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GOVERNMENT OF INDIA

**OFFICE OF THE DIRECTOR GENERAL OF CIVIL AVIATION**

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# CIVIL AVIATION REQUIREMENT
# SECTION 2 - AIRWORTHINESS
# SERIES 'O', PART XII
# ISSUE II, 22nd AUGUST 2008 EFFECTIVE: FORTHWITH

**Subject: Performance Based Navigation (PBN) - Aircraft Airworthiness, Operational and Flight Crew Training Requirements for Area Navigation (RNAV)/ Required Navigation Performance (RNP)**

## 1. INTRODUCTION

1.1 Sub-rule 3 of Rule 9 and Rule 57 of the Aircraft Rules, 1937 stipulate that every airplane shall be fitted with instrument and equipment, including radio apparatus and special equipment, as may be specified according to the use and circumstances under which the flight is to be conducted. **This CAR lays down the necessary guidance for obtaining airworthiness and operational approvals for the use of navigation system in the airspace designated for RNAV operations.** It establishes an acceptable means, but not the only means that can be used in the approval process to conduct flight in airspace or on routes where RNAV operation is applicable. The operator is also required to meet the RNAV airspace requirements of the State on which aircraft is flying.

**1.2 The Performance Based Navigation (PBN) concept specifies system performance requirements in terms of accuracy, integrity, availability, continuity and functionality needed for the proposed operations** in the context of a particular Airspace Concept, when supported by the appropriate navigation infrastructure. In that context, the PBN concept represents a shift from sensor-based to performance-based navigation. **Performance requirements are identified in navigation specifications which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements.**

PBN is one of several enablers of an Airspace Concept. Communications, ATS Surveillance and ATM are also essential elements of an Airspace Concept. The concept of Performance Based Navigation (PBN) relies on the use of an Area Navigation (RNAV) system. PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria. These include the following:

a) Reduces the need to maintain sensor-specific routes and procedures, and their associated costs. For example, moving a single VOR ground facility can impact dozens of procedures, as that VOR can be used on routes, VOR approaches, as part of missed approaches, etc. Adding new sensor specific procedures will compound this cost, and the rapid growth in available navigation systems would soon make system-specific routes and procedures unaffordable.

b) Avoids the need for development of sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive. The expansion of satellite navigation services is expected to contribute to the continued diversity of RNAV systems in different aircraft. The original Basic GNSS equipment is evolving due to the augmentations of Satellite-based Augmentation System (SBAS), Ground-based Augmentation System (GBAS) and Ground-based Regional Augmentation System (GRAS), while the introduction and modernization of GPS will further improve performance. The use of Global Navigation Satellite System (GNSS)/inertial integration is expanding.

c) Allows more efficient use of airspace (route placement, fuel efficiency, noise abatement, traffic management).

d) Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

e) Clarifies the way in which RNAV systems are to be used.

1.3 This CAR is issued under the provisions of Rule 133A of the Aircraft Rules, 1937 for information, guidance and compliance by the concerned operators operating air transport services to, through and within the RNAV airspace. **The contents of the CAR are consistent with the provisions of ICAO Annex 6 and Doc 9613 on the subject. Guidelines for implementing and obtaining approval for RNAV1, RNAV2, RNAV 5, RNP4, Basic RNP1, RNP APCH, RNP AR APCH, etc. have been specified in Volume II of ICAO Doc 9613.**

2. **DEFINITIONS**

**Area Navigation (RNAV)** - A method of navigation which permits aircraft operation on any desired flight path within the coverage of station-referenced ground or space based navigation aids or within the limits of the capability of self-contained navigation aids, or a combination of these. This removes the restriction imposed on conventional routes and procedures where the aircraft must overfly referenced navigation aids, thereby permitting operational flexibility and efficiency. The specified RNAV accuracy must be met 95% of the flight time.

- ***RNAV 1*** requires a total system error of not more than 1 NM for 95% of the total flight time.
- ***RNAV 2*** requires a total system error of not more than 2 NM for 95% of the total flight time

*Note - Area navigation includes Performance Based Navigation as well as other RNAV operations that do not meet the definition of Performance Based Navigation.*

**Area Navigation Route** - An ATS route established for the use of aircraft capable of employing area navigation.

**Aircraft-Based Augmentation System (ABAS)** - An augmentation system that augments and/or integrates the information obtained from the other GNSS elements with information available on board the aircraft.

*Note - The most common form of ABAS is receiver autonomous integrity monitoring (RAIM).*

**Airspace Concept** - An Airspace Concept provides the outline and intended framework of operations within an airspace. Airspace Concepts are developed to satisfy explicit strategic objectives such as improved safety, increased air traffic capacity and mitigation of environmental impact etc. Airspace Concepts can include details of the practical organisation of the airspace and its users based on particular CNS/ATM assumptions e.g. ATS route structure, separation minima, route spacing and obstacle clearance.

**Approach Procedure with Vertical Guidance (APV)** - An instrument procedure which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations.

Note: Specific approval for VNAV approaches would be required.

**ATS Surveillance Service** - Term used to indicate a service provided directly by means of an ATS surveillance system.

**ATS Surveillance System** - A generic term meaning variously, ADS-B, PSR, SSR or any comparable ground based system that enables the identification of aircraft.

*Note - A comparable ground-based system is one that has been demonstrated, by comparative assessment or other methodology, to have a level of safety and performance equal to or better than monopulse SSR.*

**Cyclic Redundancy Check (CRC)** - A mathematical algorithm applied to the digital expression of data that provides a level of assurance against loss or alteration of data.

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

**Mixed Navigation Environment** - An environment where different navigation specifications may be applied within the same airspace (e.g. RNP 10 routes and RNP 4 routes in the same airspace) or where operations using conventional navigation are allowed together with RNAV or RNP applications.

**Navigation Aid (Navaid) Infrastructure** - Navaid Infrastructure refers to space-based and or ground-based navigation aids available to meet the requirements in the navigation specification.

**Navigation Function** - The detailed capability of the navigation system (such as the execution of leg transitions, parallel offset capabilities, holding patterns, navigation data bases) required to meet the Airspace Concept.

*Note- Navigational functional requirements are one of the drivers for selection of a particular Navigation Specification.*

**Navigation Specification** - A set of aircraft and air crew requirements needed to support Performance Based Navigation operations within a defined airspace. There are two kinds of navigation specification: RNAV and RNP. A RNAV specification does not include requirements for on-board performance monitoring and alerting. A RNP specification includes requirements for on-board performance monitoring and alerting.

**Navigation Application** - The application of a navigation specification and the supporting Navaid infrastructure, to routes, procedures, and/or defined airspace volume, in accordance with the intended Airspace Concept.

*Note - The navigation application is one element, along with, communication, surveillance and ATM procedures meeting the strategic objectives in a defined Airspace Concept.*

**Parallel Offset Path** - A desired track parallel to and left or right of the "parent" track specified in nautical miles of offset distance.

**Performance Based Navigation** - Performance Based Navigation specifies system performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.

