



GOVERNMENT OF INDIA
CIVIL AVIATION DEPARTMENT
DIRECTOR GENERAL OF CIVIL AVIATION

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OPERATIONS CIRCULAR

Subject: Aircraft and Operators approval for RNAV 5 Operations

1. PURPOSE

This operations circular (OC) provides acceptable means of compliance (AMC) concerning aircraft and operators approval for RNAV 5 operations. An operator may use alternative means of compliance, as far as those means are acceptable to DGCA. The use of the verb in future or the word “must”, is applied to an applicant or operator choosing to fulfill the criteria described in this OC.

This OC also provides guidelines to operators when the stand-alone global positioning system (GPS) is used as the means of navigation in RNAV 5 operations (where the stand-alone GPS equipment provides the only RNAV capability installed on board the aircraft).

2. RELEVANT REGULATIONS

- (a) Rule 133B Indian Aircraft Rules 1937
- (b) CAR Section 8 Series O Part II Para 7.2.2 – Operation of Commercial Air Transport- Aeroplanes
- (c) CAR Section 8 Series O Part III Para 2.5.2– Operations of General Aviation Aeroplanes
- (d) CAR Section 8 Series S Part IV – Performance Based Navigation

3. RELATED DOCUMENTS

- (a) Annex 2 Rules of the Air
- (b) Annex 6 Operation of aircraft Part I/II
- (c) ICAO Doc 9613 Performance-based Navigation (PBN) manual
- (d) ICAO Doc 4444 Procedures for air navigation services – Air traffic management
- (e) ICAO Doc 7030 Regional Supplementary Procedures
- (f) ICAO Doc 8168 Aircraft operations Volume II – Parts I and II – General criteria
- (g) EASA AMC 20-4 Airworthiness approval and operational criteria for the use of navigation systems in European airspace designated for Basic RNAV operations and its related documentation
- (h) FAA AC 90-96A Approval of U.S. operators and aircraft to operate under instrument flight rules (IFR) in European airspace designated for basic area navigation (B-RNAV) and precision area navigation (P-RNAV) and its related documentation

4. DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

- (a) **Aircraft-based augmentation system (ABAS).**- An augmentation system that augments and/or integrates the information obtained from other GNSS elements with information available on board the aircraft.
- (b) **Area navigation (RNAV).**- A navigation method that allows aircraft to operate on 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 these.
Note.- Area navigation includes performance-based navigation as well as other RNAV operations that do not meet the definition of performance-based navigation.
- (c) **Area navigation (RNAV) specification.**- Area navigation specification that does not include the on-board performance control and alerting requirement, designated by the prefix RNAV; e.g., RNAV 5, RNAV 2, RNAV 1.

Note 1.- The Manual on Performance-based Navigation (PBN) (Doc 9613), Volume II, contains detailed guidelines on navigation specifications.

Note 2.-The term RNP, formerly defined as “a statement of the navigation performance necessary for operation within a defined airspace”, has been deleted from the Annexes to the Convention on International Civil Aviation because the RNP concept has been replaced by the PBN concept. In said Annexes, the term RNP is now only used within the context of the navigation specifications that require on-board performance control and alerting; e.g., RNP 4 refers to the aircraft and the operational requirements, including a lateral performance of 4 NM, with the requirement for on-board performance control and alerting as described in the PBN Manual (Doc 9613).

(d) **Display errors (screen protection 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 way-point definition, directly attributable to errors in the reference chart used in determining way-point positions, should be included as a component of this error. This type of error is virtually impossible to handle, and in general practice, highly accurate, published way-point locations are used to the greatest extent possible in setting up such systems to avoid such errors and reduce workload.

(e) **Fault detection and exclusion (FDE).**- Is a function performed by some on board GNSS receivers, which can detect the presence of a faulty satellite signal and automatically exclude it from the position calculation. In addition to the total number of satellites needed for receiver autonomous integrity monitoring (RAIM), at least one more available satellite is required (6 satellites).

