International Civil Aviation Organization

Performance Based Navigation/Global Navigation Satellite System Task Force (PBN/GNSS TF)

Fifth Meeting
(Cairo, Egypt, 15 - 17 April 2013)

Agenda Item 3: Developments in PBN and GNSS

GLOBAL DEVELOPMENTS AND OTHER ICAO REGIONS PBN TF

(Presented by the Secretariat)

SUMMARY

This paper presents the outcome of PBN Symposium and Workshops and some activities of other ICAO Region related to PBN and GNSS

Action by the meeting is at paragraph 3.

REFERENCES

- Other ICAO regions PBN Reports
- PBN Symposium results

1. INTRODUCTION

1.1 The PBN Symposium and Workshops were held in Montréal from 15 to 19 October 2012. The 12th Air Navigation Conference (AN-Conf/12) was held in Montréal from 19 to 30 November 2012.

2. DISCUSSION

2.1 The meeting may wish to note that the PBN Symposium and Workshops were held in Montréal from 15 to 19 October 2012. The four-day symposium and workshops brought together over 400 participants from 67 countries and 13 International Organizations. Representation included aircraft manufacturers, Air Navigation Service Providers (ANSPs), airlines, regulators, ATC system manufacturers, avionics designers, air traffic controllers, pilots, the military, aeronautical information companies and instrument procedure designers.

2.2 The summary of the two workshops PRACTICAL EXPERIENCES AND AIR TRAFFIC MANAGEMENT and PBN IN THE COCKPIT and the final outcome of the symposium are at **Appendices A, B and C** respectively to this working paper.

2.3 The 12th Air Navigation Conference was held in Montréal from 19 to 30 November 2012. At the 12th Air Navigation Conference – details are provided in WP/3.

2.4 The meeting may wish to note that all ICAO Regions are having several activities regarding the PBN where Tenth Meeting of the ICAO APAC Region Performance Based Navigation Task Force (PBN/TF/10) was held in Nadi, Fiji from 11 to 13 December 2012. The PBN/TF/10 was conducted after the PBN Workshop, which was held from 10-11 December 2012 at Nadi. The ICAO NACC Regional Office held Workshop on PBN Airspace Redesign and GNSS Implementation supporting PBN from 27-30 August, 2012, also ICAO EUR region had it EUR PBN TF/8 Meeting in Paris 23-24 January 2013.

2.5 The meeting may wish to note that PBN, CDO and CCO were the ICAO and Global Air Navigation Plan's immediate priorities and the significance that the Conference and Symposium seen in the activities of the regional PBN implementation groups and the following guidance material was published by ICAO:

a) Doc 9613 PBN Manual Edition 4.0;
b) Doc 9992 Manual on the Use of PBN in Airspace Design;
c) Doc 9993 Continuous Climb Operations (CCO) Manual; and
d) Doc 9997 PBN Operational Approval Manual

2.6 The meeting may wish to note that even EUR PBN Task Force noted that the lack of procedure designers and in general deficiencies in the States oversight capabilities with regards to the provision of PANS-OPS related services was one of the challenges to PBN, where a cooperative efforts could was suggested to overcome this challenge, and consideration are given for the establishment of Regional Procedure design office like the one in ICAO APAC Region.

2.7 The meeting may recall that Para 2.5.1 od Doc 9997 stated the following: "Individual States must publish national regulatory material which addresses the PBN applications relevant to their airspace or relevant to operations conducted in another State by the State's operators or by aircraft on their Registry. The regulations may be categorized by operation, flight phase, area of operation and/or navigation specification. Approvals for commercial operations should require specific authorization. Example regulatory text is provided at Annex C.

2.8 Based on the above the meeting may wish to note that The EASA AMCs and the FAA ACs mentioned above also address operational approval. In this regard, ICAO South American Office (SAM) has published a set of PBN Advisory Circulars covering operational approval for PBN applications for use within the region which has been revised by EUR region for use in their region as at **Appendix D** to this working paper. Many other States publish similar ACs or refer to existing ACs or AMCs in their national regulations.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the progress globally;

b) encourage State to share operational approval; and

c) develop PBN Advisory Circulars covering operational approval for PBN applications for use within the Region, if needed.

WORKSHOP A – PRACTICAL EXPERIENCES AND AIR TRAFFIC MANAGEMENT

“All you need to know to create the PBN environment”

SUMMARY

Moderator: David Maynard (CANSO)

19 October 2012

Workshop Aim

- Interactive learning/education workshop
- Explore ATM system needs, issues, and concerns
- Provide practical solutions
- Identify future actions

Workshop Program

1
ATM Requirements
Franca Pavlicevic
Eurocontrol

2
Technical Requirements
James Arrighi
FAA

3
Training Requirements
Dennis Kelly
IFATCA

4
Regulatory Requirements
Honghai Yang
CAAC

Approximately
250 Participants

Participating Speakers

Many participated in both Workshops and more than one panel

- Noppadol Pringvanich – ICAO
- Sorin-Dan Onitiu –JEPPESEN
- Bryan Jolly – EASA
- Jeremy Davidson – ICAO
- Doug Marek – FAA
- Walter White – ICAO
- Benoir Routier –DGAC
- Michael Standar –SESAR JU
- Aline Troadec –EUROCONTROL
- Shahidi Hassan –(Mitre
- Jeff Cochrane –NAV CANADA
- Dejan Damjanovic – GeoEye
- Kevin Bethwaite – Airways NZ
- Beat Zimmermann – ANI
- Franca Pavlicevic – EUROCONTROL
- Alan Storm – NATO)
- Sebastien Barjou – ENAC
- Jeff Williams – TETRATECH
- Lynn Ray – FAA
- Jeremy Davidson – ICAO
- Bryan Jolly – EASA
- Saulo Da Silva – ICAO

ATM Requirements

- GNSS is accurate
  - is there a plan or initiative to gather lateral performance data to justify a reduction in route spacing
- Mixed mode is being successfully accomplished
  - significant benefits are realized, but
  - accommodating conventional systems means not every possible benefit is achieved
  - Learn from other implementations
  - Identify champions within workforce early

ATM Requirements

- The idea of a Guided Visual Approach should be developed and in cooperated into ICAO Doc.
- Phraseology is needed in 4444 for CDO and CCO would assist in implementation
- More education on PBN requested
  - further information/education on RNAV/RNP to ILS transitions requested
  - suggestion for additional local and regional workshops
    - Include development activities
    - Adopt an ANSP

Technical Requirements

- New flight plan codes take effect Nov 15th
  - FPL 2012 and PBN – some confusion still exists and additional changes may be required
  - New codes in rev 4 of 9613 PBN codes are not included (A-RNP, RNP 2, RNP 0.3)
- GNSS signals are very reliable but
  - What about jamming and a backup plan
  - Monitoring vs. recording
    - (SARP - recording addressed in Annex 10 2.1.4.2)
- Harmonize State and ICAO Requirements

Training Requirements

- Collaboration is key
- Market PBN – only when the benefits are understood will acceptance of procedures occur.
- All disciplines must be included in the process
- Build the training plan as you develop, this will make it more comprehensive.

Training Requirements

- Training needed for all at the delivery point
- Plan for mixed/equipage and capability
- Use simulation capabilities not just briefings
- Provide a PBN Help Desk/on-line forum

Regulatory and Certification Requirements

- Environment – process must be followed, early communication and outreach to all stakeholders
  - Time consuming but effective
- SMS is a total system
  - Even in design we must take account of potential risk
- FMS memory limitations must be considered
- Determining Sep. Criteria for Free/Direct routes
  - NAV specs are attributed to route rather than an airspace
  - some functionalities disappear
  - additional guidance may be needed
- Single Approval
- Questions arose regarding ICAO PBN Endorsements

Summary –
Is There a Silver Bullet to Expedite PBN

- Clear Vision/Plan
- Business Case (Requirements/Benefits)
- Collaboration - All Stakeholders
- Education - All Stakeholders
- Training - All Stakeholders
- Global Standards and Approval Processes
- Partnerships
- Emergence/Incorporation of New Requirements
- Top Down Bottom Up

Summary –
Is There a Silver Bullet to Expedite PBN

PBN

Just Do It

WORKSHOP B – PBN IN THE COCKPIT

“Helping you prepare for PBN Flight Operations”

SUMMARY

Moderator: Jeff MacDonald (ICAO)

19 October 2012

Workshop Aim

- Interactive learning/education workshop
- Explore Flight Operations needs, issues, and concerns
- Provide practical solutions
- Identify future actions

Workshop Program

1
Flight Operations Requirements

2
Regulatory and Certification

3
Technical Requirements

4
Training Requirements

Approximately 95 Participants

"The Champions"

1
Pedro Rivas
IFALPA

2
Mark Steinbicker
FAA

3
Geoff Burtenshaw
UK CAA

4
John Sullivan
CAE

Participating Speakers

Many participated in both Workshops and more than one panel

- Thomas Buchanan – Skyguide
- Jonathan Tree – Jeppesen
- Miguel Marin – ICAO
- Carlos Pellegrino – ANAC
- Bryan Jolly – EASA
- Jeremy Davidson – ICAO
- Chuck Steigerwald – Boeing
- Waldo Krolak – Transport Canada
- Jeff Cochrane – NAV CANADA
- David Deere – WesJet
- Noppadol Pringvanich - ICAO
- Steve Fulton – GE Aviation
- Don-Jaques Ould-Ferhat – Quo Vadis
- Aline Troadec – Eurocontrol
- Dave Nakamura - Boeing

Flt Op Requirements

- Waypoints
  - Growth, numbering and naming
- PBN terminal procedures with long paths
  - to facilitate other objectives (lost comm, traffic congestion, etc)
  - Airport, ANSP and procedure designers need to be aware and work with operator
- FMS Capabilities
  - Coding ½ degrees in the North Atlantic
- Plan allow/provide mid AIRAC cycle updates to databases
- Removal of Ground-Based navigation aids
  - Human Factors (air picture)

Regulatory and Certification

- Scarce personnel and financial resources
  - Reduce number of PBN Operational Approvals and bundle
- Development of operator and inspector guidance materials
  - Doc 9997 now available – need time to assess impact
- Reciprocity between States
  - Increased communication, collaboration and sharing
  - States should have easy access to Regulatory material of other States
  - Use PBN Ops Approval Manual and recognize foreign approvals
- Regulatory Approvals
  - Different RNP AR approval process of each State
  - Standards and Guidance for GA – non-commercial operators of complex aircraft
  - Need a global consistent approach

Technical Requirements

- Overall understanding of PBN
  - Need to communicate and educate
  - Multi-disciplinary Groups
  - **“PBN is team game”**

- PANS-OPS is very conservative (Procedure Design)
  - Improve PANS-OPS criteria by taking account of performance of modern aircraft

- RNP Review
  - Is the 95% accuracy outdated? Is it too conservative?
  - Have we addressed the impact on aircraft – aircraft separation?

