are sufficient to ensure that the RNAV 10 requirements are met. If other standards are to be used, the Authority should be consulted to determine the appropriate operational approval and limitations.

4.3.5.3 Aircraft Equipped with two or more Approved INSs or IRUs

Approved Inertial systems are considered to meet RNAV 10 requirements for up to 6.2 hours of flight time, provided the system is approved in accordance with FAA FAR Part 121 Appendix G or a recognised alternative standard. This time starts when the system is placed in the navigation mode.

If systems are updated en route, the 6.2 hour RNAV 10 time limit must be adjusted to account for the accuracy of the update.

INS accuracy, reliability, training, and maintenance issues that are required by FAA FAR Part 121 Appendix G are considered to be applicable to an RNAV 10 approval, including any associated Class II navigation procedures. Except as authorised by the Executive Director, at least dual equipage of eligible INS systems is required.

Note: The consideration to use 6.2 hours of flight time is based on an inertial system with a 95 percent radial position error rate (circular error rate) of 2.0 NM/hour, which is statistically equivalent to

individual 95 percent cross-track and 95 percent along-track position error rates (orthogonal error rates) of 1.6015 NM/hour each, and 95 percent cross-track and 95 percent along-track position error limits of 10 NM each (e.g., 10 NM/1.6015 NM/hour=6.2 hours).

4.3.5.4 Aircraft Equipped with two or more INSs or IRUs Approved for North Atlantic Minimum Navigation Performance Specification (NAT/MNPS) or Australian RNAV Operations.

Aircraft equipped with dual INSs or IRUs approved for NAT/MNPS operations or RNAV operations in Australia can be considered to meet RNAV 10 requirements for up to 6.2 hours after the system is placed in the navigation mode.

4.3.5.5 Aircraft Equipped with two or more GPSs.

Aircraft approved to use GPS for oceanic and remote operations without reliance on other LRNSs are considered to meet the RNAV 10 requirements without time limitations.

The flight manual should indicate if a particular GPS installation meets the appropriate FAA or other recognised requirements for oceanic and remote operations. Dual TSO-approved GPS equipment is required, and an approved dispatch fault detection and exclusion (FDE) availability prediction program must be used.

TSO-C196 and TSO-C145/TSO-C146 ( ), (or recognised equivalent), GPS equipment are inherently capable of supporting oceanic and remote operation when used in conjunction with an approved FDE prediction program.

TSO-C129, (or recognised equivalent), GPS equipment is not inherently capable of oceanic and remote operations. Additional criteria defining an acceptable means of compliance (AMC) for this equipment to be approved for this operation is located in FAA AC 20-138, Appendix 1.

Multisensor systems integrating GPS with FDE approved using the guidance contained in FAA AC 20-138 can be considered to meet RNAV 10 requirements without time limitations.

FAA AC 20-138 provides an acceptable means of complying with installation requirements for aircraft using a GPS that is not integrated with other sensors.

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

Note: If predictions indicate that the maximum FDE outage for the intended RNAV 10 operation cannot be met, then the operation must be rescheduled when FDE is available, or RNAV 10 must be predicated on an alternate means of navigation.

4.3.5.6 Aircraft Equipped with a Single INS/IRU and a Single GPS Approved for Oceanic and Remote Operations.

Aircraft equipped with a single INS or IRU and a single GPS meet the RNAV 10 requirements without time limitations.

The INS or IRU equipment must meet the standards for Eligibility Group 2, except that only one INS/IRU is required.

GPS equipment must meet the standards for Eligibility Group 2, except that only one GPS is required.

4.3.5.7 Aircraft Equipped with a Single INS/IRU or a Single GPS.

Aircraft equipped with a single INS/IRU or a single GPS are approved for oceanic and remote navigation only where specified.

The INS or IRU equipment must meet the standards for Eligibility Group 2, except that only one INS/IRU is required.

GPS equipment must meet the standards for Eligibility Group 2, except that only one GPS is required.

4.3.6 Effect of Enroute Updates

4.3.6.1 Automatic Position Updating

Operators may extend their RNAV 10 navigation capability time by automatic position updating. Time extensions for updating procedures are based on the baseline for which they have been approved minus the time factors shown below:

(1) Automatic updating using DME/DME = baseline - 0.3 hours (e.g., an aircraft that has been approved for 6.2 hours can gain 5.9 hours following an automatic DME/DME update).
(2) Automatic updating using DME/VOR = baseline - 0.5 hours.

4.3.6.2 Conditions under which automatic radio position updating may be considered acceptable for flight in airspace where RNAV 10 is required.

Automatic updating is considered to be any updating procedure that does not require crews to manually insert coordinates. Automatic updating may be considered acceptable for operations in airspace where RNAV 10 is applied, provided that:

(1) Procedures for automatic updating are included in an operator's training programme; and
(2) Crews are knowledgeable of the updating procedures and of the effect of the update on the navigation solution.

An acceptable procedure for automatic updating may be used as the basis for an RNAV 10 approval for an extended time, as indicated by data presented to the Executive Director. This data must present a

clear indication of the accuracy of the update and the effect of the update on the navigation capabilities for the remainder of the flight.

Note: Manual position updates are not permitted for extended RNAV 10 operations beyond the baseline time.

4.3.7 Minimum Equipment List

The MEL shall reflect the effect of any unserviceability of LRNSs and associated equipment upon the aircraft's ability to meet RNAV 10 requirements.

4.3.8 Continued Airworthiness (Maintenance Requirements).

The operator shall submit, as part of his application for operational approval, all document references (if any) for periodic testing, inspection, or maintenance requirements prescribed for LRNSs.

4.4 Operational Approval

Airworthiness approval alone does not authorise an applicant or operator to conduct RNAV 10 operations. In addition to the airworthiness approval, the applicant or operator must obtain an operational approval to confirm the suitability of normal and contingency procedures in connection to the installation of a given piece of equipment.

For commercial air transport operators, and general aviation operators, the evaluation of an application for RNAV 10 operational approval is done by the Authority,

4.4.1 Requirements to obtain operational approval

The following requirements for operational performance and procedures must be met.

4.4.1.1 Navigational accuracy

All aircraft will meet a track-keeping accuracy equal to or better than ±10 NM for 95 percent of the flight time in RNAV 10 airspace. All aircraft will meet along-track positioning accuracy of ±10 NM for 95 percent of the flight time in RNAV 10 airspace.

4.4.1.2 Navigation continuity

Loss of function is classified as a major failure condition for oceanic and remote navigation. This continuity requirement is satisfied by the carriage of dual, independent LRNSs (excluding Signal in Space (SIS)).

Note: Due to the unique surveillance coverage provided in the Gulf of Mexico, the continuity requirement can be satisfied by carriage of an S-LRNS, provided it complies with subparagraph 3.(d)(v).

4.4.1.3 Navigation Integrity.

The navigation system(s) shall have integrity such that the system does not provide misleading information.

4.4.1.4 Availability of NAVAIDS

Where NAVAIDS are required for automatic position updating, the operator should ensure at dispatch or during flight planning that adequate NAVAIDs are available en route to enable the aircraft to navigate to RNAV 10.

4.4.1.5 Route Evaluation for RNAV 10 Time Limits for Aircraft Equipped with Only INSs or IRUs.

An RNAV 10 time limit must be established for aircraft equipped with only INSs or IRUs to meet the RNAV 10 accuracy requirement. When planning operations in areas where RNAV 10 is applied, the operator must evaluate its intended route(s) of flight in relation to the RNAV 10 time limit. In making this evaluation, the operator must consider the effect of headwinds. The operator may choose to make this evaluation on a one-time basis (75 percent probability wind components) or on a per-flight basis.

(1) Route Evaluation. The operator must establish its capability to satisfy the RNAV 10 time limit established for dispatch or departure into RNAV 10 airspace.
(2) Start Point for Calculation. The calculation should start at the point where the system is placed in the navigation mode or the point where it is expected to be updated.
(3) Stop Point for Calculation. The stop point may be one of the following:
    (a) The point at which the aircraft will begin to navigate by reference to ICAO standard NAVAIDs (VOR, DME, non-directional radio beacon (NDB)) or comes under radar surveillance from air traffic control (ATC), or
    (b) The point at which the navigation system is expected to be updated.
(4) Sources of Wind Component Data. The headwind component to be considered for the route may be obtained from any source found acceptable to the Authority.
(5) One-Time Calculation Based on 75-Percent Probability Wind Components. Certain sources of wind data establish the probability of experiencing a given wind component on routes between aerodrome pairs on an annual basis. If an operator chooses to make a one-time calculation of RNAV 10 time limit compliance, it may use the annual 75 percent probability level to calculate the effect of headwinds. This level has been found to be a reasonable estimation of wind components.
(6) Calculation of Time Limit for Each Specific Flight. The operator may choose to evaluate each individual flight using flight-planned winds to determine if the aircraft will comply with the specified time limit. If it is determined that the flight will exceed the time limit, then the aircraft must fly an alternate route or delay the flight until it can meet the time limit. This evaluation should be considered a flight planning or dispatch task.

4.5 Operational Procedures

4.5.1 The operator shall publish procedures for RNAV operations.

The minimum items shall include the following:

4.5.1.1 Flight Planning

During flight planning, the flight crew should pay particular attention to conditions that may affect operations in RNAV 10 airspace (or on RNAV 10 routes). These include, but may not be limited to:

(1) Approval. Verify that the aircraft is approved for RNAV 10 operations;
(2) Time Limit. Verify that the RNAV 10 time limit has been accounted for;
(3) Annotated Flight Plan. Verify that the ATC Flight Plan is correctly annotated for RNAV 10;
(4) Global Positioning System (GPS) Requirements. Verify the requirements for GPS, such as fault detection and exclusion (FDE), if appropriate for the operation; and
(5) Operating Restrictions. If required for a specific navigation system, account for any operating restriction related to RNAV 10 approval.

4.5.1.2 Pre-flight Procedures at the Aircraft for Each Flight.

The following actions must be completed during pre-flight:

(1) Review Technical/Maintenance Logs and Forms. Review technical/maintenance logs and forms to ascertain the condition of equipment required for flight in RNAV 10 airspace or on an RNAV 10 route. Ensure that the maintenance action has been taken to correct defects to required equipment;
(2) External Inspection. During the external inspection of aircraft, pay particular attention to the condition of navigation antenna and the condition of the fuselage skin in the vicinity of each of these antennas. This check may be accomplished by a qualified and authorised person other than the pilot (e.g., a flight engineer or maintenance personnel); and
(3) Contingency Procedures. Contingency procedures for operations in RNAV 10 airspace or on RNAV 10 routes are no different than normal oceanic emergency procedures with one exception: crews must be able to recognize and advise air traffic control (ATC) when the aircraft is no longer able to navigate to its RNAV 10 approval capability.

4.5.1.3 En route

Two Long-Range Navigation Systems (LRNS) Required. Except in airspace where Single Long-Range Navigation System operation is permitted, at least two LRNSs capable of navigating to the RNP should be operational at the oceanic entry point. If this is not the case, then the pilot must consider an alternate routing, which does not require that equipment, or diverting for repairs.

Check Position before Entering Oceanic Airspace. Before entering oceanic airspace, the aircraft's position should be checked as accurately as possible by using external Navigational Aids (NAVAID). This may require DME/DME and/or DME/VOR checks to determine navigation system errors through displayed and actual positions. If the system is updated, the proper procedures must be followed with the aid of a prepared checklist.

Mandatory Cross-Checking Procedures. Operator in-flight operating drills will include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent aircraft from inadvertent deviation from ATC-cleared routes.

Deterioration or Failure of the Navigation Equipment. Crews must advise ATC of any deterioration or failure of the navigation equipment below the navigation performance requirements or of any deviations required for a contingency procedure.

4.6 Training requirements

Operators must ensure that Flight Crew and, where applicable Dispatchers and Flight Operations Officers receive theoretical training and checking on the operational requirements and operational procedures listed in this Technical Standard.

Commercial operators must submit the training curriculum and other appropriate material to the Authority in order to show that the operational procedures and practices and the training aspects identified in Paragraph 5.6.1, related to RNAV 10 operations, have been included in the training programmes, where applicable (for example, initial, upgrade or recurrent training programmes for flight crews and flight operations officers). The operator will develop and standardise procedures and practices according to the guidelines established in Section 5.5, in the following areas: flight planning, aircraft pre-flight procedures for each flight, procedures before entering an RNAV 10 route or airspace and in-flight, contingency, and flight crew qualification procedures.

Note: It is not necessary to establish a separate training programme if RNAV 10 training, identified in Paragraph 12, has already been included in the operator training programme. However, it should be possible to identify what RNP 10 aspects are covered in a training programme.

General aviation operators must be familiar and show that they will conduct their operations applying the practices and procedures described in Section 5.5.

4.6.1 Training Programme

The following aspects must to be standardised and included in the training programmes for flight crews and flight operations officers. Some aspects may have already been duly standardised in the existing training programmes. The new technologies may also eliminate the need for certain actions by the flight crew. If this is the case, this paragraph can be deemed fulfilled.

4.6.1.1 PART 121 and 135 operators

Commercial operators must make sure that flight crews and flight operations officers are trained on the following aspects:

(1) General

(a) RNP definition relative to RNP 10 requirements.

(b) Knowledge of the airspace where RNP 10 is required.

(c) Aeronautical charts and documents that reflect RNP 10 operations.

(d) Required equipment and their operation for operations in RNP 10 airspace.

(e) Limitations associated with navigation equipment.

(f) Impact of updating navigation systems.

(g) Use of MEL.

(2) Operational procedures

(a) Flight planning.

(b) Pre-flight procedures.

(c) En-route operations.

(d) Contingency procedures.

4.6.1.2 Part 91 operators

Private operators must provide evidence to the Authority that the pilots have knowledge about RNP 10 operations. When determining whether or not the training of a private operator is appropriate, the Authority may:

(1) Accept a certificate issued by a training centre without any further evaluation;

(2) Assess a training programme before accepting a certificate issued by a given training centre;

(3) Accept a statement in the application of the operator indicating that the operator guarantees and will continue to guarantee that the flight crews have knowledge about RNAV 10 operational practices and procedures; and

(4) Accept a statement from the operator in the sense that it has already performed or will perform a specific RNP 10 training programme.

4.7 Navigation Database

If there is an on-board database, it must be valid and appropriate for operations and must include navigation aids and waypoints (WPT) required for the route.

The operator must obtain the navigation database from a qualified supplier.

Navigation database supplier must have a letter of acceptance (LOA) in order to process navigation information (*e.g.*, FAA AC 20-153 as amended or equivalent document on conditions for the issuance of letters of acceptance to navigation data supplier by the European Aviation Safety Agency (EASA IR 21 Subpart G as amended) or equivalent documents). An LOA recognises as data supplier one whose information quality, integrity, and quality management practices are consistent with the criteria in document DO-200A/ED-76 as amended. The data base supplier of an operator must have a Type 2 LOA and its respective suppliers must have a Type 1 or 2 LOA. The Authority may accept an LOA issued to navigation data suppliers or may issue its own LOA.

The operator must report to the navigation data suppliers any discrepancies that invalidate a route, and prohibit the use of the affected procedures through a notice to the flight crews.

Operators must consider the need to conduct periodic checks of the navigation databases in order to maintain the existing quality system or safety management system requirements.

4.8 Oversight, Investigation of Navigation Errors and Withdrawal of RNAV 10 Authorisation

The operator will establish a procedure to receive, analyse, and follow up on navigation error reports in order to determine appropriate corrective actions.

Information showing the potential of repeated errors may require changes to the training programme of the operator.

Information attributing multiple errors to a specific pilot may indicate that that pilot needs additional training or a revision of his/her license.

Repeated navigation errors attributed to a piece of equipment or a specific part of that piece of equipment or to operational procedures can entail the cancellation of an operational approval (withdrawal of RNAV 10 authorisation from the OpSpecs or withdrawal of the LOA in the case of private operators).

5. RNAV 5

5.1 General Considerations

5.1.1 Navaid infrastructure

The Authority may prescribe RNAV 5 navigation specification for specific routes or for specific areas or flight levels in an airspace. RNAV 5 systems permit aircraft navigation along any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids or a combination of both methods.

RNAV 5 operations are based on the use of RNAV equipment which automatically determines the aircraft position in the horizontal plane using input from one sensor or a combination of the following types of position sensors, together with the means to establish and follow a desired path:

(1) VOR/DME;
(2) DME/DME;
(3) INS or IRS; and
(4) GNSS.

Note the application of the sensors is subject to the limitations contained in this Technical Standard. Due to the lack of suitable ground-based navigational aids, PBN operations in Namibia are limited to the use of GNSS.

The air navigation services providers (ANSP) must assess the NAVAID infrastructure in order to ensure that it is sufficient for the proposed operations, including reversionary modes.

It is acceptable for gaps in NAVAIDS coverage to be present; when this occurs, route spacing and obstacle clearance surfaces must be considered due to the expected increase in lateral track-keeping errors during the "dead reckoning" phase of flight.

5.1.2 Communication and air traffic services (ATS) surveillance

Direct pilot to ATC voice communication is required. When reliance is placed on the use of ATS surveillance to assist contingency procedures, its performance should be adequate for that purpose.

Radar monitoring by the ATS may be used to mitigate the risk of gross navigation errors, provided the route lies within the ATS surveillance and communications service volumes and the ATS resources are sufficient for the task.

5.1.3 Obstacle clearance and route spacing

Detailed guidance on obstacle clearance is provided in PANS-OPS (Doc 8168 as amended), Volume II; the general criteria in Parts I and III apply. The ANSP is responsible for route spacing and must have ATS surveillance and monitoring tools to support detection and correction of navigation errors.

In an ATC surveillance environment, the route spacing will depend on acceptable ATC workload and availability of controller tools. The route design should account for the navigation performance achievable using the available NAVAID infrastructure, as well as the functional capabilities required by this document. Two aspects are of particular importance:

(1) Spacing between routes in turns
Automatic leg sequencing and associated turn anticipation is only a recommended function for RNAV 5. The track followed in executing turns depends upon the true airspeed, applied bank angle limits and wind. These factors, together with the different turn initiation criteria used by manufacturers, result in a large spread of turn performance. Studies have shown that for a track change of as little as 20 degrees, the actual path flown can vary by as much as 2 NM. This variability of turn performance must be considered in the design of the route structure where closely spaced routes are proposed.

(2) Along track distance between leg changes
A turn can start as early as 20 NM before the waypoint in the case of a large track angle change. Manually initiated turns may overshoot the following track. The track structure design must

ensure that leg changes do not occur too closely together. The required track length between turns must depend upon the required turn angle.

5.1.4 Publication

The AIP must clearly indicate that the navigation application is RNAV 5. The requirement for the carriage of RNAV 5 equipment in specific airspace or on identified routes should be published in the AIP.

The route must rely on normal descent profiles and identify minimum segment altitude requirements. All routes must be based upon WGS-84 coordinates.

The available NAVAID infrastructure must be clearly designated on all appropriate charts (e.g. GNSS, DME/DME, VOR/DME). Any navigation facilities that are critical to RNAV 5 operations shall be identified in the relevant publications. Due to the lack of suitable ground-based navigational aids, PBN operations in Namibia are limited to the use of GNSS.

A navigation database does not form part of the required functionality of RNAV 5. The absence of such a database necessitates manual waypoint entry, which significantly increases the potential for waypoint errors. En-route charts should support gross error checking by the flight crew by publishing fix data for selected waypoints on RNAV 5 routes.

5.1.5 Additional considerations

Many aircraft have the capability to fly a path parallel to, but offset left or right from, the original active route. The purpose of this function is to enable offsets for tactical operations authorised by ATC.

In the same way, many aircraft have the capability to execute a holding pattern manoeuvre using their RNAV system; this capability can provide flexibility to ATC in designing RNAV 5 operations.

5.2 Airworthiness and Operational Approval

In order to receive an RNAV 5 approval, the operator must comply with two types of approval: airworthiness approval and operational approval. Compliance with airworthiness requirements by themselves does not constitute the operational approval.

For Part 91 and 93 operators the Executive Director issues a Letter of Approval (LOA) after having determined that the aircraft meets all applicable requirements for RNAV 5 operations. For Part 121, 127 and 135 operators the approval must be included in the Ops Specs.

5.3 Airworthiness Approval

5.3.1 Aircraft equipment

An aircraft may be considered eligible for an RNAV 5 approval if it is equipped with one or more navigation systems approved and installed in accordance with this Technical Standard.

5.3.1.1 Aircraft Eligibility

An aircraft capacity to perform RNAV 5 operations can be demonstrated or reached in the following cases:

(1) First case: Demonstrated capacity in the manufacturing process and declared in the Aircraft flight manual (AFM) or in the AFM supplement or in the Type certificate data sheet (TCDS) or in the Pilot operating handbook (POH);

(2) Second case: Capacity reached in-service: By applying the service bulletin or supplemental type certificate or service letter or equivalent document and inclusion of the supplement in the AFM; or through aircraft navigation system approval.

5.3.1.2 Eligibility based on AFM or AFM supplement or TCDS or POH.

To determine eligibility of the aircraft in function of AFM or AFM supplement, TCDS or POH, aircraft RNAV 5 capacity must have been demonstrated in production (aircraft in manufacturing process or new construction)

(1) Aircraft RNAV 5 systems eligibility.

An aircraft may be considered eligible for RNAV 5 operations, if AFM or AFM supplement or TCDS or POH shows the appropriate instruments flight rules (IFR) navigation system installation has received airworthiness approval in accordance with this AC and any of the following documents as applicable: EASA AMC 20-4, ETSO-129a, FAA AC 90-96, AC 20-130, AC 20-138, AC 25-15.

(a) Airworthiness approval guidance included in this Technical Standard provides aircraft navigation performance equivalent to EASA AMC 20-4 and FAA AC 90-96A.
(b) Once aircraft eligibility has been established, operator approval will proceed, according to Section 6.9 of this Technical Standard.

Aircraft approval

(2) Part 91 aircraft approval

(a) PART 91 operators should revise the AFM or AFM supplement or TCDS or POH to assure that the aircraft navigation system is eligible to perform RNAV 5 operations, according to paragraph 5.3.1.2 (1) (a) of this Technical Standard.

(b) After having determined eligibility of the navigation system, PART 91 operators will present respective documents to the Authority.

(c) In case PART 91 operators are not able to determine, based on the AFM or AFM supplement or TCDS or POH, whether the Aircraft system has been installed and approved

according with an appropriate CA or AC or AMC, they will proceed according to paragraph 5.3.1.3 of this Technical Standard.

(3) Part 121 and Part 135 aircraft approval

(a) PART 121 and/or 135 operators will present sections of the AFM or AFM supplement or TCDS that details RNAV certification requirements in accordance with this Technical Standard:

(b) These operators will ensure that the aircraft navigation system will meet the functions required in paragraph 5.4.3 of this Technical Standard.

(c) In case a Part 121 or 135 operator is not able to determine, based on the AFM or AFM supplement or TCDS, whether the system has been installed and approved according to an appropriate regulatory requirements or standards, it will proceed in accordance with to the steps established in the following paragraph.

5.3.1.3 Eligibility not based on AFM or TCDS or AFM Supplement or POH – RNAV 5 capacity reached during service.

(1) Determination of the aircraft eligibility through evaluation of its navigation equipment.

(a) The operator makes a request for assessment of aircraft RNAV equipment for eligibility to the airworthiness section or equivalent Authority entity. The operator, together with the request, will provide the following:

(i) RNAV system make, model and part number;

(ii) evidence that the equipment meets lateral and longitudinal navigation accuracy on route of + 5 NM or better during 95% of the total flight time. This can be determined through the evaluation of system design. Evidence of meeting the requirements of another AP can be used for this purpose.

(iii) proof that the system meets the required functions for RNAV 5 operations described in paragraph 5.4.3 of this Technical Standard.

(iv) crew operating procedures and bulletins; and

(v) any other pertinent information required by the Authority.

(2) in case the airworthiness inspection Direction or Authority equivalent entity is not able to determine RNAV equipment eligibility, evaluation request together with supporting documents will be forward to the aircraft certification Direction or equivalent entity from the State of registry. In any case, aircraft certification Division or equivalent will inform to airworthiness inspection Direction or Authority equivalent entity about the eligibility of the proposed equipment to perform RNAV 5 operations.

(3) PART 91 Operators.- Once the Authority has determined the aircraft equipment is eligible for RNAV 5 operations, the airworthiness inspection Direction or Authority equivalent entity will issue a letter of finding documenting that the aircraft RNAV equipment is eligible to perform those operations.

(4) PART 121 or 135 Operators.- The Authority will verify aircraft RNAV system eligibility including the required functions in Section 5.4.3 of this Technical Standard.

5.3.2 Limitations on the design and/or use of navigation systems.

Although the following navigation systems offer RNAV capability, these present limitations for their use in RNAV 5 operations.

5.3.2.1 Inertial navigation systems/Inertial reference systems (INS/IRS)

Inertial systems may be used either as a stand-alone inertial navigation system (INS) or as an inertial reference (IRS) acting as part of a multi-sensor RNAV system where inertial sensors provides augmentation to the basic position sensors as well as a reversionary position data source when out of cover of radio navigation sources. .

INS without a function for automatic radio updating of aircraft position and approved in accordance with FAA AC 25-4, when complying with the functional criteria of this Technical Standard, may be used only for a maximum of two (2) hours from the last alignment/position update performed on ground. Consideration may be given to specific INS configurations (e.g. triple mix) where either equipment or aircraft manufacturer's data justifies extended use from the last position update.

INS without automatic radio updating of aircraft position, including those systems where manual selection of radio channels is performed in accordance with flight crew procedures, must be approved in accordance with FAA AC 90-45A or AC 20-130A or equivalent document.

5.3.2.2 VHF omnidirectional radio range (VOR)

VOR accuracy can typically meet accuracy requirements for RNAV 5 up to 60 NM from the navigation aid and Doppler VOR up to 75 NM. Specific regions within the VOR coverage may experience larger due to propagation effect (e.g. multipath). Where such errors exist this can be accommodated by prescribing areas where the affected VOR may not be used.

5.3.2.3 Distance measuring equipment (DME)

DME signals are considered sufficient to meet requirements of RNAV 5 wherever the signals are received and there is no closer DME on the same channel, regardless of the published coverage volume.

Where the RNAV 5 system does not take account of published "Designated operational coverage" of the DME, the RNAV system must execute data integrity checks to confirm that the correct DME signal is being received. . .

5.3.2.4 Global navigation satellite system (GNSS)

5.3.2.4.1 Global positioning system (GPS)

The use of GPS to perform RNAV 5 operations is limited to equipment approved in accordance with the TSO-C 129(), TSO-C-145() and TSO-C-146() from FAA or ETSO-129(), ETSO-145() and ETSO-146() from EASA or equivalent documents which include the minimum systems functions specified in Section 6.4.3 of this Technical Standard.

The integrity of GPS system must be provided by the receiver autonomous integrity monitoring (RAIM) or an equivalent means within a multi-sensor navigation system. The equipment must be approved in accordance with the AMC 20-5 or equivalent document. In addition, stand-alone GPS equipment must include the following functions according to the TSO-C 129a or ETSO-129a criteria:

(1) Pseudo-range step detection; and

(2) Health word checking

Compliance with these two requirements can be determined the following way:

(1) a statement in the AFM or POH indicating the GPS equipment meets the criteria for primary means of navigation in oceanic and remote airspace; or

(2) a placard on the GPS receiver certifying it meets TSO-C 129 (), TSO-C-145 () and TSO-C-146 () from FAA or ETSO-129 (), ESTO-145 () and ESTO-146 () from EASA; or

(3) a letter of design approval for the applicable equipment. Operators must contact the avionic equipment's manufacturer to determine if the equipment complies with these requirements and ask if a letter of design approval is available. Manufacturers may obtain this letter by submitting appropriate documentation to the certifications offices of the States of aircraft design or manufacturer. Operators must keep the letter of design approval within the AFM or POH as evidence of the RNAV 5 eligibility. Any limitations included in the letter of design approval must be reflected in a letter of approval to PART 91 operators or in the operations specifications (OpSpecs) for PART 121 and/or 135 operators.

Traditional navigation equipment (e.g., VOR, DME or automatic direction finder (ADF)) must be installed and operative, so as to provide an alternative navigation means of navigation in the event of loss of GPS.

5.3.2.4.2 Stand-alone GPS equipment

Stand-alone GPS equipment approved in accordance with guidance provided in this Technical Standard may be used in RNAV 5 operations, subject to the limitations included in this document.

Such equipment must be operated in accordance with procedures acceptable to the Authority. The flight crew must receive appropriate training for use the stand-alone GPS equipment regarding normal and contingency procedures detailed in the Section 6.6 of this Technical Standard.

5.4 RNAV-5 system requirements

5.4.1 Accuracy

The navigation performance of aircraft approved for RNAV 5 requires a track keeping accuracy equal to or better than + 5 NM during the 95% of the flight time. This value includes signal source error, airborne receiver error, display system error and flight technical error (FTE). This navigation

performance assumes the necessary coverage provided by satellite or ground based navigation aids is available for the intended route to be flown.

5.4.2 Availability and Integrity

The minimum level of availability and integrity required for RNAV 5 systems can be met by a single installed system comprising by:

(1) One sensor or a combination of the following sensors: VOR/DME, DME/DME, INS or IRS and GNSS or GPS;

(2) RNAV computer;

(3) Control display unit (CDU); and

(4) Navigation display(s) (e.g. navigation display (ND), horizontal situation indicator (HSI) or course indicator deviation (CDI) provided that the system is monitored by the flight crew and that in the event of a system failure the aircraft retains the capability to navigate relative to ground based navigation aids (e.g. VOR, DME or Non-directional beacon (NDB)).