(f) **Flight management system (FMS).**- An integrated system, consisting of an airborne sensor, a receiver and a computer containing both navigation and aircraft performance databases, capable of providing RNAV performance and guidance values to a display and automatic flight control system.

(g) **Flight technical error (FTE).**- The FTE is the accuracy with which an aircraft is controlled as measured by the indicated aircraft position, with respect to the indicated command or desired position. It does not include blunder errors.

Note.- For aircraft that are not capable of autopilot or flight director coupling, an FTE of 3.7 km (2 NM) for oceanic operations must be taken into account in determining any limitations.

(h) **Global navigation satellite system (GNSS).**- A generic term used by ICAO to define any global position, speed, and time determination system that includes

one or more main satellite constellations, such as GPS and the global navigation satellite system (GLONASS), aircraft receivers and several integrity monitoring systems, including aircraft-based augmentation systems (ABAS), satellite-based augmentation systems (SBAS), such as the wide area augmentation systems (WAAS), and ground-based augmentation systems (GBAS), such as the local area augmentation system (LAAS). Distance information will be provided, at least in the immediate future, by GPS and GLONASS.

(i) **Global positioning system (GPS).**-The United States global navigation satellite system (GNSS) is a satellite-based radio navigation system that uses precise distance measurements to determine position, speed, and time anywhere in the world. The GPS is made up by three elements: the spatial, control, and user elements. The GPS space segment is nominally made up by, at least, 24 satellites in 6 orbital planes. The control element consists of 5 monitoring stations, 3 ground antennas, and one main control station. The user element consists of antennas and receivers that provide the user with position, speed, and precise time.

(j) **Navigation system error (NSE).**-The difference between true position and estimated position.

(k) **Navigation specifications.**-Set of aircraft and flight crew requirements needed to support performance-based navigation operations in a defined airspace. There are two kinds of navigation specifications:

(l) **Oceanic airspace.**-The airspace over the oceanic area is considered international airspace in which ICAO procedures and separations apply. The responsibility for providing air traffic services in this airspace is delegated to those States with the greatest geographic proximity and/or that have more resources available.

(m) **Path definition error (PDE)** - The difference between the defined path and the desired path in a given place and time.

(n) **Performance-based navigation (PBN).**-Performance-based navigation specifies system performance requirements for aircraft operating along an ATS route, on an instrument approach procedure, or in a designated airspace. Performance requirements are defined in terms of the precision, integrity, continuity, availability, and functionality necessary to perform the proposed operation within the context of a particular airspace concept.

(o) **Primary means of navigation.**- A navigation system approved for a given operation or flight phase, that must meet accuracy and integrity requirements but not full availability and continuity of service. Safety is guaranteed by limiting flights to specific time periods and through the establishment of timely restrictive procedures.

(p) **Receiver autonomous integrity monitoring (RAIM).**-A technique used in a GNSS receiver/processor to determine the integrity of its navigation signals, using only GPS signals or GPS signals enhanced with barometric upper-air data. This determination is achieved by a consistency check between pseudo-range

measurements. At least one additional available satellite is required with respect to the number of satellites that are needed to obtain the navigation solution.

(q) **Required navigation performance (RNP) specification.**- Area navigation (RNAV) specification that includes the on-board performance control and alerting requirement, designated by the prefix RNP; e.g., RNP 4, RNP APCH, RNP AR APCH.

(r) **RNAV operations.**- Aircraft operations that use area navigation for RNAV applications. RNAV operations include the use of area navigation for operations that are not performed in keeping with the PBN manual.