- Need for RNP AR Departures (SIDs)
  - Aircraft must depart the airport as well

Technical Requirements

- The need for Flight Technical Error (FTE) assessment criteria for normal and abnormal conditions
  - make available to OEM
- Flight Operational Safety Assessment (FOSA) and lack of available guidelines
  - Included in Doc 9997 PBN Ops Approval Manual
- Criteria for Engine Out SID (EOSID)
  - EOSID with RNP provide safety enhancement and should be widely promoted

Training Requirements

- PBN should become part of the standard instrument rating training
- Use of flight simulators is essential and reduces training time
- Standard aircraft equipment fit to include PBN
- FPL 2012 and PBN – some confusion still exists and additional changes may be required

Summary

- Communication and Education
- PBN is a Team Game – requires a multi-disciplinary approach
- Regulatory Approval Improvements
- Emergence of new requirements

Issues and Next steps - Consolidated

Vince Galotti
Deputy Director ANB,

19 October 2012

Issues and Next steps consolidated

- States to encourage establishment of multi-disciplinary collaborative decision making teams to expedite PBN implementation

Issues and Next steps consolidated

- Block 0 is ready, ICAO has developed Standards, procedures, guidance, workshops, computer-based learning packages.

- Everybody needs to pull up their sleeves now.
- If you want it, just do it!

Issues and Next steps consolidated

- Recipe for getting started:
  - Make baby steps, don't overcomplicate!
  - Involve everyone early
  - Educate, educate, educate
  - Communicate, communicate, communicate

Issues and Next steps consolidated

- Visit and learn from other's successes
- Share regulatory and guidance material
  (ICAO to make website available)
- ICAO to provide downloadable template for jobaids and ops approval submissions

Issues and Next steps consolidated

- All stakeholders to organize workshops, courses and informational sessions to address:
  - Awareness
  - Dedicated disciplines

Issues and Next steps consolidated PBN in the cockpit

- Ops approval manual is available as basis for standardized approval process, start using it!

- Encourage recognition of foreign carrier approvals

Issues and Next steps consolidated PBN in the cockpit

- PBN should become part of the standard instrument rating training.

- Standard equipment fit to include PBN and determine to what extend

Issues and Next steps consolidated Practical experiences ATM

- Phraseology for CDO and CCO implementation required.

Issues and Next steps consolidated Practical experiences ATM

- Mixed mode implementation can be done successfully, don't wait start now!

Issues and Next steps consolidated

The sooner you start, the sooner you realize benefits.

Just do it!

APPENDIX D

ADVISORY CIRCULAR

AC	**:**	**APV/baro**
DATE	**:**	**01/01/13**
REVIEW	**:**	**1**
ISSUED BY	**:**	**PBN TF**

SUBJECT: AIRCRAFT AND OPERATORS APPROVAL FOR APPROACH OPERATIONS WITH VERTICAL GUIDANCE/BAROMETRIC VERTICAL NAVIGATION (APV/baro-VNAV)

1. PURPOSE

This advisory circular (AC) establishes APV/baro-VNAV approval requirements (barometric vertical navigation only) for aircraft and operators. Barometric vertical navigation may be included together with lateral navigation in a RNP APCH approach. Criteria of this AC together with criteria of AC RNP APCH, establish requirements for RNP APCH approach with baro-VNAV.

An operator may use alternative means of compliance, provided they are acceptable to the Civil Aviation Administration (CAA).

Use of the future tense of the verb or the term "must" applies to an applicant or operator that chooses to meet the criteria established in this AC.

2. RELATED DOCUMENTS

Annex 6	Operation of aircraft
Doc 9613	Performance-based navigation (PBN) manual
	Attachment A – Barometric VNAV
Doc 9905	Required navigation performance authorization required (RNP AR) procedure design manual
Doc 9997	PBN operational approval manual
Doc 8168	Aircraft operations
	Volume I: Flight procedures
	Part II, Section 4, Chapter 1 – APV/baro-VNAV approach procedures
	Volume II: Construction of visual and instrument flight procedures
	Part III, Section 3, Chapter 4 – APV/baro-VNAV
AMC 20-27	Airworthiness approval and operational criteria for RNP APPROACH (RNP APCH) operations including APV BARO-VNAV operations
FAA AC 90-105	Approval guidance for RNP operations and barometric vertical navigation in the U.S. National Airspace System – Appendix 4 – Use of barometric VNAV

3. DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

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

b) **Barometric vertical navigation (baro-VNAV).-** Is a navigation system that presents to the pilot computed vertical guidance referenced to a specified vertical path angle (VPA), nominally 3°. The computer-resolved vertical guidance is based on barometric altitude and is specified as a VPA from reference datum height (RDH).

c) **Decision altitude (DA) or decision height (DH).-** A specified altitude or height in the precision approach or approach with vertical guidance at which a missed approach must be initiated if the required visual reference to continue the approach has not been established.

__Note 1.-__ The decision altitude (DA) is referenced to mean sea level and the decision height (DH) is referenced to the threshold elevation.

__Note 2.-__ The required visual reference means that section of the visual aids or of the approach area which should have been in view for sufficient time for the pilot to have made an assessment of the aircraft position and rate of change of position, in relation to the desired flight path. In Category III operations with a decision height the required visual reference is that specified for the particular procedure and operation.

__Note 3.-__ For convenience where both expressions are used they may be written in the form "decision altitude/height" and abbreviated "DA/H".

d) **Flight management system (FMS).-** Integrated system made up by an on-board sensor, a receiver, and a computer with navigation and aircraft performance databases, capable of providing performance values and RNAV guidance to a display and automatic flight control system.

e) **Initial approach fix (IAF).-** Fix that marks the beginning of the initial segment and the end of the arrival segment, if applicable. In RNAV application, this fix is normally defined as a “fly-by wayponit”.

f) **Non-precision approach (NPA) procedure.-** An instrument approach procedure which utilizes lateral guidance but does not utilize vertical guidance.

g) **Precision approach (PA) procedure.-** An instrument approach procedure using precision lateral and vertical guidance with minima as determined by the category of operation.

__Note.-__ Lateral and vertical guidance refers to the guidance provided either by:

- a ground-based navigation aid; or
- computer-generated navigation data.

h) **Primary field of view.-** For purposes of this AC, the primary field of view is within 15 degrees of the primary line of sight of the pilot.

i) **Reference datum height (RDH).-** The height of the extended glide path or a nominal vertical path at the runway threshold.

j) **RNAV system**.- Area navigation system that allows the aircraft to operate on any desired flight path within the coverage of ground or airspace-based navigation aids or within the limits of the capability of self-contained navigation aids or a combination of both. An RNAV system may be included as part of a flight management system (FMS).

k) **RNP system**.- Area navigation system which supports on-board performance monitoring and alerting.

l) **Vertical navigation**.- A navigation method that allows the aircraft to operate on a vertical flight profile using altimetry sources, external flight path references, or a combination of these.

m) **Vertical path angle (VPA).-** Angle of the published final approach descent in baro-VNAV procedures.

n) **Waypoint (WPT).** A specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. Way-points are identified as either:

Fly-by waypoint (fly-by WPT).- A waypoint which requires turn anticipation to allow tangential interception of the next segment of a route or procedure, or

Flyover waypoint (flyover WPT).- A waypoint at which a turn is initiated in order to join the next segment of a route or procedure.