Note*:* RNAV 5 operations in Namibia require use of GNSS

5.4.3 Functional requirements

5.4.3.1 Required Functions.

The following system functions are the minimum required to conduct RNAV 5 operations:

(1) Continuous indication of the aircraft position relative to track to be displayed to the pilot flying (PF) on a navigation display situated in his primary field of view;

(2) In addition, where the minimum flight crew is two pilots, indication of the aircraft position relative to track to be displayed to the pilot not flying (PNF) on a navigation display situated in his primary field of view;

(3) Display of distance and bearing to the active (To) waypoint;

(4) Display of ground speed or time to active (To) waypoint;

(5) Storage of a minimum of 4 waypoints; and

(6) Appropriate failure indication of the RNAV system, including the sensors failure.

5.4.4 RNAV 5 navigation displays

Navigation data must be available for display either on a display forming part of the RNAV equipment or on a lateral deviation display (e.g. CDI, (E)HSI, or a navigation map display). These displays must be used as primary flight instruments for the navigation of the aircraft, for manoeuver anticipation and for failure/status/integrity indication. They should meet the following requirements:

(1) The displays must be visible to the pilot when looking forward along the flight path.

(2) The lateral deviation display scaling must be compatible with any alerting and annunciation limits, where implemented.

(3) The lateral deviation display must have a scaling and full-scale deflection suitable for the RNAV 5 operation.

5.4.5 Continued airworthiness

The operators of aircraft approved to perform RNAV 5 operations, must ensure the continuity of the technical capacity of them, in order to meet technical requirements established in this Technical Standard.

Each operator who applies for RNAV-5 operational approval shall submit to the Authority of State of registry, a maintenance and inspection programme that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the RNAV 5 approval criteria.

(1) The following maintenance documents must be revised, as appropriate, to incorporate RNAV 5 aspects:

(a) Maintenance control manual (MCM);

(b) Illustrated parts catalogues (IPC); and

(c) Maintenance programme.

The approved maintenance programme for the affected aircrafts should include maintenance practices listed in maintenance manuals of the aircraft manufacturer and its components, and must consider:

(i) that equipment involved in the RNAV 5 operation should be maintained according to directions given by manufacturer's components;

(ii) that any amendment or change of navigation system affecting in any way RNAV 5 initial approval, must be forwarded and reviewed by the Authority for its acceptance or approval of such changes prior to its implementation; and

(iii) that any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, should be forwarded to the Authority for acceptance or approval thereof.

(2) Within the RNAV maintenance documentation should be presented the training programme of maintenance personnel, which inter alia, should include:

(a) PBN concept;

(b) RNAV 5 application;

(c) Equipment involved in a RNAV 5 operation; and

(d) MEL use.

5.5 Operational Approval

5.5.1 Requirements to obtain the operational approval.

To obtain the operational approval, the operator will comply with the following steps considering the operational procedures established in Section 6.6 of this Technical Standard.

5.5.1.1 Airworthiness approval.

The aircraft must have the corresponding airworthiness approvals as mentioned in Section 5.3 of this Technical Standard.

5.5.1.2 Documentation.

The operator will present to the Authority the following documents:

(1) The application to obtain RNAV 5 approval;

(2) Amendments to the operations manual (OM) which must include operations procedures according to what is described in this Technical Standard, for crews and dispatchers, if applicable;

(3) Amendments, when applicable, of maintenance manuals and programmes which must have the maintenance procedures for the new equipment, as well as the training of the maintenance associated personnel, in accordance with Paragraph 5.5.1.3;

(4) A copy of the AFM parts, or AFM supplement or TCDS or POH, to verify the airworthiness approval for RNAV 5 for each affected aircraft;

(5) The amendments to the Minimum Equipment List (MEL), which must identify the minimum necessary equipment to comply with RNAV 5; and

(6) Training programmes or amendments to the operator's training programme for crews and flight dispatchers, if applicable, according to what is described in Section 6.7 of this Technical Standard.

5.5.1.3 Training.

Once the amendments to manuals, programmes and documents have been accepted or approved, the operator must provide required training to its personnel.

5.5.1.4 Validation flights.

The Authority may, for the purposes of evaluation, require the performance of a validation flight in a flight simulator or in an aircraft where the Executive Director has determined that such evaluation is necessary in the interest of safety.

5.5.1.5 Approval issuance to perform RNAV 5 operations.

Once the operator has successfully completed the operational approval process, the Authority issues the operator, when applicable, with the corresponding approval to perform RNAV 5 operations.

(1) PART 91 and Part 93 operators. For PART 91 and Part 93 operators, the Authority issues a letter of approval (LOA).

(2) PART 121, 127 and/or 135 operators. For PART 121, 127 and/or PART 135 operators, the Authority issues the corresponding Op-Specs, which will show RNAV 5 approval.

5.6 Operational procedures

5.6.1 Flight planning.

Before operating on an RNAV 5 route, the operator will establish procedures to ensure that:

(1) The aircraft has a valid RNAV 5 approval;

(2) The necessary equipment to operate RNAV 5 is installed, functions correctly and is not operationally degraded;

(3) Navigation aids based on space or ground are available;

(4) The crews routinely check the contingency procedures.

5.6.2 Stand-alone GPS equipment.

During the planning phase the following procedures must be accomplished with regard to the stand-alone GPS equipment.

An aircraft can depart without further action in the following cases, when:

(1) All satellites are scheduled to be in service; or

(2) One satellite is scheduled to be out of service in case of GPS equipment that includes barometrical altitude.

The availability of GPS integrity RAIM must be confirmed for the intended flight (route and time) through the use of a prediction programme either ground-based or incorporated in the on-board system, following the criteria established in Section xxx of this Technical Standard, when:

(1) Any satellite is scheduled to be out of service; or

(2) More than one satellite is scheduled to be out of service in case of GPS equipment that includes barometric altitude.

This prediction is required for any route and route segment RNAV 5 based upon the use of GPS.

The specified route of flight, including trajectory to any alternative aerodrome will be defined by a series of waypoints and by the estimated time of pass over them for a speed or series of speed, which at the same time will be in function of the intensity and previous wind direction.

Taking into consideration that during the flight deviations from a specified ground speed may occur and that a rapid prediction of route times may as a result become necessary based on different speeds within a predictable margin for such speeds.

A prediction programme must be executed with a maximum anticipation of two hours prior to the flight departure. The operator must confirm that data concerning the state of the constellation and GPS ephemeris, have been updated with the latest information distributed by notice to airmen (NOTAM).

In order to achieve an exact prediction, the programme must allow manual de-selection of satellites which are considered to be non-operative, as well as selection of satellites expected to achieve a back to service condition during the flight time.

The operator may not dispatch or release a flight in case of continuous prediction loss of RAIM higher than 5 minutes to any part of the previewed route. In this event, the flight must be delayed, cancelled or re-routed in which RAIM requirements may be accomplished.

5.6.3 Preview flight procedures at the aircraft.

The crew must perform on the aircraft the following procedures preview to the flight:

(1) Check registrations and forms to be sure that maintenance actions have been taken in order to correct defects in the equipment; and

(2) Check data base validation (current AIRAC cycle), if it is installed.

5.6.4 Route corresponds to that authorised.

Flight crew must perform the following procedures review prior to the flight:

(1) Check registrations and forms to be sure that maintenance actions have been taken in order to correct defects in the equipment;

(2) Check data base validation (current AIRAC cycle), if it is installed;

(3) Cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, taking into account the WPT name, sequencing, heading and distance to the next WPT and the total distance, if applicable; and

(4) If required (NOTAM, AIP, navigation charts or other resource), the exclusion of specific navigation aids must be confirmed, so as to avoid their inclusion in the position calculation by the navigation system of the aircraft.

5.6.5 Enroute operations.

The crew must assure the aircraft correct functioning of its navigation system during its operation on an RNAV 5 route, confirming that:

(1) Necessary RNAV 5 equipment has not degraded during flight;

(2) The route corresponds to that authorisation;

(3) Aircraft navigation accuracy is pertinent for RNAV 5, assuring this through pertinent cross checks;

(4) Other navigation aids (for example VOR, DME, ADF) must be selected in a way to permit a cross check or immediate reversion in the event of a RNAV capacity loss;

(5) For RNAV 5, pilots must use a lateral deviation indicator, flight director or autopilot in lateral navigation mode. Pilots may use a navigation map display as described in Paragraph 5.4.4,

without a flight director or autopilot. Pilots of aircraft with a lateral deviation display must ensure that lateral deviation scaling is suitable for the navigation accuracy associated with the route/procedure (e.g. full-scale deflection: ± 5 NM);

(6) All pilots are expected to maintain route centrelines, as depicted by on-board lateral deviation indicators and/or flight guidance, during all RNAV 5 operations, unless authorised to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the RNAV system-computed path and the aircraft estimated position relative to that path, FTE) must be limited to ± ½ the navigation accuracy associated with the procedure or route (2.5 NM). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after procedure/route turns, up to a maximum of one-times the navigation accuracy (5 NM), are allowable; and

(7) If ATS issues a heading assignment taking the aircraft off a route, the pilot may not modify the flight plan in the RNAV system until a clearance is received to re-join the route or the controller confirms a new clearance. When the aircraft is not on the published route, the specified accuracy requirement does not apply.

Note: Some aircraft do not display or compute a path during turns; pilots of these aircraft may not be able to adhere to the ±½ accuracy standard during route turns, but are still expected to satisfy the standard during intercepts of the final track following the turn and on straight segments.

5.6.6 Contingency procedures.

5.6.6.1 General Provisions

Flight crews must familiarize themselves with the following general provisions:

(1) An aircraft must not enter or continue the operations in airspace designated as RNAV 5, according to the present ATC authorization. If because of a failure or degradation the navigation systems falls under RNAV 5 requirements, the pilot must obtain as soon as possible an amended authorisation;

(2) According to ATC instructions, operations will continue with regard to the present ATC authorisation, or when not possible, a revised authorisation must be requested to return to the VOR/DME conventional navigation;

(3) In the event of communications failure, the flight crew must continue with the flight plan, in accordance with the published lost communication procedures; and

(4) In any case, the crew must follow contingency procedures established for every operation region, and obtain an ATC authorisation as soon as possible.

5.6.6.2 Stand-alone GPS equipment.

The operating procedures must identify the flight crew actions required in the event of RAIM function loss or exceedance of integrity alarm limit (erroneous position). The procedures must include:

(1) In case of loss of the RAIM detection function, the flight crew may continue navigating with the GPS equipment. The flight crew must attempt to cross-check the aircraft position with the information provided for the ICAO conventional navaids: VOR, DME and ADF, in order to confirm the existence of a required level of precision. In other cases, the crew must revert to an alternative means of navigation;

(2) In the event of an observed failure (including the failure of a satellite impacting the performance of navigation systems based on GPS), the flight crew must revert to an alternative means of navigation; and

(3) In case of exceedance of the alarm limit, the flight crew must revert to an alternative means of navigation.

5.6.6.3 On-board equipment availability VOR, DME or ADF.

The operator must have installed on the aircraft VOR, DME or ADF on-board equipment capacity according to the applied rules of operation under PART 91, 121 and 135. This capacity must be available along the intended route of flight to assure the availability of navigation alternative means in case of a GPS/RNAV system failure.

Any incidence registered in flight must be notified to the Authority in a maximum time of seventy two hours, unless there is justified cause.

5.6.6.4 Navigation error reports follow up process.

The operator must establish a process to receive, analyse and follow up on navigation error reports which allow the operator to determine the appropriate corrective action.

Repetitive navigation error occurrences, attributed to a specific part of the navigation equipment must be analysed in order to isolate the cause and apply corrective action.

The nature and severity of the error may result in temporary withdrawal of the authorisation to use the navigation equipment until the cause of the problem has been identified and rectified.

Any incidents registered in flight must be notified to the Authority within a period of seventy two hours unless there is justified cause for a longer period.

5.7 Training programme

5.7.1 General Provisions

The training programmes for flight crews and flight dispatchers must be reviewed and approved by the Authority.

The operator must include at least the following modules:

(1) Required equipment, capacities, limitations and operation of the equipment in RNAV 5 airspace;

(2) The routes and airspace for which the RNAV system is approved to operate;

(3) The NAVAID limitations in respect of the operation of the RNAV system to be used for the RNAV 5 operation;

(4) Contingency procedures for RNAV failures;

(5) The Radio/Telephony Phraseology for the airspace in accordance to Doc 4444 and Doc 7030 as appropriate;

(6) The flight planning requirements for the RNAV operation;

(7) RNAV requirements as determined from chart depiction and textual description;

(8) RNAV 5 en-route procedures;

(9) Methods to reduce navigation errors through dead-reckoning techniques;

(10) RNAV system-specific information, including:

(a) Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation.

(b) Functional integration with other aircraft systems.

(c) Monitoring procedures for each phase of flight (for example, monitor PROG or LEGS page).

(d) Types of navigation sensors (for example, DME, IRU, GNSS) utilized by the RNAV system and associated system prioritization/weighting/logic.

(e) Turn anticipation with consideration to speed and altitude effects.

(f) Interpretation of electronic displays and symbols.

(g) RNAV equipment operating procedures, as applicable, including how to perform the following actions:

(h) Verify currency of aircraft navigation data.

(i) Verify successful completion of RNAV system self-tests.

(j) Initialize RNAV system position.

(k) Fly direct to a waypoint.

(l) Intercept a course/track.

(m) Be vectored off and re-join a procedure.

(n) Determine cross-track error/deviation.

(o) Remove and reselect navigation sensor input.

(p) When required, confirm exclusion of a specific navigation aid or navigation aid type.

(q) Perform gross navigation error checks using conventional navigation aids.

5.7.2 Training programme on the GNSS as a primary means of navigation.

Besides the training modules describe on the previous paragraphs, operators' training programmes which use RNAV systems based on GNSS as a primary navigation means will include modules described in Section 6.10.

5.8 Navigation database

Where a navigation database is carried and used, it must be current and appropriate for the region of intended operation and must include the navigation aids and waypoints required for the route.

Note: Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots must have access to established procedures for ensuring the accuracy of the navigation data, including the suitability of navigation facilities used to define the routes for the flight. Traditionally, this has been accomplished by verifying electronic data against paper products.

5.9 Receiver Autonomous Integrity Monitoring (RAIM) prediction programme

Where a receiver autonomous integrity monitoring (RAIM) prediction programme is used as a means of compliance with the provisions of this document, it must meet the following criteria:

(1) The programme must provide prediction of availability of the integrity monitoring (RAIM) function of the GNSS equipment, suitable for conducting RNAV 5 operations.

(2) The prediction programme software must be developed in accordance with at least RTCA DO 178B/EUROCAE 12B as amended, Level D guidelines.

(3) The programme must use either a RAIM algorithm identical to that used in the airborne equipment or an algorithm based on assumptions for RAIM prediction that give a more conservative result.

(4) The programme must calculate RAIM availability based on a satellite mask angle of not less than 5 degrees, except where use of a lower mask angle has been demonstrated and deemed to be acceptable to the Authority.

(5) The programme must have the capability to manually exclude GPS satellites which have been notified as being out of service for the intended flight.

(6) The programme must allow the user to select:

(a) the intended route and declared alternates; and

(b) the time and duration of the intended flight.

5.10 Training programme on the GNSS as a primary means of navigation

The training programmes for flight crews that use RNAV 5 systems based on the GNSS as a primary means of navigation must include a segment with the following training modules:

5.10.1 GNSS system components and operating principles.

5.10.1.1 Understanding of the GNSS system and its operating principles:

(1) GPS system components: control segment, user segment, and space segment;

(2) on-board equipment requirements;

(3) GPS satellite signals and pseudo-random code;

(4) positioning principle;

(5) receiver clock error;

(6) masking function;

(7) performance limitations of the different types of equipment;

(8) WGS84 coordinate system;

5.10.1.2 Navigation system performance requirements.

Define the following terms in relation to the navigation system and evaluate the degree of compliance by the GPS system of the requirements associated with the following terms:

(1) accuracy;

(2) integrity;

(3) availability;

(4) continuity;

(5) means to improve GNSS integrity;

(6) RAIM; and

(7) fault detection and exclusion (FDE)

5.10.1.3 Authorisations and documentation.

Requirements applicable to pilots and navigation equipment for GPS operation:

(1) pilot training requirements;

(2) aircraft equipment requirements;

(3) AFM system certification criteria and limitations;

(4) GNSS-related NOTAMs.

5.10.1.4 GPS system errors and limitations.

Cause and magnitude of typical GPS errors:

(1) ephemeris;

(2) clock;

(3) receiver;

(4) atmospheric/ionospheric;

(5) multi-reflection;

(6) selective availability (SA);

(7) total typical error associated to the C/A code;

(8) effect of the dilution of precision (DOP) on the position;

(9) susceptibility to interference;

(10) comparison of vertical and horizontal errors; and

(11) path-tracking precision. Collision avoidance.

5.10.1.5 Human factors and GNSS

Limitations on the use of GPS equipment due to human factors.

Operating procedures that offer protection against navigation errors and loss of awareness of the real situation due to the following causes:

(1) mode errors;

(2) data entry errors;

(3) data checks and validation, including independent cross-checking procedures;

(4) automation-induced relaxation;

(5) lack of standardization of GPS equipment;

(6) information processing by humans and situational awareness.

5.10.1.6 GNSS equipment – Specific navigation procedures.

Knowledge of the appropriate operating procedures for GPS in the typical navigation tasks for each specific type of equipment in each type of aircraft that includes:

(1) selection of the appropriate operating mode;

(2) review of the different types of information contained in the navigation database;

(3) forecast of the availability of the RAIM function;

(4) procedure for entering and checking the waypoints defined by the user;

(5) procedure for entering, retrieving and checking flight plan data;

(6) interpretation of the typical information shown on the GPS navigation display: LAT/LONG, distance and heading to the waypoint, CDI;

(7) interception and maintenance of the GPS-defined routes;

(8) in-flight determination of ground speed (GS), estimated time of arrival (ETA), time and distance to the waypoint;

(9) indication of waypoints over flight;

(10) use of the "DIRECT TO" function;

(11) use of the "NEAREST AIRPORT" function;

(12) use of the GPS in GPS or DME/GPS arrival procedures.

5.10.1.7 Verification of GNSS equipment.

For each type of equipment in each aircraft, the following operational and start-up checks must be conducted at the appropriate time:

(1) constellation status;

(2) RAIM and FDE functional status;

(3) dilution of precision (DOP) status;

(4) currency of the instrument flight rules (IFR) database;

(5) receiver operating condition;

(6) CDI sensitivity;

(7) position indication.

5.10.1.8 GPS messages and warnings.

For each type of equipment in each aircraft, timely action must be recognised and taken in face of GPS messages and warnings, including the following:

(1) loss of RAIM function;

(2) 2D/3D navigation;

(3) dead-reckoning navigation mode;

(4) database not updated;

(5) loss of the database;

(6) GPS equipment failure;

(7) barometric data entry failure;

(8) power failure;

(9) prolonged parallel displacement; and

(10) satellite failure.

6. RNAV 1 and RNAV 2

6.1 General Considerations

The material described in this Technical Standard has been developed based on ICAO Doc 9613, Volume II, Part B, under the Chapter on Implementing RNAV 1 and RNAV 2. Where possible, this Technical Standard has been harmonised with the JAA TGL 10 and the FAA AC 90-100A.

Current systems that comply with the two documents (TGL-10 and AC 90-100A), automatically comply with the RNAV 1 and RNAV 2 requirements set forth in this Technical Standard.

An operational approval issued by the Authority meeting the requirements in this AP allows an operator to conduct RNAV 1 and RNAV 2 operations worldwide.

The RNAV 1 and RNAV 2 navigation specification applies to:

(1) All ATS routes, including those established in the en-route domain;
(2) Standard instrument departures and arrivals (SID/STAR); and
(3) Instrument approach procedures up to the final approach fix (FAF)/final approach point (FAP).

The final approach criteria, from the FAF to the runway threshold, along with the associated missed approach manoeuvre are covered under a different navigation specification.

The RNAV 1 and RNAV 2 navigation specification was mainly developed for RNAV operations in radar environments (SIDs are expected to have radar coverage prior to the first RNAV course change); however, these operations can be used in a non-radar environment or below the minimum vectoring altitude (MVA), if the Authority that implement these operations can ensure an appropriate safety system and justifies the lack of performance monitoring and alerting.

Since barometric vertical navigation (baro-VNAV) is not a requirement for RNAV 1 and RNAV 2 operations, this Technical Standard does not establish approval criteria for baro-VNAV systems. RNAV 1 and RNAV 2 operations are based on normal descent profiles and identify minimum altitude requirements in the segments.

Note 1: Pilots operating aircraft with a baro-VNAV system can continue using this system in routes, SIDs, STARs, and approaches to the FAF. Operators will guarantee compliance with all of the limitations published in the procedure, using the barometric altimeter as reference.

Note 2: Use of the aircraft barometric vertical navigation capability will be subject to the level of familiarisation and training of the flight crew, and on any other operational approval requirement.

Although operational approval is normally related to airspace requirements, operators and flight crews shall take into consideration the operational documents required by the Authority before conducting flights in RNAV 1 and RNAV 2 airspace.

6.1.1 Navigation aid infrastructure

This Technical Standard defines the criteria for the following RNAV systems:

(1) GNSS;
(2) DME/DME; and
(3) DME/DME/IRU.

Note: Due to the lack of suitable ground-based navigational aids, PBN operations in Namibia are limited to the use of GNSS.

Route design shall take into account the navigation performance that can be achieved with the navigation aid (NAVAID) infrastructure available. Although the requirements for RNAV 1 and RNAV 2 systems are identical, the NAVAID infrastructure can affect the required performance.

When DME is used as the only navigation service for updating position, gaps in DME coverage may prevent such update. With the inclusion of IRUs in the aircraft navigation system, an adequate level of performance can be maintained through all such gaps.

Note: Based on IRU performance assessment, it is expected that the increase in the position error will be less than 2NM for 15 minutes, after reverting to this system.

When there is no IRU on board the aircraft, the aircraft may revert to dead reckoning navigation. In such cases, additional protection is required according to ICAO Doc 8168, Volume II (PANS-OPS) in order to compensate for the increased error.

According to the ICAO global air navigation plan for communications, navigation, and surveillance/air traffic management (CNS/ATM) systems (Doc 9750), the use of GNSS should be authorised whenever possible and the limitations on the use of specific system elements should be avoided.

Note: Most modern RNAV systems give priority to GNSS input and then DME/DME positioning. Although VOR/DME positioning is usually performed in the flight management computer (FMC) when there is no DME/DME positioning criteria, avionics and infrastructure variability pose serious challenges to standardisation and harmonisation.

Therefore, this document only deals with GNSS, DME/DME, and DME/DME/IRU systems. This does not prevent the conduction of operations with systems that use VHF omni-directional radio range (VOR), provided they meet the criteria set forth in this Technical Standard.

It is considered that DME signals meet signal-in-space precision tolerances when these signals are received, regardless of the published coverage volume.

Field strength below the minimum requirement or where co-channel or adjacent channel interference may exist, are considered receiver errors. ANSPs must identify such NAVAID errors and publish them as not appropriate for RNAV 1 and RNAV 2 applications (so that they can be inhibited by the flight crew) or, not authorise the use of DME/DME or DME/DME/IRU systems. When significant performance differences are identified in a published DME facility, RNAV 1 and RNAV 2 operations in the airspace affected by such facility must be limited to GNSS.

During RNAV operations based on the inertial reference system (IRS), some aircraft navigation systems revert to VOR/DME–based navigation before reverting to IRS autonomous navigation (inertial coasting). ANSPs must assess the impact of VOR radial precision when the VOR is within 40 NM of the route/procedure and when the DME/DME navigation infrastructure is not enough to ensure that aircraft position accuracy will not be affected.

Operators and PICs of aircraft equipped with GNSS and, where applicable, with satellite-based augmentation system (SBAS), must ensure they have access to a means of predicting the availability of fault detection using the aircraft-based augmentation system (ABAS e.g., RAIM).

Outages must be identified in case of a predicted, continuous loss of ABAS fault detection of more than 5 minutes for any part of the RNAV 1 and RNAV 2 operations. If the prediction system is temporarily unavailable, ANSPs may still allow RNAV 1 and RNAV 2 operations to be conducted, taking into account the operational repercussions of such interruptions on the aircraft or the potential risk associated with an undetected satellite failure when fault detection is not available.

Note 1: Database suppliers may exclude specific DME facilities when the RNAV routes are within the reception range of these facilities, which could have a deleterious effect on the navigation solution.

Note 2: When temporary restrictions occur, the publication of restrictions on the use of DME must be accomplished by use of a notice to airmen (NOTAM) to identify the need to exclude the DME.

6.1.2 ATS communications and surveillance

When radar is used to assist in contingency procedures, its performance must be adequate for this purpose, e.g., radar coverage, precision, continuity, and availability must be adequate to ensure separation in the RNAV 1 and RNAV 2 ATS route structure, and provide contingency in case several aircraft are not capable of achieving the navigation performance established in the RNAV 1 and RNAV 2 navigation specification.

6.1.3 Obstacle clearance and route spacing

Doc 8168 (PANS OPS), Volume II, provides detailed guidance about obstacle clearance. The general criteria contained in Parts I and III of said document, applies.

The ANSP may prescribe either an RNAV 1 route or an RNAV 2 route. En-route spacing for RNAV 1 and RNAV 2 depends on route configuration, air traffic density, and intervention capability.

Until specific standards and air traffic management (ATM) procedures are developed, RNAV 1 and RNAV 2 applications may be implemented based on ATS surveillance radar.

6.1.4 Publications

The AIP should clearly indicate whether the navigation application is RNAV 1 or RNAV 2.

RNAV 1 and RNAV 2 routes, SIDs, and STARs must be based on the normal descent profiles and identify the minimum altitude requirements of the segments.

The available navigation infrastructure must be clearly designated on all appropriate charts (e.g., GNSS, DME/DME or DME/DME/IRU).

The navigation standard (e.g., RNAV 1 or RNAV 2) required for all RNAV procedures and routes must be clearly designated in all of the appropriate charts.

Any DME facility critical to RNAV 1 and RNAV 2 operations must be identified in the relevant publications.

All routes must be based on the coordinates of the World Geodetic System - 84 (WGS-84).

6.1.5 Additional considerations

For procedure design and infrastructure assessment, it is assumed that 95% of the normal limit values of the FTE, defined in the operating procedures, are:

(1) RNAV 1: 0.5 NM.
(2) RNAV 2: 1 NM

Many aircraft have the capability of flying parallel paths displaced to the left or to the right of the original active route. The purpose of this function is to allow lateral movements for tactical operations authorised by air traffic control (ATC).

Likewise, many aircraft have the capability to perform a holding pattern manoeuvre using their RNAV systems. The purpose of this function is to give ATC flexibility for the designation of RNAV operations.

6.2 Airworthiness and Operational Approval

6.2.1 Commercial Transport Operators

For a commercial air transport operator to be granted an RNAV 1 and RNAV 2 approval, it must comply with two types of approvals:

(1) The airworthiness approval, which is issued by the State of registry ; and
(2) The operational approval, which is issued by the State of the operator

6.2.2 General Aviation Operators

For general aviation operators, the State of registry determines whether or not the aircraft meets the applicable RNAV 1 and RNAV 2 requirements and issues the operational approval (e.g., letter of authorisation – LOA).

Before filing the application, operators must review all aircraft qualification requirements. Compliance with airworthiness requirements or equipment installation alone does not constitute operational approval.

6.3 Airworthiness Approval

6.3.1 Aircraft requirements - description of the RNAV navigation system

6.3.1.1 Lateral navigation (LNAV)

In LNAV, the RNAV equipment allows the aircraft to fly in accordance with the appropriate route instructions along a path defined by waypoints (WPTs) contained in an on-board navigation database.

Note: LNAV is normally a mode of flight guidance systems, in which the RNAV equipment provides path steering commands to the flight guidance system, which controls the FTE through the manual pilot control on a path deviation display or through the coupling of the flight director (FD) or automatic pilot (AP).

For purposes of this Technical Standard, RNAV operations are based on the use of RNAV equipment that automatically determines the position of the aircraft on the horizontal plane, using data input from the following types of position sensors (not listed in a specific order of priority):

(1) GNSS in accordance with TSO-C145 (), TSO-C146 (), and TSO-C129 ()

(2) DME/DME RNAV equipment that meets the criteria listed in Section 6.3.5; and
(3) DME/DME/IRU RNAV equipment that meets the criteria listed in Paragraph 6.3.5.

Note: Position data from other types of navigation sensors may be combined with GNSS data, provided they do not cause position errors that exceed total system precision requirements. Use of GNSS equipment approved by TSO-C129 () is limited to those systems that include the minimum system functions specified in Section 6.3.8 of this Technical Standard.

6.3.2 System performance, monitoring and alerting

6.3.2.1 Accuracy

(1) RNAV 1.- For operations in RNAV 1 designated airspace or routes, total lateral system error must not exceed + 1 NM for at least 95% of the total flight time. Likewise, along-track error must not exceed + 1 NM for at least 95% of the total flight time.
(2) RNAV 2.- For operations in RNAV 2 designated airspace or routes, total lateral system error must not exceed + 2 NM for at least 95% of the total flight time. Likewise, along-track error must not exceed + 2 NM for at least 95% of the total flight time.

6.3.2.2 Integrity.

Malfunctioning of the aircraft navigation equipment is classified as a major failure according to airworthiness regulations (e.g., failures should be less than 10^{-5} per hour).

6.3.2.3 Continuity.

Loss of function is classified as a minor failure if the operator can revert to a different navigation system and proceed to an appropriate aerodrome.