(s) **RNAV system.**- An area navigation system which permits aircraft operation on 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 these. An RNAV system may be included as part of a Flight Management System (FMS)

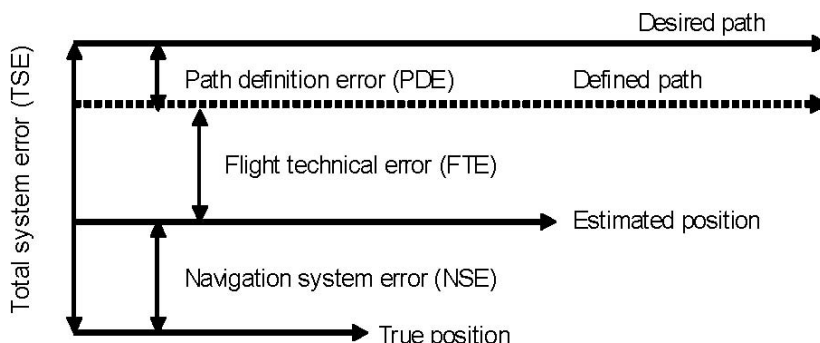
(t) **Single/Sole means of navigation.**-A navigation system approved for a given operation or flight phase, and that allows the aircraft to meet the four navigation criteria: accuracy, integrity, availability, and continuity of service.

(u) **Stand-alone global positioning system (Stand-alone GPS).**-A GPS that is not connected to, or combined with, any other navigation system or sensor.

(v) **Supplementary means of navigation.**- A navigation system that must be used together with a system considered to be a single means of navigation, and that must meet accuracy and integrity requirements but not availability and continuity conditions.

(w) **Total system error (TSE).**-Is the difference between the true position and the desired position. This error is equal to the vector sum of path definition error (PDE), flight technical error (FTE) and navigation system error (NSE).

Total system error (TSE)



4.2 Abbreviations

- AC Advisory circular (FAA)
- AFM Airplane flight manual
- AIP Aeronautical information publication
- AMC Acceptable means of compliance
- ATC Air traffic control
- ATS Air traffic services
- BRG/DIS Bearing/distance
- B-RNAV Basic area navigation
- DME Distance measuring equipment
- EASA European Aviation Safety Agency
- FAA United States Federal Aviation Administration
- FDE Fault detection and exclusion
- FIR Flight Information Region
- FMS Flight management system
- FTE Flight technical error
- GNSS Global navigation satellite system
- GLONASS Global navigation satellite system
- GPS Global positioning system
- INS Inertial navigation system
- IRS Inertial reference system
- IRU Inertial reference unit
- LOA Letter of authorisation/letter of acceptance
- LRNS Long-range navigation system
- MEL Minimum equipment list
- NSE Navigation system error
- ICAO International Civil Aviation Organization
- OM Operations manual
- OpSpecs Operations specifications
- PANS-OPS Procedures for Air Navigation Services - Aircraft Operations
- PBN Performance-based navigation
- PDE Path definition error
- P-RNAV Precision area navigation
- RAIM Receiver autonomous integrity monitoring
- RNAV Area navigation
- RNP Required navigation performance
- RNP APCH Required navigation performance approach
- RNP AR APCH Required navigation performance authorisation required approach
- SLOP Strategic lateral offset procedure
- SSR Secondary surveillance radar
- STC Supplementary type certificate
- TC Type certificate
- TSE Total system error
- TSO Technical standard order

5. INTRODUCTION

5.1 In January 1998, the European Air Safety Agency (EASA) published the document related to the acceptable means of compliance (AMC 20-4) which replaced the Temporary guidance Leaflet No. 2 (TGL No. 2) issued by former JAA. This AMC contains acceptable means of compliance related to airworthiness approval and operational criteria for the use of navigation systems in European air space designated for basic area navigation operations (Basic RNAV or B-RNAV).

5.2 In the same manner, the Federal Aviation Administration (FAA) of the United States (U.S.) replaced the AC 90-96 of March 1998 by AC 90-96A issued in January 2005. This new circular provides guidance material in regards to the airworthiness and operational approval for operators of U.S. registered civil aircraft operating in European air space designated for Basic area navigation (B-RNAV) and Precision area navigation (P-RNAV).

5.3 Both current documents, AMC 20-4 and AC 90-96A, require similar operational and functional requirements.

5.4 In the context of the terminology adopted in the Performance based navigation manual (PBN manual) of the International Civil Aviation Organization (ICAO), B-RNAV requirements are termed RNAV 5.