3.2 Abbreviations

a)	AC	Advisory circular
b)	AFM	Airplane flight manual
c)	AIM	Aeronautical information manual
d)	AMC	Acceptable means of compliance
e)	AP	Autopilot
f)	APCH	Approach
g)	APV	Approach procedure with vertical guidance
h)	APV/baro-VNAV	Approach procedure with vertical guidance/Barometric vertical navigation
i)	AR	Authorization required
j)	ARINC	Aeronautical radio, Incorporated
k)	ASE	Altimetry system error
l)	ATC	Air traffic control
m)	baro-VNAV	Barometric vertical navigation
n)	CFIT	Controlled flight into terrain
o)	CFR	US Code of Federal Regulations
p)	CS	Certification specifications (EASA)
q)	DA/H	Decision altitude/height
r)	DME	Distance measuring equipment
s)	EASA	European Aviation Safety Agency
t)	EHSI	Enhanced horizontal situation indicator
u)	FAA	US Federal Aviation Administration
v)	FAF	Final approach fix
w)	FAP	Final approach point
x)	FD	Flight director
y)	FMS	Flight management system
z)	FTD	Flight training devices
aa)	FTE	Flight technical error
bb)	GNSS	Global navigation satellite system
cc)	Hg	Inches of mercury

dd)	hPa	Hectopascals
ee)	HSI	Horizontal situation indicator
ff)	IAF	Initial approach fix
gg)	IRU	Inertial reference unit
hh)	ISA	International standard atmosphere
ii)	KIAS	Indicated airspeed
jj)	LAR	Latin American Aeronautical Regulations
kk)	LNAV	Lateral navigation
ll)	LNAV FAF	final approach fix for lateral navigation
mm)	LNAV MDA	Lateral navigation minimum descent altitude
nn)	LOA	Letter of authorization/acceptance
oo)	MAPt	Missed approach point
pp)	MAPt LNAV	Missed approach point for lateral navigation
qq)	MDA/MDH	Minimum descent altitude/height
rr)	MEL	Minimum equipment list
ss)	NPA	Non-precision approach
tt)	ICAO	International Civil Aviation Organization
uu)	OCA/H	Obstacle clearance altitude/height
vv)	OM	Operations Manual
ww)	PANS-OPS	Procedures for air navigation services - Aircraft operations
xx)	PBN	Performance-base navigation
yy)	PA	Precision approach
zz)	PDE	Path definition error
aaa)	PF	Pilot flying
bbb)	PM	Pilot monitoring
ccc)	PNF	Pilot not flying
ddd)	QNE	Standard atmosphere that corresponds to 1013 hPa or 29.92" Hg. This setting indicates the altitude above the isobaric surface of 1013 hPa, if temperature is standard
eee)	QNH	Pressure at mean sea level. This setting indicates the altitude above the means sea level (MSL), if temperature is standard.
fff)	RDH	Reference datum height
ggg)	RNAV	Area navigation
hhh)	RNP	Required navigation performance
iii)	RNP APCH	Required navigation performance approach
jjj)	RNP AR APCH	Required navigation performance approach with authorization required

kkk)	SBAS	Satellite-based augmentation system
lll)	TCH	Obstacle clearance height
mmm)	TSO	Standard technical order
nnn)	VDI	Vertical deviation indicator
ooo)	VNAV	Vertical navigation
ppp)	VNAV DA	Vertical navigation decision altitude
qqq)	VPA	Vertical path angle
rrr)	WPT	Waypoint

4. INTRODUCTION

4.1 The acceptable means of compliance of this AC are based on the use of barometric vertical navigation (baro-VNAV).

4.2 The baro-VNAV navigation system presents the pilot with estimated vertical guidance referenced to a specified vertical path angle (VPA), nominally of 3º. The computed vertical guide is based on the barometric altitude and is specified as a VPA from the reference datum height (RDH).

4.3 The calculated vertical path is stored in the instrument flight procedure specification in the database of the area navigation (RNAV) system or of the required navigation performance (RNP) system.

4.4 For other flight phases, barometric VNAV offers vertical guidance path information that can be defined by vertical angles or altitudes at the procedure fixes.

4.5 It should be noted that there is no vertical requirement in this AC associated with the use of vertical guidance outside of the final approach segment. Therefore, vertical navigation can be performed without VNAV guidance in the initial and intermediate segments of an instrument procedure.

4.6 Aircraft authorised to conduct RNP authorization required approach (RNP AR APCH) operations are considered eligible for the baro-VNAV operations described in this AC. In this sense, there is no need for a new approval according to the criteria established in this document.

4.7 The procedures to be established pursuant to this AC will permit the use of high-quality vertical navigation capabilities that will improve safety and reduce the risks of controlled flight into terrain (CFIT).

4.8 The material described in this AC has been developed based on the following documents:

- ✓ ICAO Doc 9613, Volume II, Attachment A – Barometric VNAV; and
- ✓ ICAO Doc 8168, Volume I, Part II, Section 4, Chapter 1 – APV/baro-VNAV approach procedures.

4.9 Where possible, this AC has been harmonised with the following guidance documents:

- ✓ EASA AMC 20-27 - Airworthiness approval and operational criteria for RNP APPROACH (RNP APCH) operations including APV BARO-VNAV operations; and
- ✓ FAA AC 90-105 Approval guidance for RNP operations and barometric vertical navigation in the U.S. national airspace system - Appendix 4 – Use of barometric VNAV.

Note.- *Notwithstanding harmonisation efforts, operators shall note the differences that exist between this AC and the aforementioned documents when applying for an authorization from the corresponding Administrations.*

5. GENERAL CONSIDERATIONS

5.1 Navaid infraestructure

The procedure design does not have unique infraestructure requirements. This criteria is based upon the use of barometric altimetry by an airborne RNAV/RNP system whose performance capability supports the required operation. The procedure design will have to take into account the functional capabilities required by this document.

5.2 Publications

Charting must follow the standards of Annex 4 for the designation of an RNAV procedure where the vertical flight path is specific by a glide path angle. The charting designation will remain consistent with the current convention (for example if the lateral procedures are predicated on GNSS, the charting will indicate RNAV $_{(GNSS)}$).

5.3 Air traffic control (ATC) coordination

It is expected that ATC will be familiar with aircraft VNAV capability, as well as issues associated with altimeter setting and temperature data required by the aircraft.

6. APV/baro-VNAV APPROACH PROCEDURES CLASSIFICATION

6.1 Approach procedures with vertical guidance/barometric vertical navigation (APV/baro-VNAV) are classified as instrument approach procedures for approach and landing operations with vertical guidance (see the definition in Annex 6, Part I). These procedures are published with a decision altitude/height (DA/H) and must not be confused with non-precision approach procedures (NPA), which specify a minimum descent altitude/height (MDA/H) below which the aircraft must not descend.

6.2 The use of APV/baro-VNAV procedures improves the safety of NPA procedures, providing a guided and stabilized descent for landing, thus avoiding an early descent to minimum altitudes.

6.3 Notwithstanding the above, the inherent inaccuracy of barometric altimeters and the certified performance of the specific RNAV/RNP mode used, prevent the systems of these procedures from emulating the accuracy of the systems used in a precision approach (PA). In particular, with some systems it might not be possible to keep the aircraft within the obstacle-free surfaces of Annex 14. Thus, the pilot must keep this possibility in mind when making the decision to land at the decision altitude/height (DA/H).

6.4 In APV/baro-VNAV approach procedures no final approach fix (FAF) or missed approach fix (MAPt) is identified.

6.5 The lateral part of APV/baro-VNAV criteria is based on non-precision RNAV criteria. However, the FAF is not part of the APV/baro-VNAV procedure and is replaced by a final approach point (FAP), although the RNAV FAF may be used as a final approach course fix in database design. Likewise, the MAPt is replaced by a DA/H, which depends upon the category of the aircraft.

6.6 The LNAV FAF and MAPt are used for coding purposes in the baro-VNAV procedure and are not aimed at inhibiting the descent in the FAP or restricting the DA/H.

6.7 The minimum DH for APV/baro-VNAV is 75 m (246 ft) plus the height loss margin. However, the operator may increase this minimum DH limit to at least 90 m (295 ft) plus a height loss margin, when the lateral navigation system is not certified to ensure that the aircraft will be within the inner approach, inner transitional, and balked landing surfaces indicated in Annex 14 (extended as necessary above the inner horizontal surface to the obstacle clearance altitude/height (OCA/H)) with a high degree of probability.

7. NAVIGATION SYSTEM DESCRIPTION

7.1 Vertical navigation (VNAV)

a) In VNAV, the system allows the aircraft to fly level and descent point to point in a vertical linear profile path that is kept in an on board navigation database. The vertical profile will be based upon altitude constraints or VPAs, where appropriate, associated with the lateral navigation (LNAV) path waypoints (WPT).

Note.- *Normally, VNAV is a flight guidance systems mode, where the RNAV/RNP equipment containing the VNAV capability provides path steering commands to the flight guidance system, which controls the flight technical error (FTE) by means of the pilot manual control in the vertical deviation display or through flight director (FD) or autopilot (AP) coupling.*

8. AIRWORTHINESS AND OPERATIONAL APPROVAL

8.1 In order to get an APV/baro-VNAV authorization, a commercial air transport operator shall obtain two types of approval:

a) an airworthiness approval from 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 from the State of the operator (see Paragraph 4.2.1 and Attachment F to Annex 6, Part I).

8.2 For general aviation operators, the State of registry will determine if the aircraft meets the applicable APV/baro-VNAV requirements (see Paragraph 2.5.2.2 of Annex 6, Part II).

9. AIRWORTHINESS APPROVAL

9.1 Equipment requirements

9.1.1 APV/baro-VNAV procedures are to be used by aircraft equipped with flight management systems (FMS) or other RNAV or RNP systems capable of calculating barometric VNAV paths and, based on these, display deviations on the instrument visual indicator.

9.1.2 Aircraft equipped with APV/baro-VNAV systems that have been approved by the State of registry for the corresponding level of lateral navigation operations (LNAV)/VNAV may use these systems to conduct APV/baro-VNAV approaches, provided:

a) the navigation system has a certified performance of 0.3 NM or lower, with a 95% probability. This includes:

   1) global navigation satellite systems (GNSS) certified for approach operations; or

   2) multiple-sensor systems that use inertial reference units (IRU) in combination with dual distance measuring equipment (DME/DME) or certified GNSS systems; or

   3) RNP systems approved for operations with RNP 0.3 or lower.

b) the APV/baro-VNAV equipment is operational;

c) the aircraft and the aircraft systems are properly certified for the planned APV/baro-VNAV approach operations;

d) the aircraft is equipped with an integrated LNAV/VNAV system with an accurate source of barometric altitude; and

e) VNAV altitudes and all the relevant procedural and navigation information are obtained from a navigation database whose integrity is supported by appropriate quality assurance measures.