6.3.2.4 Signal-in-space (SIS)

Note 1: RNAV 1.- If GNSS is used for operations in RNAV 1 designated airspace or routes, the aircraft navigation equipment must provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds 10-7 per hour

Note 2: RNAV 2.- If GNSS is used for operations in RNAV 2 designated airspace or routes, the aircraft navigation equipment must provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 4 NM exceeds 10-7 per hour

6.3.3 RNAV system eligibility

Aircraft with a statement of compliance with the criteria set forth in this Technical Standard or equivalent document in the AFM, the pilot operations handbook (POH), or avionics operating manual, meet the performance and functional requirements of this Technical Standard.

Aircraft approved under TGL-10 and AC 90-100A - Aircraft approved according to both documents (TGL-10 and AC 90-100A) meet the criteria set forth in this Technical Standard.

Aircraft that comply with TGL-10 - Operators approved according to TGL-10 must confirm whether or not their aircraft systems meet the requirements set forth in this Technical Standard.

Aircraft that comply with AC 90-100A - Aircraft that meet the criteria of AC 90-100A comply with this document.

Aircraft with a statement by the manufacturer - Aircraft that have a statement by the manufacturer documenting compliance with the criteria of this Technical Standard or equivalent document meet the performance and functional requirements set forth in this document. This statement must include the substantiation of airworthiness compliance. The operator must determine compliance with RNAV system requirements described in Section 6.3.5 and the functional requirements as described in Section 6.3.8 of this Technical Standard.

Note 1: The operators of aircraft having demonstrated RNP capability must announce to the Authority when the aircraft can no longer meet the performance requirements associated with the operations. However, for procedures based on DME/DME/IRU, the operator must determine whether or not it complies with the criteria set forth in Paragraph 8.3 (DME/DME and DME/DME/IRU).

Note 2: Aircraft equipped with a TSO-C129 GNSS sensor and a TSO-C115 FMS or C115a FMS might not meet the requirements set forth in this TS. The operator must then assess such equipment in accordance with the performance and functional requirements set forth in this document.

6.3.4 Aircraft flight manual, pilot operations handbook or avionics operating manual

6.3.4.1 Newly manufactured or modified aircraft.

For new (capability shown in production) or modified aircraft, the AFM, POH or avionics operating manual, whichever is applicable, shall provide a statement identifying the equipment and the certified construction or modification standard for RNAV 1 and RNAV 2 operations or that the aircraft has RNP 1 capability or better.

6.3.4.2 Aircraft in use.

For aircraft in use that are already equipped with RNAV systems but for which the AFM or POH or avionics operating manual does not define or clarify the system capability, the operator can submit documentation or a statement by the manufacturer that meets the requirements of this Technical Standard.

6.3.5 Criteria for the approval of RNAV 1 and RNAV 2 system for GNSS

The following systems meet the precision requirements of these criteria:

(1) Aircraft with TSO-C129/C129a sensor (Class B or C) and FMS that meets the criteria established in TSO-C115b, installed for IFR use in accordance with AC 20-130A;
(2) Aircraft with TSO-C145 () sensor and FMS that meets the criteria established in TSO-C115b, installed for IFR use in accordance with AC 20-130A or AC 20-138A;
(3) Aircraft with Class A1 TSO-C129/C129a (without deviation from the functional requirements described in Paragraph 8.4 of this document), installed for IFR use in accordance with AC 20-138 or AC 20-138A; and
(4) Aircraft with TSO-C146 () (without deviation from the functional requirements described in Paragraph 8.4 of this document), installed for IFR use in accordance with AC 20-138A.

For route and/or aircraft approvals that require GNSS, operators must develop procedures to check the correct operation of the GNSS when the navigation system does not automatically alert the crew about loss of such equipment.

The operator may integrate position information from other types of navigation sensors with the GNSS data, provided such information does not cause position errors that exceed the TSE budget; otherwise, means to cancel the selection of other types of navigation sensors must be provided.

The RAIM prediction programme shall meet all the criteria established in Paragraph 12 of AC-138A.

6.3.6 Criteria for the approval of RNAV 1 and RNAV 2 system for the RNAV DME/DME system

Note: This is applicable to operations in regions where navigational aids support DME/DME RNAV systems. Such operations are not available in Namibia.

6.3.6.1 Purpose

The Authority is responsible for assessing DME coverage and availability in accordance with the minimum standards of the DME/DME RNAV system for each route and procedure. Detailed criteria are needed to define DME/DME RNAV system performance, since that system is related to DME infrastructure. Section 6.3.7.2 describes the minimum DME/DME RNAV system performance and functions required to support the implementation of RNAV 1 and RNAV 2 routes, SIDs, and STARs. These criteria must be used for the airworthiness approval of new equipment or can be used by manufacturers for the certification of their existing equipment.

6.3.6.2 MINIMUM REQUIREMENTS FOR DME/DME RNAV SYSTEMS

Paragraph	Criteria	Explanation
a)	Accuracy is based on the	

Paragraph	Criteria	Explanation
	performance standards set forth in TSO-C66c	
b)	Tuning and updating position of DME facilities	The DME/DME RNAV system must: 1) Update its position within 30 seconds of tuning on DME navigation facilities; 2) Auto-tune multiple DME facilities; and 3) Provide continuous DME/DME position updating. If a third DME facility or a second pair has been available for at least the previous 30 seconds, there must be no interruption in DME/DME positioning when the RNAV system switches between DME stations/pairs.
c)	Use of facilities contemplated in State AIPs	DME/DME RNAV systems must only use the DME facilities identified in the State AIPs. Systems must not use the facilities that States list in their AIPs as not appropriate for RNAV 1 and/or RNAV 2 operations, or facilities associated to an ILS or MLS that uses a range offset. This can be done through: 1) Excluding specific DME facilities which are known to have a deleterious effect on the navigation solution from the aircraft navigation database when RNAV routes are within the reception range of said DME facilities. 2) The use of an RNAV system that conducts reasonableness checks to detect errors in all of the DME facilities and excludes those facilities from the navigation position solution as appropriate (*e.g.*, preclude tuning on co-channel signal facilities when the DME facilities signal-in-space overlap).

d)	DME facilities relative angles	When it is necessary to generate a DME/DME position, the RNAV system must use, as a minimum, DMEs with a relative angle between 30° and 150°.
e)	Use of DMEs through the RNAV system	The RNAV system may use any valid (listed in the AIP) DME facility, regardless of its location. A valid DME facility: 1) Issues a precise signal that identifies the facility; 2) Meets the minimum signal intensity requirements; and 3) Is protected against interference from other DME signals, in accordance with co-channel and adjacent channel requirements. When needed to generate a DME/DME position, as a minimum, the RNAV system must use an available and valid low altitude and/or high altitude DME anywhere within the following region around the DME facility: 1) Greater than or equal to 3 NM from the facility; and 2) Less than 40° above the horizon when viewed from the DME facility and at a distance of 160 NM. **Note:** The use of a figure-of-merit (FOM) in approximating the designated operational coverage (DOC) of particular facilities is acceptable, provided precautions are taken to ensure that the FOM is coded in such a way that the aircraft can use the facility anywhere within the DOC. The use of DMEs associated with ILS or MLS is not required.
f)	No requirement to use VOR, NDB, LOC, IRU or AHRS	There is no requirement to use VOR, non-directional radio beacon (NDB), localiser (LOC), IRU or attitude and heading reference system (AHRS) during normal operation of the DME/DME RNAV system.

g)	Position estimation error (PEE)	When using a minimum of two DME facilities that meet the criteria contained in Paragraph e) above and any other valid facility that does not meet such criteria, the position estimation error during 95% of the time must be better than or equal to the following equation: $2\sigma_{DME/DME} \leq 2\frac{\sqrt{(\sigma^2_{1,air} + \sigma^2_{1,sis}) + (\sigma^2_{2,air} + \sigma^2_{2,sis})}}{\sin(\alpha)}$ where: σ_{sis} = 0.05 NM σ_{air} is MAX {(0.085 NM, (0.125% of the distance)} α = angle of inclusion (30° to 150°) **Note:** This performance requirement may be met by any navigation system that uses two DME facilities simultaneously, limits the DME inclusion angle between 30° and 150° and uses DME sensors that meet TSO-C66c precision requirements. If the RNAV system uses DME facilities outside of the published designated operational coverage, it can still be assumed that the DME signal-in-space error of valid facilities is σ_{gorund} = 0.05 NM.
h)	Preventing erroneous guidance from other facilities	The RNAV system must ensure that the use of facilities outside the service volume (where field intensity and common or adjacent interference requirements cannot be met) do not cause misguidance. This could be achieved by including reasonableness checks when initially tuning on a DME facility, or by excluding a DME facility when there is a co-channel DME within line-of-sight.
i)	Preventing erroneous VOR signals-in-space	The RNAV system may use a VOR. However, the RNAV system must make sure that an erroneous VOR signal-in-space does not affect the position error when the system is within DME/DME coverage. This can be achieved by monitoring the VOR signal with DME/DME to make sure that it does not mislead position results (*e.g.*, through reasonableness checks).
j)	Ensuring RNAV systems use	The RNAV system must use operational DME facilities. DME facilities listed in the NOTAMs as inoperative (for example, being tested or undergoing maintenance) could

	operational facilities	still reply to on-board interrogation. Consequently, inoperative facilities must not be used. An RNAV system can exclude inoperative DME facilities by verifying the identification code or inhibiting the use of facilities identified as inoperative.

k)	Operational mitigation	Operational mitigations, such as the monitoring by pilots of the sources to update the RNAV navigation system, or time scheduling, or the exclusion of multiple DME facilities, must be performed before any period of intensive workload or any critical flight phase. **Note:** The exclusion of individual facilities listed in the NOTAMS as out of service and/or the programming of a route/procedure defined as critical DME is acceptable when such mitigation does not require action by the pilot during a critical phase of the flight. Likewise, a programming requirement does not imply that the pilot must manually enter the DME facilities that are not in the navigation database.
l)	Reasonableness checks	Many RNAV systems perform reasonableness checks to verify the validity of DME measurements.- Reasonableness checks are very effective against database errors or erroneous system inputs (such as, inputs from co-channel DME facilities) and normally can be divided into two classes: 1) The ones the RNAV system uses after a new DME has been captured, where the system compares the aircraft's position before using the DME with the range of the aircraft to that DME; and 2) The ones the RNAV system continuously uses, based on redundant information (for example, additional DME signals or IRU information). General requirements Reasonableness checks are intended to prevent navigation aids from being used for navigation updating in areas where data can lead to errors in the radio position fix due to co-channel interference, multipath, and direct signal screening. Instead of using the service volume of NAVAIDs, the navigation system must provide checks that preclude the use of duplicate frequencies of the NAVAIDs within range, over-the-horizon NAVAIDs, and NAVAIDs with poor geometry.

		Assumptions.- Under certain conditions, reasonableness checks can be invalid. 1) A DME signal will not remain valid just because it was valid when captured. 2) *Additional DME signals might not be available.* The intent of this specification is to support operations where infrastructure is minimal (for example, when only two DMEs are available for en-route segments). *Use of stressing conditions to test the effectiveness of the verification*.- When a reasonableness check is used to meet any requirement of these criteria, the effectiveness of the check must be tested under extreme conditions. An example of this condition is when a DME signal, valid when captured, becomes distorted during the test, when there is only one supporting DME or two signals of equal strength.

6.3.6.3 Process to confirm the performance of RNAV systems that use DME

New systems may demonstrate compliance with these criteria as part of the airworthiness approval. For existing systems, operators must determine compliance with the equipment and aircraft criteria set forth in this Technical Standard based on the information provided by aircraft and equipment manufacturers. Manufacturers that have achieved compliance with the requirements of paragraph (6.3.6.2) above and of this paragraph must provide this information through a letter to their customers. Operators may use this approval as the basis for their operations.

Manufacturers will also be required by the Authority to provide a copy of the aforementioned letter in order to facilitate making this information available to all operators. Guidance is provided below for aircraft and FMS and DME manufacturers.

6.3.6.4 Aircraft manufacturers (type certificate (TC) holders that incorporate FMS and DME/DME positioning).

The manufacturer must review the available data on the integrated navigation system and must obtain additional data, as appropriate, to determine compliance with the criteria set forth in this Technical Standard. Manufacturers that have achieved compliance with these criteria must provide this information by letter to their customers. Manufacturers are also requested to provide a copy of this letter to the Authority in order to facilitate making this information available to all operators.

6.3.6.5 Equipment manufacturers (normally individual DME and/or FMS TSO holders) – DME sensor.

The only requirement in this paragraph that needs to be considered for a DME sensor is accuracy. DME sensors have been tested for a variety of performance requirements of TSO-C66 – Distance-measuring equipment (DME) that operates within the radio frequency range of 960-1215 megahertz and documents of the Radio Technical Commission for Aeronautics (RTCA).

TSO-C66 performance standards have evolved as follows:

(1) TSO-C66: (August 1960) RTCA/DO99.

(2) TSO-C66a: (September 1965) RTCA/DO151, accuracy requirement of a total error of 0.1 NM attributed to the ground facility, an accuracy of 0.5 NM for airborne equipment or 3% distance, whichever is greater, with a maximum of 3 NM.

(3) TSO-C66b: (November 1978) RTCA/DO151a, accuracy requirement of a total error of 0.1 NM attributed to the ground facility, an accuracy of 0.5 NM for airborne equipment or 1% of the distance, whichever is greater, with a maximum of 3 NM.

(4) TSO-C66c: (September 1985) RTCA/DO189, accuracy requirement as total error for the airborne equipment of 0.17 NM or 0.25% of distance, whichever is greater.

6.3.6.5.1 TSO-C66c required precision.

The accuracy required by TSO-C66c is adequate to support the criteria of this section of this Technical Standard, and DME equipment manufacturers under this TSO version do not need to further assess their equipment for RNAV 1 and RNAV 2 operations. DME sensor manufacturers may use the following process to establish a more precise performance than originally credited.

6.3.6.5.2 Determination of the precision achieved.

Rather than relying on the originally demonstrated performance, the applicant may choose to make a revision under the original TSO, TC data, or TC supplement to determine proven accuracy, and/or make any appropriate changes to qualification tests to determine the precision achieved.

Note: When conducting the precision analysis, the DME signal-in-space error may be assumed to be 0.1 NM 95% of the time. If accuracy is demonstrated on a test bench or under flight test conditions, the accuracy of the test bench equipment or ground facility must be considered.

6.3.6.5.3 Accomplishing new testing.

New tests must be conducted under the same conditions used to demonstrate compliance with the original TSO-C66 standard.

Manufacturers who have demonstrated a more precise DME performance must indicate the demonstrated accuracy in a letter to their customers. Manufacturers must also provide a copy of this letter to the Authority to facilitate making this information available to all operators.

6.3.6.6 Equipment manufacturers - multi-sensor systems.

The manufacturer must review the data on the integrated navigation system and obtain additional data, as appropriate, to comply with the criteria contained in of this Technical Standard.

Manufacturers that have achieved compliance with such criteria must provide this information in a letter to their customers, along with any operational limitation (for example, if the pilot must manually inhibit the use of facilities listed as unavailable in the NOTAM).

The certification of the manufacturer may limit compliance to specific DME systems, or may reference any DME to TSO-C66c requirements. Manufacturers must also provide a copy of the letter to the Authority.

6.3.6.6.1 FMS accuracy.

FMS accuracy depends on a number of factors, including latent effects, the selection of DME facilities, the method of combining information from multiple DMEs, and the effects of other sensors used for positioning.

For FMSs that use two or more DMEs at the same time and that limit the DME inclusion angle to between 30° and 150°, the precision requirement may be met if the DME sensors meet the precision requirements of TSO-C66c.

For FMSs that lack these characteristics, precision must be assessed under inadequate DME geometry scenarios and it becomes necessary to consider the demonstrated precision of the DME sensor. Inadequate geometry scenarios may include angles at the previously specified limits, with or without additional DME facilities available outside these conditions.

6.3.6.6.2 Identification of conditions.

The conditions that might prevent compliance with precision requirements and the means to avoid them must be identified.

6.3.7 Criteria for the approval of RNAV 1 and RNAV 2 system for the RNAV DME/DME/IRU system

Note: This sub-section is applicable to operations in regions where navigational aids support DME/DME/IRU RNAV systems. Such operations are not currently available in Namibia.

6.3.7.1 Purpose

This paragraph defines the minimum performance for the DME/DME/IRU (D/D/I) RNAV system.

6.3.7.2 MINIMUM REQUIREMENTS FOR DME/DME/IRU RNAV SYSTEMS (INERTIAL SYSTEM PERFORMANCE)

Paragraph	Criteria	Explanation
a)	Inertial system performance must meet the criteria set forth in Appendix G to Part 121 or equivalent.	
b)	Automatic position updating capability is required from the DME/DME solution.	**Note:** Operators/pilots must contact manufacturers to discern if any annunciation of inertial coasting is suppressed following loss of radio updating.
c)	Since some aircraft systems revert to VOR/DME-based navigation before reverting to inertial coasting, the impact of VOR radial accuracy when the VOR is greater than 40 NM from the aircraft, must not affect aircraft position accuracy.	A method to comply with this objective is to exclude from the RNAV system the VORs that are more than 40 NM away from the aircraft

6.3.8 Functional requirements – Navigation displays and functions

6.3.8.1 Purpose

The purpose of the requirements contained in this Technical Standard help to guarantee that the aircraft RNAV system performance complies with the design criteria of the procedure.

6.3.8.2 Functional requirements – navigation functions and displays

Paragraph	Functional requirements	Explanation
a)	Navigation data, including the to/from indication and a failure indicator, must be shown on a lateral deviation display [*e.g.*, a course deviation indicator (CDI), an enhanced horizontal situation indicator (E)HSI) and/or a navigation chart display]. These lateral deviation displays must be used as primary means of navigation of the aircraft, for manoeuvre anticipation, and for indication of failure/status/integrity. They must meet the following requirements:	Non-numeric lateral deviation displays (*e.g.*, CDI, (E)HSI), with to/from indication and failure warning, for use as primary means of navigation of the aircraft, manoeuvre anticipation, and indication of failure/status/integrity, with the following five attributes: 1) Displays will be visible to the pilot and will be located in the primary field of view (± 15 degrees from the normal line of sight of the pilot) when looking forward along the flight path; 2) The lateral deviation display scale must be consistent with all alerting and advisory limits, if implemented; 3) The lateral deviation display must also have a full-scale deflection suitable for the flight phase and must be based on the total system precision required; 4) The display scale may be automatically adjusted by default logic, or set to a value obtained from the navigation database. The full-scale deflection value must be known or must be available for display to the pilot, and must be consistent with the values for en-route, terminal, and approach operations; and 5) The lateral deviation display must be automatically slaved to the RNAV calculated path. The course selector of the lateral deviation display shall be automatically adjusted to the RNAV calculated path. **Note:** The normal functions of the stand-alone GNSS meet this requirement. As an alternate means, a navigation chart display must provide a function equivalent to a lateral deviation display, as described in Paragraph a) 1)

Paragraph	Functional requirements	Explanation
		from (a) to (e), with appropriate chart scales; which may be manually adjusted by the pilot. **Note:** A number of modern aircraft eligible for this specification uses a chart display as an acceptable means to meet the prescribed requirements.

Paragraph	Functional requirements	Explanation
b)	The following RNAV 1 and RNAV 2 system functions are required as a minimum:	1) The capability to continuously display to the pilot flying (PF), on the primary flight navigation instruments (primary navigation displays), the calculated desired RNAV path and the position of the aircraft relative to that path. For operations where the minimum flight crew is two pilots, means will be provided for the pilot not flying the aircraft (PNF) or pilot monitoring (PM) to check the desired path and the position of the aircraft relative to that path; 2) A navigation database containing current navigation data officially issued for civil aviation, which can be updated in accordance with the aeronautical information regulation and control (AIRAC) cycle and from which ATS routes can be retrieved and loaded into the RNAV system. The stored resolution of the data must be sufficient to achieve negligible path definition error (PDE). The database must be protected against flight crew modification of the stored data; 3) The means to display to the flight crew the period of validity of the navigation database; 4) The means to retrieve and display the data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the flight crew to verify the route to be flown; and 5) The capability to load on the RNAV system, from the navigation database, the complete RNAV segment of the SIDs or STARs to be flown. **Note:** Due to variability in RNAV systems, this document defines the RNAV segment from the first occurrence of a named WPT, track or course up to the last occurrence of a named WPT, track or course. Legs or segments prior to the first named WPT or after the last named WPT must not be loaded from the navigation database.

Paragraph	Functional requirements	Explanation
c)	The means to show the following items, either on the primary field of view of the pilots, or on a readily accessible page display [*e.g.*, on a multi-function control display unit (MCDU)]:	1) The active navigation sensor type; 2) The identification to the active (TO) waypoint; 3) The ground speed or time to the active (TO) waypoint; and 4) The distance and bearing to the active (TO) waypoint. **Note:** When the CDU/MCDU is used to support precision checks by the pilot, said CDU/MCDU must have the capability of displaying lateral deviation with a resolution of at least 0.1 NM.
d)	The capability to execute the "direct to" function.	
e)	The capability for automatic leg sequencing, displaying the sequence to the flight crew.	
f)	The capability of executing ATS routes retrieved from the on-board database, including the capability of performing fly-by and flyover turns.	
g)	The aircraft must have the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent: (i) Initial fix (IF); (ii) Course to a fix (CF); (iii) Direct to a fix (DF); and (iv) Track to a fix (TF).	Note 1.- Path terminators are defined in ARINC 424 specification, and their application is described in more detail in RTCA documents DO-236B and DO-201A and in EUROCAE ED-75B and ED-77 Note 2.- Numeric values for courses and tracks must be automatically loaded from the RNAV system database.

Paragraph	Functional requirements	Explanation
h)	The aircraft must have the capability to automatically execute leg transitions consistent with the following ARINC 424 path terminators: heading to an altitude (VA), heading to a manual termination (VM), and heading to an intercept (VI), or must be capable of being manually flown on a heading to intercept a course or to fly direct to another fix after reaching an altitude of a specified procedure.	
i)	The aircraft must have the capability to automatically execute leg transitions consistent with the following ARINC 424 path terminators: course to an altitude (CA) and course from a fix to a manual termination (FM), or the RNAV system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint.	

Paragraph	Functional requirements	Explanation
j)	The capability to load an RNAV ATS route from the database into the RNAV system by its name is a recommended function. However, if all or part of an RNAV route (not SID or STAR) is entered by manual entry of WPTs from the database, the paths between the manual entry of WPTs and the preceding or subsequent WPTs must be flown in the same way as a TF leg in terminal airspace.	
k)	The capability of showing an indication of RNAV system failure, including the associated sensors, in the primary field of view of the pilots.	
l)	For multi-sensor systems, the capability for automatic reversion to an alternate RNAV sensor if the primary RNAV sensor fails. This does not preclude the provision of a means for manual selection of the navigation source.	
m)	Database integrity	Navigation database suppliers must comply with RTCA DO-200/EUROCAE document ED 76 - Standards for processing aeronautical data. A Letter of acceptance (LOA) issued by the

Paragraph	Functional requirements	Explanation
		appropriate regulatory authority to each of the participants in the data chain shows compliance with this requirement. Discrepancies that invalidate a route must be reported to database providers, and the affected routes must be prohibited through a notice from the operator to its flight crews. Aircraft operators must consider the need to conduct periodic checks of the navigation databases in order to meet the requirements of the existing safety system.
n)	It is recommended that the RNAV systems provide lateral guidance so that aircraft remain within the lateral boundaries of the fly-by transition area.	

6.3.9 Continued airworthiness

The operators of aircraft approved to perform RNAV 1 and RNAV 2 operations, must ensure the continuity of the technical capacity of them, in order to meet technical requirements established in this Technical Standard.

Each operator who applies for RNAV 1 and RNAV 2 operational approval must submit to the Authority of State of registry, a maintenance and inspection programme that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the RNAV 1 and RNAV 2 approval criteria.

The following maintenance documents must be revised, as appropriate, to incorporate RNAV 1 and RNAV 2 aspects:

(1) Maintenance control manual (MCM);
(2) Illustrated parts catalogues (IPC); and
(3) Maintenance programme.

The approved maintenance programme for the affected aircraft should include maintenance practices listed in maintenance manuals of the aircraft manufacturer and its components, and must consider:

(1) That equipment involved in the RNAV 1 and RNAV 2 operation should be maintained according to directions given by the manufacturers of components;
(2) That any amendment or change of navigation system affecting in any way RNAV 1 and RNAV 2 initial approval, must be forwarded and reviewed by the Authority for its acceptance or approval of such changes prior to its implementation; and
(3) That any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, must be forwarded to the Authority for acceptance or approval thereof.

Within the RNAV maintenance documentation be presented the training programme of maintenance personnel, which inter alia, should include:

(1) PBN concept;
(2) RNAV 1 and RNAV 2 application;
(3) equipment involved in a RNAV 1 and RNAV 2 operation; and
(4) MEL use.

6.4 Operational Approval

Airworthiness approval alone does not authorise an applicant or operator to conduct RNAV 1 and RNAV 2 operations. In addition to the airworthiness approval, the applicant or operator must obtain an operational approval to confirm the suitability of normal and contingency procedures in connection to the installation of a given piece of equipment.

Concerning commercial air transport, the assessment of an application for RNAV 1 and RNAV 2 operational approval is done by the State of the operator, in accordance with standing operating rules (e.g., Part 121.995 (b) and Part 135.565 (c) or equivalent) supported by the criteria described in this Technical Standard.

For general aviation, the assessment of an application for RNAV 1 and RNAV 2 operational approval is carried out by the State of registry, in accordance with standing operating rules (e.g., Part 91.1015 and Part 91.1640 or equivalent) supported by the criteria described in this Technical Standard.

6.4.1 Requirements to obtain operational approval

6.4.1.1 Requirements

In order to obtain RNAV 1 and RNAV 2 approval, the applicant or operator must take the following steps, taking into account the criteria established in this Section and in Sections 6.5, 6.6, 6.7 and 6.8 of this Technical Standard:

(1) Airworthiness approval: Aircraft must have the corresponding airworthiness approvals, pursuant to Section 6.3 of this Technical Standard;

(2) Application: The operator must submit the following documentation to the Authority:

(a) RNAV 1 and RNAV 2 operational approval application;

(b) Description of aircraft equipment - the operator must provide a configuration list with details of the relevant components and the equipment to be used for RNAV 1 and RNAV 2 operations. The list shall include each manufacturer, model, and equipment version of GNSS, DME/DME, DME/DME/IRU equipment and software of the installed FMS;

(c) Airworthiness documents related to aircraft eligibility.- The operator must submit relevant documentation, acceptable to the Authority, showing that the aircraft is equipped with RNAV systems that meet the RNAV 1 and RNAV 2 requirements set forth in Section 7.3 of this Technical Standard. For example, the parts of the AFM or AFM supplement that contain the airworthiness statement;

(d) Training programme for flight crews and flight dispatchers (FD);

(i) Commercial operators (Part 121 and Part 135) must submit to the Authority the RNAV 1 and RNAV 2 training syllabus to show that the operational procedures and practices and the training aspects described in this Section 6.6 of this Technical Standard have been included in the initial, promotional or periodic training programmes for flight crews and FDs;

Note: It is not necessary to establish a separate training programme if the RNAV 1 and RNAV 2 training identified in Section 6.6 has already been included in the training programme of the operator. However, it must be possible to identify what aspects of RNAV are covered in the training programme.

(ii) Private operators (e.g., Part 91 operators) shall be familiar with and demonstrate that they will perform their operations based on the practices and procedures described in Section 6.6.

(e) Operations manual and checklists;

(i) Commercial operators (Part 121 and Part 135) must review the operations manual (OM) and the checklists in order to include information and guidance on the standard operational procedures detailed in Section 6.5 of this Technical Standard. The appropriate manuals must contain the operation instructions for navigation equipment and contingency procedures. The manuals and checklists must be submitted for review along with the formal application in Phase two of the approval process.

(ii) Private operators (e.g., Part 91 operators) must operate their aircraft based on the practices and procedures identified in Section 6.5 of this Technical Standard.

(f) Minimum Equipment List (MEL) - the operator must send to the Authority for approval any revision to the MEL that is necessary for the conduction of RNAV 1 and RNAV 2 operations. If an RNAV 1 and RNAV 2 operational approval is granted based on a specific operational procedure, operators must modify the MEL and specify the required dispatch conditions.

(g) Maintenance - the operator must submit for approval a maintenance programme for the conduction of RNAV 1 and RNAV 2 operations;
(h) Training programme for maintenance personnel - operators must submit the training curriculum that corresponds to maintenance personnel;
(i) Navigation data validation programme - operators must present details about the navigation data validation programme as described in Section 6.5 of this Technical Standard.

(3) Training programme - once the amendments to manuals, programmes, and documents submitted have been accepted or approved, the operator must provide the required training to its personnel.
(4) Validation flight - the Authority may deem it advisable to perform a validation flight before granting the operational approval. Such validation may be performed on commercial flights.

6.4.1.2 Issuance of the approval to conduct RNAV 1 and RNAV 2 operations

Once the operator has successfully completed the operational approval process, the Authority must grant the operator approval to conduct RNAV 1 and RNAV 2 operations provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

6.4.1.2.1 Part 121, 127 and/or Part 135 operators

The Authority must issue the corresponding operations specifications (OpSpecs) that will reflect the RNAV 1 and RNAV 2 approval provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

6.4.1.2.2 Part 91 operators

The Authority will issue a letter of authorisation provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

6.5 Operating Procedures

Operators and flight crews must become familiar with the following operating and contingency procedures associated with RNAV 1 and RNAV 2 operations.

6.5.1 Pre-flight planning

6.5.1.1 General

On-board navigation data must be current and appropriate for the region of intended operations and must include NAVAIDS, WPTs, and the relevant ATS route codes for arrivals, departures, and alternate aerodromes.