5.5 The basis of specifications developed by EASA and FAA are supported on the capacity of RNAV equipment incorporated in the early 70s.

5.6 While RNAV operation requirements are addressed primarily in an ATS surveillance environment, RNAV 5 implementation has occurred in areas where there is no surveillance. This has required an increase in route spacing to ensure compliance with the desired level of safety (TLS).

5.7 RNAV 5 specification does not require an alert to the pilot in the event of excessive navigation errors, neither requires two RNAV Systems, thus, the potential for loss of RNAV capability requires the aircraft to be provided of an alternative navigation source.

5.8 The performance level selected for RNAV operations allows a wide range of RNAV systems to be approved for these operations, including INS with a two hour limit after its last alignment/position update performed on the ground, when they do not have a function for automatic radio updating of aircraft position.

5.9 Although RNAV 5 specification does not include requirements for on-board performance monitoring and alerting, it does require that the on-board equipment keeps a lateral and longitudinal navigation accuracy on route of ± 5 NM or better during 95% of the total flight time.

6. GENERAL INFORMATION

6.1 Navigation aid infrastructure

(a) AAI has already prescribed RNAV 5 navigation specification for many routes known as Q routes.

(b) RNAV 5 systems permit aircraft navigation along any desired flight path within the coverage of ground or space-based navigation aids (NAVAIDS) or within the limits of the capability of self-contained aids or a combination of both methods.

(c) 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 OC.

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

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

6.2 ATS communications and surveillance

(a) Direct pilot to ATC voice communication is required.

(b) When reliance is placed on the use of ATS surveillance to assist contingency

procedures, its performance should be adequate for that purpose.

(c) 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.

6.3 Obstacle clearance and route spacing

(a) Detailed guidance on obstacle clearance is provided in PANS-OPS (Doc 8168), Volume II; the general criteria in Parts I and III apply.

(b) The ANSP is responsible for route spacing and should have ATS surveillance and monitoring tools to support detection and correction of navigation errors.

(c) In an ATC surveillance environment, the route spacing will depend on acceptable ATC workload and availability of controller tools.

(d) 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

(i) 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.

(ii) The track structure design has to ensure leg changes do not occur too closely together. The required track length between turns shall depend upon the required turn angle.

6.4 Publications

(a) The AIP shall clearly indicate 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.

- (b) The route must rely on normal descent profiles and identify minimum segment altitude requirements.
- (c) The navigation data published in the AIP for the routes and supporting navigation aids must meet the requirements of Annex 15 - Aeronautical Information Services.
- (d) All routes must be based upon WGS-84 coordinates.
- (e) 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.
- (f) 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.

6.5 Additional considerations

- (a) 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 authorized by ATC.
- (b) 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.

7. AIRWORTHINESS AND OPERATIONAL APPROVAL

7.1 To obtain RNAV 5 authorisation, a commercial air transport operator must comply with two types of approvals:

- (a) the airworthiness approval granted by the State of registry (see Article 31 of the Chicago Convention and Paragraphs 5.2.3 and 8.1.1 of Annex 6 Part I); and
- (b) the operational approval, granted by DGCA.

7.2 For general aviation operators, the State of registry will determine whether or not the aircraft meets the applicable RNAV 5 requirements and will issue the operation authorisation (e.g., a letter of authorisation– LOA).

7.3 Before submitting the application, operators shall review all aircraft qualification requirements. Compliance with airworthiness requirements or the

installation of the equipment alone does not constitute operational approval.

8. AIRWORTHINESS APPROVAL

8.1 Aircraft equipment

(a) 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 the guide included in this document.

(b) 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:

(i) By applying the service bulletin or supplemental type certificate or service letter or equivalent document and inclusion of the supplement in the AFM; or

(ii) through aircraft navigation system approval.

8.2 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).

(a) Aircraft RNAV 5 systems eligibility.