9.1.3 In cases where LNAV/baro-VNAV procedures have been published, the approach area will be assessed in order to identify obstacles invading the inner approach surfaces, the inner transitional surfaces, and the balked landing surface defined of Annex 14. If obstacles infringe these surfaces, a restriction amounting to the minimum value of the allowed OCA/H will be imposed.

9.1.4 APV/baro-VNAV operations are based on RNAV/RNP systems that receive inputs from equipment that may include:

a) an air data computer: FAA Technical Standard Order (TSO)-C 106.

b) an air data system: Aeronautical Radio, Incorporated (ARINC) 706, Mark 5 Air Data System.

c) a barometric altimetry system of the following types: DO-88 altimetry, ED-26 MPS for airborne altitude measurements and coding systems, ARP-942 pressure altimeter systems, ARP-920 design and installation of pitot static systems for transport aircraft.

d) integrated type-certified systems providing the capabilities of an air data system comparable to the one described in paragraph b).

Note 1.- *Position data from other sources may be integrated with the barometric altitude information, provided they do not cause position errors exceeding the path-keeping precision requirements.*

Note 2.- *The altimetry system performance will be demonstrated separately through the certification of static pressure systems (e.g., *14 CFR 25.1325 or *CS 25.1325 or equivalent sections), where performance must be 30 ft by 100 knots of indicated airspeed (KIAS). Altimetry systems that meet this requirement will meet the altimetry system error (ASE) requirements for baro-VNAV operations. Additional compliance or demonstration is not required.*

**14 CFR 25.1325: Section 1325 of Part 25 of Title 14 of the United States Code of Federal Regulations (CFR).*

**CS 25.1325: Certification Specification (CS) 25.1325 of EASA certification specifications for large aircraft (CS 25).*

9.1.5 Continuity of function.- At least one RNAV system is required to conduct baro-VNAV operations.

9.2 System accuracy

9.2.1 For instrument approach operations, it must be demonstrated that the on board VNAV equipment error, excluding altimetry, is lower than the values described in Table 9-1, with a probability of 99.7%.

Table 9-1

	Level flight segments and climb/descent intercept altitude region of specified altitudes (ft)	Climbs/descents along the specified vertical profile (angle) (ft)
At or below 5 000 ft	50	100
5 000 ft to 10 000 ft	50	150
Above 10 000 ft	50	220

Note 1.- *The VNAV equipment error is the error associated with the calculation of the vertical path. This includes the path definition error (PDE) and an approach performed by the VNAV equipment from the construction of the vertical path, if any.*

9.2.2 Vertical flight technical errors (FTE).- Using satisfactory displays of vertical guidance information, it must be demonstrated that the flight technical errors are below the values shown in Table 9-2, on a three-sigma basis:

Table 9-2

	Level flight segments and climb/descent intercept altitude region of specified altitudes (ft)	Climbs/descents along the specified vertical profile (angle) (ft)
At or below 5 000 ft	150	200

5 000 ft to 10 000 ft	240	300
Above 10 000 ft	240	300

9.2.3 Regarding the facility, a sufficient number of test flights should be conducted to verify that these values could be maintained. Lower FTE values can be achieved, especially when the VNAV system is coupled to an AP or FD. However, at least the total system vertical precision shown in Table 9-3 must be maintained.

9.2.4 If a facility produces higher FTEs, the total vertical error of the system (excluding altimetry) can be determined by combining the FTEs with the equipment errors using the root sum square method. The result shall be lower than the values listed in Table 9-3:

Table 9-3

	Level flight segments and climb/descent intercept altitude region of specified altitudes (ft)	Climbs/descents along specified vertical profile (angle) (ft)
At or below 5 000 ft	158	224
5 000 ft to 10 000 ft	245	335
Above 10 000 ft	245	372

9.2.5 The approval of the VNAV system in accordance with FAA AC 20-129, and the approval of the altimetry system in accordance with FAR/CS/LAR 25.1325 or equivalent, constitutes acceptable means of compliance with the aforementioned precision requirements.

9.3 functional requirements for APV/baro-VNAV operations

9.3.1 Required functions

a) **Displays**.- APV/baro-VNAV deviations must be shown on a vertical deviation display (*e.g.,* the horizontal situation indicator (HSI), the enhanced horizontal situation indicator (EHSI), and the vertical deviation indicator (VDI)).

This display must be used as primary flight instrument during the approach. The display must be visible to the pilot and be located in the primary field of view of the pilot.

The deviation display must have a suitable full-scale deflection based on the required vertical track error.

b) **Continuous deviation display**.- The navigation display must provide the capacity of continuously showing the aircraft position relative to the defined vertical path to the pilot flying the aircraft (PF), on the primary navigation flight instruments. The display must permit the pilot to readily note if the vertical deviation exceeds +100/-50 ft. The deviation shall be monitored and the pilot will take the appropriate action to minimise errors.

Note.- *When the minimum crew consists of two pilots, a means shall be provided for the pilot not flying the aircraft (PNF) (pilot monitoring (PM)) to check the desired path and the aircraft position relative to the path.*

1) It is recommended that a properly graduated non-numerical deviation display (*e.g.,* the vertical deviation indicator) be located on the primary field of view of the pilot. A fixed-scale deviation indicator is acceptable, provided said indicator demonstrates the proper setting and sensitivity for the planned operation. Alert and annunciation limits must also correspond to scale values.

Note.- *Current systems incorporate vertical deviation scales in the range of ± 500 ft. These deviation scales shall be assessed based on the aforementioned requirements.*

2) Instead of duly graduated vertical deviation indicators, it may be acceptable to have a numeric vertical deviation display, depending on the flight crew workload and display characteristics.

The use of a numerical display may require initial and recurrent training for the flight crew.

3) Since the vertical deviation scale and sensitivity vary significantly, an eligible aircraft may also be equipped with an operational FD or AP capable of following a vertical path.

c) **Definition of the vertical path**.- The navigation system must be capable of defining a vertical path in accordance with the published vertical path. It must also be capable of specifying a vertical path within the altitude constraints at two fixes in the flight plan. Altitude constraints at fixes must be defined as one of the following:

1) an AT or ABOVE altitude constraint (for example, 2400A may be appropriate when there is no need to limit the vertical path);

2) an AT or BELOW altitude constraint (for example, 4800B may be appropriate when there is a need to limit the vertical path);

3) an AT altitude limitation (for example, 5200); or

4) a WINDOW-type altitude constraint (for example, 2400A3400B).

Note.- *For RNP AR APCH procedures, any segment with a published path will define that path based on an angle to the fix and altitude.*

d) **Path construction**.- The system must be capable to construct a path to provide guidance from current position to a vertically constrained fix.

e) **Capability to load procedures from the navigation database**.- The navigation system must have the capability to load and modify the entire procedures to be flown, based upon ATC instruction, into the RNAV/RNP system from onboard navigation database. This includes the approach (including vertical angle), the missed approach, and the approach transitions for the selected aerodrome and runway. The RNAV/RNP system shall preclude modification of the procedure data contained in the navigation database.

f) **User interface (control and displays)**.- the display readout and entry resolution for vertical navigation information shall be as follows:

Table 9-4

Parameters		Display resolution	Entry resolution
Altitude	Above the transition level altitude	Flight level	Flight level
	Below the transition level altitude	1 ft	1 ft
Vertical path deviation		10 ft	Not applicable
Flight path angle		0.1º	0.1º
Temperature		1º	1º

g) The navigation database must contain the necessary information to fly the APV/baro-VNAV approach. This database must contain the Wets and associated vertical information (obstacle clearance height (TCH) and flight path angle (VPA)) for the procedure.

Vertical constraints (altitudes and airspeeds) associated with published procedures must be automatically retrieved from the navigation database once the approach procedure has been selected.

h) The navigation system must be capable of indicating the navigation loss (*e.g.,* system failure) in the pilot's primary field of view through a warning signal (flag) or equivalent indicator on the vertical navigation display.

i) The aircraft must show barometric altitude from two independent altimetry sources, one in each pilot's primary field of view. When single pilot operation is permitted, the two displays must be visible from the pilot position.

9.3.2 **Recommended functions**

a) **Temperature compensation** The baro-VNAV navigation system should be capable of automatically adjusting the vertical flight path for temperature effects. The equipment should provide the capability for entry of altimeter source temperature to compute temperature compensation for the vertical flight path angle. The system should provide clear and distinct indication to the flight crew of this compensation/adjustment.

b) Capability to automatically intercept the vertical path at the final approach point (FAP), using a vertical fly-by technique.

9.4 Aircraft eligibility

a) **RNP system capability.-** An aircraft is eligible for RNP operations when it meets the RNP performance and functional requirements described in AC RNP APCH or AC RNP AR APCH or equivalents.

b) **Barometric VNAV capability.**- An aircraft is eligible when it has a flight manual (AFM) or AFM supplement which clearly states that the VNAV system is approved for approach operations in accordance with FAA AC 20-129 or AC 20-138 o equivalents documents. In addition, for a VNAV system to be approved for approach operations according to AC 20-129 or AC 20-138 or equivalents documents, it must have a vertical deviation indicator (VDI). Since VDI sensitivity and setting vary significantly, an eligible aircraft must also be equipped and use either a flight director (FD) of an autopilot (AP) capable of following the vertical path. Pilot deviation of +100/-50 ft is considered acceptable on a published VNAV path.

Note.- *An aircraft with RNP AR APCH authorisation is considered eligible for conducting baro-VNAV operations in accordance with this AC. No further evaluation is required.*

c) **Database requirements.-** The aircraft database must include the WPTs and the associated VNAV information, *e.g.,* altitudes and vertical angles for the procedure to be flown.