RNAV STAR procedures may be designated using multiple runway transitions. Operators that lack this function must provide an alternate means of compliance (for example, a navigation database adjusted for these operations). If there is no alternate means of compliance to fly an RNAV designated procedure that contains multiple runway transitions, operators may not submit or accept an approval for these procedures.

Note: It is expected that the navigation database will be up to date during the operation. If the AIRAC cycle expires during the flight, operators and pilots must establish procedures to ensure the precision of navigation data, including the suitability of navigation facilities used to determine the routes and procedures for the flight. Normally, this is done comparing electronic data with written documents. An acceptable means of compliance is to compare aeronautical charts (new and old) to check navigation reference points before dispatch. If an amended chart is published for the procedure, the database may not be used to conduct the operation.

The availability of the navigation infrastructure required for the intended routes, including any non-RNAV contingency, must be confirmed for the foreseen period of the operation, using all available information.

6.5.1.2 Aircraft not equipped with GNSS

Aircraft not equipped with GNSS must be capable of updating the DME/DME and DME/DME/IRU position for RNAV 1 and RNAV 2 routes and for SIDs and STARs.

If only TSO-C129 equipment is used to meet RNAV 1 and RNAV 2 requirements, RAIM availability for the flight route (route and time) foreseen, using current GNSS satellite information, must be confirmed.

If only TSO-C145/C146 equipment is used to meet RNAV requirements, the pilot/operator may not need to make any prediction provided it is confirmed that the wide area augmentation system (WAAS) coverage is available along the entire flight route.

Note: For areas where WAAS coverage is not available, operators that use TSO-C145/C146 receivers must confirm the GNSS RAIM availability.

6.5.1.3 RAIM (ABAS) availability

The RAIM levels required for RNAV 1 and RNAV 2 operations may be verified, either through NOTAMs (when available) or through prediction services. Operators must become familiar with the prediction information available for the intended route.

The available RAIM prediction must take into account the latest usable NOTAMs and the avionics model (where available). The RAIM prediction service may be provided through the ANSPs, the avionics manufacturers, other entities, or through an on-board RAIM prediction receiver.

In the event of a predicted, continuous loss of appropriate level of fault detection of more than five (5) minutes for any part of the RNAV 1 and RNAV 2 operation, the flight plan must be revised (e.g., delaying the departure or planning a different departure procedure).

The RAIM availability prediction software does not guarantee the service. This software is only a tool for assessing the expected capacity to meet the required navigation performance. Due to unplanned failures of some GNSS elements, pilots and ANSPs must understand that both RAIM and GNSS navigation can be lost while the aircraft is in flight, which may require reversion to an alternate means of navigation. Therefore, pilots must assess their navigation capabilities (potentially to an alternate aerodrome) in case of failure of GNSS navigation.

6.5.1.4 DME availability

For DME-based navigation, it is necessary to check the NOTAMs to confirm the status of critical DMEs. Pilots must assess their navigation capabilities (potentially to an alternative aerodrome) if a critical DME fails while the aircraft on flight.

6.5.2 General operating procedures

Operators and pilots may not apply for or submit RNAV1 and RNAV 2 routes, SIDs or STARs in the flight plan, unless they meet all the criteria set forth in this Technical Standard. If an aircraft that does not meet these criteria is cleared by the ATC to conduct an RNAV procedure, the pilot must notify the ATC that it cannot accept such clearance and will request alternate instructions;

The pilot must comply with any instruction or procedure identified by the manufacturer, as necessary, to meet the performance requirements set forth in this section.

6.5.2.1 System initialisation

At system initialisation, pilots must:

(1) Confirm that the navigation database is up-to-date;
(2) Verify the current position of the aircraft;
(3) Verify the appropriate entry of the assigned ATC route once they receive the initial clearance, and of any subsequent change in route; and
(4) Ensure that the sequence of WPTs as depicted in their navigation system matches the route drawn in the appropriate charts and the assigned route.

Pilots may not fly an RNAV 1 or RNAV 2 SID or STAR, unless it can be retrieved from the on-board navigation database using the name of the procedure, and coincides with the procedure in the chart.

However, the route may be modified afterwards by inserting or deleting specific WPTs in response to ATC clearance.

Manual entry or the creation of new WPTs through manual insertion of latitude and longitude or rho/theta values is not permitted.

Likewise, pilots may not change any RNAV SID or STAR database WPT type from a fly-by WPT to a flyover WPT or vice versa.

Whenever possible, RNAV 1 or RNAV 2 routes must be obtained from the database as a whole, instead of individually loading the route WPTs from the database to the flight plan.

However, the individual selection and insertion of designated fixes and WPTs from the navigation database is permitted, provided all the fixes along the published route to be flown are inserted.

Likewise, the route may be modified afterwards through the insertion or deletion of specific WPTs in response to ATC clearance.

Manual entry or the creation of new WPTs through the manual insertion of latitude and longitude or rho/theta values is not permitted.

Flight crews must cross-check the cleared flight plan by comparing charts or other applicable resources to the navigation system text displays and aircraft chart displays, as applicable. If required, the exclusion of specific NAVAIDs must be confirmed. A procedure may not be used if there are any doubts about the validity of the procedure in the navigation database.

Note: Pilots may note a small difference between the navigation information described in the chart and the primary navigation display. Differences of 3° or less may result from the equipment manufacturer's application of magnetic variation and where this occurs such differences are operationally acceptable.

During the flight, whenever feasible, the flight crew must use the information available from the NAVAIDs ground-based to confirm navigation reasonableness.

6.5.2.2 Lateral Deviation Indicator

For RNAV 2 routes, pilots must use a lateral deviation indicator, an FD or an AP on lateral navigation mode. Pilots may use a navigation chart display with functionality equivalent to a lateral deviation indicator without an FD or AP.

For RNAV 1 routes, pilots must use a lateral deviation indicator, an FD or an AP on lateral navigation mode.

Pilots of aircraft with a lateral deviation display must make sure that the lateral deviation scale is suitable for the navigation accuracy associated to the route/procedure (e.g., full-scale deflection: ± 1 NM for RNAV 1, ± 2 NM for RNAV 2 or ± 5 NM for TSO-C129 () equipment in RNAV 2 routes).

All pilots are expected to follow the route centre-line, as represented on the on-board lateral deviation indicators and/or flight guidance, during all RNAV 1 and RNAV 2 operations, unless cleared by the ATC to deviate or due to an emergency.

6.5.2.3 Cross Track Error

For normal operations, the cross-track error/deviation (the difference between the RNAV system computed path and the aircraft estimated position relative to that path, i.e. FTE) must be limited to ± ½ the navigation precision associated with the route or flight procedure (i.e., 0.5 NM for RNAV 1 and 1.0 NM for RNAV 2). Small lateral deviations from this requirement are allowed (e.g., overshooting or undershooting the path) during or immediately after an en-route turn/procedure, up to a maximum of 1 times (1xRNP) the navigation precision (i.e., 1 NM for RNAV 1 and 2 NM for RNAV 2).

Note: Some aircraft do not display or do not estimate a path during turns. Pilots of such aircraft may not be capable of meeting the ± ½ precision requirement during en-route turns; however, they are expected to meet interception requirements after the turn or in straight segments.

6.5.2.4 Modification of Flight Plan

If the ATC issues a heading assignment that places the aircraft out of the route, the pilot may not modify the flight plan in the RNAV system until a new clearance is received permitting the aircraft to return to the route or until the controller confirms a new route clearance. When the aircraft is not on the published route, the specified precision requirements do not apply.

6.5.2.5 Selection of Bank Angle

Manual selection of functions that limit the banking angle of the aircraft may reduce the ability of the aircraft to maintain its desired track and is not recommended. Pilots must acknowledge that manual selection of functions that limit the banking angle of the aircraft could have the effect of reducing their ability to meet ATC path expectations.

6.5.2.6 Selection of RNP value

Pilots operating aircraft with RNAV approval in accordance with the provisions of this Technical Standard do not need to modify the predetermined RNP values of the manufacturer established in the FMC.

6.5.3 RNAV SIDs specific requirements

Before beginning take-off, the pilot must verify that the airborne RNAV system is available and operating correctly, and that the appropriate aerodrome and runway data have been loaded.

Before the flight, pilots must verify that the airborne navigation system is operating correctly and that the appropriate runway and departure procedure (including any applicable en-route transition) have been loaded and are duly displayed.

Pilots who are assigned to an RNAV departure procedure and who subsequently receive a change of runway, procedure or transition, must verify that the appropriate changes have been entered and are available for navigation before take-off. A final check of proper runway entry and correct route depiction, shortly before take-off, is recommended.

6.5.3.1 Altitude for connecting the RNAV equipment

The pilot must be capable of connecting the RNAV equipment in order to follow the flight guidance in the RNAV lateral navigation mode before reaching 153 m (500 ft) above the aerodrome elevation. The altitude at which the RNAV guidance on a route begins can be higher (e.g., climb to 1000FT then direct to…)

6.5.3.2 Appropriate level of performance for RNAV 1

Pilots must use an authorised method (lateral deviation indicator/navigation chart display /FD/AP) to achieve appropriate level of performance for RNAV 1.

6.5.3.2.1 DME/DME aircraft

Pilots of aircraft without GNSS that use DME/DME sensors without inertial input may not use their RNAV systems until the aircraft is under the appropriate DME coverage. The ANSP must make sure that adequate DME coverage is available in every (DME/DME) RNAV SID.

6.5.3.2.2 DME/DME/IRU aircraft

Pilots of aircraft without GNSS that use DME/DME RNAV systems with an IRU (DME/DME/IRU) must make sure that the position in the inertial navigation system (INS) is within 304 m (1000FT/0.17 NM) from a known position at the starting point of the take-off roll. This is usually achieved through the use of a manual or automatic runway updating function. The navigation chart may also be used to confirm the position of the aircraft if the pilot procedures and the display resolution allow compliance with the 304 m (1000FT) tolerance requirement.

Note: Based on the assessment of IRU performance, the increase of the position error after reverting to IRU can be expected to be less than 2 NM per 15 minutes.

6.5.3.2.3 GNSS aircraft

When a GNSS is used, the signal must be obtained before starting the take-off roll. For aircraft using TSO-C129/C129a equipment, the take-off aerodrome must be loaded in the flight plan in order to achieve monitoring and the appropriate navigation system sensitivity. For aircraft using TSO-C145a/C146a avionics, if the departure begins at a runway waypoint, then the departure airport does not need to be in the flight plan to obtain appropriate monitoring and sensibility.

6.5.4 RNAV STARs specific requirements

Before the arrival phase, the flight crew must verify that the correct terminal route has been loaded. The active flight plan must be checked, comparing the charts to the chart display (if applicable) and the MCDU. This includes confirmation of WPT sequence, the reasonableness of track angles and distances, any altitude or speed constraints, and ascertaining, whenever possible, which are fly-by WPTs and which are flyover WPTs. If required by a route, it will be necessary to confirm that the update will exclude a particular NAVAID. A route may not be used where are any doubts about its validity in the navigation database.

Note: As a minimum, verifications in the arrival phase could consist of simple inspections of an appropriate chart display that will meet the objectives of this paragraph.

The creation of new WPTs by the flight crew through manual entries into the RNAV system invalidates any route and is not permitted.

Where contingency procedures require reversion to a conventional arrival route, the flight crew must complete the necessary preparations before commencing the RNAV route.

Route modification in the terminal area may take the form of radar headings or “direct to” clearances. In this sense, the flight crew must be capable of reacting in time. This may include the insertion of tactical WPTs loaded from the database. The flight crew may not make manual entries or modify a loaded route, using temporary WPT or fixes not provided in the database.

Pilots must verify that the aircraft navigation system is operating properly and that the correct arrival procedure and runway are properly inserted and displayed.

Where a specific method has not been established, any altitude or speed constraints must still be observed.

6.5.5 Contingency procedures

The pilot must notify the ATC of any loss of RNAV capability, together with the proposed course of action. If it is not possible to meet the requirements of an RNAV route, pilots must notify the ATS as

soon as possible. Loss of RNAV capability includes any failure or event that causes the aircraft to be unable to meet the RNAV requirements of the route.

In case of a communication failure, the flight crew must continue on the RNAV route, according to the established procedure for lost communication.

6.6 Training Programme

The training programme for flight crews and flight dispatchers must provide sufficient training (e.g., using flight training devices, flight simulators, and aircraft) on the RNAV system to the extent necessary. The training programme must include the following topics:

(1) Information about this Technical Standard;
(2) The meaning and proper use of aircraft equipment and navigation suffixes;
(3) The characteristics of procedures, as determined in chart displays and in the text description;
(4) the representation of the types of WPTs (fly-by and fly-over) and ARINC 424 path terminations provided in Section 6.3.8 and any other type used by the operator, as well as those associated with the aircraft flight paths;
(5) The navigation equipment required to operate in RNAV 1 and RNAV 2 routes, SIDs and STARs (e.g., GNSS, DME/DME and DME/DME/IRU).
(6) Specific information on the RNAV system:
    (a) Levels of automation, annunciation modes, changes, alerts, interactions, reversals, and degradation;
    (b) Integration of functions with other aircraft systems;
    (c) The meaning and convenience of en-route discontinuities, as well as procedures related to the flight crew;
    (d) Pilot procedures consistent with the operation;
    (e) Types of navigation sensors (e.g., GNSS, DME, IRU) used by the RNAV system and establishment of priorities, weighting, and consistency with associated systems;
    (f) Turns anticipation taking into account the effects of speed and altitude;
    (g) Interpretation of electronic displays and symbols;
    (h) Understanding aircraft configuration and the operating conditions required to support RNAV operations, e.g., appropriate selection of CDI scale (lateral deviation display scale);
(7) Operating procedures for RNAV equipment, as applicable, including how to carry out the following:
    (a) Verify currency and integrity of aircraft navigation data;
    (b) Verify the successful completion of RNAV system self-test;
    (c) Initialize RNAV system position;
    (d) Retrieve and fly a SID or STAR with the appropriate transition;
    (e) Adhere to speed and altitude constraints associated with a SID or STAR;
    (f) Select the appropriate SID or STAR for the active runway and become familiar with the procedures to deal with a runway change;
    (g) Perform a manual or automatic update (with take-off point shift, if applicable);
    (h) Verify the WPTs and flight plan programming;

(i) Fly direct to a WPT;
(j) Fly a course/track to a WPT;
(k) Intercept a course/track;
(l) Fly radar vectors and return to an RNAV route from a "heading" mode;
(m) Determine cross-track errors and deviations;
(n) Resolve en-route discontinuities (insert and delete/eliminate en-route discontinuities);
(o) Remove or reselect the navigation sensor inputs;
(p) When required, confirm the exclusion of a specific NAVAID or any type of navigation aid;
(q) When required by the Authority, performs gross navigation errors checks using conventional NAVAIDs;
(r) Change the arrival and alternate aerodromes;
(s) Perform parallel offset functions if that capability is available. Pilots must know how offset are applied, the functionality of the particular RNAV system, and the need to advise the ATC if this functionality is not available; and
(t) Perform RNAV holding functions (e.g., insert or delete a holding pattern).

(8) levels of automation recommended by the operator for each flight phase and workload, including the methods to minimise cross-track error that permit the aircraft to follow the route centreline;
(9) radiotelephony phraseology used for RNAV applications; and
(10) contingency procedures for RNAV failures.

6.7 Navigation Database

The operator must obtain the navigation database from a supplier that complies with document RTCA DO 200A/EUROCAE ED 76 – Standards for aeronautical data processing. Navigation data must be compatible with the intended function of the equipment (see Annex 6 Part I paragraph 7.4.1). A letter of acceptance (LOA) issued by the appropriate regulatory authority to each participant in the data chain shows compliance with this requirement (e.g., FAA LOA issued in accordance with FAA AC 20-153, or EASA LOA issued in accordance with EASA IR 21 Subpart G).

The operator must advise the navigation data supplier of discrepancies that invalidate a route, and prohibit the use of the affected procedures through a notice to flight crews.

Operators must consider the need to check the navigation database periodically in order to maintain the existing requirements of the quality system or safety management system.

DME/DME RNAV systems must only use the DME facilities identified in AIPs.

Systems must not use the facilities indicated by the Authority as inappropriate for RNAV 1 and RNAV 2 operations in the AIP, or facilities associated with an ILS or MLS that uses a range offset. This can be done excluding the specific DME facilities known to have a detrimental effect on the navigation

solution from the aircraft database, when RNAV routes are within the receiving range of such DME facilities.

6.8 Oversight, Investigation of Navigational Errors, and withdrawal of RNAV 1 and RNAV 2 Approval

The operator must establish a procedure to receive, analyse, and follow up on navigation error reports in order to determine appropriate corrective action.

Information indicating a potential for repetitive errors may require the modification of the training programme of the operator.

Information attributing multiple errors to a pilot in particular may call for additional training or assessment of competence for that pilot.

Repetitive navigation errors attributed to the equipment or a specific part of the navigation equipment or to operating procedures may cause cancellation of an operational approval (withdrawal of RNAV 1 and RNAV 2 Operational Specification approval or withdrawal of the LOA in the case of non-commercial operators).

7 RNP 4

7.1 General Considerations

7.1.1 Navigation aid infrastructure

RNP 4 was developed for operations in oceanic and remote areas and therefore does not require any ground-based navaid infrastructure. The global navigation satellite system (GNSS) is the primary navigation sensor that supports RNP 4, either as a stand-alone navigation system or as part of a multi-sensor system.

7.1.2 ATS communications and surveillance

Although this Technical Standard was developed to support 30 NM lateral and longitudinal separation minima based on RNP 4, it should be noted that it only includes the navigation requirements associated to these standards and does not specifically refer to air traffic service (ATS) communications or surveillance requirements.

Note: The provisions related to these separation minima, including ATS communications and surveillance requirements, are contained in Section 5.4 of ICAO Doc 4444 – Procedures for air navigation services – Air traffic management (PANS-ATM). Provided that they can support an increased reporting rate required, controller-pilot data link communications (CPDLC) and automatic dependent surveillance – contract (ADS – C) systems which meet the requirements for application of

the 50 NM lateral and longitudinal separation minima based on RNAV 10 will also meet the requirements for the application of the 30 NM lateral and longitudinal minima.

7.1.3 Obstacle clearance and en-route spacing

Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations (PANS OPS), Volume II, provides a detailed guide on obstacle clearance. The general criteria of Parts I and III apply.

Separation minima are described in Section 5.4 of Doc 4444 PANS-ATM.

RNP 4 may be used to support the application of en-route separation/spacing standards of less than 30 NM in continental airspace, provided the relevant authority has conducted the necessary safety assessments described in Doc 4444, PANS-ATM. However, the ATS communications and surveillance parameters that support the application of new separation standards will be different from those used for a 30 NM standard.

7.1.4 Publications

When reference is made to the existing routes, the AIP should clearly indicate that the navigation application is RNP 4. The route should identify the minimum altitude requirements of the segments.

The navigation information published in the AIP for routes and supporting navigation aids must meet the requirements of Annex 15 – Aeronautical information services. All routes must be based on the World Geodetic System - 1984 (WGS-84) coordinates.

7.1.5 Additional considerations

Many aircraft have the following capabilities:

(1) Fly parallel paths displaced to the left or right of the original active route; and

(2) Execute a holding pattern manoeuvre using an RNP system. The purpose of this function is to give the ATC flexibility for the design of RNP operations.

7.3 Airworthiness and Operational Approval

Commercial air transport operators require two types of approvals before receiving an RNP 4 approval:

1) Airworthiness approval, issued by the State of Registry and

2) Operational approval, issued by the State of the Operator.

For general aviation operators, the State of Registry will determine if the aircraft meets the applicable RNP 4 requirements, and will issue the operational authorisation (e.g., a letter of authorisation – LOA).

Before submitting their request, operators must review all aircraft qualification requirements. Compliance with airworthiness or equipment installation requirements, by itself, does not constitute operational approval.

7.4 Airworthiness Approval

7.4.1 Aircraft requirements

7.4.1.1 Navigation systems

For RNP 4 operations in oceanic or remote airspace, the aircraft must have, at least two fully operational and independent long-range navigation systems (LRNS), with integrity such that the navigation system does not provide misleading information and form part of the basis upon which RNP 4 operations approval is granted. GNSS must be used as either a stand-alone navigation system or as one of the sensors in a multi-sensor system.

7.4.1.1.1 The United Stated Federal Aviation Administration (FAA) AC 20-138A

Airworthiness approval of global navigation satellite system (GNSS) equipment, or equivalent documents acceptable to the Executive Director provide an acceptable means of complying with installation requirements for aircraft that use, but do not integrate, the GNSS output with that of other sensors.

7.4.1.1.2 The FAA AC 20-130A

Airworthiness approval of navigation or flight management systems integrating multiple navigation sensors, or equivalent documents describe an acceptable means of compliance for navigation systems with multiple sensors that incorporate GNSS.

The configuration of the equipment used for demonstrating the required accuracy must be identical to the one specified in the minimum equipment list (MEL) or in the aircraft flight manual (AFM).

The installation design must meet the design standards applicable to the aircraft that is being modified, and changes must be reflected in the AFM before starting operations requiring RNP 4 navigation approval.

7.4.1.2 System performance, monitoring and alerting

(1) Accuracy.- During operations in airspace or on routes designates as RNP4:

  (a) The lateral total system error must not exceed $\pm$ 4 NM for at least 95% of the total flight time.

  (b) Likewise, the along-track error must not exceed $\pm$ 4 NM at least 95% of the total flight time.

  (c) A flight technical error (FTE) of 2.0 NM (95%) may be assumed.

(2) Integrity.- Malfunctioning of the aircraft navigation equipment is classified as a major failure according to airworthiness regulations (e.g., 10^{-5} per hour).

(3) Continuity.- Loss of function is classified as a major failure for oceanic and remote navigation. The continuity requirement is met by carrying on board two independent LRNS systems (excluding the signal-in-space).

(4) Performance monitoring and alerting.- The RNP system or the RNP system in combination with the pilot will provide an alert if the accuracy requirement is not met, or if the probability that the lateral total system error exceeds 8 NM is greater than 10^{-5}.

7.4.1.3 Signal-in-space

If GNSS is used, the aircraft navigation equipment must provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 8 NM exceeds 10^{-7} per hour (ICAO Annex 10, Volume I, Table 3.7.2.4-1).

Note: Compliance with the performance monitoring and alerting requirement does not imply an automatic monitor of FTE. The on-board monitoring and alerting function should consist at least of a navigation system error (NSE) monitoring and alerting algorithm and a lateral deviation display that enables the crew to monitor the FTE. To the extent operational procedures are used to monitor FTE, the crew procedures, equipment characteristics, and installations are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures. The path definition error (PDE) is considered negligible due to the quality assurance process and crew procedures.

7.4.1.4 GNSS Monitor

The GNSS navigation system must detect satellite failures before they cause the aircraft to exceed the limits of the defined airspace. This requirement is derived from the overall effect of a GNSS failure and applies to all navigation uses of the system. The probability of missed detection of satellite failures must be less than or equal to 10^{-3} and the effective limit of the monitor for these failures of the navigation solution, known as the horizontal alert limit (HAL) must consider the other normal errors that may exist during the satellite fault, the latency of the alert, the crew reaction time to an alert and the aircraft response. An acceptable means of compliance is to use a HAL of 4 NM for RNP 4 oceanic airspace.

7.4.2 Determination of aircraft eligibility for RNP 4 operations

7.4.2.1 Airworthiness eligibility documents

The operator must have relevant documentation acceptable to the Authority of the State of Registry showing that aircraft are equipped with RNP systems that meet RNP 4 requirements.

In order to avoid unnecessary regulatory activity, the determination of the eligibility of existing systems should take into account the acceptance of manufacturer documentation of compliance, e.g. EASA AMC 20 series.

New systems may demonstrate compliance with RNP 4 requirements for oceanic or remote operations as part of their airworthiness approval.

For existing systems, the operator must determine RNP 4 compliance as stated in the AFM supplement or additional airworthiness documents, or as obtained per amended type certificate (TC) or supplemental type certificate (STC).

Documented confirmation by the manufacturer will be required, indicating that aircraft meet the RNP 4 performance requirements of this Technical Standard, if the operator chooses to claim additional performance beyond the original airworthiness approval or as declared in the AFM, amended TC or STC. Navigation performance must consider the navigation infrastructure used in the original airworthiness approval.

7.4.3 Aircraft eligibility groups

7.4.3.1 Group 1: RNP certification

Group 1 aircraft are those that have official certification and approval of on-board RNP integration. RNP compliance is documented in the AFM.

Certification will not be necessarily limited to a given type of RNP. The AFM must address the RNP levels that have been demonstrated and any related provisions applicable to their use (e.g., navaid sensor requirements). Operational approval is based on the performance stated in the AFM.

This method is also applicable in case where certification is received through an STC issued to cover retrofitting of equipment, such as the installation of GNSS receivers to enable the aircraft to meet RNP 4 requirements in oceanic and remote airspace.

7.4.3.2 Group 2: Previous certification of the navigation system

Group 2 aircraft are those than can equate their certified level of performance, granted on the basis of previous requirements, to RNP 4 criteria.

The following standards can be used to classify aircraft in Group 2:

7.4.3.2.1 Global navigation satellite systems (GNSS) as primary means of navigation.

Aircraft equipped only with GNSS as primary means of long-range navigation, approved for operations in oceanic and remote airspace, must meet the technical requirements specified in Paragraph 8.1.1 of this section.

The AFM must indicate that dual GNSS equipment, approved according to an appropriate standard, is required. The appropriate standards are FAA technical standard orders (TSO) C129a or C146(), and the European technical standard orders (ETSO) C129a or C146() of EASA. Furthermore, an approved dispatch fault detection and exclusion (FDE) availability prediction programme must be used. The maximum allowable time for which FDE capability is projected to be unavailable on any event is 25 minutes. This maximum outage time must be included as a condition for RNP 4 operational approval. If predictions indicate that the maximum allowable FDE outage time will be exceeded, the operation must be rescheduled to a time when FDE is available.

7.4.3.2.2 Multi-sensor systems that incorporate GNSS with integrity provided by receiver autonomous integrity monitoring (RAIM).

Multi-sensor systems that incorporate the global positioning system (GPS) with RAIM and FDE, and which are approved based on FAA AC 20-130A or other equivalent documents, meet the performance requirements specified in 8.4.1.1 of this section. It should be noted that there is no requirement to use dispatch FDE availability prediction programmes when multi-sensor systems are installed and used.

7.4.3.2.3 Multi-sensor systems that incorporate GNSS with integrity provided by aircraft autonomous integrity monitoring (AAIM).

The AAIM uses the redundancy of position calculations from multiple sensors, including GNSS, to provide integrity performance that is at least equivalent to RAIM. These airborne augmentations must be certified according to TSO C-115b, ETSO C-115b or other equivalent documents. An example is

the use of an inertial navigation system or other navigation sensors as an integrity check on GNSS data when RAIM is not available but GNSS positioning information continues to be valid.

7.4.3.3 Group 3: New technology

This group has been included in order to cover new navigation systems that meet the technical requirements for operations in RNP 4 airspace.

7.4.4 The on-board navigation system must provide the following functions:

(1) navigation data display;

(2) track to a fix (TF);

(3) direct to a fix (DF);

(4) direct to function;

(5) course to a fix (CF);

(6) parallel offset;

(7) fly-by transition criteria

(8) user interface displays;

(9) displays and controls;

(10) flight planning path selection;

(11) flight planning fix sequencing;

(12) user defined course to fix (CF);

(13) path steering;

(14) alerting requirements;

(15) navigation database access; and

(16) WGS 84 reference system.

7.4.4.1 Explanation of the required functions

7.4.4.1.1 Navigation data display

The navigation data display must use either a lateral deviation display or a navigation map display that meets the following requirements:

(1) A non-numerical lateral deviation display (e.g., a lateral deviation indicator (CDI) or an electronic horizontal situation indicator ((E)HSI)), with a to/from indication and failure annunciation, to be used as a primary flight instrument for aircraft navigation, for manoeuvre anticipation, and for failure/status/integrity indication, with the following attributes:

(2) The display must be visible to the pilot and located in his/her primary field of view (+ 15 degrees from the pilot´s normal line of sight) when looking forward along the flight path;

(3) Lateral deviation scaling must agree with any alerting and annunciation limits;

(4) The lateral deviation display must be automatically slaved to the RNP computed path. The lateral deviation display also must have full-scale deflection suitable for the current phase of flight, and must be based on the required track-keeping accuracy. The course selector of the

lateral deviation display must be automatically slewed to the RNP computed path, or the pilot must adjust the CDI or HSI selected course to the computed desired track;

Note: The normal function of stand-alone GNSS equipment meets this requirement.

(5) The display scaling may be set automatically by default logic or set to a value obtained from the navigation database. The full-scale deflection value must be known or must be available to the pilot and must be consistent with the values of the en-route, terminal or approach phases;

(6) A navigation map display, readily visible to the pilot, with appropriate map scales (scaling may be set manually by the pilot) and giving equivalent functionality to a lateral deviation display.

7.4.4.1.2 Track to a fix (TF)

The primary segment of an RNAV straight route is a TF route. The TF leg is a geodetic path between two waypoints (WPT). The first is a termination WPT of the previous leg or an initial fix (IF). The intermediate and final approach segments should always be TF routes. In cases where an FMS requires a course to fix (CF) to the final approach segment, the database coder may use a CF instead of a TF. The termination fix is normally provided by the navigation database, but may also be defined by the user.

7.4.4.1.3 Direct to a fix (DF)

The DF leg is used to define a route segment from an unspecified position, on the aircraft´s present track, to a specified fix/WPT. The DF path termination does not provide a predictable flight path that can be repeated, and is very variable in its application.