1) 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 OC or AMC 20-4 or with one of the following FAA documents:

(i) AC 90-96, AC 90-45A, AC 20-121A, AC 20-130, AC 20-138 o AC 25-

15

2) Airworthiness approval guidance included in this OAC provides aircraft navigation performance equivalent to EASA AMC 20-4 and FAA AC 90-96A.

3) Once aircraft eligibility has been established, operator approval will

proceed, according to paragraph 9 of this OC.

(b) General aviation operator's aircraft approval

1) General aviation 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 describe on paragraph 8.2 a) 1) of this OC.

2) After having determined eligibility of the navigation system, general aviation operators will present respective documents to the Dte of Airworthiness, DGCA.

3) In case general aviation 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 OC or AC or AMC, they will proceed according to paragraph 8.3. of this document.

(c) Commercial operator's aircraft approval

1) Commercial operators will present the following documents to Dte of Airworthiness, DGCA:

Sections of the AFM or AFM supplement or TCDS that document airworthiness approval in accordance with this OC or with guidance materials mentioned in Paragraph 8.2 a) 1) of the this document.

2) These operators will ensure that the aircraft navigation system will meet the functions required in paragraph 8.6 of this OC.

3) In case a commercial 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 OC or AC or AMC, it will proceed in accordance with to the steps established in the following paragraph.

8.3 Eligibility not based on AFM or TCDS or AFM Supplement or POH – RNAV 5 capacity reached during service with 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 Dte of Airworthiness, DGCA. The operator, together with the request, will provide the following:

1) RNAV system make, model and part number;

2) 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 AC can be used for this purpose.

3) proof that the system meets the required functions for RNAV 5 operations described in this OC on paragraph 8.6.

4) crew operating procedures and bulletins; and

5) any other pertinent information required by the DGCA.

(b) *General Aviation Operators.*-Once the DGCA has determined the aircraft equipment is eligible for RNAV 5 operations, DAW, DGCA will issue a letter of finding documenting that the aircraft RNAV equipment is eligible to perform those operations.

(c) *Commercial Operators.*-The DGCA will verify aircraft RNAV system eligibility including the required functions on paragraph 8.6 of this AC.

8.4 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.

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

1) 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.

2) 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 paragraph 8.6 of this OC, 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.

3) 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 any other equivalent document.

(b) VHF omnidirectional radio range (VOR)

1) 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.

(c) Distance measuring equipment (DME)

1) 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.

(d) Global navigation satellite system (GNSS)

1) Global positioning system (GPS)

(i) 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 this OC at Paragraph 8.6.

(ii) 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:

- Pseudo-range step detection; and
- Health word checking

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

- 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
- a placard on the GPS receiver certifying it meets TSO-C 129 (), TSO-C-145 () and TSO-C-146 () from FAA or ETSO-129 (), ETSO-145 () and ETSO-146 () from EASA; or
- a CAA letter of design approval for the applicable equipment. Operators should contact the avionics 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 certification offices of the States of aircraft design or manufacturer. Operators will 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 should be reflected in a letter of finding to general aviation operators or in the operations specifications (OpSpecs) for commercial operators.

(iv) 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.

(v) Where approval for RNAV 5 requires the use of traditional navigation equipment as a back up in the event of loss of GPS, the required navigation aids as defined in the approval (e.g. VOR, DME or ADF) must be installed and serviceable.

2) Stand-alone GPS equipment

Stand-alone GPS equipment approved in accordance with guidance provided in this OC 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 DGCA. The flight crew must receive appropriate training for use the stand-alone GPS equipment regarding normal and contingency procedures detailed in the Paragraph 10 of this OC.

8.5 RNAV 5 system requirements

(a) Accuracy

1) 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).

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

(b) 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)).

8.6 Functional requirements

(a) *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.