9.5 Aircraft approval

a) **Eligibility based on the AFM or AFM supplement**

Operators must review the aircraft AFM or AFM supplement in order to establish the eligibility of the navigation system as described in Paragraph 9.4 and present to the CAA.

b) **Eligibility that is not based on the AFM or AFM supplement**

1) An operator may not be in a position to determine the eligibility of the equipment for conducting APV/baro-VNAV approaches based on the AFM or AFM supplement. In this case, operators must request that the Airworthiness inspection division of the CAA or equivalent, assess the baro-VNAV equipment to determine its eligibility.

2) Together with the request, the operator will provide to the Airworthiness inspection division or equivalent the following information:

   (a) name of the manufacturer, model, and part number of the RNAV/RNP system;

   (b) any evidence of IFR approval of the navigation system; and

   (c) relevant information about flight crew operating procedures.

3) If the Airworthiness inspection division or equivalent is not in a position of determining the eligibility of the equipment, it shall send the request, together with the supporting data, to the Aircraft certification division or equivalent.

4) The Aircraft certification division or equivalent will verify that the aircraft and the RNAV/RNP system meet the baro-VNAV criteria and that the system can safely fly VNAV paths associated to instrument approach procedures, applying a DA instead of an MDA. The Aircraft certification division or equivalent will provide written documentation (*e.g.,* a report of an amended flight standard bulletin or other official document) to verify the eligibility of the equipment.

5) If the CAA determines that the navigation equipment is eligible for baro-VNAV instrument approach operations, the Airworthiness inspection division or equivalent will provide documentation showing that the aircraft equipment is approved for said operations.

6) Compliance with airworthiness or equipment installation requirements, by itself, does not constitute operational approval.

9.6 Aircraft modification

a) If any system required for baro-VNAV operations is modified (*e.g.,* change in the software or hardware), the aircraft modification must be approved.

b) The operator must obtain a new operational approval that is supported by operational and aircraft qualification documentation presented by the operator.

10. OPERATIONAL APPROVAL

10.1 To obtain the operational approval, the operator will take the following steps:

a) *Airworthiness approval*.- aircraft shall have the corresponding airworthiness approvals as established in Paragraph 9.

b) *Application*.- The operator will submit the following documentation to the CAA:

   1) *the application to obtain the APV/baro-VNAV authorization*;

   2) *aircraft qualification documentation*.- Documentation showing that the equipment of the proposed aircraft meets the requirements described in Paragraph 9 of this AC.

   3) *Type of aircraft and description of the aircraft equipment to be used*.- The operator will provide a configuration list describing in detail the relevant components and the equipment to be used in the APV/baro-VNAV operation. The list shall include each manufacturer, model and version of the FMS software installed.

   Note.- *Barometric altimetry and the associated equipment, such as air data systems, are basic capabilities required for flight operations.*

   4) *Operational procedures*.- Operator manuals shall properly indicate the navigation procedures identified in Paragraphs 11 and 12 of this AC.

   5) *Training programmes*.- Operators will submit the training curriculums in accordance with Paragraph 13 of this AC, which describe the operational and maintenance practices and

procedures and training aspects related to VNAV approach operations (*e.g.,* initial, promotion, and recurrent training for flight crews, flight dispatchers, and maintenance personnel).

Note.- *A separate training programme is not required if RNAV and VNAV training is already part of the training programme of the operator. However, it should be possible to identify the practices and procedures concerning VNAV aspects covered in the training programme.*

6) *Operations manual (OM) and checklists*.- Operators will submit the operations manuals and checklists containing information and guidance on APV/baro-VNAV operations.

7) *Maintenance procedures*.- The operator will submit the maintenance procedures containing airworthiness and maintenance instructions concerning the systems and equipment to be used in the operation. The operator will provide a procedure to remove and restore the APV/baro-VNAV operational capacity of the aircraft.

8) *MEL*.- The operator will submit any revision to the MEL needed to conduct APV/baro-VNAV operations.

9) *Validation*.- The CAA will determine the need to conduct validation tests based on the type of operation and operator experience. If validation tests are necessary, the operator will submit a validation test plan to show its capacity to conduct the proposed operation. The validation plan must at least include the following:

   (a) a statement indicating that the validation plan has been designated to demonstrate the capacity of the aircraft to execute APV/baro-VNAV procedures;

   (b) operational and dispatch procedures; and

   (c) MEL procedures.

Note 1*.- the validation plan shall make use of ground training devices, flight simulators, and aircraft demonstrations. If the demonstration will be conducted in an aircraft, it must be completed during the day and under VMC.*

Note 2.*- validations may be required for each manufacturer, model, and version of the installed FMS software.*

10) *Navigation data validation program*.- The operator shall submit the details of the navigation data validation program as described in Appendix 1 of this AC.

c) *Training*.- Once the CAA has accepted or approved the amendments to the manuals, programmes and documents submitted, the operator will provide the respective training to its personnel.

d) *Validation flights*.- Validation flights, if required, will be conducted according to Paragraph 11.1 b) 9).

e) *Issuance of the authorisation*.- Once all the aforementioned steps have been completed satisfactorily, the CAA will issue the OpSpecs or a LOA.

11. OPERATIONAL PROCEDURES

11.1 For APV/baro-VNAV operations, the crews must be familiar with the following procedures:

a) **Corrections for cold temperatures**.- Pilots are responsible for any cold temperature correction required at all minimum altitudes/heights published. This includes:

   a) The altitudes/heights for initial and intermediate segments;

   b) The DA/H; and

   c) Subsequent missed approach altitudes/heights.

Note.- *The VPA of the final approach path is protected against the effects of cold temperatures by the procedure design.*

b) **Altimeter setting**.- APV/baro-VNAV operations will only be conducted when:

1) a current and local source for altimeter setting is available; and

2) the *QNH/*QFE is properly selected in the aircraft altimeter.

*QNH: Pressure at mean sea level. This setting indicates the altitude above mean sea level, (MSL) with standard temperature.

*QFE: Standard atmosphere that corresponds to 1013 hPa or 29.92" Hg. This setting indicates the altitude above the isobaric surface of 1013 hPa, with standard temperature.

Note.- *A remote source for altimetry setting shall not be used.*

c) **Actions to be taken at the DA**.- The flight crew is expected to operate the aircraft along the published vertical path, and to execute a missed approach procedure once it reaches the DA, unless the required visual references to continue with the approach are in sight.

d) **Temperature limitation**.- Because of the pronounced effect of nonstandard temperature on baro-VNAV operations, instrument approach procedures will contain a temperature limitation below which the use of a vertical navigation decision altitude (VNAV DA) based on baro-VNAV is not authorized. The temperature limitation will be shown through a note in the instrument approach procedure. If the aircraft system is capable of temperature compensation, the crew must follow the operator procedures based on the manufacturer instructions.

e) **VNAV path mode selection**.- The flight crew must know the correct selection of the vertical mode(s) that command vertical navigation via the published flight path. Other vertical modes, such as vertical speed are not applicable to baro-VNAV approach.

f) **Restriction to using a remote source for altimeter setting**.- The use of baro-VNAV up to a DA is not authorised if the altimeter setting is issued from a remote source. For APV/baro-VNAV operations, a current altimetry setting is required for the landing aerodrome. When minima related to a remote altimetry setting are shown, the VNAV function can be used, but only up to the published lateral navigation minimum descent altitude (LNAV MDA).

g) **Manual adjustments**.- If manual adjustments to stored altitude information are necessary, *e.g.,* cold temperature adjustments, the flight crew must make appropriate adjustments to the procedure altitudes and revert to use of the temperature adjusted LNAV MDA.

12. TEMPERATURE LIMITATIONS

a) For aircraft using barometric vertical navigation without temperature compensation to conduct the approach, cold temperature limits are reflected in the procedure design and identified along with any high temperature limits on the charted procedure. Cold temperatures reduce the actual glidepath angle, while high temperatures increase the glidepath angle. Aircraft using barometric vertical navigation with temperature compensation or aircraft using an alternate means of vertical guidance (*e.g.,* satellite-based augmentation system (SBAS)) may disregard the temperature restrictions.

b) Since the temperature limits established in the charts are only assessed for obstacle clearance in the final approach segment, and since temperature compensation only affects vertical guidance, the pilot may need to adjust the minimum altitude on the initial and intermediate approach segments, and at the decision altitude/height (DA/H)).

Note 1*.- Temperature affects the indicated altitude. The effect is similar to having high and low pressure changes, but not as significant as such changes. When the temperature is higher than standard (temperature under international standard atmospheric (ISA) conditions)), the aircraft will be flying above the indicated altitude. When the temperature is below the standard, the aircraft will be flying below the altitude indicated in the altimeter. For further information, refer to altimetry errors in the aeronautical information manual (AIM)*

Note 2.*- The ISA standard conditions at sea level are:*

- *The standard temperature is defined as 15º Celsius (centigrade's) or 288.15º Kelvin;*

- *The standard pressure is defined as 29.92126 inches of mercury (Hg) or 1013.2 hectopascals (hPa); and*
- *The standard density for these conditions is 1.225 kg/m^3 or 0.002377 slugs/cubic ft.*

13. TRAINING PROGRAMME

13.1 The training programme of the operator shall include sufficient training on aircraft VNAV capabilities for flight crews and flight dispatchers (*e.g.,* ground training, flight simulators, flight training devices (FTD) or aircraft). Training will cover the following areas:

a) information about this AC;

b) the meaning and proper use of aircraft systems;

c) the characteristics of APV/baro-VNAV procedures, as determined from chart depiction and textual description;

1) description of WPT types (fly-by and flyover WPTs), path terminators, and any other type of terminator used by the operator, as well as the associated flight paths of the aircraft;

2) information about the specific RNAV/RNP system;

3) automation levels, annunciation modes, changes, alerts, interactions, reversions, and degradation;

4) functional integration with other aircraft systems;

5) the meaning of vertical path discontinuities and related flight crew procedures;

6) monitoring procedures for each flight phase (*e.g*., monitoring of “PROGRESS” o “LEGS” pages);

7) turn anticipations, taking into account the effect of airspeed and altitude; and

8) interpretation of electronic displays and symbols.

d) VNAV equipment operating procedures, where applicable, including how to perform the following actions:

1) adhere to speed and/or altitude constraints associated with an approach procedure;

2) verify WPTs and flight plan programming;

3) fly direct to a WPT;

4) determine vertical track error/deviation;

5) insert and delete route discontinuity;

6) change destination and alternate aerodromes;

7) contingency procedures for VNAV failures;

e) the functioning of barometric altimeters.- Barometric altimeters are calibrated to indicate the true altitude under ISA atmospheric conditions. If, on a given day, the temperature is warmer than ISA, the true altitude will be higher than indicated altitude. Conversely, on a day colder than ISA, the true altitude will be lower than indicated altitude. These errors increase in magnitude as the altitude above the altimeter setting source increases.

f) altimetry setting procedures and cold temperatures.