7.4.4.1.4 "Direct to" function

The "direct to" function must be able to be activated at any time by the flight crew, as necessary. The "direct to" function must be available to any fix. The system must be capable of generating a geodetic path to the designated "to" fix. The aircraft must capture this path without "S turns" and without undue delays.

7.4.4.1.5 Course to a fix (CF)

A CF is defined as a course that ends at a fix/WPT followed by a specific route segment. The inbound course at the termination fix and the fix are provided by the navigation database. If the inbound course is defined as the magnetic course, the source of the magnetic variation needed to convert magnetic courses to true courses is required.

7.4.4.1.6 Parallel offset

The system must have the capability to fly parallel tracks at a selected offset distance.

When executing a parallel offset, the navigation precision and all the performance requirements of the original route in the active flight plan must be applicable to the offset route.

The system must permit the entry of offset distances in increments of 1 MN, to the left or right of the course.

The system must be capable of offsets of at least 20 NM. When in use, the system offset mode of operation must be clearly indicated to the flight crew. When in offset mode, the system must provide reference parameters (for example, cross-track deviation, distance to-go, time to-go) relative to the offset path and offset reference points.

An offset must not be propagated through route discontinuities, unreasonable (excessive) path geometries, or beyond the initial approach fix.

An announcement must be given to the flight crew before the end of the offset path, giving sufficient time to return to the original path.

Once a parallel offset has been activated, it must remain active throughout all the route segments of the flight plan until removed automatically, until the flight crew enters a direct-to route, or until manually cancelled by the flight crew.

The parallel offset function must be available for the en-route TF segment and the geodetic portion of DF leg types.

7.4.4.1.7 "Fly-by" transition criteria

The navigation system must be capable of performing "fly-by" transitions.

No predictable and repeatable path is specified because the optimum path varies with airspeed and bank angle. However, the boundaries of the transition are defined.

The path definition error (PDE) is defined as the difference between the defined path and the theoretical transition area. If the path lies within the transition area, there is no PDE. "Fly-by" transitions must be the default transitions when the type of transition is not specified. The theoretical transition area requirements are applicable for the following assumptions:

(1) Course changes do not exceed 120º for low altitude transitions (when the barometric altitude of the aircraft is less than FL 195); and

(2) Course changes do not exceed 70º for high-altitude transitions (when the barometric altitude of the aircraft is equal to or greater than FL 195).

7.4.4.1.8 User interface displays

The general features of user interface displays must permit the display of information, provide situational awareness, and be designed and implemented taking into account human factors. The main design considerations include:

(1) minimizing reliance on flight crew memory for any operational procedure or task of a system;

(2) developing a clear and unambiguous display of system modes and sub-modes and navigation data, with emphasis on the requirements for enhanced situational awareness for any automatic changes in the mode, if provided;

(3) the use of the context-sensitive help capability and error messages (e.g., invalid inputs or invalid data entry messages should provide a simple means for determining how to enter "valid" data);

(4) failure-tolerant data entry methods instead of rigid rule-based concepts;

(5) placing special emphasis on the number of steps and minimizing the time required to accomplish flight plan modification to accommodate ATS clearances, holding procedures, changes of runway and instrument approaches, missed approaches and diversions to alternate destination aerodromes; and

(6) minimising the number of nuisance alerts so that the flight crew may recognize the real ones and properly respond when so required.

7.4.4.1.9 Displays and controls

Each display element used as primary flight instrument for aircraft guidance and control, for manoeuvre anticipation, or for failure/status/integrity annunciation, must be located in a place clearly visible to the pilot (in the pilot´s primary field of view) with the least possible deviation with respect to the normal position of the pilot and his/her line of vision when looking forward towards the flight path.

It is expected that aircraft that meet the requirements of Part 25 of the United States Code of Federal Regulations (CFR) / Certification Specification (CS) 25 of the European Air Safety Agency (EASA) or equivalent documents, will meet the provisions of certification documents.

All system displays, controls and annunciations must be readable under normal cockpit conditions and under foreseen ambient lighting conditions. Night lighting provisions must be compatible with other lighting conditions in the cockpit.

All displays and controls must be arranged to facilitate access and use by the flight crew. The controls that are normally adjusted in flight must be readily accessible and have standardized labels indicating their function. System controls and displays must be designed to maximize operational suitability and minimize pilot workload.

The controls intended for use during the flight must be designed to minimize errors, and when operated in all possible combinations and sequences, they must not result in a condition that would be detrimental to the continued performance of the system. System controls must be arranged to provide adequate protection against inadvertent system failure.

7.4.4.1.10 Flight planning path selection

The navigation system must provide the crew the capability to create, review and activate a flight plan. The system must provide the capability for modification (e.g., deletion and addition of fixes and creation of along the track fixes), review and user acceptance of changes to the flight plans. When this capability is exercised, guidance output must not be affected until the modification(s) is (are) activated. The activation of any flight plan modification must require a positive action and verification by the flight crew after data entry.

7.4.4.1.11 Flight planning fix sequencing

The navigation system must provide the capability for automatic sequencing of fixes.

7.4.4.1.12 User-defined course to a fix (CF)

The navigation system must provide the capability to define a user-defined course to a fix. The pilot must be able to intercept the user-defined course.

7.4.4.1.13 Path steering

The system must provide data to enable the generation of command signals for the autopilot/flight director/CDI, as applicable. In all cases, a path steering error (PSE) must be defined at the time of certification, which will meet the requirements of the desired RNP operation in combination with the other system errors. During the certification process, the ability of the crew to operate the aircraft within the specified PSE must be demonstrated.

Aircraft type, operating enveloped, displays, autopilot performance and leg transition guidance (specifically between arc legs) should be accounted for in the demonstration of PSE compliance. A measured PSE value may be used to monitor system compliance with RNP requirements.

For operations in all leg types, this value must be the distance to the defined path. In order to comply with cross-track containment, any inaccuracies in the cross-track errors computation (e.g., resolution) must be accounted for in the total system error (TSE),

7.4.4.1.14 Alerting requirements

The system must also provide an annunciation if the manually entered navigation accuracy is larger than the navigation accuracy associated with the current airspace as defined in the navigation data base. Any subsequent reduction of the navigation accuracy must reinstate this annunciation. When an aircraft is approaching to RNP airspace from non-RNP airspace, an alert must be provided when the cross-track distance to the desired path is equal to or less than one-half the navigation accuracy and the aircraft has passed the first fix in the RNP airspace.

7.4.4.1.15 Navigation database access

The navigation database must provide access to navigation information in support of navigation system references and flight planning characteristics. Manual modification of data in the navigation database must not be possible. This requirement does not preclude the storage of "user-defined data" in the equipment (e.g., for flex-track routes). When data are retrieved from storage they must also be retained in storage. The system must provide a means to identify the version of the navigation database and the validity of the operating period.

7.4.4.1.16 Geodetic reference system

The World Geodetic System - 1984 (WGS-84) or an equivalent Earth reference model must be the reference Earth model for error determination. If the WGS-84 is not used, any differences between the selected Earth model and the WGS-84 Earth model must be included as part of the PDE. Errors induced by the data resolution must also be taken into account.

7.4.4.2 Recommended functions

The following additional functions are recommended:

(1) Display of cross-track error on the control and display unit (CDU);

(2) Display present position of the aircraft in terms of distance/bearing to the selected waypoints (WPT);

(3) Provide time to WPTs on the CDU;

(4) Display along-track distance;

(5) Display ground speed (GS);

(6) Provide automatic navigation aids selection;

(7) Manually inhibit a navigation facility;

(8) Automatic selection and tuning of the distance-measuring equipment (DME) and/or VHF omnidirectional radio range (VOR);

(9) Estimate of position uncertainty (EPU);

(10) Display current RNP level and type selection;

(11) Capability to display flight plan discontinuities; and

(12) Display of operating and degraded navigation sensors.

7.4.4.3 Automatic radio position updating

Automatic updating is considered to be any updating procedure that does not require the crew to insert the coordinates manually. If used, automatic updating may be considered as acceptable for operations in RNP 4 airspace, provided:

(1) Automatic updating procedures are included in the operator training programme; and

(2) Crews are knowledgeable of the updating procedures and of the effect of the update on the navigation solution.

7.4.5 Continued airworthiness

Operators of RNP 4 approved aircraft must ensure the continuity of their technical capability to meet the technical requirements established in this Technical Standard.

Each operator requesting an RNP 4 operational approval must submit to the Authority a maintenance and inspection programme that includes all those maintenance requirements needed to ensure that the navigation systems will continue to meet the RNP 4 approval criteria.

The following maintenance documents must be revised, as applicable, to incorporate RNP 4 aspects:

(1) Maintenance control manual (MCM);

(2) Illustrated part catalogues (IPC); and

(3) Maintenance programme.

The approved maintenance programme for the aircraft involved must include the maintenance practices indicated in the corresponding maintenance manual of the aircraft and component manufacturer, and must consider that:

(1) Equipment involved in RNP 4 operations must be maintained according to the instructions of the component manufacturer;

(2) Any modification or change in the navigation system that affects in any way the initial RNP 4 approval must be reported and reviewed by the Authority for acceptance or approval of said changes prior to their implementation; and

(3) Any repair that is not included in the approved/accepted maintenance documentation and that could affect navigation performance integrity must be reported to the Authority for its acceptance and approval of such repair.

RNP maintenance documentation must contain the training programme for maintenance personnel, which, amongst other aspects, must include:

(1) The PBN concept;

(2) RNP 4 implementation;

(3) The equipment involved in the RNP 4 operation; and

(4) Use of the MEL.

7.5 Operational approval

Airworthiness approval alone does not authorise an applicant or operator to conduct RNP 4 operations. In addition to the airworthiness approval, the applicant or operator must obtain an operational approval to confirm the suitability of normal and contingency procedures in connection to the installation of specific equipment.

7.5.1 Requirements to obtain operational approval

7.5.1.1 Requirements

In order to obtain RNP 4 approval, the applicant or operator will take the following steps, taking into account the criteria established in this Section:

(1) Airworthiness approval - aircraft shall have the corresponding airworthiness approvals, pursuant to Section 7 of this Technical Standard;

(2) Application - the operator will submit the following documentation to the Authority:

(a) The application for RNP 4 operational approval;

(b) Airworthiness documents related to aircraft eligibility - the operator must submit relevant documentation, acceptable to the Authority, establishing that the aircraft has long-range navigation systems (LRNS) that meet RNP 4 requirements, as described in this Technical Standard. For example, the operator must submit the parts of the AFM or AFM supplement that contain the airworthiness statement;

(c) Description of aircraft equipment - the operator will provide a configuration list with details of the relevant components and the equipment to be used for RNP 4 operations. The list must include each manufacturer, model and version of the GNSS equipment and of the software of the installed FMS;

(d) Flight crew and flight dispatcher training programme - operators must submit to the Authority the training curriculum and other appropriate material (e.g., computer-based training) to show that operational procedures and practices and the training aspects described in this Technical Standard concerning RNP 4 operations, have been included in the training programmes, as applicable (for example, in the initial, upgrade or recurrent training curriculum for flight crews and flight dispatchers);

Note: A separate training programme is not required if the RNP 4 training identified in this Technical Standard has already been included in the training programme of the operator. However, it should be possible to identify what aspects of RNP 4 are covered in the training programme;

(e) Operations manual and checklists;

(i) Operators must revise the operations manual (OM) and the checklists to include information and guidance on the standard operating procedures (SOP) detailed in this Technical Standard. The appropriate manuals must contain the operating instructions of the navigation system and the contingency procedures, where specified (e.g., procedures for deviations due to weather conditions). The manuals and checklists must be submitted for review as attachments to the formal application in Phase 2 of the approval process.

(f) Minimum equipment list (MEL) - any revision of the MEL to incorporate RNP 4 provisions must be approved. Operators must modify the MEL and specify the required dispatch conditions;

(g) Maintenance - all operators or owners must submit for approval, at the time of the application, their maintenance programmes, including equipment monitoring reliability programme. The holder of the design approval, including either the type certificate (TC) or supplemental type certificate (STC), for each individual navigation system installation, must provide at least one set of complete instructions for continuing airworthiness;

(h) Training programme for maintenance personnel - operators must send the training curriculum that corresponds to their maintenance personnel as described in Section 7.4.5;

(i) Performance history - the application will include the operating history of the operator. The applicant will include the events or incidents related to navigation errors in oceanic or remote airspace (e.g., those reported in the navigation error investigation forms of each State) and the methods used by the operator to address such events or incidents through new or revised training programmes, procedures, maintenance or aircraft modifications.

(j) Navigation data validation programme - the operator will present the details of the navigation data validation programme, as described in this Technical Standard;

(3) Programming of the training - once the amendments to manuals, programmes and documents submitted have been accepted or approved, the operator must provide the required training to its personnel;

(4) Validation flight - the Authority may deem it advisable to conduct a validation flight before granting the operational approval. Such validation may be performed on commercial flights.

7.5.1.2 Issuance of the approval to conduct RNP 4 operations

Once the operator has successfully completed the operational approval process, the Authority must grant the operator the approval to conduct RNP 4 operations provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

7.5.1.2.1 Part 121, 127 and/or 135 operators

The Authority will issue the corresponding operation specifications (OpSpecs) reflecting the approval to conduct RNP 4 operations provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

7.5.1.2.2 Part 91 operators

The Authority will issue a letter of approval provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

7.6 Operational requirements

7.6.1 Navigation performance

For RNP 4 operations, aircraft must meet a cross-track (lateral) keeping accuracy and along-track (longitudinal) position accuracy of not greater than $\pm$ 4 NM for 95% of the flight time.

7.6.1.1 Navigation equipment

For RNP 4 operations in oceanic or remote airspace, the aircraft must have, at least two fully operational and independent long-range navigation systems (LRNS), with integrity such that the navigation system does not provide misleading information and form part of the basis upon which RNP 4 operations approval is granted. GNSS must be used as either a stand-alone navigation system or as one of the sensors in a multi-sensor system.

Note: It is expected that navigation databases will be valid for the duration of the flight. If the AIRAC cycle expires during the flight, operators and pilots must establish procedures to ensure the accuracy of the navigation data, including the adequacy of navigation facilities used for defining the routes and procedures for the flight.

7.6.1.2 Availability of navigation aids (NAVAIDS)

At the time of aircraft dispatch or during flight planning, the operator must make sure that the appropriate en-route navigation aids are available to allow the aircraft to conduct RNP 4 operations.

7.7 Operating procedures

The following topics must be standardised and included in the training programmes and in the operational practices and procedures. Some topics may have been properly standardized in the existing programmes and procedures of the operator. The new technologies may also eliminate the need for the crew to take some actions. If this is the case, it can be considered that the objective of this text has been met.

Note: This guidance material has been written for a wide variety of operator types and therefore some topics may not be applicable to all operators.

7.7.1 Flight planning

During flight planning, flight crews and flight dispatchers must pay special attention to the conditions that may affect operations in RNP 4 airspace or routes, including, but not limited to:

(1) Verifying if the aircraft is approved for RNP 4 operations in oceanic or remote airspace;

(2) Verifying if the operator is authorised to conduct RNP 4 operations in oceanic or remote airspace. This approval supports the 30 NM lateral and longitudinal separation (or other) minima required by RNP 4 operations;

(3) Verifying GNSS requirements, such as FDE, if applicable to the operation; and

(4) Verifying if any operating restriction related to the RNP 4 approval has been taken into account, if so required.

Note: the approval only addresses navigation requirements associated to these standards. The approval does not consider communications or surveillance requirements. These requirements are listed in the AIPs and in the regional supplementary procedures (ICAO Doc 7030) for a specific airspace or ATS route.

7.7.2 Pre-flight procedures

7.7.2.1 The following action must be taken during pre-flight:

(1) Review the technical flight records (maintenance logs) and forms to determine the condition of the equipment required for flying in RNP 4 airspace or route;

(2) Ensure that maintenance action has been taken to correct defects on the required equipment; and

(3) Review the contingency procedures for operations in airspace or routes that require RNP 4 navigation capability. These are no different than normal oceanic contingency procedures with one exception: crews must be able to recognize, and the ATC must be advised, when the aircraft is no longer able to navigate to its RNP 4 navigation capability.

7.7.2.2 GNSS availability

During flight planning or at dispatch, the operator must ensure that GNSS availability requirements on which the operator approval has been based will be met throughout the flight.

7.7.3 En-route procedures

7.7.3.1 The following must be available:

(1) At least two LRNS, capable of navigating to RNP 4 and listed in the AFM, must be operational at the entry point of the RNP airspace. Where an item of equipment required for RNP 4 operations is unserviceable, then the pilot must consider an alternate route or diversion for repairs;

(2) In-flight operating procedures of the operator must include mandatory cross-check procedures to identify navigation errors sufficiently in advance, in order to prevent the aircraft from inadvertently deviating from the routes cleared by the ATC; and

(3) Crews must advise the ATC of any deterioration or failure of the navigation equipment that cause navigation performance to fall below the required level, and/or any deviation required for a contingency procedure.

7.7.3.2 Lateral Deviation Indicator

Pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode on RNP 4 routes. Pilots may use a navigation map display with equivalent functionality to a lateral deviation indicator. Pilots of aircraft with a lateral deviation indicator must ensure that the lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the route (i.e. ± 4 NM). All pilots must maintain route centrelines, as depicted by on-board lateral deviation indicators and/or flight guidance during all RNP 4 operations, unless authorised to deviate by ATC or under emergency conditions.

7.7.3.3 Cross Track Error

For normal operations, cross-track error/deviation (the difference between the RNAV system computed path and the aircraft estimated position relative to that path, i.e. FTE) must be limited to ± ½ the navigation accuracy associated with the route (i.e. 2 NM). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after route turns, up to a maximum of one-times the navigation accuracy (i.e. 4 NM), are allowable.

7.8 Contingency procedures

Flight crews and flight dispatchers must be familiar with the following general provisions:

(1) If an aircraft cannot continue the flight according to the current ATC authorisation or cannot maintain RNP 4 accuracy, it must not enter into or continue operating in RNP 4 airspace. In this case, the pilot will obtain a revised clearance, if that is possible, before initiating any action.

(2) In all cases, the flight crew shall follow the contingency procedures established for each region or area of operation (e.g., South Atlantic (SAT), Pacific, etc.) and obtain ATC clearance as soon as possible.

(3) Procedures for flight contingencies, deviations due to weather conditions and strategic lateral offset procedures. The operator must develop procedures for flight contingencies, deviations due to weather conditions and strategic lateral offset procedures (SLOP), in accordance with Paragraph 15.2 of ICAO Doc 4444 – Special procedures for flight contingencies in oceanic

airspace. These procedures are of general application in oceanic and remote continental areas of operation. As a minimum, the following aspects must be included:

(a) Special procedures for flight contingencies in oceanic airspace.

(i) Introduction;

(ii) General procedures; and

(iii) Extended-range operations by twin-engine aeroplanes (ETOPS/EDTO)

(b) Procedures for deviating due to weather conditions, (General);

(c) Measures to be adopted when controller-pilot communications are established;

(d) Measures to be adopted if a revised clearance from the ATC cannot be obtained; and

(e) Strategic lateral offset procedures in oceanic airspaces and remote continental areas.

7.9 Training programme

Operators or owners must ensure that flight crews have been trained and have the appropriate knowledge on the topics contained in these guidelines.

Operators must make sure that their programmes cover training for flights crews and flight dispatchers on the following aspects:

(1) General

(a) Definition of RNP in relation to RNP 4 requirements;

(b) Knowledge of the airspace where RNP 4 is required;

(c) Aeronautical charts and documents that reflect RNP 4 operations;

(d) Equipment required to operate in RNP 4 airspace, and its operation;

(e) Limitations associated to navigation equipment; and

(f) Use of the MEL.

(2) Operational procedures

(a) Flight planning;

(b) Pre-flight procedures;

(c) GNSS availability;

(d) Enroute operations;

(e) Contingency procedures; and

(f) Aspects contained in this Technical Standard.

7.10 Navigation database

The on-board database must be valid and suitable for RNP 4 operations and must include the navigation aids and waypoints (WPTs) required for the route.

The operator must obtain the navigation database from a supplier that complies with document RTCA DO 200A/EUROCAE ED 76 – Standards for processing aeronautical data.

Navigation data suppliers must have a letter of acceptance (LOA) for processing navigation information (e.g., FAA AC 20-153 or a document on the conditions for the issuance of letters of acceptance to navigation data suppliers by the European Aviation Safety Agency – EASA (EASA IR 21 Sub-part G) or equivalent documents). An LOA recognises as data suppliers the one whose information quality, integrity and quality management practices are consistent with the criteria contained in document DO-200A/ED-76. The database suppliers of an operator must have a Type 2 LOA and its respective suppliers must have a Type 1 or 2 LOA. The Authority may accept an LOA issued to navigation data suppliers or issue its own LOA.

The operator must advise the navigation data supplier of any discrepancy that invalidates a route, or prohibit the use of the procedures involved through a notice to flight crews.

Operators must consider the need to conduct periodic verifications of the navigation databases in order to maintain the existing requirements of the quality system or safety management system.

7.11 Surveillance, investigation of navigation errors and withdrawal of RNP 4 approval

The operator will establish a process to receive, analyse and follow-up on navigation error reports in order to determine the appropriate corrective action.

The information on the potential of repetitive errors may call for a modification of the training programme of the operator.

Information that attributes multiple errors to the pilot may call for additional training or a license revision.

The occurrence of repetitive navigation errors attributed to a piece of equipment or a specific part of the navigation equipment or to operating procedures is a ground for the cancellation of the operational approval (withdrawal of RNP 4 approval from the OpSpecs or withdrawal of the LOA in the case of non-commercial operators).

8. RNP 2

8.1 General Considerations

8.1.1 Introduction

RNP 2 is primarily intended for a diverse set of en-route applications; particularly in geographic areas with little or no ground Navigational Aid (NAVAID) infrastructure, limited or no Air Traffic Service (ATS) surveillance, and low to medium density traffic. This Technical Standard provides guidance for RNP operations in airspace so specified. This Technical Standard does not address communications or surveillance requirements that may be specified to operate on a particular route or in a particular area.

8.1.2 Source Document

This Technical Standard for RNP 2 is based upon FAA Advisory Circular AC 90-105A, Appendix E.

8.2 Airworthiness and Operational Approval

In order to receive an RNP 2 approval, the operator must comply with two types of approval: airworthiness approval and operational approval. Compliance with airworthiness requirements by themselves does not constitute the operational approval.

8.3 Airworthiness Approval

8.3.1 Statement of compliance

Airworthiness approval must be granted to an applicant who submits a statement of compliance in the form of one of the following documents:

(1) An AFM or AFM supplement statement of compliance for RNP 2, in compliance with FAA AC 20-138 or an equivalent acceptable to the Executive Director;

(2) A pilot's operating handbook (or equivalent) or avionics system operating manual statement of compliance for RNP 2, in compliance with FAA AC 20-138 or recognised equivalent;

(3) Provided the granting of such approval will not compromise aviation safety.

8.3.2 Service Bulletin (SB)

Avionics or aircraft manufacturers may provide an SB for a pilot or equipment operating handbook entry, or other notification stating aircraft with the equipment in subparagraph 3. (d), and an appropriate airworthiness approval, has RNP 2 capability.

8.3.4 Approval basis

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

8.3.5 Qualified Avionics Equipment and Airworthiness Approval.

Aircraft with the following avionics equipment and an appropriate airworthiness approval automatically qualify for RNP 2 minima capability without further documentation by virtue of the avionics Technical Standard Order (TSO) and airworthiness approval:

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

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

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

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

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

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

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

8.3.6 Navigation equipment requirements

Navigation equipment for oceanic/remote continental RNP 2 operations, where higher continuity is specified, requires dual independent GPS LRNS. Navigation equipage for all RNP 2 domestic and offshore operations areas must have at least a single GPS LRNS.

8.3.7 Specification basis

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

8.3.7.1 Fault Detection and Exclusion (FDE) Function.

An FDE function must be available when conducting RNP 2 oceanic or remote continental operations.

8.3.7.2 GNSS Fault Detection.

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

8.3.7.3 GNSS Signal Interference.

RNP 2 must not be used in areas of known GNSS signal interference.

8.3.8 System performance, monitoring and alerting

8.3.8.1 Accuracy

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

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

8.3.8.2 Integrity

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

8.3.8.3 Continuity

For RNP 2 oceanic and remote continental operations, loss of function is a major failure condition. For RNP 2 in the U.S. National airspace system (NAS) or offshore airspace areas, loss of function is classified as a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable aerodrome.

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

8.3.8.4 Performance Monitoring and Alerting

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

8.3.8.5 Path Definition.

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

8.3.8.6 Signal in Space (SIS).

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

8.3.8.7 Maintenance requirements

Operators must have established maintenance procedures for all LRNS intended for use in RNP 2 operations.

8.3.9 Functional Requirements of Navigation Data Displays

8.3.9.1 Installation

The following navigation displays and functions are required and must be installed in accordance with AC 20-138 or equivalent airworthiness installation advisory material:

8.3.9.2 Navigation Data Displays.

Navigation data, including a TO/FROM indication and a failure indicator, must be displayed on a lateral deviation display (course deviation indicator (CDI), electronic horizontal-situation indicator (EHSI)) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation and for failure/status/integrity indication. A non-numeric lateral deviation display (e.g., CDI, EHSI), with a TO/FROM indication and a failure annunciation, for use as primary flight instruments for navigation of the aircraft, for manoeuvre anticipation, and for failure/status/integrity indication, must have the following attributes:

(1) The displays must be visible to the pilot and located in the primary field of view (FOV);

(2) The lateral deviation display scaling must agree with any alerting and annunciation limits;

(3) The lateral deviation display must have a full-scale deflection suitable for the current phase of flight and must be based on the required total system accuracy; ±2 NM for RNP 2. It is also acceptable for the scaling to be more conservative (e.g., ±1 NM for an RNP 2 route);

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

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

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

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

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

8.3.10 System Capabilities.

The following system capabilities are required as a minimum within any RNP 2 equipment:

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

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

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

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

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

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

Note 2: Due to variability in systems, this document defines the segment from the first occurrence of a named waypoint, track, or course to the last occurrence of a named waypoint, track, or course. Heading legs prior to the first named waypoint or after the last named waypoint do not have to be loaded from the database.

(6) The capability to automatically set RNP 2 from the onboard navigation database for each leg segment of a RNP 2 route or procedure;

(7) For RNP 2 tracks in oceanic/remote continental airspace using flexible (e.g., organized) tracks, a means to enter the unique waypoints required to build a track assigned by the ATS provider. Manual entry or creation of new waypoints is permitted, by manual entry of latitude and longitude;

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

(a) The active navigation sensor type,

(b) The identification of the active (To) waypoint,

(c) The ground speed and time to the active (To) waypoint;

(d) The distance and bearing to the active (To) waypoint;

(e) The capability to execute a "direct to" function; and

(f) The capability to execute a parallel offset.

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

(9) The capability for automatic leg sequencing with display to the pilots;

(10) The capability to automatically execute waypoint transitions and maintain track consistent with the RNP 2 performance requirements with the following Aeronautical Radio, Inc. (ARINC) Specification 424 path terminators:

(a) Course to Fix (CF),

(b) Direct to Fix (DF), and

(c) Track to Fix (TF).

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

(11) The capability to display an indication of the RNP 2 system failure in the pilot's primary FOV;

(12) The capability to indicate to the crew when the Navigation System Error (NSE) alert limit is exceeded (i.e., the alert provided by the onboard performance monitoring and alerting function);

(13) Capability for the crew to create, review and activate a flight plan;

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

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

8.3.11 Database Integrity.

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

8.3.12 Path Terminators.

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

8.3.13 Aircraft eligibility

Systems meeting the requirements in AC 20-138( ) are eligible for RNP 2 operations.

8.3.14 System operational requirements

8.3.14.1 Navigation equipment.

All RNP 2 operations in oceanic and remote continental areas must have at least dual independent GPS LRNS.

8.3.14.2 Configuration.

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

8.4 Operational Approval

8.4.1 Part 91 and 93 operators

The Executive Director will issue a Letter of Approval (LOA) once it has determined that the aircraft meets all applicable requirements for RNP 2 operations.

8.4.2 Part 121, 127 and 135 operators

The approval shall be included in the Ops Specs.

8.5 Operational considerations.

Applicants for operational approval for PBN 2 must comply with the operational considerations specified in this Technical Standard.

8.5.1 GNSS availability prediction programme.

The operator must have an approved GNSS availability prediction program ensuring the requisite availability of the GNSS FDE function. Prior to conducting RNP 2 operations oceanic or remote continental areas, the operator must use this prediction program prior to dispatch. In the event of a predicted, continuous loss of appropriate level of fault detection of more than 5 minutes for any part of the RNP 2 operation, the operator must revise the flight plan (e.g., delay the departure or plan a different route).

8.5.2 Pre-flight planning.

The following actions must be completed during pre-flight:

(1) Review maintenance logs and forms to ascertain the condition of equipment required for flight in RNP 2 airspace or on an RNP 2 route, and

(2) Ensure that maintenance action has been taken to correct defects to required equipment.

8.5.2.1 RAIM Availability Prediction

Domestic Operations.

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

Oceanic and Remote Continental Operations.

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

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

RAIM availability prediction software does not guarantee the service; rather, RAIM prediction tools assess the expected capability to meet the RNP. Because of unplanned failure of some GNSS elements, pilots and ANSPs must realize that RAIM or GNSS navigation may be lost while airborne, and this may require reversion to an alternative means of navigation. Therefore, pilots must prepare to assess their capability to navigate (potentially to an alternate destination) in case of failure of GNSS navigation.