(b) *RNAV 5 navigation displays*

- 1) 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).
- 2) These displays must be used as primary flight instruments for the navigation of the aircraft, for maneuver anticipation and for failure/status/integrity indication. They should meet the following requirements:
 - (i) The displays must be visible to the pilot when looking forward along the flight path.
 - (ii) The lateral deviation display scaling should be compatible with any alerting and annunciation limits, where implemented.
 - (iii) The lateral deviation display must have a scaling and full-scale deflection suitable for the RNAV 5 operation.

8.7 Continued airworthiness

(a) 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 OC.

(b) Each operator who applies for RNAV-5 operational approval shall submit to the DGCA, a maintenance and inspection program that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the RNAV 5 approval criteria.

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

- 1) Continuing Airworthiness Management Exposition (CAME);
- 2) Illustrated parts catalogs (IPC); and
- 3) Maintenance program.

(d) The approved maintenance program 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 RNAV 5 operation should be maintained according to directions given by manufacturer's components;
- 2) that any amendment or change of navigation system affecting in any way RNAV 5 initial approval, must be forwarded and reviewed by the DGCA 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 DGCA for acceptance or approval thereof.

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

- 1) PBN concept;
- 2) RNAV 5 application;
- 3) equipment involved in a RNAV 5 operation; and
- 4) MEL use.

9. OPERATIONAL APPROVAL

9.1 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 Paragraph 10 of this OC.

(a) **Airworthiness approval.**- The Aircraft must have the corresponding airworthiness approvals as mentioned in Paragraph 8 of this OC.

(b) **Documentation.**- The operator will present to the DGCA the following documents:

- 1) The application to obtain RNAV 5 authorization;
- 2) Amendments to the operations manual (OM) which must include operations procedures according to what is described in Paragraph 10 of this OC, for crews and dispatchers, if applicable;
- 3) Amendments, when applicable, of maintenance manuals and programs which must have the maintenance procedures for the new equipment, as well as the training of the maintenance associated personnel, in accordance with Paragraph 8.7 (e);
- 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 programs or amendments to the operator's training program for crews and flight dispatchers, if applicable, according to what is described in Paragraph 11 of this document;

(c) **Training.**- Once the amendments to manuals, programs and documents have been accepted or approved, the operator will provide required training to its personnel.

(d) **Proving flight.**- The DGCA may deem it advisable to perform a proving flight before granting the operational approval. Such validation can be performed on commercial flights. The proving flight will be carried according to the provisions of CAP 3100 Air Operator's Certification Manual.

9.2 Authorization issuance to perform RNAV 5 operations.

Once the operator has successfully completed the operational approval process, FSD, DGCA will grant the operator the authorisation to conduct RNP 10 operations.

(a) For commercial operators, the DGCA will issue the corresponding operations specifications (OpSpecs) that will reflect the RNAV 5 authorisation.

(b) For general aviation operators, the DGCA will issue a letter of authorisation (LOA).

10. OPERATING PROCEDURES

10.1 General

Airworthiness certification alone does not authorize flights in airspace or along routes for which RNAV 5 approval is required. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

10.2 Preflight planning

10.2.1 Operators and pilots intending to conduct operations on RNAV 5 routes should file the appropriate flight plan suffixes indicating their approval for operation on the routes.

10.2.2 During the preflight planning phase, 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. The pilot must also confirm availability of the on-board navigation equipment necessary for the operation.

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

10.2.4 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, Volume I, 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.

10.3 ABAS availability

10.3.1 En-route RAIM levels are required for RNAV 5 and 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.

- 10.3.2 RAIM availability prediction should take into account the latest GPS constellation NOTAMs and avionics model. The service may be provided by the ANSP, avionics manufacturer, other entities or through an airborne receiver RAIM prediction capability.
- 10.3.3 In the event of a predicted, continuous loss of appropriate level of fault detection of more than five minutes for any part of the RNAV 5 operation, the flight planning should be revised (i.e. delaying the departure or planning a different departure procedure).
- 10.3.4 RAIM availability prediction software is a tool used to assess the expected capability of meeting the navigation performance. Due to unplanned failure of some GNSS elements, pilots/ANSP must realize that RAIM or GPS navigation may be lost altogether 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.