1) Altimeter setting.- Flight crews must take precautions when changing the altimeter setting and will request a current altimeter setting if the reported setting may not be recent, especially when pressure tends to drop quickly. Remote altimeter setting is not permitted for APV/baro-VNAV operations.

2) Cold temperatures.- In case of cold temperatures, the pilot shall verify the instrument approach procedure chart to determine the temperature limit for using the baro-VNAV capability. If the aircraft system has temperature compensation capability, the crew shall follow the procedures established by the operator based on the manufacturer instructions for using the baro-VNAV function.

g) Knowledge of failures and reversal modes.- The flight crew shall have knowledge of failures and reversal modes that adversely impact the aircraft's ability to conduct baro-VNAV approach operations. In addition, the flight crew must be aware of contingency procedures (*e.g.,* reversal to LNAV MDA following a VNAV failure).

h) Operational verification of altimeters.- When two pilots are required on an aircraft, the flight crew must complete an altimetry crosscheck ensuring both pilots´ altimeters agree within ± 100 ft prior to the FAF. If the altimeter crosscheck fails, the instrument approach procedure must not be executed, or, if said procedure is in progress, it must not be continued. If the avionics system provides a warning system that compares the pilots´ altimeters, flight crew procedures shall indicate the action to be taken in the event of a warning from the pilot altimeter comparator when executing an APV/baro-VNAV operation.

Note.- *This operational crosscheck of the altimeters is not necessary if the aircraft automatically compares the altitudes within 100 ft.*

14. NAVIGATION DATABASE

a) The operator must obtain the navigation database from a qualified supplier that complies with RTCA document DO-200A / EUROCAE ED- 76, Standards for processing aeronautical data.

b) Navigation data suppliers must have a letter of acceptance (LOA) in order to process the navigation information (*e.g.,* FAA AC 20-153 or European aviation safety agency (EASA) document on the conditions for the issuance of letters of acceptance for navigation database suppliers by the Agency (EASA IR 21 Sub-part G) or equivalent documents). A LOA recognizes the data of a supplier as those in which information quality, integrity, and quality management practices are consistent with the criteria of document DO-200A/ED-76. The operator's database supplier (*e.g.,* an FMS company) must have a Type 2 LOA and their respective suppliers must have a Type 1 or 2 LOA.

c) The operator must report to the navigation data provider any discrepancy that invalidates a procedure, and prohibit the use of the affected procedures by means of a notice to flight crews.

d) Operators should consider the need to periodically verify the navigation databases, in order to maintain the existing requirements of the quality system or safety management system.

15. OVERSIGHT, INVESTIGATION OF NAVIGATION ERRORS AND WITHDRAWAL OF APV/baro-VNAV AUTHORISATION

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

b) Information that indicates the potential of repeated errors may require modification of an operator's training programme.

c) Information that attributes multiple errors to a particular pilot may required remedial training or license review.

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

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APPENDIX 1

NAVIGATION DATA VALIDATION PROGRAMME

1. INTRODUCTION

The procedure stored in the navigation database defines the aircraft lateral and vertical guidance. The navigation database is updated every 28 days. The navigation data used in each update are critical for the integrity of each APV/baro-VNAV approach. Taking into account the reduced obstacle clearance associated with these approaches, navigation data validation requires special consideration. This appendix provides guidance on the operator procedures to validate the navigation data associated with APV/baro-VNAV approaches.

2. DATA PROCESSING

a) The operator will identify the person responsible for updating the navigation data.

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

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

3. INITIAL DATA VALIDATION

3.1 The operator must validate every APV/baro-VNAV procedure before flying the procedure in instrument meteorological conditions (IMC) to ensure compatibility with their aircraft and to ensure the resulting path correspond to the published procedure. As a minimum, the operator must:

a) compare the navigation data of the procedure to be loaded on the FMS with a published procedure.

b) validate the navigation data of the loaded procedure, either in the flight simulator or in the actual aircraft under visual meteorological conditions (VMC). The depicted procedure on the map display must be compared to the published procedure. The entire procedure must be flown to ensure that the path can be used, that it has no apparent lateral or vertical path disconnections, and is consistent with the published procedure.

c) once the procedure is validated, a copy of the validated navigation data must be kept and maintained to be compared with subsequent data updates.

4. DATA UPDATING

Whenever the operator receives a navigation data update and before using such data on the aircraft, the update must be compared with the validated procedure. This comparison must identify and resolve any discrepancy in the navigation data. If there are any significant changes (any change affecting the approach path or performance) to any part of the procedure, the operator must validate the amended procedure in accordance with the initial data validation (Paragraph 3 of this AC).

5. NAVIGATION DATA SUPPLIERS

Navigation data suppliers must have a letter of acceptance (LOA) to process these data (*e.g.,* FAA AC 20-153 or EASA document on the conditions for the issuance of letters of acceptance for navigation data suppliers (EASA IR 21 Sub-part G) or equivalent document). An LOA recognizes the data of a supplier as having an information quality; integrity and quality management practices that are consistent with the criteria of document DO-200A/ED-76. The operator's database supplier must have a Type 2

LOA and their respective suppliers must have a Type 1 or 2 LOA. The AAC may accept a LOA submitted by navigation data suppliers or issues its own LOA.

6. AIRCRAFT MODIFICATIONS (DATA BASE UP TO DATE)

If an aircraft system required for APV/baro-VNAV operations is modified (*e.g.,* a change in the software), the operator is responsible for validation of APV/baro-VNAV procedures with the navigation database and the modified system. This may be accomplished without any direct evaluation if the manufacturer verifies that the modification has no effect on the navigation database or on path computation. If this verification is not accomplished by the manufacturer, the operator must carry out an initial navigation data validation with the modified system.

APPENDIX 1

APV/baro-VNAV APPROVAL PROCESS

a) The APV/baro-VNAV approval process consists of two types of approvals: the airworthiness and operational approvals. Although the two have different requirements, they must be considered under a single process.

b) This process constitutes an orderly method used by the CAAs to ensure that applicants meet the established requirements.

c) The approval process consists of the following phases:

   1) Phase one: Pre-application
   2) Phase two: Formal application
   3) Phase three: Review of the documentation
   4) Phase four: Inspection and demonstration
   5) Phase five: Approval

d) In *Phase one - Pre-application*, the CAA meets with the applicant or operator (pre-application meeting), who is advised of all the requirements it must meet during the approval process.

e) In *Phase two - Formal application*, the applicant or operator submits the formal application, accompanied by all the relevant documentation, as established in Paragraph 11 of this AC.

f) In *Phase three - Review of documentation*, the CAA evaluates the documentation and the navigation system to determine their eligibility and the approval method to be applied with respect to the aircraft. As a result of this review and evaluation, the CAA may accept or reject the formal application together with the documentation.

g) In *Phase four - Inspection and demonstration*, the operator will train its personnel and conduct validation flights, if required.

h) In *Phase five - Approval*, the CAA issues the APV/baro-VNAV authorization once the operator has met the airworthiness and operational requirements. For LAR 121 and 135 operators, the CAA will issue the corresponding OpSpecs, and for LAR 91 operators, it will issue a LOA.

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ADVISORY CIRCULAR

DATE : 01/01/13
REVISION : 1
ISSUED BY : PBN TF

SUBJECT: AIRCRAFT AND OPERATORS APPROVAL FOR RNAV 5 OPERATIONS

1. PURPOSE

This advisory circular (AC) provides acceptable means of compliance (AMC) concerning aircraft and operators approval for RNAV 5 operations.

An operator may use other means of compliance, as far as those means are acceptable for their respective Civil Aviation Authority (CAA).

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 AC.