8.5.3 General In-Flight Considerations.

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

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

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

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

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

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

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

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

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

All pilots must maintain centreline, as depicted by onboard lateral deviation indicators and/or flight guidance during all RNP operations described in this AC unless authorized to deviate by ATC, performing a Strategic Lateral Offset Procedure (SLOP), or under emergency conditions. For normal operations the permitted cross-track (XTK) error/deviation (the difference between the displayed path and the displayed aircraft position relative to the displayed path, (i.e., FTE)) is limited to half the RNP value associated with the procedure (i.e., 1 NM for RNP 2). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the RNP value (i.e., 2 NM for RNP 2), are allowable.

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

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

If ATC issues a heading assignment taking the aircraft off a procedure, the pilot may not modify the primary flight plan in the RNP system until a clearance is received to rejoin the route or the controller confirms a new route clearance. The specified accuracy requirement does not apply when the aircraft is not on the published RNP 2 procedure.

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

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

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

Emergency procedures for operations in RNP 2 airspace or on RNP 2 routes do not differ from normal oceanic emergency procedures with one exception, crews must be able to recognize and ATC must be advised when the aircraft is no longer able to navigate to its RNP 2 approved capability.

8.5.4 Prior to Commencing the RNP 2 Procedure.

In addition to normal operating procedures, prior to commencing the procedure the flight crew must accomplish the following:

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

(2) Where Controller-Pilot Data Link Communication (CPDLC) is used to uplink flight plan changes for routing that is not contained in the navigation database, the flight crew must confirm the RNP in effect matches the airspace requirement. If not, the flight crew must manually enter the RNP applicable to the route.

9. RNP 1

9.1 General Consideration

9.1.1 Navigation aid infrastructure

The GNSS is the main navigation system that supports RNP 1 operations.

Although RNP systems based on DME/DME are capable of providing RNP 1 accuracy, the use of this navigation specification has been foreseen mainly for environments where DME infrastructure cannot support DME/DME area navigation with the required performance.

The increased complexity in the DME infrastructure requirements and assessment make RNP 1 operations based on DME/DME impractical and unprofitable for a general application.

Route design must take into account the navigation performance that can be achieved with the available navigation aid (NAVAID) infrastructure. Although the requirements of RNAV 1 and RNAV 2 navigation systems are identical, NAVAID infrastructure can affect the required performance.

Air navigation service providers (ANSPs) must ensure that the operators of GNSS equipped aircraft have a means available to predict fault detection using an aircraft-based augmentation system (ABAS) [e.g., receiver autonomous integrity monitoring (RAIM)].

When applicable, the ANSPs must also ensure that the operators of aircraft equipped with a satellite-based augmentation system (SBAS) have a means to predict fault detection.

The prediction services may be provided by the ANSP, airborne equipment manufacturers or other entities.

Prediction services can only be for receivers that meet the minimum performance of a technical standard order (TSO) or be specific to the receiver design. The prediction service shall use status information on GNSS satellites and a horizontal alerting limit (HAL) appropriate for the operation (1 NM within 30 NM from the aerodrome and 2 NM otherwise).

Outages shall be identified in the event of a predicted, continuous loss of ABAS fault detection of more than 5 minutes for any part of the RNP 1 operation.

ANSPs must undertake an assessment of the NAVAIDS infrastructure. It must be demonstrated that the assessment is sufficient for the proposed operations, including reversionary modes.

9.1.4 Communications and ATS surveillance

The RNP 1 navigation specification is intended for use in environments where ATS surveillance is limited or not available.

RNP 1 SIDs and STARs are primarily intended to be conducted in direct controller-pilot communication environments.

9.1.5 Obstacle clearance and horizontal separation

Doc 8168 (PANS OPS), Volume II, provides detailed guidance on obstacle clearance. The general criteria contained in Parts I and III of said document apply.

The obstacle clearance criteria for SIDs, STARs, initial and intermediate approach, final missed approach, holding pattern, and route of the RNP 1 navigation specification are described in Doc 8168 (PANS-OPS), Volume II, Part III.

Obstacle clearance criteria for final approach and for initial and intermediate missed approach are specific to the classification of non-precision approaches (NPA), approaches with vertical guidance (APV) and precision approaches (PA).

9.1.6 Publications Requirements

SIDs, STARs and RNP 1 procedures must be based on normal descent profiles and identify minimum altitude requirements of the segments.

All procedures must be based on the coordinates of the world geodetic system - 84 (WGS-84).

The AIP must clearly indicate whether the navigation application is RNP 1.

The available navigation infrastructure must be clearly designated in all the appropriate charts (e.g., GNSS).

The required navigation standard (e.g., RNP 1) for all RNP 1 procedures must be clearly designated in all the appropriate charts.

9.1.7 Additional considerations

For procedure design and infrastructure evaluation, it is assumed that 95% of the normal limit value of the FTE, defined in the operating procedures, is 0.5 NM for the RNP 1 navigation specification.

The default value of the alerting functionality of a TSO-C129a sensor (stand-alone or integrated) switches between terminal alerting (± 1 NM) and en-route alerting (± 2 NM) at 30 miles from the airport reference point (ARP).

9.2 Airworthiness and Operational Approval

For a commercial air transport operator to be granted a RNP 1 approval, it must comply with two types of approvals:

(1) The airworthiness approval, issued by the State of registry; and
(2) The operational approval, issued by the State of the operator.

For general aviation operators, the State of registry determines whether or not the aircraft meets the applicable RNP 1 requirements and issues the operational approval (e.g., letter of authorisation – LOA). The Authority issues a letter of approval accompanied by a PBN certificate for the applicable navigation standards per aircraft type.

A separate application shall be submitted for each navigation specification and aircraft type.

Before filing the application, operators must review all aircraft qualification requirements. Compliance with airworthiness requirements or equipment installation alone does not constitute operational approval.

9.3 Airworthiness Approval

9.3.1 System and aircraft requirements - Description of the RNP navigation system

9.3.1.1 Lateral navigation (LNAV)

In LNAV, the RNP equipment allows the aircraft to fly in accordance with the appropriate route instructions along a path defined by waypoints (WPTs) contained in an on-board navigation database.

Note: LNAV is normally a mode of flight guidance systems, in which the RNP equipment provides path steering commands to the flight guidance system, which controls the FTE through the manual pilot control on a path deviation display or through the coupling of the flight director (FD) or automatic pilot (AP).

For purposes of this TS, RNP 1 operations are based on the use of RNP equipment that automatically determines the position of the aircraft on the horizontal plane, using data input from the GNSS.

9.3.1.2 System performance, control, and alerting

9.3.1.2.1 Accuracy

For operations in RNP 1 designated airspace or routes, total lateral system error must not exceed $\pm$ 1 NM during at least 95% of total flight time. Likewise, along-track error must not exceed $\pm$ 1 NM during

at least 95% of total flight time. In order to meet the accuracy requirement, 95% of the flight technical error (FTE) must not exceed 0.5 NM.

Note: The use of a deviation indicator with a full-scale deflection of 1 NM constitutes an acceptable means of compliance. The use of a flight director (FD) or an automatic pilot (AP) also represents an acceptable means of compliance (roll stabilization systems do not meet the requirements).

9.3.1.2.2 Integrity

Malfunctioning of the aircraft navigation equipment is classified as a major failure according to airworthiness regulations (e.g., 10^{-5} per hour).

9.3.1.2.3 Continuity

Loss of function is classified as a minor failure if the operator can revert to a different navigation system and proceed to an appropriate aerodrome.

9.3.1.2.4 Performance monitoring and alerting

The RNP system or the RNP system in combination with the pilot will provide an alert if the accuracy requirement is not met, or if the probability that the lateral total system error (TSE) exceeds 2 NM is greater than 10^{-5} per hour.

9.3.1.2.5 Signal-in-space

If GNSS is used, the aircraft navigation equipment will provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds 10^{-7} per hour.

9.3.2 Aircraft eligibility requirements for RNP 1 operations in terminal area

The following systems installed in the aircraft meet the requirements defined in this Technical Standard. This equipment requires evaluation by the manufacturer and operator against all the functional and performance requirement established in this Technical Standard.

(1) Aircraft with E/TSO-C129a Class A1 system or E/TSO-C146 ( ) system installed for IFR use in accordance with FAA AC 20-138 or AC 20-138A;
(2) Aircraft with E/TSO-C129/C129a sensor (Class B or C) installed in a flight management system (FMS) that meets the criteria of TSO-C115b and installed for IFR use in accordance with AC 20-130A;
(3) Aircraft with E/TSO-C145 ( ) sensor installed in an FMS that meets TSO-C115b requirements and installed for IFR use in accordance with FAA AC 20-130A or AC 20-138A; and
(4) Aircraft with certified RNP capability, or approved based on equivalent standards.

9.3.3 System eligibility requirements for RNP 1 operations

9.3.3.1 Stand-alone systems

Stand-alone E/TSO-C129 Class A1 or A2 systems (without deviation from AC 91-008 functional requirements) or E/TSO-C146 Class 1, 2 or 3 systems (without deviation of functional requirements establish in this Technical Standard) meet aircraft qualification requirements for RNP 1 operations. GNSS systems must be approved in accordance with AC 20-138A.

9.3.3.2 Multi-sensor systems

Multi-sensor systems using E/TSO-C129 Class B o C sensors or E/TSO-C145 Class 1, 2 and 3 sensors, meet aircraft qualification requirements for RNP 1 operations, provided that the installations comply with the criteria of this Technical Standard. RNP systems must be installed in accordance with AC 20-138A and the associated FMS must comply with E/TSO-C115b and AC 20-130A.

9.3.4 Aircraft qualification documentation

Aircraft or avionics manufacturers must produce aircraft qualification documentation showing compliance with the applicable criteria, as appropriate. For aircraft not approved for flying RNP 1 procedures, aircraft and avionics manufacturers must develop aircraft qualification documentation showing compliance with this TS, provided the equipment is properly installed and operated. The necessary documentation must also define the appropriate maintenance procedures. This documentation is not required for aircraft that have an AFM or AFM supplement that explicitly states that the RNP system is approved for operations with values of RNP 1 or lower, and that the equipment meets the reliability and performance requirements of the following documents: AC 20-138A, AC 20-130A, E/TSO-C115b and AC 20-129, as applicable.

Operators must submit this documentation, together with the formal application, in Phase 2 of the approval process.

9.3.4.1 Acceptance of documentation by the Authority

9.3.4.1.1 For new aircraft/equipment (capability shown in production)

The new aircraft/equipment qualification documentation may be approved as part of an aircraft certification project, and will be reflected in the AFM and related documents.

9.3.4.1.2 For aircraft/equipment in use

Previous approvals to conduct RNAV 1 procedures using the GNSS (GPS), according to AC 91-003 or AC 90-100/AC 90-100A, do not require an additional assessment, provided it is shown that the RNAV equipment meets the on-board performance monitoring and alerting requirements. For installations/equipment that are not eligible for conducting RNP 1 procedures, the operator must send

the RNP 1 and aircraft qualification documentation to the corresponding bodies of the Authority (e.g., Aircraft certification division or Airworthiness inspection division, or equivalents).

The corresponding bodies of the Authority, where appropriate, will accept the data package for RNP 1 operations. This acceptance must be documented in a letter to the operator.

9.3.4.1.3 Aircraft and systems eligibility for RNP 1 operations in terminal area

Aircraft that have a statement of compliance with respect to the criteria set forth in this Technical Standard or equivalent document (e.g., FAA AC 90-105 Appendix 2) in the AFM, AFM supplement, pilot operating handbook (POH) or avionics operating manual, meet the performance and functional requirements of this Technical Standard.

Aircraft that have a statement by the manufacturer documenting compliance with the criteria set forth in this Technical Standard or equivalent meet the performance and functional requirements of this document. This statement must include the airworthiness basis for compliance. The aircraft or equipment manufacturer must determine compliance with sensor requirements, while the operator will determine, through inspection, compliance with the functional requirements of this document.

For modified aircraft, the original equipment manufacturer (OEM) or the holder of the aircraft installation approval, e.g., the holder of a supplemental type certificate (STC), must demonstrate compliance to the Authority, and the approval can be submitted in the documentation of the manufacturer (e.g., service letters).

Stand-alone GNSS systems must be approved according to E/TSO-C129a Class A1 or E/TSO-C146 and operational Class 1, 2 or 3 (with no deviation from the functional requirements described in this Technical Standard), and installed for IFR use in accordance with AC 20-138A.

Aircraft with E/TSO-C129a sensor(s) Class B or C or E/TSO-C145 sensor(s) and FMS that meet E/TSO-C115b requirements and are installed for IFR use according to FAA AC 20-130A.

Aircraft/equipment approved under SRVSOP AC 91-003 or equivalent (e.g., FAA AC 90-100A) for the use of GNSS, are approved under this Technical Standard for RNP 1 operations.

RNP aircraft with P-RNAV approval based on GNSS capability meet the functional requirements of this Technical Standard for RNP 1 operations, such as SIDs and STARs. The GNSS system approved according to E/TSO-C129 and satisfying the step-detection and health word checking contained in E/TSO-C129A, meets P-RNAV performance requirements.

Note: RNP 1 operations are based on GNSS positioning. Positioning data from other navigation sensors can be integrated into GNSS data provided they do not cause position errors that exceed the total system

error (TSE) budget. Otherwise, means to deselect or cancel the other types of navigation sensors must be provided.

9.3.4.2 Functional requirements

The following table contains the functional requirements that meet the criteria of this document.

Functional requirements

Paragraph	Functional requirements	Explanation
a)	Navigation data, including the to/from indication and a failure indicator, must be displayed on a lateral deviation display [*e.g.*, a course deviation indicator (CDI), an enhanced horizontal situation indicator (E)HIS) and/or a navigation map display]. These lateral deviation displays will be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation, and for indication of failure/status/integrity. They must meet the following requirements:	1) Non-numeric lateral deviation display (e.g. CDI, (E)HSI)), with a to/from indication and a failure annunciation, for use as primary flight instruments for navigation of the aircraft, for manoeuvre anticipation, and for failure/status/integrity indication, with the following five attributes: (a) The displays must be visible to the pilot and located in the primary field of view (±15 degrees from the pilot's normal line of sight) when looking forward along the flight path. (b) The lateral deviation display scaling must agree with any alerting and annunciation limits, if implemented. (c) The lateral deviation display must also have a full-scale deflection suitable for the current phase of flight and must be based on the required total system accuracy. (d) The display scaling may be set automatically by default logic or set to a value obtained from a navigation database. The full-scale deflection value must be known or must be available for display to the pilot commensurate with en-route, terminal, or approach values. (e) The lateral deviation display must be automatically slaved to the

Paragraph	Functional requirements	Explanation
		RNP computed path. The course selector of the deviation display should be automatically slewed to the RNP computed path. Note.- The normal functions of the autonomous GNSS meet this requirement. 2) As an alternate means, a navigation map display must give equivalent functionality to a lateral deviation display as described in Paragraph a) 1) from (a) to (e), with appropriate map scales which may be set manually by the pilot. Note.- A number of modern aircraft eligible for this specification use a map display as an acceptable means to meet the prescribed requirements.

b)	The following functions of the RNP 1 system are required as a minimum:	(1) The capability to continuously display to the pilot flying (PF), on the primary flight navigation instruments (primary navigation displays), the RNP calculated desired path and the position of the aircraft relative to that path. For operations where the minimum flight crew consists of two pilots, the means for the pilot not flying (PNF) the aircraft or monitoring pilot (MP) to verify the desired path and the aircraft position relative to that path must also be provided; (2) A navigation database containing current navigation data officially issued for civil aviation, which can be updated in accordance with the aeronautical information regulation and control (AIRAC) cycle and from which ATS routes can be retrieved and loaded into the RNP system. The resolution of the stored data must be sufficient to achieve an insignificant path definition error (PDE). The database must be protected against any modification of the stored data by the flight crew; (3) The means to display to the flight crew the period of validity of the navigation database; (4) The means to retrieve and display the data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the flight crew to verify the route to be flown; and (5) The capability to load on the RNP 1 system, from the navigation database, the complete RNP segment of the SIDs or STARs to be flown. Note.- Due to the variability of RNP systems, this document defines the

Paragraph	Functional requirements	Explanation
		RNP segment from the first occurrence of a named WPT, track or course up to the last occurrence of a named WPT, track or course. Legs or segments prior to the first named WPT or after the last named WPT must not be loaded from the navigation database. Heading legs prior to the first named WPT or after the last named WPT do not have to be loaded from the navigation database. The complete SID must be considered in the RNP 1 procedure.
c)	The means to display the following items, either on the primary field of view of the pilots, or on a readily accessible display page [*e.g.*, on a multi-function control display unit (MCDU)]:	(1) The active navigation sensor type; (2) The identification of the active (to) waypoint; (3) The ground speed or time to the active (to) waypoint; and (4) The distance and bearing to the active (to) waypoint.
d)	The capability to execute a "direct to" function.	
e)	The capability for automatic leg sequencing with the display of sequencing to the flight crew.	
f)	The capability to execute RNP 1 terminal procedures extracted from the on-board database, including the capability to execute flyover and fly-by turns.	
g)	The aircraft must have the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent:	Note 1.- Path terminators are defined in the ARINC 424 specification, and their application is described in more detail in RTCA documents DO-236B and

Paragraph	Functional requirements	Explanation
	i.Initial fix (IF); ii.Course to a fix (CF); iii.Direct to a fix (DF); and iv.Track to a fix (TF).	DO-201A and in EUROCAE ED-75B and ED-77 Note 2.- Numeric values for courses and tracks must be automatically loaded from the RNP system database.
h)	The aircraft must have the capability to automatically execute leg transitions consistent with the following ARINC 424 path terminators: heading to an altitude (VA), heading to a manual termination (VM) and heading to an intercept (VI), or must be able to be manually flown on a heading to intercept a course or to fly direct to another fix after reaching an altitude of a specific procedure.	
i)	The aircraft must have the capability to automatically execute leg transitions consistent with the following ARINC 424 path terminators: course to an altitude (CA) and course from a fix to a manual termination (FM), or the RNP system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint.	
j)	The capability to load an RNP 1 procedure from the database into the RNP system by its name.	
k)	The capability to display an indication of the RNP 1 system failure in the pilot´s primary field of view.	

Paragraph	Functional requirements	Explanation
l)	Database integrity	The navigation database suppliers must comply with RTCA DO-200/EUROCAE document ED 76 - Standards for processing aeronautical data. A Letter of acceptance (LOA) issued by the appropriate regulatory authority to each of the participants in the data chain is a means of demonstrating compliance with this requirement. Discrepancies that invalidate a route must be reported to database suppliers and the affected routes must be prohibited through a notice from the operator to its flight crews. Aircraft operators must consider the need to conduct periodic checks of the navigation databases in order to meet existing safety system requirements.

9.3.5 Continued airworthiness

The operators of aircraft approved to perform RNP 1 operations, must ensure the continuity of the technical capacity of them, in order to meet technical requirements established in this Technical Standard.

Each operator who applies for RNP 1 operational approval must submit to the Authority of the State of registry, a maintenance and inspection programme that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the -RNP 1 approval criteria.

The following maintenance documents must be revised, as appropriate, to incorporate RNP 1 aspects:

(1) Maintenance control manual (MCM);
(2) Illustrated parts catalogues (IPC); and
(3) Maintenance programme.

The approved maintenance programme for the affected aircraft must include maintenance practices listed in maintenance manuals of the aircraft manufacturer and its components, and must consider:

(1) that equipment involved in the RNP 1 operation must be maintained according to directions given by manufacturer's components;
(2) that any amendment or change of navigation system affecting in any way RNP 1 initial approval, must be forwarded and reviewed by the Authority for its acceptance or approval of such changes prior to its implementation; and
(3) that any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, must be forwarded to the Authority for acceptance or approval thereof.

Within the RNP 1 maintenance documentation must be presented the training programme of maintenance personnel, which inter alia, must include:

(1) PBN concept;
(2) RNP 1 application;
(3) equipment involved in an RNP 1 operation; and
(4) MEL use.

9.4 Operational Approval

Airworthiness approval alone does not authorise an applicant or operator to conduct basic RNP 1 operations. In addition to the airworthiness approval, the applicant or operator must obtain an operational approval to confirm the suitability of normal and contingency procedures in connection to the installation of a given piece of equipment.

Concerning commercial air transport, the assessment of an application for RNP 1 operational approval is done by the State of the operator, in accordance with standing operating rules (e.g., Part 121, 127 and 135 and relevant Operational Directive) supported by the criteria described in this Technical Standard.

For general aviation, the assessment of an application for RNP 1 operational approval is carried out by the State of registry, in accordance with standing operating rules (Part 91 and 93) supported by the criteria established in this Technical Standard.

9.4.1 Requirements to obtain operational approval

9.4.1.1 Requirements

In order to obtain RNP 1 approval, the applicant or operator must take the following steps, taking into account the criteria established in this paragraph and in the following paragraphs.

(1) Airworthiness approval.- Aircraft must have the corresponding airworthiness approvals, pursuant to this Technical Standard;
(2) Application.- The operator must submit the following documentation to the Authority:

(a) RNP 1 operational approval application;
(b) Description of aircraft equipment - The operator must provide a configuration list with details of the relevant components and the equipment to be used for RNP 1 operations. The list must include each manufacturer, model, and equipment version of GNSS equipment and software of the installed FMS;
(c) Airworthiness documents related to aircraft eligibility - The operator must submit relevant documentation, acceptable to the Authority, showing that the aircraft is equipped with RNP systems that meet the RNP 1 requirements, as described in this Technical Standard. For example, the operator must submit the parts of the AFM or AFM supplement that contain the airworthiness statement;
(d) Training programme for flight crews and, where applicable, for flight dispatchers / flight operations officers Operators must present to the Authority the RNP 1 training curriculums to show that the operational procedures and practices and the training aspects have been included in the initial, upgrade or recurrent training curriculums for flight crews and flight dispatchers;
Note: It is not necessary to establish a separate training programme if the RNP 1 training identified in this Technical Standard has already been included in the training programme of the operator. However, it must be possible to identify what aspects of RNP 1 are covered in the training programme.
(e) Operations manual and checklists;
Note: Operators must review the operations manual (OM) and the checklists in order to include information and guidance on the operating procedures detailed in this Technical Standard. The appropriate manuals must contain the operating instructions for navigation equipment and contingency procedures. The manuals and checklists must be submitted for review along with the formal application in Phase 2 of the approval process.
(f) Minimum Equipment List (MEL) - The operator must send to the Authority for approval any revision to the MEL that is necessary to conduct RNP 1 operations. If an RNP 1 operational approval is granted based on a specific operational procedure, operators must modify the MEL and specify the required dispatch conditions;
(g) Maintenance - The operator must submit for approval a maintenance programme to conduct RNP 1 operations;
(h) Training programme for personnel - Operators must submit the training curriculums that correspond to personnel in accordance with Section 9.7 of this Technical Standard.
(i) Navigation data validation programme - The operator must present the details about the navigation data validation programme;

(3) Training - Once the amendments to manuals, programmes, and documents submitted have been accepted or approved, the operator must provide the required training to its personnel.
(4) Validation flight - The Authority may deem it advisable to perform a validation flight before granting the operational approval. Such validation may be performed on commercial flights.

9.4.1.2 Issuance of the approval to conduct RNP 1 operations

Once the operator has successfully completed the operational approval process, the Authority must grant the operator the approval to conduct RNP 1 operations provided that the said operations are conducted in accordance with the applicable regulations and procedures and that the granting of such approval will not compromise aviation safety.

9.4.1.2.1 Commercial Operators

The Authority will issue the corresponding operations specifications (OpSpecs) that will reflect the basic RNP 1 approval.

9.4.1.2.2 Private Operators

The Authority will issue a letter of approval.

9.5 Operating Procedures

The operator and the flight crews must become familiar with the following operating and contingency procedures associated with RNP 1 operations.

9.5.1 Pre-flight planning

9.5.1.1 General

On-board navigation data must be current and include appropriate procedures.

Note: It is expected that the navigation database will be up to date during the operation. If the AIRAC cycle expires during the flight, operators and pilots must establish procedures to ensure the precision of navigation data, including the suitability of navigation facilities used to determine the routes and procedures for the flight. Normally, this is done comparing electronic data with written documents. An acceptable means of compliance is to compare aeronautical charts (new and old) to check navigation reference points before dispatch. If an amended chart is published for the procedure, the database must not be used to conduct the operation.

The availability of the NAVAID infrastructure required for the intended routes, including any non-RNP contingency, must be confirmed for the period of intended operations, using all available information. Since Annex 10 Volume I requires GNSS integrity (RAIM or SBAS), it is also necessary to confirm appropriate availability of these devices. For aircraft that navigate with SBAS receivers [all TSO-C145 ( ) / C146 ( ) receivers], operators must confirm appropriate availability of the GNSS RAIM in areas where the SBAS signal is not available.

9.5.1.2 RAIM (ABAS) availability

RAIM levels required for RNP 1 can be verified either through NOTAMs (where available) or through prediction services. Operators must be familiar with the prediction information available for the intended route.

For systems whose integrity is based on RAIM, RAIM prediction must be done before departure. This capability may be provided by a ground service or through the RAIM prediction capability of the aircraft on-board receiver.

The prediction of RAIM availability must take into account the last NOTAMs of the GPS constellation and the avionics model (if available). The RAIM prediction service can be provided through the ANSPs, the avionics manufacturers, other entities, or through the RAIM prediction capability of the aircraft on-board receiver. RAIM availability can be confirmed using a model-specific RAIM prediction software.

The predictive capability must account for known and predicted outages of GPS satellites or other effects on the navigation system sensors. The prediction programme must not use a mask angle below 5 degrees, since operational experience indicates that satellite signals on low elevations are not reliable. RAIM availability prediction must take into account the latest GPS constellation notices to airmen (NOTAMs) issued by the Authority or by the ANSPs, and use an identical algorithm to that used in the airborne equipment or an algorithm based on assumptions for RAIM prediction that provides a more conservative result.

In the event that a continuous loss of the appropriate failure detection level is forecast for more than five (5) minutes for any portion of the RNP 1 operation, the flight plan must be revised (e.g., delaying the departure or planning a different departure procedure).

The RAIM availability prediction software does not guarantee the service. This software is only a tool for assessing the expected capacity to meet the required navigation performance. Due to unplanned failures of some GNSS elements, pilots and ANSPs must understand that both RAIM and GNSS navigation can be lost while the aircraft is on flight, which may require reversal to an alternate means of navigation. Therefore, pilots must assess their navigation capabilities (potentially to an alternate aerodrome) in case of failure of GNSS navigation. If system integrity needs to be verified, the RAIM prediction programme must meet the criteria of FAA AC 20-138, or equivalent standard.

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

9.5.2 General operating procedures

The pilot must comply with any instruction or procedure identified by the manufacturer, as necessary, to meet the performance requirements of this section.

Note: Pilots must adhere to any AFM limitation or operating procedure required to maintain RNP 1 performance.

Operators and pilots may not request or file RNP 1 routes, SIDs or STARs, unless they meet all the criteria set forth in this Technical Standard. If an aircraft that does not meet these criteria and is cleared by the ATC to conduct a RNP 1 procedure, the pilot must notify the ATC that he or she cannot accept such clearance and therefore will request alternate instructions;

9.5.2.1 System Initialisation

At system initialization, pilots must:

(1) Confirm that the navigation database is current;
(2) Verify that the aircraft position has been entered correctly;
(3) Verify the appropriate entry of the assigned ATC route once they receive the initial clearance, and of any subsequent change in route; and
(4) Ensure that the sequence of WPTs as depicted in their navigation system matches the route drawn in the appropriate charts and the assigned route.

Pilots may not fly a RNP 1 procedure, unless it can be retrievable from the on-board navigation database by its name, and conforms with the procedure in the chart. However, the procedure can be modified afterwards by inserting or deleting specific WPTs in response to ATC clearance. Manual entry or the creation of new WPTs through manual insertion of latitude and longitude or rho/theta values is not permitted. Likewise, pilots may not change any type of WPT from a fly-by WPT to a flyover WPT or vice versa.

Flight crews must cross-check the cleared flight plan by comparing charts or other applicable resources to the navigation system text displays and aircraft map displays, as applicable. If required, the exclusion of specific NAVAIDs must be confirmed. A procedure may not be used where there are any doubts about the validity of the procedure in the navigation database.

Note: Pilots may note a small difference between the navigation information described in the chart and the primary navigation display. Differences of 3° or less may result from applying the magnetic variation to the equipment of the manufacturer, and these are operationally acceptable.

A cross-check is not required for conventional NAVAIDs, since the absence of integrity alert is considered sufficient to meet integrity requirements. However, it is suggested that the navigation reasonableness be checked, and any loss of RNP capability must be reported to the ATC.

9.5.2.2 Lateral Deviation Indictor

For RNP 1 procedures, pilots must use a lateral deviation indicator, an FD or an AP in lateral navigation mode (LNAV). Pilots of aircraft with a lateral deviation display must make sure that the lateral deviation scale is appropriate for the navigation precision associated to the route/procedure (e.g., full-scale deflection: ± 1 NM for RNP 1).

All pilots must follow the route centreline, as represented on the on-board lateral deviation indicators and/or flight guidance, during all RNP 1 operations, unless cleared by the ATC to deviate or due to an emergency.

9.5.2.3 Cross Track Error

For normal operations, the cross-track error/deviation (the difference between the path estimated by the RNP system and the position of the aircraft relative to the path, e.g. FTE) is limited to ± ½ the navigation precision associated with the procedure (e.g., 0.5 NM for basic RNP 1). Small lateral deviations from this requirement are allowed (e.g., overshooting or undershooting the path) during or immediately after a turn, up to a maximum of 1 times the navigation precision (1xRNP) (e.g., 1 NM for basic RNP 1).

Note: Some aircraft do not display or do not estimate a path during turns. Pilots of such aircraft may not be capable of meeting the ± ½ precision requirement during enroute turns; however, they must be able to meet interception requirements after the turn or in straight segments.