**Procedural Control** - Air traffic control service provided by using information derived from sources other than an ATS surveillance system

**Receiver Autonomous Integrity Monitoring (RAIM)** - A form of ABAS whereby a GNSS receiver processor determines the integrity of the GNSS navigation signals using only GPS signals or GPS signals augmented with altitude (baro aiding). This determination is achieved by a consistency check among redundant pseudo-orange measurements. At least one additional satellite needs to be available with the correct geometry over and above that needed for the position estimation for the receiver to perform the RAIM function.

**RNAV Equipment** - A combination of navigation equipment used to provide RNAV guidance.

**RNAV Operations** - Aircraft operations using area navigation for RNAV applications. RNAV operations include the use of area navigation for operations which are not developed in accordance with the PBN Manual.

**RNAV System** - A navigation system which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these. A RNAV system may be included as part of a Flight Management System (FMS).

**RNP and RNAV Specifications** - For oceanic, remote, en route and terminal operations, a RNP specification is designated as RNP X e.g. RNP 4. RNAV specification is designated as RNAV X, e.g. RNAV 1. If two navigation specifications share the same value for X, they may be distinguished by use of a prefix e.g. Advanced-RNP 1 and Basic- RNP 1.

For both RNP and RNAV designations the expression 'X' (where stated) refers to the lateral navigation accuracy in nautical miles that is expected to be achieved at least 95 percent of the flight time by the population of aircraft operating within the airspace, route or procedure.

**RNP (Required Navigation Performance)** - A statement of the navigation performance accuracy necessary for operation within a defined airspace.

**RNP Route** - An ATS Route established for the use of aircraft adhering to a prescribed RNP Specification

**RNP System** - An area navigation system which supports on-board performance monitoring and alerting.

**RNP Operations** - Aircraft operations using a RNP System for RNP applications.

**Satellite Based Augmentation System (SBAS)** - A wide coverage augmentation system in which the user receives augmentation from a satellite-based transmitter.

**Standard Instrument Arrival (STAR)** - A designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

**Standard Instrument Departure (SID)** - A designated instrument flight rule (IFR) departure route linking the aerodrome or a specified runway of the aerodrome with a specified significant point, normally on a designated ATS route, at which the en-route phase of a flight commences.

## 3. BASIC REQUIREMENTS

No person shall operate Indian registered aircraft in airspace designated for RNAV operations unless:

(i) Aircraft is equipped with a RNAV system able to support the desired navigation.
(ii) RNAV system and aircraft operations are compliant with the requirements contained in this CAR for the particular navigation application and authorized by DGCA for the operation.
(iii) The Operations Specifications contained in the Operating Permit of this operator are endorsed by DGCA to conduct RNAV operations.

Note: The navigation specification details the flight crew and aircraft requirements needed to support the navigation application. This specification includes the level of navigation performance, functional capabilities, and operational considerations required for the RNAV system.

## 4. Airworthiness Approval Process

The Airworthiness approval process assures that each item of the RNAV equipment installed is of a kind and design appropriate to its intended function and that the installation functions properly under foreseeable operating conditions. Additionally, the airworthiness approval process identifies any installation limitations that need to be considered for operational approval. Such limitations and other information elevant to the approval of the RNAV system installation are documented in the AFM, or AFM Supplement as applicable. Information may also be repeated and expanded upon in other documents such as Pilot Operating Handbooks (POHs) or Flight Crew Operating Manuals (FCOMs).

4.1 For airworthiness approval, the following information shall be submitted along with the application:

a) Sufficient data for assessment of the equipment/system regarding its acceptability for intended use.
b) Evidence of testing carried out to demonstrate the navigation performance accuracy appropriate to the RNP type.
c) Where the system is intended for use in designated areas for which airworthiness approval would be required, the information must adequately reflect the relevant airworthiness considerations that would affect the aircraft's ability to comply with the operational requirements for flight within such designated airspace.

4.2 Appropriate RNAV equipment certified for use in all required phases of flight shall be installed.

### *4.3 Approval of RNAV Systems for RNAV-X Operation*

The RNAV system installed should be compliant with a set of basic performance requirements described in the "navigation specification" which defines accuracy, integrity and continuity criteria. The RNAV system installed should be compliant with a set of specific functional requirements described in the navigation specification. For a multi-sensor RNAV system, an assessment should be conducted to establish which sensors are compliant with the performance requirement described in the navigation specification.

The RNAV system installed should have a navigation data base and should support each specific path terminator as required by the navigation specification.

*Note: For certain navigation applications, a navigation data base may be optional.*

The navigation specification generally indicates if a single or a dual installation is necessary to fulfill availability and/or continuity requirements. The Airspace Concept and Navaid infrastructure are key elements to decide if single or dual installation is necessary.

### *4.4 Approval of RNP Systems for RNP-X Operation*

The RNP system installed should be compliant with a set of basic RNP performance requirement described in the navigation specification. The RNP system should include an on board performance monitoring and alerting function. The RNP system installed should be compliant with a set of specific functional requirement described in the navigation specification. For a multi-sensor RNP system, an assessment should be conducted to establish sensors which are compliant with the RNP performance requirement described in the RNP specification. The RNP system installed should have a navigation data base and should support path terminator as required by the navigation specification

### 4.5 Acceptable Means of Compliance

Where reference is made in the AFM/ manufacturer regarding installation of RNAV system or specific level of required navigation performance (RNP), it is acceptable for issuance of airworthiness approval for RNAV-X operation provided the aircraft eligibility was determined through demonstration of compliance against the relevant airworthiness criteria (**e.g.** TGL No. 10 or FAA AC 90-100A for RNAV1 and/ or RNAV 2).

## 5. Operational Approval

### 5.1 General

The operational approval process assumes first that the corresponding installation/airworthiness approval has been granted. During operation, the crew should respect AFM and AFM supplements limitations. Normal procedures are provided in the navigation specification and detailed necessary crew action to be conducted during pre-flight planning, prior to commencing the procedure and duringthe procedure. Abnormal procedures are provided in the navigation specification. These procedures should detail crew action in

case of on-board RNAV system failure and in case of system inability to maintain the prescribed performance of the on board monitoring and alerting function. The Operator should have in place a system for investigation events affecting the safety of operations to determine its origin (coded procedure, accuracy problem, etc) Minimum equipment list (MEL) should identify the minimum equipment necessary to satisfy the navigation application.

5.2 The assessment of a particular operator shall be made by DGCA for granting operational approval taking into account:

a) Evidence of aircraft eligibility (Airworthiness Approval has been granted).
b) Assessment of the operating procedures for the navigation systems to be used.
c) Control of those procedures through acceptable entries in the Operations Manual.
d) Identification of flight crew training requirements.
e) Where required, control of navigation database process.

5.3 The operational approval should be documented in the Air Operators Certificate (AOC) andamendment to the operations manual.

5.4 The following minimum requirements shall be considered while approving the specific RNAV approval for each operator:

a) Approval is required to be obtained by each individual operator, as well as for each individual aircraft type group/ equipment (manufacturer/ model) utilized by an operator;
b) Each aircraft type/ group utilized by an operator shall be shown to be capable of maintaining navigation performance accuracy relevant to the level of RNAV approval being sought;
c) Each aircraft carrying RNAV/ flight management systems shall receive airworthiness approval prior to being reviewed for operational approval. DGCA shall evaluate the airworthiness documents for each aircraft type/group equipment (manufacturer/ model).