This AC 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. RELATED DOCUMENTS

ICAO Doc 9613	Performance based navigation (PBN) Manual
ICAO Doc 9997	PBN Operational Approval Manual
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
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

3. DEFINITIONS AND ABREVIATIONS

3.1 Definitions

a) **Area navigation (RNAV)**.- A method of navigation 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.

b) **Area navigation route**.- An Air traffic services (ATS) route established for the use of aircraft capable of employing area navigation.

c) **Global positioning system (GPS)**.- The United States Global navigation Satellite System (GNSS) is a satellite-based radio navigation system which utilizes precise range measurements to determine position, velocity and time in anywhere in the world. The GPS is composed by three elements: space, control, and user. The space element is formed of at least 24 satellites in 6 orbital planes. The control element consists of 5 monitor stations, 3 ground antennas, and a master control station. The user element consists of antennas and receivers that provide positioning, velocity and precise timing to the user.

d) **Navigation specifications**.- 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 specifications: 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.

e) **Performance based navigation (PBN)**.- Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.

f) **Receiver autonomous integrity monitoring (RAIM)**.- A technique used within a GPS receiver/processor to determine the integrity of its navigation signals using only GPS signals, or GPS signals augmented with barometrical altitude data. This determination is achieved by a consistency check among redundant pseudo-orange measurements. At least one additional satellite needs to be available in respect to the number of satellites that are needed to obtain the navigation solution.

g) **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.

h) **RNAV system**.- 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 both. A RNAV system may be included as part of the Flight Management System (FMS)

3.2 Abreviations

a)	AC	Advisory circular
b)	ADF	Automatic direction finder
c)	AFM	Aircraft flight manual
d)	AIP	Aeronautical information publication
e)	AIRAC	Aeronautical information regulation and control
f)	AMC	Aceptable means of compliance
g)	ANSP	Air navigation services provider
h)	ATC	Air traffic control
i)	ATS	Air traffic services
j)	B-RNAV	Basic area navigation
k)	CAA	Civil Aviation Authority
l)	CDI	Course deviation indicator
m)	CDU	Control display unit
n)	DME	Distance measuring equiment
o)	DOP	Dilution of precision
p)	EASA	European Aviation Safety Agency
q)	ETSO	EASA Technical standard order
r)	EUROCAE	European organization for civil aviation equipment
s)	FAA	Federal Aviation Administration (United States)
t)	FDE	Fault detection and exclusion

u)	FMS	Flight management system
v)	FTE	Flight technical error
w)	GNSS	Global navigation satellite system
x)	GPS	Global positioning system
y)	HSI	Horizontal situation indicator
z)	IFR	Instrument flight rules
aa)	INS	Inertial navigation system
bb)	IRS	Inertial referente system
cc)	IRU	Inertial referente unit
dd)	LOA	Letter of authorization/Letter of acceptance
ee)	MEL	Minimum equipment list
ff)	NAVAIDS	Navigation aids
gg)	NDB	Non-directional beacon
hh)	ND	Navigation display
ii)	NOTAM	Notice to airmen
jj)	OM	Operations manual
kk)	PBN	Performance based navigation
ll)	PF	Pilot flying
mm)	PNF	Pilot not flying
nn)	POH	Pilot operating handboock
oo)	RAIM	Receiver autonomous integrity monitoring
pp)	P-RNAV	Precision area navigation
qq)	RAIM	Receiver autonomous integrity monitoring
rr)	RNAV	Area navigation
ss)	RTCA	Radio technical commission for aeronautics
tt)	SA	Selective availability
uu)	SB	Service bulletin
vv)	STC	Supplemental type certificate
ww)	TCDS	Type certificate data sheet
xx)	TLS	Target level of safety
yy)	TSO	Technical standard order
zz)	VOR	Very hight frecuency (VHF) omni-directional radio range
aaa)	WGS	World geodetic system
bbb)	WPT	Waypoint

4. INTRODUCTION

4.1 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).

4.2 In the same manner, the Federal Aviation Administration (FAA) of the United States 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).

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

4.4 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.

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

4.6 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).

4.7 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.

4.8 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.

4.9 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 $\pm$ 5 NM or better during 95% of the total flight time.

5. GENERAL CONSIDERATIONS

5.1 Navaid infrastructure

a) The CAA may prescribe RNAV 5 navigation specification for specific routes or for specific areas or flight levels of an airspace.

b) RNAV 5 systems permit aircraft navigation along any desired flight path within the coverage of ground or space-base 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 AC.*

d) The ANSP 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.

5.2 Communication and air traffic services (ATS) 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.

5.3 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**

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

2) **Along track distance between leg changes**

(a) 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.

(b) 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.

5.4 Publication

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 Chicago Convention 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.

5.5 **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.

6. AIRWORTHINESS AND OPERATIONAL APPROVAL

6.1 In order to the operator receives an RNAV 5 authorization, this must comply with two types of approval:

a) Airworthiness approval in charge of the State of registry; (See Art. 31, Chicago Convention, Paragraph 5.2.3 and 8.1.1 of Annex 6, Part I; and

b) Operational approval required by the State of the operator (See Paragraph 4.2.1 and Attachment F of Annex 6 Part I).

6.2 For general aviation operators, the State of registration (See Paragraph 2.5.2.2 of Annex 6 Part II) will submit a Letter of Appointment (LOA) once determined that the aircraft accomplishes all applicable requirements of this document for RNAV 5 operations.

6.3 Compliance with airworthiness requirements by themselves does not constitute the operational approval.

7. AIRWORTHINESS APPROVAL

7.1 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:

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

(b) through aircraft navigation system approval.

7.2 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 AC or AMC 20-4 or with one of the following FAA documents:

(a) 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 AC 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 8 of this AC.

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

a) *Determination of the aircraft eligibility through evaluation of its navigation equipment.*

1) The operator makes a request for assessment of aircraft RNAV equipment for eligibility to the airworthiness inspection Direction or equivalent CAA entity. The operator, together with the request, will provide the following:

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

(b) 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.

(c) proof that the system meets the required functions for RNAV 5 operations described in this AC on paragraph 7.6.

(d) crew operating procedures and bulletins; and

(e) any other pertinent information required by the CAA.

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

7.4 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 7.6 of this AC, 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 n 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 equiment (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)**

(a) 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 the present AC on Paragraph 7.6.

(b) 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:

- Pseudorange step detection; and
- Health word checking

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

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

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

(3) a CAA letter of design approval for the applicable equipment. Operators should contact the avionic equipment’s manufacturer to determine if the equipment complies with these requirements and ask if a letter of design approval is available. Manufacturers may obtain this letter by submitting appropriate documentation to the certifications offices of the States of aircraft design or manufacturer. Operators will keep the letter of design approval within the AFM or POH as evidence of the RNAV 5 eligibility..

(d) 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.

(e) 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 equipments**

(a) Stand-alone GPS equipments approved in accordance with guidance provided in this AC 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 CAA. The flight crew must receive appropriate training for use the stand-alone GPS equipment regarding normal and contingency procedures detailed in the Paragraph 9 of this AC.

7.5 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 $\pm$ 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 o 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)).

7.6 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:

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

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

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

7.7 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 AC.

b) Each operator who applies for RNAV-5 operational approval shall submit to the CAA of State of registry, 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) Maintenance control manual (MCM);

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 CAA 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 CAA 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.

8. OPERATIONAL APPROVAL

8.1 *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 9 of this AC.

a) *Airworthiness approval*.- The Aircraft must have the corresponding airworthiness approvals as mentioned in Paragraph 7 of this AC.

b) *Documentation*.- The operator will present to the CAA 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 9 of this AC, 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 7.7 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 10 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) *Validation flights*.- The CAA may perform a validation flight, if determines it is necessary in the interest of safety.

8.2 *Authorization issuance to perform RNAV 5 operations*.- Once the operator has successfully completed the operational approval process, the CAA will issue the operator, when applicable, the corresponding authorization to perform RNAV 5 operations.

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9. OPERATION PROCEDURES

9.1 Flight planning.

a) Before operating on a RNAV 5 route, the operator will ensure that:

1) The aircraft counts on a RNAV 5 approval;

2) The necessary equipment to operate RNAV 5 work correctly and are not degraded;

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

4) The crews check the contingency procedures.

b) *Stand-alone GPS equipment.* During the planning phase the following procedures must be accomplish in regards to the stand-alone GPS equipment:

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

(a) all satellites are scheduled to be in service; or

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

2) The availability of GPS integrity RAIM shall be confirmed for the intended flight (route and time) through the use of a prediction program either ground-based or incorporated in the on-board system, following the criteria established in Appendix 1, when:

(a) any satellite is scheduled to be out of service; or

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

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

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

5) Taking in consideration that during flight may occur deviations in regards to the specified ground speedy, prediction must be done using different speeds within the predictable margin for them.

6) Prediction program must be executed with a maximum anticipation of two hours preview to the flight departure. The operator will confirm that data about the state of the constellation and GPS ephemerides, have been updated with the latest information distributed by notice to airmen (NOTAM).

7) In order to get exact prediction, the program will allow manual de-selection of satellites considered non operative, as well as selection of those back to service condition during the flight time.

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

c) *ATS – ICAO flight plan*.- At the time to file the ATS flight plan, authorized aircraft operators on RNAV 5 route, will insert corresponding code on flight plan form's fields 10 and 18, as defined within ICAO Doc 4444 and 7030 for these operations.

9.2 **Preview flight procedures at the aircraft.-** The crew will perform on the aircraft the following procedures preview to the flight:

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

b) check data base validation (current AIRAC cycle), if it is installed.

c) route corresponds to the authorization. Flight crews must cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, taking into account the WPT name, sequencing, heading and distance to the next WPT and the total distance, if applicable. If required (NOTAM, AIP, navigation charts or other resource), the exclusion of specific navigation aids should be confirmed, so as to avoid their inclusion in the position calculation by the navigation system of the aircraft.

9.3 En route operations.

a) The crew will assure the aircraft correct functioning of its navigation system during its operation in a RNAV 5 route, confirming that:

1) necessary RNAV 5 equipment have not degraded during flight;

2) route corresponds to the authorization;

3) aircraft navigation accuracy is pertinent for RNAV 5, assuring this through pertinent cross check;

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

5) For RNAV 5, pilots must use a lateral deviation indicator, flight director or autopilot in lateral navigation mode. Pilots may use a navigation map display as described in Paragraph 7.6 b), without a flight director or autopilot. Pilots of aircraft with a lateral deviation display must ensure that lateral deviation scaling is suitable for the navigation accuracy associated with the route/procedure (e.g. full-scale deflection: ± 5 NM);

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

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

7) If ATS issues a heading assignment taking the aircraft off a route, the pilot must 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.