9.5.2.4 Enroute Considerations

If ATC issues a course assignment that places the aircraft out of the route, the pilot may not modify the flight plan in the RNP system until a new clearance is received allowing the aircraft to return to the route or until the controller confirms a new route clearance. When the aircraft is not on the published RNP 1 route, the specified precision requirements do not apply.

Manual selection of functions that limit the banking angle of the aircraft can reduce the ability of the aircraft to maintain its desired track and is not recommended. Pilots should acknowledge that manual selection of functions that limit the banking angle of the aircraft could reduce their ability to meet ATC path expectations, especially when turns with large banking angles are performed. This cannot be construed as a requirement to deviate from AFM procedures. Pilots must be encouraged to select such functions only within accepted procedures.

Pilots operating aircraft that have a barometric vertical navigation system (baro-VNAV) can continue using said system while conducting RNP 1 SID and STAR procedures. Operators must ensure compliance with all altitude limitations, as published in the procedure, using the barometric altimeter as reference. Use of the barometric vertical navigation capability of the aircraft is subject to the level of familiarisation and training of the flight crew, and on any other operational approval requirement.

9.5.3 Prior to commencing an RNP 1 operation

Before starting an RNP 1 procedure, flight crews must:

(1) Confirm that the correct procedure has been selected. This process includes verifying WPT sequence, the reasonableness of track angles, distances, and of any other parameter that can be modified by the pilot, such as altitude or speed constraints; and
(2) For multi-sensor systems, verify that the correct sensor is being used for position computation.

9.5.3.1 Aircraft with RNP selection capability

Pilots of aircraft with the capability of selecting RNP input must select RNP 1 or lower for RNP 1 SIDs, STARs or procedures.

9.5.4 RNP 1 SID specific requirements

Before beginning take-off, the pilot must verify that the airborne RNP 1 system is available and operating correctly, and that the appropriate aerodrome and runway data have been loaded. Before the flight, pilots must verify that the airborne navigation system is operating correctly and that the appropriate runway and departure procedure (including any applicable en-route transition) have been loaded and are properly displayed. Pilots who have been assigned to a RNP 1 departure procedure and who subsequently receive a change of runway, procedure or transition, must verify that the appropriate changes have been entered and are available for navigation before take-off. A final check of proper runway entry and correct route depiction, shortly before take-off, is recommended.

9.5.4.3 Altitude for engagement the RNAV equipment

The pilot must be capable of connecting the RNP equipment in order to follow the flight guidance in the RNP lateral navigation mode before reaching 153 m (500FT) above the aerodrome elevation.

9.5.4.4 Appropriate level of performance

Pilots must use an authorised method (lateral deviation indicator/navigation map display/FD/AP) to achieve an appropriate level of performance for RNP 1.

When a GNSS is used, the signal must be obtained before starting the take-off roll. For aircraft using E/TSO-C129a equipment, the take-off aerodrome must be loaded into the flight plan in order to achieve the appropriate navigation system monitoring and sensitivity. For aircraft using E/TSO-C145 /C146 equipment, if the departure starts at a runway waypoint (WPT), then the departure aerodrome does not need to be in the flight plan in order to obtain the appropriate monitoring and sensitivity mentioned above. If an RNP 1 SID extends beyond 30 NM from the aerodrome and a lateral deviation indicator is used, its full-scale sensitivity must be set to a value not greater than 1 NM between 30 NM from the aerodrome and the termination of the RNP 1 SID.

For aircraft using a lateral deviation display (e.g., a navigation map display), the scale must be adjusted for the RNP 1 SID and FD or AP must be used.

9.5.5 RNP 1 STAR specific requirements

Before the arrival phase, the flight crew must verify that the correct terminal route has been loaded. The active flight plan must be checked, comparing the charts to the map display (if applicable) and the multi-function control display unit (MCDU). This includes confirmation of WPT sequence, the reasonableness of track angles and distances, any altitude or speed constraints, and, whenever possible, which are fly-by WPTs and which are flyover WPTs. If required by a route, a check must be made to confirm that updating will exclude a particular NAVAID. A route may not be used where there are doubts about its validity in the navigation database.

Note: As a minimum, verifications in the arrival phase may consist of a simple inspection of a suitable map display that will meet the objectives of this paragraph.

The creation of new WPTs by the flight crew through manual entries into the RNP 1 system will invalidate any route, and is not permitted.

When contingency procedures require reverting to a conventional arrival route, the flight crew must make the necessary preparations before starting the RNP 1 procedure.

Modification made to a route in the terminal area may take the form of radar headings or “direct to” clearances. In this sense, the flight crew must be capable of reacting in time. This may include the insertion of tactical WPTs loaded from the database. The flight crew may not make manual entries or to modify a loaded route, using temporary WPT or fixes not provided in the database.

Pilots must verify that the aircraft navigation system is operating properly and that the correct arrival procedure and runway are properly entered and displayed.

Although a particular method is not mandated, any published altitude and speed constraints must be observed.

For Aircraft with E/TSO-C129a GNSS RNP systems, if an RNP 1 STAR begins beyond 30 NM from the aerodrome and a lateral deviation indicator is used, its full-scale sensitivity must be set to a value not greater than 1 NM before commencing the STAR. For aircraft that use a lateral deviation display (e.g., a navigation map display), the scale must be adjusted to the RNP 1 STAR and the FD or AP must be used.

9.6 Contingency procedures

The pilot must notify the ATC of any loss of RNP capability (integrity alerts or loss of navigation), together with the proposed course of action. If, for any reason, it is not possible to meet the requirements of a RNP 1 SID or STAR, pilots must notify the ATS as soon as possible. Loss of RNP capability includes any failure or event that causes the aircraft to be unable to meet the RNP 1 requirements of the route.

In case of a communication failure, the flight crew must continue with the established procedure for loss of communication.

9.7 Training Programmes

The training programme for flight crews and flight dispatchers shall provide sufficient training (e.g., using flight training devices, flight simulators and aircraft) on the RNP system to the extent necessary. The training programme will include the following topics:

(1) Information about this Technical Standard;
(2) The meaning and proper use of aircraft equipment and navigation suffixes;
(3) The procedures characteristics as determined from chart depiction and textual description;
(4) The depiction of WPTs types (fly-by and flyover) and ARINC 424 path terminators provided in Table 9.3.4 to this Technical Standard and any other types used by the operator, as well as those associated with the aircraft flight paths;
(5) The navigation equipment required to conduct RNP 1 SIDs and STARs;
(6) Specific information on the RNP system:
    (a) Levels of automation, annunciation modes, changes, alerts, interactions, reversals, and degradation;
    (b) Integration of functions with other aircraft systems;
(7) The meaning and appropriateness of route discontinuities as well as related flight crew procedures;
(8) Pilot procedures consistent with the operation;
(9) Types of navigation sensors (e.g., GNSS) used by the RNP system and associated system prioritization, weighting and logic;
(10) Turns anticipation, taking into account the effects of speed and altitude;
(11) Interpretation of electronic displays and symbols;
(12) Understanding aircraft configuration and operational conditions required to support Basic RNP 1 operations; e.g., appropriate selection of the lateral deviation indicator (CDI) scaling;
(13) Operating procedures for RNP equipment, as applicable, including how to perform the following:
    (a) Verify currency and integrity of aircraft navigation data;
    (b) Verify the successful completion of RNP system self-tests;
    (c) Initialize RNP system position;
    (d) Retrieve and fly an RNP 1 SID or STAR with the appropriate transition;
    (e) Adhere to speed and altitude constraints associated with an RNP 1 SID or STAR;
    (f) Select the appropriate RNP 1 SID or STAR for the active runway and become familiar with the procedures to deal with a runway change;

(g) Verify WPTs and flight plan programming;
(h) Fly direct to a WPT;
(i) Fly a course/track to a WPT;
(j) Intercept a course/track;
(k) Fly radar vectors and rejoining an RNP 1 route from a "heading" mode;
(l) Determine cross-track errors and deviations; specifically, the maximum allowable deviations to support RNP 1 must be understood and respected;
(m) Resolve route discontinuities (insert and delete/eliminate en-route discontinuities);
(n) Remove or reselect the navigation sensor inputs;
(o) When required, confirm the exclusion of a specific NAVAID or a type of navigation aid;
(p) Change the arrival and alternate aerodromes;
(q) Perform parallel offset if that capability is available. Pilots must know how to apply offsets, the functionality of the particular RNP system, and the need to advise the ATC if this functionality is not available; and
(r) Perform RNP holding pattern functions (e.g., insert or delete a holding pattern).

(14) Levels of automation recommended by the operator for each flight phase and workload, including the methods to minimise cross-track error that will permit the aircraft to follow the route centreline;
(15) Radiotelephony phraseology used for RNP applications; and
(16) RNP failure contingency procedures.

9.8 Navigation Database

The operator must obtain the navigation database from a supplier that complies with RTCA (Radio Technical Commission for Aeronautics) document DO 200A/EUROCAE ED 76 – Standards for aeronautical data processing. Navigation data must be compatible with the foreseen function of the equipment (see ICAO Annex 6 Part I paragraph 7.4). A letter of acceptance (LOA) issued by the appropriate regulatory authority to each participant in the data chain must show compliance with this requirement (e.g., FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA IR 21 Subpart G).

The operator must advise the navigation data supplier of discrepancies that invalidate a SID or STAR, and prohibit their use through a notice to flight crews.

Operators must consider the need to check the navigation database periodically in order to maintain the requirements of the existing quality system or safety management system.

Note: In order to minimise the path definition error (PDE), the database must comply with DO 200A or there must be an equivalent operational means available to ensure database integrity for the RNP 1 SIDs or STARs.

9.9 Oversight, Investigation of Navigation Errors, AND Withdrawal of RNP 1 Approval

The operator must establish a procedure to receive, analyse, and follow up on navigation error reports in order to determine appropriate corrective action.

Information indicating a potential for repetitive errors may require the modification of the training programme of the operator.

Information attributing multiple errors to a pilot in particular may call for additional training or a license revision for that pilot.

Repetitive navigation errors attributed to the equipment or a specific part of the navigation equipment or to operating procedures can be a ground for cancellation of an operational approval (withdrawal of RNP 1 Ops Spec approval or withdrawal of the LOA in the case of private operators).

10 RNP APCH

10.1 General Consideration

RNP APCH procedures based on GNSS may include barometric vertical navigation. Baro-VNAV systems are optional capabilities that do not constitute a minimum requirement to fly RNP APCH procedures using an LNAV line of minima.

This Technical Standard also provides general considerations on the approval of stand-alone and multi-sensor aircraft systems, including their requirements of availability, accuracy, integrity, continuity of function, and limitations, together with operational considerations.

Stand-alone and multi-sensor RNP systems that use GNSS and that comply with EASA AMC 20-27 and with the FAA ACs 90-105, 20-138A, 20-130A, 20-138B or TSO C 115b/ETSO C 115b, meet the ICAO RNP APCH navigation specification.

10.1.1 Navaid infrastructure

The global navigation satellite system (GNSS) is the primary navigation system that supports RNP APCH procedures down to LNAV or LNAV/VNAV minima.

The missed approach segment may be based upon the conventional navaid (e.g., VOR or DME)

For baro-VNAV RNP APCH operations, the procedure design is based upon the use of a barometric altimetry by an airborne RNP system whose capabilities support the required operation.

The acceptability of the risk of loss of RNP APCH capability for multiple aircraft due to satellite failure or loss of on-board monitoring and alerting functions (for example, spaces with RAIM holes), must be considered by the responsible airspace authority.

10.1.2 Obstacle clearance

10.1.2.1 RNP APCH operations without baro-VNAV guidance

Detailed guidance on obstacle clearance is provided in ICAO Doc 8168 (PANS-OPS), Volume II – Construction of visual and instrument flight procedures; the general criteria in Parts I and III apply.

The missed approach procedures may be supported by either RNAV or by conventional segments (e.g., segments based on VOR or DME.

Procedure design must take into account the absence of vertical navigation (VNAV) capability on the aircraft.

10.1.2.2 RNP APCH operations with baro-VNAV guidance

Baro-VNAV is applied where vertical guidance and information is provided to the flight crew during instrument approach procedures containing a vertical path defined by a vertical path angle (VPA).

Detailed guidance on obstacle clearance is provided in Doc 8168 (PANS-OPS), Volume II – Construction of visual and instrument flight procedures. Missed approach procedures may be supported by RNAV or conventional segments (e.g., segments based on VOR, DME, NDB).

10.1.3 Approach Charts/Publications

The instrument approach charts must clearly identify the RNP APCH application as RNP APCH (older established charts may still refer to the approach as RNAV (GNSS)). The Navigation Specification being used, RNP APCH, will be clearly identified in the PBN Box on the chart.

For RNP APCH operations without baro-VNAV (down to LNAV minima only), the procedure design is based on normal descent profiles, and the charts must identify minimum altitude requirements for each segment, including a lateral navigation obstacle clearance altitude/height (LNAV OCA/H).

For RNP APCH operations with baro-VNAV (down to LNAV/VNAV minima), the charts must follow the standards of ICAO Annex 4 section on the designation of an RNAV procedure where the vertical path is specified by a glide path angle. The chart designation must be consistent with the said Annex and a lateral and vertical navigation obstacle clearance altitude or height must be issued (LNAV/VNAV OCA or OCH).

When the missed approach segment is based on conventional means, the navaid facilities or the airborne navigation means that are necessary to conduct the missed approach must be identified in the relevant publications.

The navigation information published in the applicable aeronautical information publication (AIP) for the procedures and the supporting NAVAIDs must meet the requirements of ICAO Annexes 15 and 4 as appropriate. Procedure charts must provide sufficient data to support navigation database checking by the flight crew (including waypoint names (WPT), tracks, distances for each segment and the VPA).

All procedures must be based on the 1984 World Geodetic Coordinates (WGS 84).

10.1.4 Communications and Air traffic service (ATS) surveillance

RNP APCH operations do not include specific requirements for communication or ATS surveillance. An adequate obstacle clearance is achieved through aircraft performance and operating procedures. Where reliance is placed on the use of radar to assist contingency procedures, it must be demonstrated that its performance is adequate for this purpose. The radar service requirement must be identified in the AIP.

10.1.5 Navigation accuracies associated with the flight phases of a RNP APCH approach

Navigation accuracies associated with the flight phases of a RNP APCH approach are the following:

(1) Initial segment: RNP 1.0
(2) Intermediate segment: RNP 1.0
(3) Final segment: RNP 0.3
(4) Missed approach segment: RNP 1.0

10.1.6 Additional considerations

Many aircraft have the capability to execute a holding pattern manoeuvre using their RNP system.

10.2 Airworthiness and Operational Approval

In order to get an RNP APCH approval, a commercial air transport operator must ensure the following:

(1) An aircraft eligibility review by airworthiness inspectorate; and
(2) An operational approval from flight operations inspectorate.

For general aviation operators, the Authority will determine if the aircraft meets the applicable RNP APCH requirements and, when appropriate, issue the operational approval (e.g., a letter of authorisation – LOA).

Before submitting the application, operators must review all the aircraft qualification requirements. Compliance with airworthiness requirements or the installation of the equipment, by themselves does not constitute operational approval.

10.3 Airworthiness Approval

10.3.1 General

The following airworthiness criteria are applicable to the installation of RNP systems required for RNP APCH operations:

(1) This Technical Standard uses FAA AC 20-138/AC 20-138A/AC 20-138B (GPS stand-alone system) or FAA AC 20-130A/AC 20-138B (multi-sensors systems) as a basis for the airworthiness approval of an RNP system based on GNSS; and
(2) For APV/baro-VNAV operations, FAA AC 20-129/AC 20-138B may be used.

10.3.2 Aircraft and system requirements

Aircraft approved to conduct RNP APCH meet the performance and functional requirements of this Technical Standard for RNP APCH instrument approaches without radius to fix segments (without RF segments).

Aircraft that have a statement of compliance with respect to the criteria contained in this Technical Standard or equivalent documents in their flight manual (AFM), AFM supplement, pilot operations handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this Technical Standard.

Aircraft that have a statement from the manufacturer documenting compliance with the criteria of this Technical Standard or equivalent documents meet the performance and functional requirements of this document. This statement must include the airworthiness basis for such compliance. Compliance with the sensor requirements must be determined by the equipment or aircraft manufacturer, while compliance with the functional requirements may be determined by the manufacturer or through an inspection by the operator.

If the RNP installation is based on GNSS stand-alone system, the equipment must be approved in accordance with Technical Standard Order (TSO) C129a/ETSO-C129a Class A1 (or subsequent revisions) or with TSO-C146a/ETSO-C146a Class Gamma, Operational Class 1, 2, or 3 (or subsequent revisions) and meet the functionality requirements of this document.

If the RNP installation is based on GNSS sensor equipment used in a multi-sensor system (e.g., FMS, the GNSS sensor must be approved in accordance with TSO-C129 ()/ETSO-C129 () Class B1, C1, B3, C3 (or subsequent revisions) or TSO-C145 ()/ETSO-C145 () Class Beta, Operational Class 1, 2 or 3 (or subsequent revisions) and meet the functionality requirements of this document.

Multi-sensor systems using GNSS must be approved in accordance with AC 20-130A/CA 20-138B or TSO-C115b/ETSO-C115b and meet the functionality requirements of this document.

Note 1: The GNSS equipment approved in accordance with TSO-C129a/ETSO-C129a must meet the system functions specified in this document. In addition, integrity should be provided through an aircraft-based augmentation system (ABAS). It is recommended that GNSS receivers include the capability of fault detection and exclusion (FDE) to improve continuity of function.

Note 2: Multi-sensor systems that use DME/DME or DME/DME/IRU as the only means of RNP compliance are not authorised to conduct RNP APCH operations.

10.3.2 Performance and functional requirements for RNP APCH systems

10.3.2.1 Accuracy

The total system error (TSE) in the lateral and longitudinal dimensions of the on-board navigation equipment must be within:

(1) ± 1 NM for at least 95 percent of the total flight time in the initial and intermediate approach segments and for the missed approach of a RNP APCH procedure.
(2) Note: There is no specific RNP accuracy requirement for the missed approach if this segment is based on conventional NAVAIDs (e.g. VOR, DME) or on dead reckoning.
(3) ± 0.3 NM for at least 95 percent of the total flight time in the final approach segment of the procedure.

To satisfy the accuracy requirement, the 95 % FTE may not exceed:

(1) 0.5 NM on the initial, intermediate, and missed approach segments of a RNP APCH procedure; and
(2) 0.25 NM on the final approach segment of the procedure.

Note: The use of a deviation indicator with 1 NM full-scale deflection (FSD) on the initial, intermediate and missed approach segments and 0.3 NM FSD on the final approach segment is considered to be an acceptable means of compliance. The use of an autopilot or flight director is considered to be an acceptable means of compliance (roll stabilization systems do not meet the necessary conditions).

An acceptable means of compliance with the accuracy requirements described in the previous paragraphs is to have an RNP system approved for RNP APCH approaches down to LNAV minima, in accordance with the 2D navigation accuracy criteria of FAA AC 20-138, AC 20-130A or AC 20-138B.

10.3.2.2 Integrity

Malfunction of the aircraft navigation equipment that causes the TSE to exceed 2 times the RNP value is classified as a major failure condition under airworthiness regulations (i.e., 10-5 per hour). In the horizontal plane (lateral and longitudinal), the system must provide an alert if the accuracy requirement

is not met, or if the probability that the TSE exceeds 2 NM for initial, intermediate and missed approach segments or 0.6 NM for the final approach segment is greater than 10^{-5} per hour.

10.3.2.3 Continuity

Loss of the RNP APCH function is classified as a minor failure condition if the operator can revert to a different navigation system and safely proceed to a suitable airport. If the missed approach procedure is based on conventional NAVAIDs (e.g., VOR, DME, NDB), the associated navigation equipment must be installed and operational. For RNP APCH operations, at least one RNP navigation system is required.

Note: From an operational point of view, the operator must develop contingency procedures in case of loss of the RNP APCH capability during approach.

10.3.2.4 On-board performance monitoring and alerting

During operations on the initial, intermediate and the missed approach segments of a RNP APCH procedure, the RNP system or the RNP system and pilot in combination, must provide an alert if the accuracy requirement is not met or if the probability that the lateral TSE exceeds 2 NM is greater than 10^{-5}. During operations on the final approach segment of an RNP APCH down to LNAV or LNAV/VNAV minima, the RNP system, or the RNP system and pilot in combination, shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 0.6 NM is greater than 10^{-5}.

10.3.2.5 Signal-in-space

During operations on the initial, intermediate, and missed approach segments of an RNP APCH procedure, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds 10^{-7} per hour (Annex 10, Volume I, Table 3.7.2.4-1). During operations on the final approach segment of an RNP APCH down to LNAV or LNAV/VNAV minima, the aircraft navigation equipment must provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 0.6 NM exceeds 10^{-7} per hour (Annex 10, Volume I, Table 3.7.2.4-1).

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

10.3.2.6 Path definition

Aircraft performance is evaluated around the path defined by the published procedure and by document RTCA/DO-236B Sections 3.2.

10.3.3 Functional requirements of navigation displays

10.3.3.1 Lateral Deviation Displays

The following navigation displays and functions are required, according to FAA AC 20-130 and AC 20-138 or equivalent advisory material. Navigation data, including a to/from indication and a failure indicator must be displayed on a lateral deviation display (course deviation indicator (CDI), enhanced horizontal situation indicator (EHSI)) and/or a navigation map display. These displays must be used as primary flight instruments for the navigation of the aircraft, manoeuvre anticipation and for failure/status/integrity indication. The aforementioned non-numerical lateral deviation displays must have the following attributes:

(1) The displays must be visible to the pilot and located in the primary field of view (± 15 degrees from the pilot´s normal line of sight) when looking forward along the flight path;
(2) The lateral deviation display scaling must agree with any alerting and annunciation limits;
(3) The lateral deviation display must also have an FSD suitable for the current phase of flight and must be based on the TSE requirement. Scaling is ± 1 NM for the initial and intermediate segments and ± 0.3 NM for the final segment;
(4) The display scaling must be set automatically by default or set to a value obtained from a navigation database. The FSD value must be known or must be available for display to the pilot commensurate with approach values;
(5) As an alternate means, a navigation map display must provide equivalent functionality to a lateral deviation display with appropriate map scales (scales may be set manually by the pilot). **Note:** To be approved, the navigation map display must be shown to meet TSE requirements;
(6) The lateral deviation display must be automatically slaved to the RNP computed path. It is recommended that the course selector of the deviation display is automatically slaved to the RNP computed path;
Note: This does not apply for installations where an electronic map display contains a graphical display of the flight path and path deviation.
(7) Enhanced navigation displays (e.g., electronic map displays or EHSI) to improve lateral situational awareness, navigation surveillance and approach verification (flight plan verification) could be mandatory if the RNP installation does not support the display of information necessary for the accomplishment of these crew tasks.

10.3.4 System capabilities

10.3.4.1 The following system capabilities are required as a minimum:

(1) The capability to continuously display to the pilot flying (PF) the aircraft, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNP computed

desired path and aircraft position relative to the path. For aircraft where the minimum flight crew is two pilots, the means for the pilot not flying the aircraft (PNF) to verify the desired path and the aircraft position relative to the path must also be provided;

(2) A navigation database containing current navigation data officially promulgated by the Authority, which can be updated in accordance with the aeronautical information regulation and control (AIRAC) cycle and from which approach procedures can be retrieved and entered in the RNP system. The stored resolution of the data must be sufficient to achieve the required track-keeping accuracy. The database must be protected against pilot modification of the stored data;

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

(4) the means to retrieve and display data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the pilot to verify the procedure to be flown;

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

(6) the means to display the following items, either in the pilot´s primary field of view or on a readily accessible display page:
   (a) the identification of the active (to) WPT;
   (b) the distance and bearing to the active (to) WPT; and
   (c) the ground speed or time to the active (to) WPT.

(7) the means to display the following items on a readily accessible display page:
   (a) the display of distance between the WPTs of the operational flight plan;
   (b) the display of distance to go;
   (c) the display of along-track distances; and
   (d) the active navigation sensor type, if there is another sensor in addition to the GNSS sensor.

(8) the capability to execute the “direct to” function;

(9) the capability for automatic leg sequencing with the display of sequencing to the pilot;

(10) the capability to execute procedures extracted from the on-board database, including the capability to execute fly-over and fly-by turns;

(11) the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent:
   (a) ARINC 424 path terminators
   (b) initial fix (IF)
   (c) track to fix (TF)
   (d) direct to fix (DF)

   Note 1: Path terminators are defined in ARINC Specification 424 and their application is described in more detail in RTCA documents DO-236B and DO-201A.

   Note 2: Numerical values for tracks must be automatically entered from the RNP system database.

(12) the capability to display an indication of the RNP system failure, including the associated sensors, in the primary field of view of the pilot.

(13) the capability to indicate to the flight crew when the NSE alert limit is exceeded (alert provided by the on-board performance monitoring and alerting function).

10.3.5 Flight director/autopilot

A flight director and/or autopilot is not required for this type of operation, however, it is recommended that the flight director (FD) and/or autopilot (AP) remain coupled for RNP approaches. If the lateral TSE cannot be demonstrated without these systems, it becomes mandatory. In this case, coupling to the flight director and/or automatic pilot from the RNP system must be clearly indicated at the cockpit level.

10.3.6 Database integrity

The navigation database suppliers must comply with RTCA DO-200A. A letter of acceptance (LOA), issued by the appropriate regulatory authority to each one of the participants in the data chain, demonstrates compliance with this requirement. Positive compliance with this requirement will be considered for those LOAs issued prior to the publication of this Technical Standard.

10.3.7 Eligibility and approval of the system for RNP APCH operations down to LNAV and LNAV/VNAV minima

10.3.7.1 Introduction.

The original equipment manufacturer (OEM) or the holder of installation approval for the aircraft (e.g., the holder of the supplementary type certificate (STC)), must demonstrate to the Authority of the State of registry or manufacturer that it complies with the appropriate provisions of this TS. The approval may be recorded in the documentation of the manufacturer (e.g., service letters (SL), etc.). Provided the Authority accepts the manufacturer documentation, it need not be recorded in the AFM.

10.3.7.2 Eligibility for RNP APCH operations down to LNAV and LNAV/VNAV minima.

Systems that meet the requirements of this Technical Standard are eligible for RNP APCH operations down to LNAV minima. Systems that meet the requirements of this Technical Standard and (APV/baro-VNAV) or equivalent are eligible for RNP APCH operations down to LNAV/VNAV minima. Aircraft qualified in accordance with requirements with RNP AR APCH, (e.g., FAA AC 90-101 or EASA AMC 20-26) are considered qualified for RNP APCH operations down to LNAV and LNAV/VNAV minima without further examination.

10.3.8 System eligibility for RNP APCH operations down to LNAV or LNAV/VNAV minima

10.3.8.1 Lines of minima

RNP APCH approaches supported by GNSS normally include at least two lines of minima: LNAV and LNAV/VNAV. The LNAV line of minima is based on the use of systems that meet the performance criteria of this Technical Standard and procedure design requirements for APV/baro-VNAV.

10.3.8.2 LNAV Line of minima qualification

10.3.8.2.1 Stand-alone systems.-

Stand-alone systems that comply with TSO-C129/ETSO-C129 Class A1 or TSO-C146/ETSO-C146 Classes 1, 2, or 3 meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided the IFR equipment installations have been performed in accordance with FAA AC 20-138. RNP systems must be approved in accordance with FAA AC 20-138 or equivalent.

Note: it is considered that these systems meet the functional and performance requirements set out in this Technical Standard in the aspects that correspond.

10.3.8.2.2 Multi-sensor systems

Multi-sensor systems that use TSO-C129/ETSO-C129 Classes B1, B3, C1, or C3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided:

(1) The equipment installations meet the criteria of this Technical Standard; and
(2) The associated flight management system (FMS) complies with TSO-C115b/ETSO-C115b and is installed in accordance with FAA AC 20-130 or FAA AC 20-138B or subsequent.

Multi-sensor systems that use TSO-C145/ETSO-C145 Classes 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided:

(1) The equipment installations meet the criteria of this Technical Standard; and
(2) Are installed in accordance with FAA AC 20-138.

Note: it is considered that these systems meet the functional and performance requirements set out in this Technical Standard in the aspects that correspond.

10.3.8.3 LNAV/VNAV Line of minima qualification

10.3.8.3.1 Stand-alone systems

Stand-alone TSO-C146/ETSO-C146 Classes 2 or 3 systems meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima, provided that the installations meet at least the performance and functional requirements of this Technical Standard.

The systems that meet TSO-C129/ETSO-C129 can be used for RNP APCH operations using the LNAV/VNAV line of minima if they meet the criteria of this Technical Standard.

RNP systems must be approved in accordance with FAA AC 20-138 or equivalent, and those systems that utilize conventional baro-VNAV must provide vertical navigation system performance that meets or exceeds the criteria of APV-baro-VNAV requirements.

10.3.8.3.2 Multi-sensor systems

Multi-sensor systems that use TSO-C129/ETSO-C129 Classes B1, B3, C1, or C3 sensors or TSO-C145/ETSO-C145 Classes 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima, provided the installations meet the requirements of this Technical Standard.

RNP systems that utilize conventional baro-VNAV must provide a vertical navigation system performance that meets or exceeds the criteria of APV-baro-VNAV requirements.

RNP systems must be installed in accordance with FAA AC 20-138 or equivalent and/or the associated FMS must comply with TSO-C115b/ETSO-C115b and must be installed in accordance with FAA AC 20-130 or AC 20-138B or equivalent.

10.3.9 Aircraft modification

If any system required for RNP APCH operations is modified (e.g., changes in the software or hardware), the aircraft modification must be approved.