If in-service experience shows that the navigation performance of a particular aircraft type utilized by an operator does not meet the requirements, the operator shall take steps to improve navigation performance to the required level. If performance is not improved, operational approval for the aircraft type may be withdrawn from that operator. In case where navigation performance is observed to be grossly in error, approval shall be withdrawn immediately.

5.5 Detailed requirements on system performance, monitoring and alerting; criteria for specific navigation systems; and oversight for operators on RNP/RNP APCH/ RNAV 1 and 2 are given in Appendix I and II.

6. ***Training Requirements***

6.1 Commercial operators should have a training program addressing the operational practices, procedures and training items related to applicable RNAV operations (e.g. initial, upgrade or recurrent training for flight crew, dispatchers and maintenance personnel).

*Note: It is not required to establish a separate training program if RNAV training is already an integrated element of a training program. However, it should be possible to identify what aspects of RNAV are covered within a training program.*

Private operators should be familiar with the practices and procedures as identified in Pilot Knowledge/Training.

6.2 The pilot training programme shall be approved by DGCA.

6.3 The Training Programme shall consist of:

**6.3.1 For RNAV 5**

The following items should be addressed in the pilot training program (for example, simulator, training device, or aircraft) for the aircraft's RNAV system:

a) The capabilities and limitations of the RNAV system installed.
b) The operations and airspace for which the RNAV system is approved to operate.
c) The Navaid limitations in respect of the operation of the RNAV system to be used for the RNAV 5 operation.
d) Contingency procedures for RNAV failures.
e) The Radio/Telephony Phraseology for the airspace in accordance to Doc 4444 and Doc 7030 as appropriate.
f) The flight planning requirements for the RNAV operation.
g) RNAV requirements as determined from chart depiction and textual description.
h) RNAV system-specific information, including:

    i) Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation.
    ii) Functional integration with other aircraft systems.

iii) Monitoring procedures for each phase of flight (for example, monitor PROG or LEGS page).
iv) Types of navigation sensors (for example, DME, IRU, GNSS) utilised by the RNAV system and associated system prioritization/ weighting/logic.
v) Turn anticipation with consideration to speed and altitude effects.
vi) Interpretation of electronic displays and symbols.

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

i) Verify currency of aircraft navigation data.
ii) Verify successful completion of RNAV system self-tests.
iii) Initialize RNAV system position.
iv) Fly direct to a waypoint.
v) Intercept a course/track.
vi) Be vectored off and rejoin a procedure.
vii) Determine cross-track error/deviation.
viii) Remove and reselect navigation sensor input.
ix) When required, confirm exclusion of a specific navigation aid or navigation aid type.
x) Perform gross navigation error check using conventional navigation aids.

6.3.2 **For RNAV 1 and 2 OR Basic RNP 1**

The training program should provide sufficient training (for example, simulator, training device, or aircraft) on the aircraft's RNAV system to the extent that the pilots are familiar with the following:

a) The information given in Volume II Part B Chapter 3 (RNAV 1 and 2)/ Part C Chapter 3 (Basic RNP 1) of ICAO Doc 9613

b) The meaning and proper use of Aircraft Equipment/Navigation Suffixes.

c) Procedure characteristics as determined from chart depiction and textual description.

d) Depiction of waypoint types (fly-over and fly-by) and path terminators (provided in section 3.4.3.4 AIRINC 424 path terminators) and any other types used by the operator) as well as associated aircraft flight paths.

e) Required navigation equipment for operation on Basic-RNP 1 SIDs, and STARs and RNAV routes/SIDs/STARs e.g. DME/DME, DME/DME/IRU, and GNSS.

f) RNP/RNAV system-specific information:

i) Levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation.
ii) Functional integration with other aircraft systems.
iii) The meaning and appropriateness of route discontinuities as well as related flight crew procedures.
iv) Pilot procedures consistent with the operation.
v) Types of navigation sensors utilized by the RNP system and RNAV system (e.g. DME, IRU, GNSS) associated system prioritization/ weighting/logic.
vi) Turn anticipation with consideration to speed and altitude effects.
vii) Interpretation of electronic displays and symbols.
viii) Understanding of the aircraft configuration and operational conditions required to support Basic- RNP 1/RNAV operations, i.e., appropriate selection of CDI scaling (lateral deviation display scaling).

g) RNP/RNAV system operating procedures, as applicable, including how to perform the following actions:

i) Verify currency and integrity of aircraft navigation data.
ii) Verify successful completion of RNP/RNAV system self-tests.
iii) Initialize navigation system position.
iv) Retrieve and fly a SID or STAR with appropriate transition.
v) Adhere to speed and/or altitude constraints associated with a SID or STAR.
vi) Select the appropriate SID or STAR for the active runway in use and be familiar with procedures to deal with a runway change.
vii) Perform a manual or automatic update (with takeoff point shift, if applicable)
viii) Verify waypoints and flight plan programming.
ix) Fly direct to a waypoint.
x) Fly a course/track to a waypoint.
xi) Intercept a course/track.
xii) Flying radar vectors and rejoining a Basic-RNP 1/RNAV route from 'heading' mode.
xiii) Determine cross-track error/deviation. More specifically, the maximum deviations allowed to support Basic-RNP 1/RNAV must be understood and respected.
xiv) Resolve route discontinuities.
xv) Remove and reselect navigation sensor input.
xvi) When required, confirm exclusion of a specific navigation aid or navigation aid type.

xvii) Change arrival airport and alternate airport.
xviii) Perform parallel offset function if capability exists. Pilots should know how offsets are applied, the functionality of their particular RNP/RNAV system and the need to advise ATC if this functionality is not available.
xix) Perform RNAV holding function.

h) Operator-recommended levels of automation for phase of flight and workload, including methods to minimize cross-track error to maintain route centreline.

i) R/T phraseology for RNAV/RNP applications

j) Contingency procedures for RNAV/RNP failures.

## 5. OPERATING PROCEDURES

Airworthiness certification alone does not authorise flight in airspace or along routes for which RNAV 2 or RNAV 1 approval is required or to conduct RNP APCH operation. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

### 1.1 Pre-flight Planning

Operators and pilots intending to conduct operations on Basic-RNP 1 SIDs & STARs/RNAV 1 & RNAV 2/RNP APCH and should file the appropriate flight plan suffixes. The onboard navigation data must be current and include appropriate procedures.

*Note: Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots should establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the routes and procedures for flight.*

In addition to the normal pre-flight planning checks the following must be included:

a) The pilot must ensure that approaches which may be used for the intended flight (including alternates aerodromes) are selectable from a valid navigation data base (current AIRAC cycle), have been verified by the appropriate process (navigation data base integrity process) and are not prohibited by a company instruction or NOTAM.

b) During the pre-flight phase, the pilot should ensure sufficient means are available to navigate and land at the destination or at an alternate aerodrome in the case of loss of RNP APCH airborne capability.

c) Operators and flight-crews must take account of any NOTAMs or operator briefing material that could adversely affect the aircraft system operation, or the availability or suitability of the procedures at the airport of landing, or any alternate airport.

d) For missed approach procedures based on conventional means (VOR,NDB) the appropriate airborne equipment required to fly this procedure is installed in the aircraft and is operational. Also, the associated ground-based Navaids are operational.