10.4 General operating procedures

- 10.4.1 Operators and pilots should not request or file RNAV 5 routes unless they satisfy all the criteria in the relevant documents. If an aircraft not meeting these criteria receives a clearance from ATC to conduct an RNAV procedure, the pilot must advise ATC that he/she is unable to accept the clearance and must request alternate instructions.
- 10.4.2 The pilot should comply with any instructions or procedures identified by the manufacturer as being necessary to comply with the performance requirements in this manual.
- 10.4.3 Pilots of RNAV 5 aircraft must adhere to any AFM limitations or operating procedures required to maintain the navigation accuracy specified for the procedure.
- 10.4.4 Where installed, pilots must confirm that the navigation database is up to date.
- 10.4.5 The pilots should cross-check 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 NAVAIDs should be confirmed.
- 10.4.6 During the flight, where feasible, the flight progress should be monitored for

navigational reasonableness, by cross-checks with conventional NAVAIDs using the primary displays in conjunction with the RNAV CDU.

10.4.7 For RNAV 5, pilots should use a lateral deviation indicator, flight director or autopilot in lateral navigation mode. Pilots may use a navigation map display as described in 2.3.3.3.2, 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).

10.4.8 All pilots are expected to maintain route centre lines, as depicted by on-board lateral deviation indicators and/or flight guidance, during all 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 RNAV system-computed path and the aircraft position relative to the path) should be limited to $\pm \frac{1}{2}$ the navigation accuracy associated with the procedure or route (i.e. 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 (i.e. 5 NM), are allowable.

Note.— Some aircraft do not display or compute a path during turns; pilots of these aircraft may not be able to adhere to the $\pm \frac{1}{2}$ 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.

10.4.9 If ATS issues a heading assignment taking the aircraft off a route, the pilot should not modify the flight plan in the RNAV system until a clearance is received to rejoin 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.

10.5 Contingency procedures

10.5.1 The pilot must notify ATC when the RNAV performance ceases to meet the requirements for RNAV 5. The communications to ATC must be in accordance with the authorized procedures (Doc 4444 or Doc 7030, as appropriate).

10.5.2 In the event of communications failure, the pilot should continue with the flight plan in accordance with the published “lost communications” procedure.

10.5.3 Where stand-alone GNSS equipment is used:

- a) In the event of that there is a loss of the RAIM detection function, the GNSS position may continue to be used for navigation. The pilot should attempt to cross-check the aircraft position, with other sources of position information, (e.g. VOR, DME and/or NDB information) to confirm an acceptable level of navigation performance. Otherwise, the pilot should revert to an alternative means of navigation and advise ATC.
- b) In the event that the navigation display is flagged invalid due to a RAIM alert, the pilot should revert to an alternative means of navigation and advise ATC.

11. NAVIGATION ERROR REPORTS FOLLOW UP PROCESS

- (a) The operator will establish a process to receive, analyze and do a follow up of the navigation error reports which allow determine the appropriate corrective action.
- (b) Repetitive navigation error occurrences, attributed to a specific part of the navigation equipment must be analyzed in order to correct its cause.
- (c) The nature and severity of the error may result in temporary withdrawn of the authorization to use the navigation equipment until the cause of the problem has been identified and rectified.

12. PILOT KNOWLEDGE AND TRAINING

The pilot training programme should address the following items:

- (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 with respect to 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 with 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 the flight (e.g. monitor PROG or LEGS page);
 - iv) types of navigation sensors (e.g. DME, IRU, GNSS) utilized by the RNAV system and associated system prioritization/weighting/logic;
 - v) turn anticipation with consideration to speed and altitude effects; and
 - vi) interpretation of electronic displays and symbols;
- (i) RNAV equipment operating procedures, as applicable, including how to perform the following actions:
- i) verify that the aircraft navigation data is current;
 - ii) verify the 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 NAVAID or NAVAID type; and
 - x) perform gross navigation error checks using conventional NAVAIDs.