The operator must obtain a new operational approval that is supported by updated aircraft operational and qualification documentation.

10.3.10 Continued airworthiness

The operators of aircraft approved to perform RNR APCH operations down to LNAV or LNAV/VNAV minima, must ensure the continuity of the technical capacity of them, in order to meet technical requirements established in this Technical Standard.

Each operator who applies for RNP APCH operational approval down to LNAV or LNAV/VNAV minima must submit to the Authority, a maintenance and inspection programme that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the approval criteria for RNP APCH operations down to LNAV or LNAV/VNAV minima.

The following maintenance documents must be revised, as appropriate, to incorporate aspects concerning RNP APCH operations down to LNAV or LNAV/VNAV minima:

(1) Maintenance control manual (MCM);
(2) Illustrated parts catalogues (IPC); and
(3) Maintenance programme.

The approved maintenance programme for the affected aircrafts should include maintenance practices listed in maintenance manuals of the aircraft manufacturer and its components, and must consider:

(1) That equipment involved in the RNP APCH operation down to LNAV or LNAV/VNAV minima should be maintained according to directions given by manufacturer's components;
(2) That any amendment or change of navigation system affecting in any way RNP APCH initial approval down to LNAV or LNAV/VNAV minima, must be forwarded and reviewed by the Authority for its acceptance or approval of such changes prior to its implementation; and
(3) That any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, should be forwarded to the Authority for acceptance or approval thereof.

Within the RNP APCH maintenance documentation should be presented the training programme of maintenance personnel, which inter alia, should include:

(1) PBN concept;
(2) Application of RNP APCH down to LNAV or LNAV/VNAV minima;
(3) Equipment involved in an RNP APCH operation down to LNAV or LNAV/VNAV minima; and
(4) MEL use.

10.4 Operational Approval

The airworthiness approval, by itself, does not authorise the operator to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima. In addition to the airworthiness approval, the operator must obtain an operational approval confirming that the installation of the specific equipment is consistent with normal and contingency procedures.

10.4.1 Requirements to obtain Operational Approval

To obtain the approval for RNP APCH operations down to LNAV or LNAV/VNAV minima, the operator must take the following steps, taking into account the criteria established in this Technical Standard.

10.4.1.1 Description of the aircraft equipment

The operator must establish and have available a configuration list detailing the components and equipment to be used for RNP APCH operations down to LNAV or LNAV/VNAV minima.

The list of required equipment must be established during the operational approval process, taking into account the AFM. This list shall be used for updating the MEL for each type of aircraft that the operator intends to operate.

The details of the equipment and its use in accordance with the approach characteristics appear in this Technical Standard.

10.4.2 Aircraft qualification documentation

10.4.2.1 For aircraft currently conducting RNAV (GPS) or GPS approaches under FAA AC 90-94 or equivalent

Documentation is not required for aircraft that have an AFM or AFM supplement which states the aircraft is approved to fly RNAV (GPS) or GPS approaches, to the LNAV line of minima.

10.4.2.2 For aircraft without approval to fly RNAV (GPS) or GPS instrument approach procedures

Operators will submit to the Authority the RNP qualification documentation showing compliance with this Technical Standard, provided the equipment is properly installed and operated.

Note: Before requesting an approval to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima, operators must review all equipment performance requirements. Equipment installation by itself does not guarantee operational approval nor permit its operational use.

10.4.3 RNP APCH operational documentation

The operator must develop the operational documentation for using the equipment for RNP APCH operations down to LNAV or LNAV/VNAV minima, based on the aircraft or avionics manufacturer documentation.

The operational documentation of the aircraft or avionics manufacturer must consist of recommended operational procedures and training programmes for the flight crew, in order to assist operators meet the requirements of this Technical Standard.

10.4.3.1 Acceptance of documentation

10.4.3.1.1 New aircraft/equipment (aircraft/equipment in the process of being manufactured or recently manufactured)

The aircraft/equipment qualification documentation may be approved as part of an aircraft certification project and be reflected in the AFM and related documents.

10.4.3.1.2 Aircraft/equipment in service (capacity achieved in service)

Previous approvals issued to conduct RNAV (GPS) or GPS instrument approaches according to FAA AC 90-94 or equivalent do not require further evaluations. For installations/equipment not eligible to conduct RNAV (GPS) or GPS instrument approaches, the operator must submit aircraft or avionics qualification documentation to the Authority.

The Authority's inspectors must review the application package for RNP APCH operations down to LNAV or LNAV/VNAV minima.

10.5 Operating procedures

10.5.1 Pre-flight planning

10.5.1.1 General Procedures

Operators and pilots intending to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima must file the appropriate flight plan suffixes, and on board navigation data must be current and include the appropriate procedures.

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

Note: Navigation databases are expected to be current for the duration of the flight. Where the AIRAC cycle is due to change during the flight, the operators and pilots must establish procedures to ensure the accuracy of navigation data, including the suitability of navigation facilities used to define the routes and procedures for the flight. Traditionally, this has been done by comparing electronic data with printed documents. An acceptable method is to compare aeronautical charts (new and old) in order to verify navigation fixes before dispatch. If an amended letter for the procedure is published, the database must not be used for conducting the operation.

Pilots must verify the proper entry of their ATC assigned route once they have received the initial clearance and following any subsequent changes of the route. Likewise, pilots must ensure the WPT sequence depicted by their navigation system matches their assigned route and the route depicted on the appropriate charts.

Note 1: Pilots may notice a slight difference between the navigation information portrayed on the chart and the heading shown on the primary navigation display. A difference of 3 degrees or less may be due to a magnetic variation applied by the equipment manufacturer and may be operationally acceptable.

Note 2: Manual selection of functions that limit the aircraft bank angle can reduce the aircraft's ability to maintain the desired track and is not recommended.

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

Pilots must ensure that the approaches which can be used for the intended flight (including alternate aerodromes):

(1) Have been selected from a valid navigation data base (current AIRAC cycle);
(2) Have been verified through an appropriate process (navigation database integrity process); and
(3) Are not prohibited by an operational instruction of the company or NOTAM.

Pilots must ensure that there are sufficient means available to fly and land at the destination or alternate aerodrome in case of loss of on board RNP APCH capability.

Operators and flight crews must take account of all NOTAMs or operator briefing material that could adversely affect the aircraft system operation or the availability or suitability of the procedures at the aerodrome of landing or at any alternate aerodromes.

For missed approach procedures based on conventional means (e.g. VOR, NDB), operators and flight crews must ensure that the appropriate airborne equipment required to fly these procedures is installed and operational in the aircraft, and that the associated ground-based navigation aids are operational.

The availability of the NAVAID infrastructure, required for the intended routes, including any non-RNP contingencies, must be confirmed for the period of intended operations, using all available information. Since GNSS integrity [receiver autonomous integrity monitoring (RAIM) or satellite-based augmentation system (SBAS) signal] is required by Annex 10, Volume I, the availability of these signals must also be determined as appropriate. For aircraft navigating with SBAS receivers [all TSO-C145()/C146()/ETSO-C145()/C146()], operators must check appropriate GPS RAIM availability in areas where the SBAS signal is unavailable.

10.5.1.2 GNSS availability

RAIM prediction must be performed prior to departure.

10.5.1.3 ABAS availability

RAIM levels required for RNP APCH operations down to LNAV or LNAV/VNAV minima can be verified either through notices to airmen (NOTAMs) (if available) or through prediction services. The operating authority may provide specific guidance on how to comply with this requirement (e.g., if sufficient satellites are available, a prediction may not be necessary). Operators shall be familiar with the prediction information available for the intended route.

RAIM availability prediction shall take into account the latest GPS constellation NOTAMs and use the identical algorithm to that used in the airborne equipment, or an algorithm based on RAIM prediction assumptions that give a more conservative result.

The RAIM prediction service may be provided by ANSPs, avionics manufacturers, other entities or through an airborne receiver RAIM prediction capability. RAIM availability may be confirmed by using model specific RAIM prediction software.

In the event of a predicted, continuous loss of appropriate level of fault detection (FD) of more than five minutes for any part of the RNP APCH operation, the flight planning must be revised (e.g., the flight must be delayed, cancelled, or re-routed where RAIM requirements can be met).

The RAIM availability prediction software does not guarantee the service; rather it is a tool to assess the expected capability of meeting the required navigation performance.

Because of unplanned failures of some GPS elements, pilots must realize that RAIM or GPS navigation may be lost while airborne which may require reversion to an alternative means of navigation. Therefore, pilots must assess their capability to navigate to an alternate aerodrome in case of failure of GPS navigation.

The predictive capability must account for known and predicted coverage gaps of GPS satellites or other effects on navigation system sensors.

The prediction programme may not use a mask angle below 5 degrees, as operational experience indicates that satellite signals at low elevations are not reliable.

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

10.5.1.4 Availability of SBAS and other augmented GNSS systems

Aircraft and operators approvals for RNP APCH operations down to LP and LPV minima using GNSS augmented by SBAS, contain the criteria to assess GNSS SBAS vertical guidance availability.

If the aircraft uses other GNSS augmentations or improvements to a basic GNSS capability (e.g., use of multiple constellations, dual frequency, etc.), the RNP APCH operation must be supported by a prediction capability based on the specific characteristics of these other augmentations.

10.5.2 Prior to commencing the procedure

In addition to the normal procedure, prior to commencing the approach [before the initial approach fix (IAF)] and in compatibility with crew workload), the flight crew must verify the correct procedure was loaded by comparison with the approach charts.

This check must include:

(1) The WPT sequence;
(2) The reasonableness of the tracks and distances of the approach legs, the accuracy of the inbound course, and the length of the final approach segment.

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

The flight crew must also check, using the published charts, the map display or the control and display unit (CDU), which WPTs are fly-by and which are flyover.

For multi-sensor systems, the flight crew must verify, during the approach, that the GNSS sensor is used for position computation.

For an RNP system with an aircraft-based augmentation system (ABAS) requiring barometric corrected altitude, the current aerodrome barometric altimeter setting must be input at the appropriate time and location, consistent with the performance of the flight operation.

When the operation is predicated on ABAS availability, the flight crew must perform a new RAIM availability check if the estimated time of arrival (ETA) is more than 15 minutes different from the ETA used during the pre-flight planning. This check is also processed automatically 2 NM before the FAF for an E/TSO-C129a Class A1 receiver.

ATC tactical interventions in the terminal area may include radar headings, "direct to" clearances which bypass the initial legs of an approach, interception of an initial or intermediate segment of an approach, or the insertion of WPTs loaded from the database.

Note: Bypassing of the Initial Approach Fix is NOT PERMITTED in Namibia.

In complying with ATC instructions, the flight crew must be aware of the following:

(1) The manual entry of coordinates into the RNP system by the flight crew for operations within the terminal area is not permitted; and
(2) The lateral definition of the flight path between the FAF and the missed approach point (MAPt) must not be revised by the flight crew under any circumstances.

Note: "Direct to" clearance to the IF or FAF is not permitted in Namibia.

10.5.3 During the procedure

10.5.3.1 General Procedures

Pilots must comply with the instructions or procedures identified by the operator, as necessary, to meet the performance requirements of this Technical Standard.

Before starting the descent, the aircraft must be established on the final approach course no later than the final approach fix (FAF) to ensure terrain and obstacle clearance.

The flight crew must check if the approach mode annunciator (or equivalent) is properly indicating the approach mode integrity within 2 NM prior to the FAF.

Note: This check does not apply to certain RNP systems (e.g., aircraft already approved with a demonstrated RNP capability). For such systems, other means are available, including electronic map displays, flight guidance mode indications, etc., which clearly indicate to the flight crew that the approach mode is activated.

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

(1) The RNP computed desired path (DTK); and
(2) The aircraft position relative to the path (cross-track deviation) for flight technical error (FTE) monitoring.
(3) An RNP APCH procedure must be discontinued:
(4) If the navigation display is flagged invalid: or
(5) In case of loss of the integrity alerting function; or
(6) If the integrity alerting function is annunciated not available before passing the FAF; or
Note: Discontinuing the procedure may not be necessary for a multi-sensor RNP system that includes demonstrated RNP capability without GNSS. Manufacturer documentation must be examined to determine the extent the system may be used in this configuration.
(7) If the FTE is excessive.

The missed approach must be flown in accordance with the published procedure. Use of the RNP system during the missed approach is acceptable, provided:

(1) The RNP system is operational (e.g., there is no loss of function, no NSE alert, no failure indication, etc.); and
(2) The whole procedure (including the missed approach) has been loaded from the navigation data base.

10.5.3.2 Lateral Deviation Indicator

During the RNP APCH procedure down to LNAV or LNAV/VNAV minima, pilots must use a lateral deviation indicator, FD and/or AP in the lateral navigation mode. Although the scale should change automatically, pilots of aircraft provided with a lateral deviation indicator (e.g., CDI) must ensure that the lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the procedure (i.e., ± 1.0 NM for the initial, intermediate, and missed approach segments, and ± 0.3 NM for the final approach segment down to LNAV or LNAV/VNAV minima).

All pilots must maintain route centreline, as depicted by on-board lateral deviation and/or flight guidance indicators throughout the RNP APCH procedure unless authorised to deviate by ATC or under emergency conditions.

10.5.3.3 Cross Track Error

For normal operations, cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) must be limited to ± ½ of the navigation accuracy associated with the procedure (i.e., 0.5 NM for the initial, intermediate and missed approach segments and 0.15 NM for the final approach segment). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one-times the navigation accuracy (e.g., 1.0 NM for the initial and intermediate segments), are allowable.

Note: Some aircraft do not display or compute a path during turns, but are still expected to satisfy standard during intercepts following turns and on straight segments.

10.5.3.4 Use of Baro-VNAV

When barometric VNAV is used for vertical path guidance during the final approach segment, deviations above and below the barometric VNAV path must not exceed + 75/-75FT respectively.

Pilots must execute a missed approach if the lateral or vertical deviations exceed the aforementioned criteria, unless the pilot has in sight the visual references required to continue the approach.

For aircraft requiring two pilots, the flight crew must verify that each pilot's altimeter has the current setting before beginning the final approach of an RNP APCH approach procedure down to LNAV or LNAV/VNAV minima. The flight crew must also observe any operational limitations related to altimeter setting sources and the verification and setting latency of altimeters when approaching the FAF.

RNP APCH procedures down to LNAV or LNAV/VNAV require flight crew monitoring of lateral and, if installed, vertical track deviations on the pilot's primary flight displays (PFD) to ensure the aircraft remains within the boundaries defined by the procedure.

10.5.4 General operating procedures

Operators and pilots must not request an RNP APCH procedure down to LNAV or LNAV/VNAV minima unless they satisfy all the criteria required by the Authority. If an aircraft not meeting these criteria receives a clearance from ATC to conduct an RNP APCH procedure down to LNAV or LNAV/VNAV minima, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

The pilot must comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this navigation specification.

If the missed approach procedure is based on conventional means (e.g., NDB, VOR, DME), related navigation equipment must be installed and be serviceable.

Pilots must use the flight director and autopilot in lateral navigation mode, whenever available.

10.6 Contingency procedures

The pilots must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action.

If unable to comply with the requirements of an RNP APCH procedure down to LNAV or LNAV/VNAV minima, they must notify air traffic service (ATS) as soon as possible.

The loss of RNP APCH capability includes any failure or event causing the aircraft to no longer satisfy the RNP APCH requirements of the procedure.

The operators must develop contingency procedures in order to react safely following the loss of the RNP APCH capability during the approach.

In the event of communication failure, the flight crew must continue with the RNP APCH procedure in accordance with the published radio communication failure procedure.

The operator's contingency procedures must address at least the following conditions:

(1) Failure of the RNP system components, including those affecting lateral or vertical deviation performances (e.g., failures of a GPS sensor, FD or AP); and
(2) Loss of navigation signal-in-space (loss or degradation of the external signal).

The pilot must ensure the capability of navigating and landing at an alternate aerodrome if loss of RNP APCH capacity occurs.

10.7 Training programme

The training programme must provide sufficient training (e.g., in simulator, training devices or aircraft) on the aircraft's RNP system to the extent that the pilots are not just task oriented.

The training programme must cover at least the following aspects:

(1) The information on this Technical Standard.
(2) The meaning and proper use of RNP systems.
(3) Procedure characteristics as determined from chart depiction and textual description.
(4) Knowledge regarding depiction of WPT types (fly-by and flyover waypoints), required path terminators (IF, TF, and DF) and any other types used by the operator, as well as the associated aircraft flight paths.
(5) Knowledge on the required navigation equipment in order to conduct RNP APCH operations down to LNAV or LNAV/VNAV minima (at least one RNP system based on GNSS).
(6) Knowledge of RNP system-specific information:

(a) Automation levels, mode annunciations, changes, alerts, interactions, reversions and degradation;
(b) Functional integration with other aircraft systems;
(c) The meaning and appropriateness of route discontinuities as well as related flight crew procedures;
(d) Monitoring procedures for each phase of flight;
(e) Types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic;
(f) Turn anticipation with consideration to speed and altitude effects; and
(g) Interpretation of electronic displays and symbols.

(7) Knowledge of RNP equipment operating procedures, as applicable, including how to perform the following actions:
(a) Verify currency of aircraft navigation data;
(b) Verify the successful completion of RNP system self-tests;
(c) Initialise RNP system position;
(d) Retrieve and fly an RNP APCH procedure;
(e) Adhere to speed and/or altitude constraints associated with an approach procedure;
(f) Fly interception of an initial or intermediate segment of an approach following air traffic control (ATC) notification;
(g) Verify WPTs and flight plan programming;
(h) Fly direct to a WPT;
(i) Determine cross-track error/deviation;
(j) Insert and delete route discontinuity;
(k) When required by the Authority, perform gross navigation error checks using conventional NAVAIDs; and
(l) Change arrival airport and alternate airport.

(8) Knowledge levels of automation recommended by the operator for each phase of flight and workload, including methods to minimize cross-track error to maintain procedure centreline.

(9) Knowledge of radio telephony phraseology for RNP applications.

(10) Ability to conduct contingency procedures following RNP system failures.

10.8 Navigation database

The operator must obtain the navigation databases from a qualified supplier that complies with RTCA DO 200A/EUROCAE document ED 76 – Standards for processing aeronautical data.

A letter of acceptance (LOA) issued by the appropriate regulatory authority is a means of demonstrating compliance with this requirement (e.g., FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA OPINION Nr. 01/2005.

The database supplier of an operator must have a Type 2 LOA and their respective suppliers must have a Type 1 or 2 LOA. The Authority must normally accept a LOA issued to the navigation data suppliers.

Discrepancies that invalidate a procedure must be reported to the navigation database supplier and affected procedures must be prohibited by an operator´s notice to its flight crew.

Aircraft operators should conduct periodic checks of the operational navigation database in order to meet existing quality system requirements.

10.9 Oversight of Operators – Navigation Errors

The operator must establish a process to receive, analyse, and do the follow-up of navigation error reports in order to determine the appropriate corrective action.

The Authority may consider any navigation error reports in determining remedial action.

Repeated navigation error occurrences attributed to a specific piece of navigation equipment is a ground for cancellation of the approval for use of that equipment.

Information that indicates the potential for repeated errors may cause the Authority to require modification of an operator´s training programme.

Information that attributes multiple errors to a particular pilot may necessitate remedial training or licence review.

11 RNP 0.3

11.1 General considerations

11.1.1 Source document

This Technical Standard for RNP 0.3 is based upon FAA Advisory Circular AC 90-105A, Appendix D, adapted for use within the Namibian Civil Aviation System.

11.1.2 Introduction

This Technical Standard provides guidance for rotorcraft RNP 0.3 en-route and terminal operations servicing offshore rigs and where RNP 0.3 accuracy may be needed to support low level mountainous operations and also in high density airspace.

11.2 Airworthiness and operational approval

In order to receive an RNP 0.3 approval, the operator must comply with two types of approval: airworthiness approval and operational approval. Compliance with airworthiness requirements by themselves does not constitute the operational approval.

For Part 91 and 93 operators the Executive Director must issue a Letter of Approval (LOA) once it has determined that the aircraft meets all applicable requirements for RNP 2 operations provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

For Part 121, 127 and 135 operators the approval must be included in the Ops Specs, provided the said operations are conducted in accordance with the applicable regulations and procedures and the granting of such approval will not compromise aviation safety.

11.3 Airworthiness approval

11.3.1 Qualification methods.

The following qualification methods are:

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

11.3.2 System Performance, Monitoring, and Alerting.

11.3.2.1 Accuracy

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

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

11.3.2.2 Integrity

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

11.3.2.3 Continuity

For the purpose of this specification, loss of function is a major failure condition for oceanic and remote continental operations. The carriage of dual independent long-range navigation systems (LRNS) may satisfy the continuity requirement. Loss of function is classified as a minor failure condition for other D-2 3/7/16 AC 90-105A Appendix D RNP 0.3 operations if the operator can revert to a different available navigation system and proceed to a suitable airport.

11.3.2.4 Performance Monitoring and Alerting

The RNP system, or the RNP system and the pilot in combination, is required to monitor TSE and provides an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 0.6 NM is greater than 10^{-5} per hour.

11.3.2.5 Path Definition

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

11.3.2.6 Signal in Space (SIS)

The rotorcraft navigation equipment must provide an alert if the probability of SIS errors causing a lateral position error greater than 0.6 NM exceeds 1 x 10-7 per hour.

11.4 Functional Requirements.

11.4.1 Navigation Data Displays

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

11.4.1.1 Navigation Displays and Functions Requirements.

The RNP 0.3 system must have the following navigation displays and functions installed:

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

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

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

11.5 System Capabilities

The following system capabilities and functions are required as a minimum within any RNP 0.3 equipment:

(1) The capability to continuously display to the PF, on the primary flight instruments for navigation of the rotorcraft (primary navigation display), the RNP-computed desired path and rotorcraft position relative to the path. For operations where the required minimum flight crew is two pilots, a means for the PNF (pilot monitoring) to verify the desired path and the rotorcraft position relative to the path must also be provided;

(2) A navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the Aeronautical Information Regulation and Control (AIRAC) cycle. The stored resolution of the data must be sufficient to achieve negligible Path Definition Error (PDE). The stored resolution of the data must be sufficient to achieve the required track-keeping accuracy. The database must be protected against pilot modification of the stored data;
(3) The means to display the validity period of the navigation data to the pilot;
(4) The means to retrieve and display data stored in the navigation database relating to individual waypoints and navigation aids, to enable the pilot to verify the route to be flown;
(5) The capability to load from the database into the RNP system the RNP 0.3 procedure and/or route to be flown;

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

Note 2: Due to variability in systems, this document defines the segment from the first occurrence of a named waypoint, track, or course to the last occurrence of a named waypoint, track, or course. Heading legs prior to the first named waypoint or after the last named waypoint do not have to be loaded from the database.

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

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

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

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

(13) The capability to automatically or manually permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint. The system may use CA and Fix to Manual Termination (FM) path terminators for automatic capability;

(14) The capability for the flight crew to build an en-route or offshore segment in the equipment flight plan function using individual waypoints from the database. This is similar to existing en route capability;

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

(15) The capability to load numeric values for courses and tracks from the onboard navigation database;

(16) The capability to display an indication of the RNP 0.3 system failure, in the pilot's primary FOV;

(17) The capability to indicate to the crew when the Navigation System Error (NSE) alert limit is exceeded (alert provided by the onboard performance monitoring and alerting function);

(18) FD/AP. For all rotorcraft RNP 0.3 operations, the use of an AP and/or FD is an acceptable means of complying with FTE assumptions. Any alternate means of FTE bounding will require a demonstration.

11.6 Navigation Database Integrity

11.6.1 Type 2 Letter of Acceptance (LOA).

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

11.6.2 Path Terminators

The database supplier must not substitute path terminators in lieu of those specified in the original State Aeronautical Information Publication (AIP) data.

11.7 Operational Approval

11.7.1 Documentation for Operational Approval

11.7.1.1 Rotorcraft Qualification Documentation

The rotorcraft and avionics manufacturers must develop and make available rotorcraft qualification documentation that shows compliance. For rotorcraft without RFM approval for RNP 0.3 operations, the rotorcraft and avionics manufacturers must develop RNP 0.3 qualification documentation showing compliance with this sub-section. The necessary documentation must also define the recommended

operations and maintenance procedures. This is not required for rotorcraft with an RFM or RFMS which explicitly states that the RNP system is approved for IFR operations with RNP values as low as RNP 0.3.

11.7.1.2 RNP Capability Statement

The GPS/SBAS-enabled navigation system equipment manufacturer must provide an RNP capability statement that the equipment meets the performance and functional criteria in AC 20-138, Chapter 9, Section 9-5 for rotorcraft en route and terminal RNP 0.3 operations. If an RNP capability statement is provided, it must include a description of the equipment procedures for pilots to select the rotorcraft en route and terminal RNP 0.3 capability.

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

11.8 Operational Procedures

11.8.1 Normal and Contingency Procedures

Operators must include normal and contingency RNP 0.3 operational procedures for their particular equipment installation.

11.8.2 Required Equipment

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

11.8.3 Pre-flight Planning

RNP 0.3 is predicated on wide area augmentation system (WAAS) integrity. The availability of WAAS integrity should be confirmed by checking WAAS Notices to Airmen (NOTAM) prior to flight.

11.8.4 General In-Flight Considerations

11.8.4.1 General

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

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

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

Note: Refer to FAA AC90-105A Appendix H, Advanced Required Navigation Performance (A-RNP) for guidance on scalability and Appendix I, Additional Capabilities, for Radius to Fix (RF).

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

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

11.8.4.2 Lateral Deviation Indicator

All pilots must maintain centreline, as depicted by on-board lateral deviation indicators and/or flight guidance during all RNP operations described in this sub-section unless authorized to deviate by ATC or under emergency conditions.

11.8.4.3 Cross Track Error

For normal operations, cross-track (XTK) error/deviation (the difference between the displayed path and the displayed rotorcraft position relative to the displayed path, (i.e., FTE)) is limited to half the RNP value associated with the procedure (i.e., 0.15 NM for RNP 0.3). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one times the RNP value (i.e., 0.3 NM for RNP 0.3), are allowable.

Note: Some rotorcraft avionics do not display or compute a path during turns. As such, pilots of rotorcraft may not be able to adhere to half the lateral navigation accuracy during turns but must still satisfy the standard during intercepts following turns and on straight segments.

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

If ATC issues a heading assignment taking the rotorcraft off a procedure, the pilot should not modify the primary flight plan in the RNP system until a clearance is received to rejoin the route or the controller confirms a new route clearance. The specified accuracy requirement does not apply when the rotorcraft is not on a published RNP 0.3 procedure.

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

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

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

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

11.8.4.4 Manual Entry of RNP

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

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

11.8.5 RNP 0.3 SID Specific Requirements

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

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

11.8.6 RNP 0.3 STAR Specific Requirements

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

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

11.9 Contingency Procedures

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

11.10 Pilot Knowledge and Training

11.10.1 Knowledge

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

(1) The information in this Technical Standard;

(2) The meaning and proper use of rotorcraft navigation suffixes;
(3) Procedure characteristics as determined from chart depiction and textual description;
(4) Depiction of waypoint types (flyover and flyby) and any other types used by the operator as well as associated aircraft flightpaths;
(5) Required navigation equipment and MEL for operation on RNP 0.3 ATS routes;
(6) RNP 0.3 system-specific information:
    (a) Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
    (b) Functional integration with other rotorcraft systems;
    (c) The meaning and appropriateness of route discontinuities as well as related flight crew procedures;
    (d) Pilot procedures consistent with the operation (e.g., monitor PROG or LEGS page);
    (e) Types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic/limitations;
    (f) Turn anticipation with consideration for airspeed and altitude effects;
    (g) Interpretation of electronic displays and symbols used to conduct an RNP 0.3 operation; and
    (h) Understanding of the rotorcraft configuration and operational conditions required to support RNP 0.3 operations (i.e., appropriate selection of CDI scaling/lateral deviation display scaling).
(7) RNP equipment operating procedures, as applicable, including how to perform the following actions:
    (a) Verifying currency and integrity of rotorcraft navigation data.
    (b) Verifying successful completion of RNP system self-tests.
    (c) Entry of and update to the rotorcraft navigation system initial position.
    (d) Retrieving and flying an IFP with appropriate transition.
    (e) Adhering to speed and/or altitude constraints associated with an RNP 0.3 IFP.
    (f) Impact of pilot selectable bank limitations on rotorcraft ability to achieve the required accuracy on the planned route.
    (g) Selecting the appropriate STAR or SID for the active runway in use and be familiar with flight crew procedures required to deal with a runway change.
    (h) Verifying waypoint and flight plan programming.
    (i) Flying direct to a waypoint.
    (j) Flying a course/track to a waypoint.
    (k) Intercepting a course/track.
    (l) Following vectors and rejoining an RNP ATS route from “heading” mode.
    (m) Determining XTK/deviation. More specifically, the maximum deviations allowed to support RNP 0.3 must be understood and respected.
    (n) Inserting and deleting route discontinuities.
    (o) Removing and reselecting navigation sensor inputs.
    (p) When required, confirming exclusion of a specific NAVAID or NAVAID type.
    (q) Changing the arrival airport/heliport and the alternate airport.

(r) Performing a parallel offset function, if the capability exists. The pilot should know how to apply offsets within the functionality of their particular RNP system and the need to advise ATC if this functionality is not available.
(s) Performing a conventional holding pattern.
(t) Operator-recommended levels of automation for phase of flight and workload, including methods to minimize XTK to maintain route centerline,
(u) Receiver/Transmitter (R/T) phraseology for RNP applications, and
(v) Contingency procedures for RNP failures.

11.10.2 Training Program Modification

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

12 RNP AR APCH

Technical Standards for RNP AR APCH are yet to be developed.