The availability of the Navaid infrastructure, required for the intended routes, including any non-RNAV contingencies, must be confirmed for the period of intended operations using all available information. Since GNSS integrity (RAIM or SBAS signal) is required by Annex 10, the availability of these should also be determined as appropriate. For aircraft navigating with SBAS receivers (all TSO-C145()/C146()), operators should check appropriate GPS RAIM availability in areas where SBAS signal is unavailable.

## 5.2 ABAS Availability

RAIM levels required for Basic-RNP 1/RNAV1 & RNAV2/RNP APCH can be verified either through NOTAMs (where 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 should be familiar with the prediction information available for the intended route. RAIM availability prediction should take into account the latest GPS constellation NOTAMs and avionics model (when available). The service may be provided by the ANSP, avionics manufacturer, other entities or through an airborne receiver RAIM prediction capability.

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 Basic-RNP 1/RNAV1 & RNAV2 operation, the flight planning should be revised (e.g., delaying the departure or planning a different departure procedure).

RAIM availability prediction software does not guarantee the service, they are rather tools to asses the expected capability to meet the required navigation performances. Because of unplanned failure of some GNSS elements, pilots/ANSP must realize that RAIM or GPS navigation altogether may be lost

while airborne which may require reversion to an alternative means of navigation. Therefore, pilots should assess their capability to navigate (potentially to an alternate destination) in case of failure of GPS navigation.

## 5.3 DME Availability

For navigation relying on DME, NOTAMs should be checked to verify the health of critical DMEs. Pilots should assess their capability to navigate (potentially to an alternate destination) in case of failure of critical DME while airborne.

## 5.4 Prior to Commencing the Procedure

In addition to normal procedure prior to commencing the approach, the flight crew must verify the correct procedure was loaded by comparison with the approach charts. This check must include:

a) The waypoint sequence.

b) Reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and 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.*

Crew must also check from the published charts, map display or Control Display Unit (CDU), which waypoints are fly-by and which are fly-over.

For multi-sensor systems, crew must verify during the approach that GNSS sensor is used for position computation.

For an RNP system with ABAS requiring barometric corrected altitude, the current airport barometric altimeter setting, should be input at the appropriate time and location, consistent with the performance of the flight operation.
When the operation is predicated on the availability of ABAS, the flight crew should perform a new RAIM availability check if ETA is more than 15 minutes different from the ETA used during the preflight 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 waypoints loaded from the database. In complying with ATC instructions, the flight crew should be aware of the implications for the RNP system.

a) The manual entry of coordinates into the RNAV system by the flight crew for operation within the terminal area is not permitted.

b) 'Direct to' clearances may be accepted to the Intermediate Fix (IF) provided that the resulting track change at the IF does not exceed 45°.

*Note: Direct to clearance to FAF is not acceptable.*

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.

**5.6 During the Procedure**

The crew must be established on the RNP APCH final approach course no later than 2 NM before the FAF.

The crew must check the approach mode annunciator (or equivalent) is properly indicating approach-mode integrity within 2 NM before the FAF.

*Note: This will not apply for certain RNP system (e.g. aircraft already approved with demonstrated RNP capability). For such systems, other means are available including electronic map displays, flight guidance mode indications, etc. which clearly indicate to the crew that the approach mode is activated.*

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

a) The RNAV computed desired path, and

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

The procedure must be discontinued:

a) If the navigation display is flagged invalid,

b) Or in case of loss of integrity alerting function,

c) Or if integrity alerting function is annunciated not available before passing the FAF.

*Note: Discontinuing the procedure may not be necessary for a multi-sensor RNP system that includes demonstrated RNP capability without GNSS.*

*Manufacturer documentation should be examined to determine the extent the system may be used in such configuration.*

d) Or if FTE is excessive*.*

The missed approach must be flown in accordance with the published procedure. Use of the RNAV system during the missed approach is acceptable provided:

i) The RNAV system is operational (e.g. no loss of function, no NSE alert, no failure indication).

ii) The whole procedure (including the missed approach) is loaded from the navigation data-base.

During the RNP APCH procedure, pilots must use a lateral deviation indicator, flight director and/or autopilot in lateral navigation mode. Pilots of aircraft with a lateral deviation indicator (e.g. CDI) must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the procedure (i.e., ±1.0 NM for the Initial and Intermediate segments, ±0.3 NM for the Final Approach segment, and ±1.0 NM for the Missed Approach segment). All pilots are expected to maintain procedure centrelines, as depicted by onboard lateral deviation indicators and/or flight guidance during all the approach procedure unless authorized 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 position relative to the path) should be limited to ± ½ the navigation accuracy associated with the procedure (i.e., 0.5 NM for the Initial and Intermediate segments, 0.15 NM for the Final Approach segment, and 0.5 NM for the Missed Approach segment). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of 1 times the navigation accuracy (i.e. 1.0 NM for the Initial and Intermediate segments), are allowable.

When Baro-VNAV is used for vertical path guidance during the final approach segment, deviations above and below the Baro-VNAV path must not respectively exceed +100/-50 feet.

Pilots must execute a Missed Approach if the lateral deviations or vertical deviations (if provided) exceed the criteria above, unless the pilot has in sight the visual references required to continue the approach.

## 5.7 General Operating Procedures

5.7.1 The pilot should comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements given hereunder.

*Note: Pilots must adhere to any AFM limitations or operating procedures required to maintain Basic-RNP 1 performance for the SID or STAR.*

5.7.2 Operators and pilots should not request or file Basic-RNP 1/RNAV1 & RNAV2 procedures unless they satisfy all the criteria in the relevant State documents. If an aircraft not meeting these criteria receives a clearance from ATC to conduct a Basic-RNP 1 procedure/RNAV route, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.

5.7.3 At system initialization, pilots must confirm the navigation database is current and verify that the aircraft position has been entered correctly. Pilots must verify proper entry of their ATC assigned route upon initial clearance and any subsequent change of route. Pilots must ensure the waypoints sequence depicted by their navigation system matches the route depicted on the appropriate chart(s) and their assigned route.

5.7.4 Pilots must not fly a Basic-RNP 1/RNAV 1 & RNAV2 SID or STAR unless it is retrievable by procedure name from the onboard navigation database and conforms to the charted procedure. However, the procedure may subsequently be modified through the insertion or deletion of specific waypoints in response to ATC clearances. The manual entry, or creation of new waypoints, by manual entry of latitude and longitude or rho/theta values is not permitted. Additionally, pilots must not change any SID or STAR database waypoint type from a fly-by to a fly-over or vice versa.

5.7.5 Flight crews should crosscheck the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, if applicable. If required, the exclusion of specific navigation aids should be confirmed.

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

5.7.6 Whenever possible, RNAV 1 and RNAV 2 routes in the en route domain should be extracted from the database in their entirety, rather than loading

individual waypoints from the database into the flight plan. However, it is permitted to select and insert individual, named fixes waypoints from the navigation database, provided all fixes along the published route to be flown are inserted. Moreover, the route may subsequently be modified through the insertion or deletion of specific waypoints in response to ATC clearances. The creation of new waypoints by manual entry of latitude and longitude or rho/theta values is not permitted.