13. 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 1.-Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots should

establish procedures to ensure the accuracy of 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.

14. OVERSIGHT OF OPERATORS

A process needs to be established whereby navigation error reports can be submitted and analysed in order to establish the need for remedial action. Repeated navigation error occurrences attributed to a specific piece of navigation equipment need to be followed up and action taken to remove the causal factor(s).

The nature of the error cause will determine the remedial action which could include the need for remedial training, restrictions in the application of the system, or requirements for software changes in the navigation system.

The nature and severity of the error may result in temporary cancellation of the approval for use of that equipment until the cause of the problem has been identified and rectified.

Sd/-
(Capt Ajay Singh)
Chief Flight Operations Inspector
For Director General of Civil Aviation

GPS INTEGRITY MONITORING (RAIM) PREDICTION PROGRAM

Where a GPS integrity monitoring (RAIM) prediction program is used as a means of compliance with the provisions of this document, it should meet the following criteria:

- (a) The program should provide prediction of availability of the integrity monitoring (RAIM) function of the GPS equipment, suitable for conducting RNAV 5 operations.
- (b) The prediction program software must be developed in accordance with at least RTCA DO 178B/EUROCAE 12B, Level D guidelines.
- (c) The program should 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.
- (d) The program should 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 DGCA.
- (e) The program should have the capability to manually exclude GPS satellites which have been notified as being out of service for the intended flight.
- (f) The program should allow the user to select:
 - 1) the intended route and declared alternates; and
 - 2) the time and duration of the intended flight.

TRAINING PROGRAM ON THE GPS AS A PRIMARY MEANS OF NAVIGATION

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

(a) GPS system components and operating principles.- Understanding of the GPS 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;

(b) 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) precision;
- 2) integrity;
 - means to improve GPS integrity: RAIM and fault detection and exclusion (FDE)
- 3) availability;
- 4) service continuity

(c) Authorizations 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) GPS-related NOTAMs.

(d) GPS system errors and limitations.- Cause and magnitude of typical GPS errors:

- 1) ephemerides;
- 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.

(e) Human factors and GPS.- 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.

(f) GPS 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.

(g) Verification of GPS 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.

(h) GPS messages and warnings.- For each type of equipment in each aircraft, timely action must be recognized 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.

RNAV 5 APPROVAL PROCESS

1. The RNAV 5 approval process consists of two kinds of approvals: the airworthiness and the operational approvals. Although both have different requirements, they must be considered under a single process.
2. This process is an organised method used by the DGCA to ensure that applicants meet the established requirements.
3. The approval process is made up by the following phases:
 - Phase one: Pre-application
 - Phase two: Formal application
 - Phase three: Documentation evaluation
 - Phase four: Inspection and demonstration
 - Phase five: Approval
4. In *Phase one - Pre-application*, the DGCA invites the applicant or operator to the pre-application meeting. At this meeting, the DGCA informs the applicant or operator about all the operational and airworthiness requirements it must meet during the approval process, including the following:
 - (a) the contents of the formal application;
 - (b) the review and evaluation of the application by the DGCA;
 - (c) the limitations (if any) applicable to the approval; and
 - (d) the conditions under which the RNAV 5 approval could be cancelled.
5. In *Phase two – Formal application*, the applicant or operator submits the formal application, together with all the relevant documentation, as established in paragraph 9.1. of this OC.
6. In *Phase three – Documentation evaluation*, the DGCA analyses all the documentation and the navigation system in order to determine its eligibility and what approval method is to be applied regarding the aircraft. As a result of this analysis and evaluation, the DGCA may accept or reject the formal application together with the documentation.

7. In *Phase four – Inspection and demonstration*, the operator will provide training for its personnel and perform the proving flights, if so required.
8. In *Phase five - Approval*, the DGCA issues the RNAV 5 authorisation, once the operator has met the airworthiness and operational requirements. For GA operators, the DGCA will issue an LOA.