5.7.7 During the flight, where feasible, the flight crew should use available data from ground-based navigation aids to confirm navigational reasonableness.

5.7.8 For RNAV 2 routes, pilots should use a lateral deviation indicator, flight director or autopilot in lateral navigation mode. Pilots may use a navigation map display with equivalent functionality to a lateral deviation indicator without a flight director or autopilot.

5.7.9 For RNAV 1 routes, pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode.

5.7.10 Cross-checking with conventional Navaids is not required as the absence of integrity alert is considered sufficient to meet the integrity requirements. However, monitoring of navigation reasonableness is suggested, and any loss of RNP capability shall be reported to ATC.

5.7.11 For Basic-RNP 1 routes, pilots must use a lateral deviation indicator, flight director, or autopilot in lateral navigation mode. 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: ± 1 NM for Basic-RNP 1, ± 1 NM for RNAV 1, ± 2 NM for RNAV 2, or ± 5 NM for TSO-C129() equipment on RNAV 2 routes).

5.7.12 All pilots are expected to maintain centrelines, as depicted by onboard lateral deviation indicators and/or flight guidance during all Basic-RNP 1/RNAV operations described in this manual unless authorized to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the system computed path and the aircraft position relative to the path, i.e. FTE) should be limited to ± ½ the navigation accuracy associated with the procedure (i.e. 0.5 NM for Basic-RNP 1 and 0.5 NM for RNAV 1, 1.0 NM for RNAV 2). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of 1 times the navigation accuracy (i.e. 1.0 NM for Basic-RNP 1 and 1.0 NM for RNAV 1, 2.0 NM for RNAV), are allowable.

*Note: Some aircraft do not display or compute a path during turns. As such, pilots of these aircraft may not be able to adhere to the ±½ lateral navigation*

*accuracy during turns but are still expected to satisfy the standard during intercepts following turns and on straight segments.*

5.7.13 If ATC issues a heading assignment taking the aircraft off a route, the pilot should not modify the flight plan in the RNP/RNAV system until a clearance is received to rejoin the route or the controller confirms a new route clearance. When the aircraft is not on the published route, the specified accuracy requirement does not apply.

5.7.14 Manually selecting aircraft bank limiting functions may reduce the aircraft's ability to maintain its desired track and are not recommended. Pilots should recognize manually selectable aircraft bank-limiting functions might reduce their ability to satisfy ATC path expectations, especially when executing large angle turns. This should not be construed as a requirement to deviate from Airplane Flight Manual procedures; rather, pilots should be encouraged to limit the selection of such functions within accepted procedures.

## 5.5 Specifics for RNP Operations

### 5.5.1 Aircraft with RNP Selection Capability

Pilots of aircraft with RNP input selection capability should select RNP 1 or lower, for Basic-RNP 1 SIDs and STARs.

### 5.5.2 Basic-RNP 1 SID Specific Requirements

Prior to commencing takeoff, the pilot must verify the aircraft's Basic-RNP1 system is available, operating correctly, and the correct airport and runway data are loaded. Prior to flight, pilots must verify their aircraft navigation system is operating correctly and the correct runway and departure procedure (including any applicable en route transition) are entered and properly depicted. Pilots who are assigned a Basic-RNP 1 departure procedure and subsequently receive a change of runway, procedure or transition must verify the appropriate changes are entered and available for navigation prior to takeoff. A final check of proper runway entry and correct route depiction, shortly before takeoff, is recommended.

*Engagement Altitude*. The pilot must be able to use Basic-RNP 1 equipment to follow flight guidance for lateral RNAV no later than 500 feet above airport elevation.

Pilots must use an authorized method (lateral deviation indicator/navigation map display/flight director/autopilot) to achieve an appropriate level of performance for Basic-RNP 1.

*GNSS Aircraft*. When using GNSS, the signal must be acquired before the take-off roll commences. For aircraft using TSO-C129a equipment, the departure airport must be loaded into the flight plan in order to achieve the appropriate navigation system monitoring and sensitivity. For aircraft using TSO-C145()/C146() 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 sensitivity. If the Basic-RNP 1 SID extends beyond 30 NM from the ARP and a lateral deviation indicator is used, its full scale sensitivity must be selected to not greater than 1NM between 30NM from the ARP and the termination of the Basic-RNP 1 SID.

For aircraft using a lateral deviation display (i.e., navigation map display), the scale must be set appropriate for the Basic- RNP 1 SID, and the flight director or autopilot should be used.

### 5.5.3 Basic-RNP 1 STAR Specific Requirements

Prior to the arrival phase, the flight crew should verify that the correct terminal route has been loaded. The active flight plan should be checked by comparing the charts with the map display (if applicable) and the MCDU. This includes confirmation of the waypoint sequence, reasonableness of track angles and distances, any altitude or speed constraints, and, where possible, which waypoints are fly-by and which are fly-over. If required by a route, a check will need to be made to confirm that updating will exclude a particular navigation aid. A route must not be used if doubt exists as to the validity of the route in the navigation database.

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

The creation of new waypoints by manual entry into the Basic-RNP 1 system by the flight crew would invalidate the route and is not permitted.

Where the contingency procedure requires reversion to a conventional arrival route, necessary preparation must be completed before commencing the Basic-RNP 1 procedure.

Procedure modifications in the terminal area may take the form of radar headings or "direct to" clearances and the flight crew must be capable of reacting in a timely fashion. This may include the insertion of tactical waypoints loaded from the database. Manual entry or modification by the flight crew of the loaded route, using temporary waypoints or fixes not provided in the database, is not permitted. Pilots must verify their aircraft navigation system is operating correctly and the correct arrival procedure and runway (including any applicable transition) are entered and properly depicted.

Although a particular method is not mandated, any published altitude and speed constraints must be observed.

Aircraft with TSO-C129a GNSS RNP systems: If the Basic-RNP 1 STAR begins beyond 30 NM from the ARP and a lateral deviation indicator is used, its full scale sensitivity should be manually selected to not greater than 1 NM prior to commencing the STAR. For aircraft using a lateral deviation display (i.e., navigation map display), the scale must be set appropriate for the Basic-RNP 1 STAR, and the flight director or autopilot should be used.

## 5.6 Specifics for RNAV Operations

### 5.6.1 RNAV SID Specific Requirements

Prior to commencing takeoff, the pilot must verify the aircraft's RNAV system is available, operating correctly, and the correct airport and runway data are loaded. Prior to flight, pilots must verify their aircraft navigation system is operating correctly and the correct runway and departure procedure (including any applicable en route transition) are entered and properly depicted. Pilots who are assigned an RNAV departure procedure and subsequently receive a change of runway, procedure or transition must verify the appropriate changes are entered and available for navigation prior to takeoff. A final check of proper runway entry and correct route depiction, shortly before takeoff, is recommended.

### 5.6.2 RNAV STAR Specific Requirements

Prior to the arrival phase, the flight crew should verify that the correct terminal route has been loaded. The active flight plan should be checked by comparing the charts with the map display (if applicable) and the MCDU. This includes confirmation of the waypoint sequence, reasonableness of track angles and distances, any altitude or speed constraints, and, where possible, which waypoints are fly-by and which are fly-over. If required by a route, a check will need to be made to confirm that updating will exclude a particular navigation aid. A route must not be used if doubt exists as to the validity of the route in the navigation database.

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

The creation of new waypoints by manual entry into the RNAV system by the flight crew would invalidate the route and is not permitted.

Where the contingency procedure requires reversion to a conventional arrival route, necessary preparation must be completed before commencing the RNAV route.

Route modifications in the terminal area may take the form of radar headings or "direct to" clearances and the flight crew must be capable of reacting in a timely fashion. This may include the insertion of tactical waypoints loaded from the database. Manual entry or modification by the flight crew of the loaded route, using temporary waypoints or fixes not provided in the database, is not permitted.

Pilots must verify their aircraft navigation system is operating correctly and the correct arrival procedure and runway (including any applicable transition) are entered and properly depicted.

Although a particular method is not mandated, any published altitude and speed constraints must be observed.

## 5.11 Contingency Procedures

The pilot must notify ATC of any loss of the RNP/ RNP APCH/RNAV capability (integrity alerts or loss of navigation), together with the proposed course of action. If unable to comply with the requirements of a Basic-RNP 1 SID or STAR/ RNP APCH/RNAV route for any reason, pilots must advise ATS as soon as possible. The loss of RNP/RNP APCH/RNAV capability includes any failure or event causing the aircraft to no longer satisfy the Basic-RNP 1/ RNP APCH/ RNAV requirements of the route. In the event of communications failure, the flight crew should continue with established lost communication procedure.

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**DIRCTOR GENERAL OF CIVIL AVIATION**

**APPENDIX I**

## REQUIRED NAVIGATION PERFORMANCE RNP 1

1. The Basic RNP 1 Navigation Specification provides a means to develop routes for connectivity between the en route structure and TMAs with no or limited ATS Surveillance, with low to medium density traffic.

   GNSS will be the primary navigation system to support the Basic-RNP 1. While DME/DME based RNAV systems are capable of Basic-RNP 1 accuracy, this navigation specification is primarily intended for environments where the DME infrastructure cannot support DME/DME area navigation to the required performance. The increased complexity in the DME infrastructure requirements and assessment mean it is not practical or cost effective for widespread application.

   This appendix does *not* address all requirements that may be specified for operation on a particular route or in a particular area. These requirements are specified in other documents such as operating rules, aeronautical information publications (AIPs) etc.

   While operational approval primarily relates to the navigation requirements of the airspace, operators and flight crew are still required to take account of all operational documents relating to the airspace required by the appropriate State authority before conducting flights into that airspace. This appendix addresses both RNP-1 and RNP APCH.

2. **An Operator Wishing to Fly into RNP-1 Designated Airspace:**

   a) First establish the aircraft eligibility. This may be accomplished through prior documentation of compliance to the requirements of this navigation specification by providing information from the Airplane flight Manual and or any other appropriate document from manufacturer/OEM.

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

*3.1* ***Accuracy***: During operations in airspace or on routes designated as Basic-RNP 1, the lateral total system error must be within ±1 NM for at least 95% of the total flight time. The along-track error must also be within ±1 NM for at least 95% of the total flight time. To satisfy the accuracy requirement, the 95% FTE should not exceed 0.5 NM.

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

*3.2* ***Integrity***: Malfunction of the aircraft navigation equipment is classified as a Major failure condition under airworthiness regulations (i.e. $10^{-5}$ per hour).

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

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

*3.5* ***Signal-in-Space***: If using GNSS, 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 (ICAO Annex 10, Table 3.7.2.4-1).

*Note: Compliance with the performance monitoring and alerting requirement does not imply an automatic monitor of flight technical error. 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 enabling the crew to monitor the Flight Technical Error (FTE). To the extent operational procedures are used to monitor FTE, the crew procedure, equipment characteristics, and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures. Path Definition Error (PDE) is considered negligible due to the quality assurance process and crew procedures.*

## 4. Criteria for Specific Navigation Systems

Basic-RNP 1 is based on GNSS positioning. Positioning data from other types of navigation sensors may be integrated with the GNSS data provided it does not cause position errors exceeding the Total System Error (TSE) budget. Otherwise**,** means should be provided to deselect the other navigation sensor types.

4.1 **Functional Requirement – Navigation Displays and Required functions**

a) Navigation data, including a to/from indication and a failure indicator, must be displayed on a lateral deviation display (CDI, (E)HSI) 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. They must meet the following requirements: Non-numeric lateral deviation display (for example, 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:

i) The displays must be visible to the pilot and located in the primary field of view (± 15° from pilot's normal line of sight) when looking forward along the flight path.

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

iii) 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.

iv) 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.

v) The lateral deviation display must be automatically slaved to the RNAV computed path. The course selector of the deviation display should be automatically slewed to the RNAV computed path. As an alternate means, a navigation map display should give equivalent functionality to a lateral deviation display, with appropriate map scales (scaling may be set manually by the pilot), and giving equivalent functionality to a lateral deviation display.

b) The following system functions are required as a minimum within any Basic-RNP 1 equipment:

i) The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNAV computed desired path and aircraft position relative to the path. For operations where the required minimum flight crew is

two pilots, the means for the pilot not flying to verify the desired path and the aircraft position relative to the path must also be provided.

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

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

iv) 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.

v) Capacity to load from the database into the Basic-RNP 1 system the entire segment of the SID or STAR to be flown.

*Note: Due to variability in systems, this document defines the RNAV 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* Volume II, Part C C-3-7 *after the last named waypoint do not have to be loaded from the database. The entire SID will be still be considered an RNP 1 procedure.*

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

i) The active navigation sensor type
ii) The identification of the active (To) waypoint
iii) The ground speed or time to the active (To) waypoint
iv) 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 pilot.

f) The capability to execute Basic- RNP 1 terminal procedures extracted from the onboard database including the capability to execute fly-over 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.

- Initial Fix (IF)
- Course to Fix (CF)
- Direct to Fix (DF)
- Track to Fix (TF)

*Note 1: Path terminators are defined in ARINC Specification 424, and their application is described in more detail in RTCA documents DO-236B/EUROCAE ED-75B and DO-201A/EUROCAE 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 VA, VM and VI ARINC 424 path terminators, or must be able to be manually flown on a heading to intercept a course or to go direct to another fix after reaching a procedure-specified altitude.

i) The aircraft must have the capability to automatically execute leg transitions consistent with CA and FM ARINC 424 path terminators, or the RNAV system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint. C-3-8 Performance Based Navigation Manual, Volume I.

j) The capability to load a Basic RNP-1 procedure from the database, by procedure name, into the RNAV system.

k) The capability to display an indication of the Basic RNP-1 system failure, in the pilot's primary field of view.

l) Database Integrity The navigation database suppliers should comply with RTCA DO-200A/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, demonstrates compliance with this requirement. Discrepancies that invalidate a route must be reported to the navigation database supplier and affected routes must be prohibited by an operator's notice to its flight crew. Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements.

5. **Database**

The navigation database must be obtained from a supplier that complies with RTCA DO-200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data, and should be compatible with the intended function of the equipment (reference ICAO Annex 6, Part 1, Chapter 7.4). A Letter of Acceptance (LOA), issued by the appropriate regulatory authority to each of the participants in the data chain, demonstrates compliance with this requirement (e.g., FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA IR 21 subpart G).

Discrepancies that invalidate a SID or STAR must be reported to the navigation database supplier and affected SID or STAR must be prohibited by an operator's notice to its flight crew. Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements.

*Note: To minimize path definition error, the database should comply with DO 200A, or an equivalent operational means must be in place to ensure database integrity for the Basic-RNP 1 SIDs or STARs.*

6. **Oversight of Operators**

DGCA shall consider any navigation error reports in determining remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment. 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 crew may necessitate remedial training or license review.

7. Procedure for reporting of incidents shall be established by the operator.

## REQUIRED NAVIGATION PERFORMANCE RNP- APCH

1. GNSS is the primary navigation system to support RNP APCH procedures. The missed approach segment may be based upon the conventional Navaid (e.g., VOR, DME, NDB). 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 function (e.g. RAIM holes), must be considered by the responsible airspace authority.

2. **An Operator Wishing to fly into RNP-APCH Designated Airspace**

First establish the aircraft eligibility. This may be accomplished through prior documentation of compliance to the requirements of this navigation specification by providing information from the Airplane flight Manual and or any other appropriate document from manufacturer/OEM.

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

*3.1* ***Accuracy***: During operations on the initial, intermediate segment and for the RNAV missed approach of an RNP APCH, the lateral total system error must be within ±1 NM for at least 95% of the total flight time. The along-track error must also be within ±1 NM for at least 95% of the total flight time. During operations on the final approach segment of an RNP APCH, the lateral total system error must be within ±0.3 NM for at least 95% of the total flight time. The along-track error must also be within ±0.3 NM for at least 95% of the total flight time.

To satisfy the accuracy requirement, the 95% FTE should not exceed 0.5 NM on the initial, intermediate and for the RNAV missed approach of an RNP APCH. The 95% FTE should not exceed 0.25 NM on the final approach segment of an RNP APCH.

*Note: The use of a deviation indicator with 1 NM full-scale deflection on the initial, intermediate and missed approach and 0.3 NM full-scale deflection on the final approach segment has been found to be an acceptable means of compliance. The use of an autopilot or flight director has been found to be an acceptable means of compliance (roll stabilization systems do not qualify).*

*3.2* ***Integrity***: Malfunction of the aircraft navigation equipment is classified as a Major failure condition under airworthiness regulations (i.e. $10^{-5}$ per hour).

*3.3* ***Continuity***: Loss of function is classified as a Minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport. If the missed approach procedure is based on conventional means

(e.g. NDB, VOR, DME), related navigation equipment must be installed and be serviceable.

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

*3.5* ***Signal-in-Space***: During operations on the initial, intermediate segment and for the RNAV missed approach of an RNP APCH, 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 (ICAO Annex 10, Table 3.7.2.4-1). During operations on the final approach segment of an RNP APCH, the aircraft navigation equipment shall 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 (ICAO Annex 10, Table 3.7.2.4-1).

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

*Note 2: Compliance with the performance monitoring and alerting requirement does not imply an automatic monitor of flight technical error. 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 enabling the crew to monitor the Flight Technical Error (FTE). To the extent operational procedures are used to monitor FTE, the crew procedure, equipment characteristics, and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures.*

*3.6 Path Definition Error (PDE) is considered negligible due to the quality assurance process and crew procedures.*

*Note 3: The following systems meet the accuracy, integrity and continuity requirements of these criteria:*

*a) GNSS stand-alone systems, equipment should be approved in accordance with TSO-C129a/ ETSOC129a Class A1 or E/TSO-C146() Class Gamma and operational class 1, 2 or 3.*

*b) GNSS sensors used in multi-sensor system (e.g. FMS) equipment should be approved in accordance with TSO C129 ( )/ ETSO-C129 ( ) Class B1, C1, B3, C3 or E/TSO C145() class 1, 2 or 3. For GNSS receiver approved in accordance with E/TSO-C129(), capability for satellite Fault detection and Exclusion (FDE) is recommended to improve Continuity of function.*

*c) Multi-sensor systems using GNSS should be approved in accordance with AC20-130A or TSOC115b, as well as having been demonstrated for RNP APCH capability.*

## 4. Criteria for Specific Navigation Systems

RNP APCH is based on GNSS positioning. Positioning data from other types of navigation sensors may be integrated with the GNSS data provided it does not cause position errors exceeding the Total System Error (TSE) budget**,** or if means are provided to deselect the other navigation sensor types.

### 4.1 Functional Requirements - Navigation Displays and Required Functions

Navigation data, including a to/from indication, and a failure indicator, must be displayed on a lateral deviation display (CDI, (E)HSI) 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) The displays must be visible to the pilot and located in the primary field of view (± 15° from pilot's normal line of sight) when looking forward along the flight path.

b) The lateral deviation display scaling should agree with any alerting and annunciation limits.

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 Total System Error requirement. Scaling is ± 1NM for the initial and intermediate segments and ± 0.3 NM for the final segment.

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 approach values.

e) As an alternate means, a navigation map display must give equivalent functionality to a lateral deviation display with appropriate map scales

(scaling may be set manually by the pilot), and giving equivalent functionality to a lateral deviation display. To be approved, the navigation map display must be shown to meet the TSE requirements.

f) It is highly recommended that the course selector of the deviation display is automatically slaved to the RNAV 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*.

g) Flight director and/or autopilot is not required for this type of operation however if the lateral Total System Error cannot be demonstrated without these systems, it becomes mandatory. In this case coupling to the flight director and/or automatic pilot from the RNAV system must be clearly indicated at the cockpit level.

h) Enhanced navigation display (e.g. electronic map display or enhanced EHSI) to improve lateral situational awareness, navigation monitoring and approach verification (flight plan verification) could become mandatory if the RNAV installation doesn't support the display of information necessary for the accomplishment of these crew tasks. The following system functions are required as a minimum:

i) The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNAV 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 to verify the desired path and the aircraft position relative to the path must also be provided.

ii) A navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the Aeronautical Information Regulation and Control (AIRAC) cycle and from which approach procedures can be retrieved and loaded into the RNAV 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.

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

iv) 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 procedure to be flown.

v) Capacity to load from the database into the RNAV system the whole approach to be flown. The approach must be loaded from the database, into the RNAV system, by its name.

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

- The identification of the active (To) waypoint
- The distance and bearing to the active (To) waypoint
- The ground speed or time to the active (To) waypoint

vii) The means to display the following items on a readily accessible display page:

- The display of distance between flight plan waypoints
- The display of distance to go
- The display of along track distances
- The active navigation sensor type if there is other sensor in addition to the GNSS one.

viii) The capability to execute a "Direct to" function.

ix) The capability for automatic leg sequencing with the display of sequencing to the pilot.

x) The capability to execute procedures extracted from the onboard database including the capability to execute fly-over and fly-by turns.

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

- Initial Fix (IF)
- Track to Fix (TF)
- Direct to Fix (DF)

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

xi) The capability to display an indication of the RNAV system failure, including the associated sensors, in the pilot's primary field of view.

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

5. **Navigation Database**

The navigation database should be obtained from a 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 demonstrates 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.

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 consider the need to conduct ongoing checks of the operational navigation databases in order to meet existing quality system requirements.

6. **Oversight of Operators**

DGCA shall consider any navigation error reports in determining remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment. 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 crew may necessitate remedial training or license review.

7. Procedure for reporting of incidents shall be established by Operators.

**APPENDIX II**

## AREA NAVIGATION RNAV 1 AND RNAV 2

1. The RNAV 1 and RNAV 2 Navigation Specification is applicable to all ATS routes, including routes in the en route domain, Standard Instrument Departures (SIDs), and Standard Arrival Routes (STARS). It also applies to instrument approach procedures up to the Final Approach Fix where promulgated.

   RNAV 1 and RNAV 2 Navigation Specification were primarily developed for RNAV operations in a radar environment (for SIDs, radar coverage is expected prior to the first RNAV course change).

   RNAV 1 and RNAV 2 are identical, while some operating procedures are different and RNAV 1 and RNAV 2 routes are envisioned to be conducted in direct controller pilot communication environments.

   RNAV 1 and RNAV 2 operations are based upon the use of RNAV equipment that automatically determines aircraft position in the horizontal plane using inputs from the following types of position sensors (no specific priority).

   a) Global Navigation Satellite System (GNSS)
   b) DME/DME RNAV
   c) DME/DME/IRU RNAV

   This appendix does *not* address all requirements that may be specified for operation on a particular route or in a particular area. These requirements are specified in other documents such as operating rules, aeronautical information publications (AIPs) etc.

   While operational approval primarily relates to the navigation requirements of the airspace, operators and flight crew are still required to take account of all operational documents relating to the airspace required by the appropriate State authority before conducting flights into that airspace.

2. **Operator Wishing to Fly into RNAV 1 or RNAV 2 Designated Airspace**

   First establish the aircraft eligibility. This may be accomplished through prior documentation of compliance to the requirements of this navigation specification by providing information from the Airplane flight Manual and or any other appropriate document from manufacturer/OEM.

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

3.1 ***Accuracy***: During operations in airspace or on routes designated as RNAV 1, the lateral total system error must be within ± 1NM for at least 95% of the total flight time. The along-track error must also be within ±1 NM for at least 95% of the total flight time. During operations in airspace or on routes designated as RNAV 2, the lateral total system error must be within ±2 NM for at least 95% of the total flight time. The along-track error must also be within ±2 NM for at least 95% of the total flight time.

3.2 ***Integrity***: Malfunction of the aircraft navigation equipment is classified as a Major failure condition under airworthiness regulations (i.e. $10^{-5}$ per hour).

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

3.4 ***Signal-in-Space***: During operations in airspace or on routes designated as RNAV 1 if using GNSS, 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 (ICAO Annex 10, Table 3.7.2.4-1). During operations in airspace or on routes designated as RNAV 2 if using GNSS, the aircraft navigation equipment shall 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 (ICAO Annex 10, Table 3.7.2.4-1).

## 4. Criteria for Specific Navigation Systems

RNAV 1 and RNAV 2 operations are based upon the use of RNAV equipment that automatically determines aircraft position in the horizontal plane using inputs from the following types of position sensors (no specific priority).

a) Global Navigation Satellite System (GNSS)
b) DME/DME RNAV
c) DME/DME/IRU RNAV

### 4.1 Functional Requirement

a) Navigation data, including a to/from indication and a failure indicator, must be displayed on a lateral deviation display (CDI, (E)HSI) 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. They must meet the following requirements:

Non-numeric lateral deviation display (for example, 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:

1) The displays must be visible to the pilot and located in the primary field of view (± 15° from pilot's normal line of sight) when looking forward along the flight path.

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

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

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

5) The lateral deviation display must be automatically slaved to the RNAV computed path. The course selector of the deviation display should be automatically slewed to the RNAV computed path. As an alternate means, a navigation map display should give equivalent functionality to a lateral deviation display with appropriate map scales (scaling may be set manually by the pilot), and giving equivalent functionality to a lateral deviation display.

*Note: A number of modern aircraft eligible for this specification utilize a map display as an acceptable method to satisfy the stated requirements.*

b) The following system functions are required as a minimum within any RNAV 2 or RNAV 1 equipment:

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

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

path definition error. 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) Capacity to load from the database into the RNAV system the entire RNAV segment of the SID or STAR to be flown.

*Note: Due to variability in RNAV systems, this document defines the RNAV 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.*

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

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
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 pilot.

f) The capability to execute ATS routes extracted from the onboard database including the capability to execute fly-over 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.

- Initial Fix (IF)
- Course to Fix (CF)
- Direct to Fix (DF)
- Track to Fix (TF)

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

i) The aircraft must have the capability to automatically execute leg transitions consistent with CA and FM ARINC 424 path terminators, or the RNAV 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 RNAV ATS route from the database, by route name, into the RNAV system is a recommended function. However, if all or part of the RNAV route (not SID or STAR) is entered through the manual entry of waypoints from the navigation database, the paths between a manually entered waypoint and the preceding and following waypoint must be flown in the same manner as a TF leg in terminal airspace.

k) The capability to display an indication of the RNAV system failure, including the associated sensors, in the pilot's primary field of view.

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 providing a means for manual navigation source selection.

m) Data base Integrity

The navigation data base suppliers should comply with RTCA DO-200A/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, demonstrates compliance with this requirement. Discrepancies that invalidate a route must be reported to the navigation data base supplier and affected routes must be prohibited by an operator's notice to its flight crew. Aircraft operators should consider the need to conduct periodic checks of the operational navigation data bases in order to meet existing quality system requirements.

## 5. Navigation Database

The navigation database should be obtained from a supplier that complies with RTCA DO-200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data and should compatible with the intended function of the equipment (reference ICAO Annex 6, Part 1, Chapter 7.4). A Letter of Acceptance (LOA), issued by the appropriate regulatory authority to each of the participants in the data chain, demonstrates compliance with this

requirement (e.g. FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA IR 21 subpart G).

Discrepancies that invalidate a route must be reported to the navigation database supplier and affected routes must be prohibited by an operator's notice to its flight crew. Aircraft operators should consider the need to conduct periodic checks of the operational navigation databases in order to meet existing quality system requirements. DME/DME RNAV systems must only use DME facilities identified in State AIPs. Systems must not use facilities indicated by the State as inappropriate for RNAV 1 and RNAV 2 operation in the AIP or facilities associated with an ILS or MLS that uses a range offset. This may be accomplished by excluding specific DME facilities, which are known to have a deleterious effect on the navigation solution, from the aircraft's navigation database when the RNAV routes are within reception range of these DME facilities.

6. **Oversight of Operators**

DGCA shall consider any navigation error reports in determining remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment. 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 crew may necessitate remedial training or license review.

7. Procedure for reporting of incidents shall be established by Operators.

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