9.4 Contingency procedures.

a) Flight crews must familiarize with the following general provisions:

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

2) According to ATC instructions, operations will continue in regards to the present ATC authorization, or when not possible, will be requested a revised authorization to return to the VOR/DME conventional navigation;

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

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

b) Stand-alone GPS equipment.

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

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

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

(c) In case of exceedance of the alarm limit.- The flight crew must revert to an alternative means of navigation.

2) *On-board equipment availability VOR, DME or ADF*.- The operator must have installed on the aircraft the VOR, DME or ADF on-board equipment capacity to assure the availability of navigation alternative means in case of a GPS/RNAV system failure.

c) Any incidence registered in flight must be notified to the CAA in a maximum time of seventy two hours, unless justified cause.

10. 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.

11. TRAINING PROGRAM

a) The training programs for flight crews and flight dispatchers, if correspond, must be reviewed and approved by the CAA. The operator will included at least the following modules:

   1) Required equipments, capacities, limitations and operation of these equipments in RNAV 5 airspace.

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

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

   4) Contingency procedures for RNAV failures.

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

   6) The flight planning requirements for the RNAV operation.

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

   8) RNAV 5 en route procedures;

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

   10) RNAV system-specific information, including:

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

      (b) Functional integration with other aircraft systems.

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

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

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

      (f) Interpretation of electronic displays and symbols.

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

      (a) Verify currency of aircraft navigation data.

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

      (c) Initialize RNAV system position.

      (d) Fly direct to a waypoint.

      (e) Intercept a course/track.

      (f) Be vectored off and rejoin a procedure.

(g) Determine cross-track error/deviation.

(h) Remove and reselect navigation sensor input.

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

(j) Perform gross navigation error check using conventional navigation aids.

b) Training program on the GPS as a primary means of navigation.

1) Besides the training modules describe on the previous paragraphs, operators' training programs which use RNAV systems based on GPS as a primary navigation means will include modules described in Appendix 2.

12. NAVIGATION DATA BASE

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.*

Appendix 1

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 Civil Aviation Authority (CAA).

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.

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Appendix 2

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;

(a) 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.

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Appendix 3

RNAV 5 approval process

a) The RNAV 5 approval process is comprised of two types of approvals: the airworthiness approval and the operational approval, even though, they have different requirements, both must be considered under one process only.

b) This process constitutes a well-arrange method, which is used by the CAA to ensure the applicants comply with the established requirements.

c) The approval process is conformed by the following phases:

1) Phase one: Pre-application

2) Phase two: Formal application

3) Phase three: Analysis of the documentation

4) Phase four: Demonstration and inspection

5) Phase five: Approval

d) *In Phase One - Pre-aplication*, the CAA holds a meeting with the operator (the pre-aplication meeting), in which the operator will be informed about all the requirements that he needs to comply during the approval process.

e) *In Phase Two - Formal application*, the operator submits the formal application with all applicable documents.

f) *In Phase Three - Analysis of the documentation*, the CAA reviews the submission and evaluates the navigation equipment in order to determine the method of approval (aircraft equipment eligibility). As a result of this evaluation the CAA may accept or return the Formal Application with the documentation.

g) *In Phase Four - Demonstration and inspection*, the operator will accomplish the training program and the validation flight if this is required by the CAA, otherwise the process will advance to the next phase.

h) *In phase Five - Approval*, the CAA issues the RNAV 5 authorization, once the operator has completed the airworthiness and operations requirements..

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ADVISORY CIRCULAR

AC	**:**	**RNAV1/2**
DATE	**:**	**01/01/13**
REVISION	**:**	**1**
ISSUED BY	**:**	**PBN TF**

SUBJECT: AIRCRAFT AND OPERATORS APPROVAL FOR RNAV 1 AND RNAV 2 OPERATIONS

1. PURPOSE

This advisory circular (AC) establishes the RNAV 1 and RNAV 2 approval requirements for aircraft and en-route and terminal area operations.

An operator may use alternate means of compliance, as long as such means are acceptable to the Civil Aviation Authority (CAA).

The future tense of the verb or the term “shall” apply to operators who choose to meet the criteria set forth in this AC.

2. RELATED DOCUMENTS

Annex 6	Operation of aircraft
	Part I – International commercial air transport – Aeroplanes
	Part II – International general aviation - Aeroplanes
ICAO Doc 9613	Performance-based navigation (PBN) manual
ICAO Doc 9997	PBN operational approval manual
ICAO Doc 7030	Regional supplementary procedures
ICAO Doc 8168	Aircraft operations
	Volume I: Flight procedures
	Volume II: Construction of visual and instrument flight procedures
JAA TGL - 10	Airworthiness and operational approval for precision RNAV operations in designated European airspace
FAA AC 90-100A	Terminal and en route area navigation (RNAV) operations
FAA AC 90-96A	Approval of 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)

3. DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

a) **Aircraft-based augmentation system (ABAS).-** an augmentation system which augments and/or integrates the information obtained from the other GNSS elements with information available on board the aircraft. The most common form of ABAS is receiver autonomous integrity monitoring (RAIM).

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.

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 route**.- ATS route established to be used by aircraft with the capability of applying area navigation.

d) **Area navigation system (RNAV system)**.- An area navigation system that 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 the Flight Management System (FMS).

e) **Critical DME.** A distance-measuring equipment (DME) facility that, when not available, results in navigation service which is insufficient for DME/DME- and DME/DME//IRU-based operations along a specific route or procedure. For example, standard instrument departures and arrivals (SID/STAR) may be published with only two DMEs, in which case, both DMEs are critical.

f) **DME/DME (D/D) RNAV**. - Area navigation that uses the line of sight of at least two DME facilities to determine aircraft position.

g) **DME/DME/Inertial (D/D/I) RNAV**. - Area navigation that uses the line of sight of at least two DME facilities to determine aircraft position, along with an inertial reference unit (IRU) that provides sufficient position information in areas without DME coverage (DME gaps).

h) **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.

i) **Global navigation satellite system (GNSS)**.- A generic term used by the International Civil Aviation Organization (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.

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

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 specification:

Required Navigation Performance (RNP) Specification. Area navigation specification that includes the performance control and alerting requirement, designated by the prefix RNP; *e.g.,* RNP 4, RNP APCH, RNP AR APCH.

Area Navigation (RNAV) Specification.- Area navigation specification that does not include the 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.*

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

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

n) **Performance-based navigation (PBN)**.- Performance-based area navigation requirements for aircraft operating along an ATS route, on an instrument approach procedure, or in a designated airspace.

Performance requirements are defined in navigation specifications (RNAV and RNP specifications) 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) **Position estimation error (PEE).-** Difference between true position and estimated position.

p) **Receiver autonomous integrity monitoring (RAIM)**.- A technique used in a GPS receiver/processor to determine the integrity of its navigation signals, using only GPS signals or GPS signals enhanced with barometric altitude 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 for the navigation solution.

q) **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.

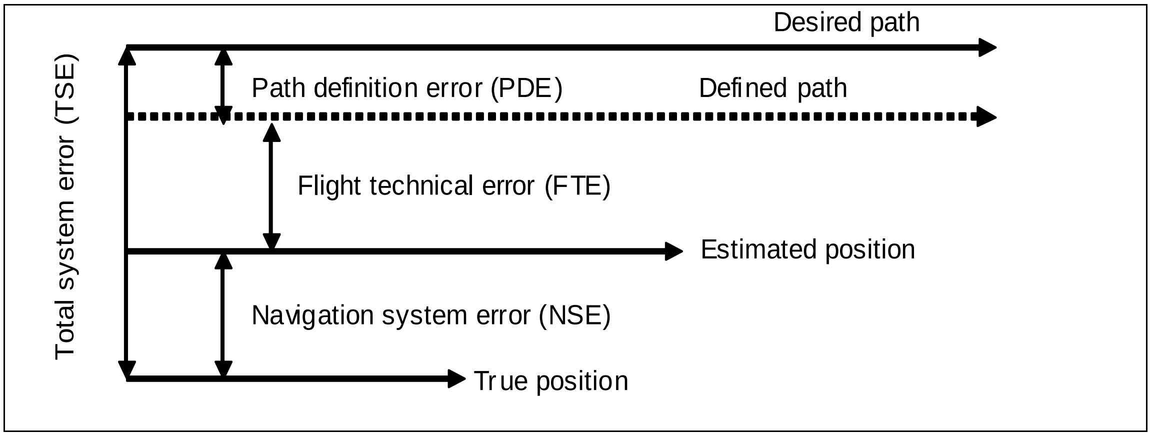
r) **Standard instrument arrival (STAR)**.- A designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

s) **Standard instrument departure (SID).-** A designated instrument flight rules (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 the flight commences.

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

*Note**.-** Sometimes the FTE is referred to as the path steering error (PSE) and the NSE is referred to as the position estimation error (PEE).*

Total system error (TSE)



4.2 Abbreviations

a)	CAA	Civil Aviation Administration /Civil Aviation Authority
b)	ABAS	Aircraft-based augmentation system
c)	AC	Advisory circular
d)	AFE	Field elevation
e)	AFM	Aircraft flight manual
f)	AHRS	Attitude and heading reference system
g)	AIP	Aeronautical information publication
h)	AIRAC	Aeronautical information regulation and control
i)	AP	Automatic pilot
j)	ANSP	Area navigation service providers
k)	ATC	Air traffic control
l)	ATM	Air traffic management
m)	ATS	Air traffic services
n)	baro-VNAV	Barometric vertical navigation
o)	B-RNAV	Basic area navigation
p)	CA	Advisory circular in Spanish (SRVSOP)
q)	CA	Course to an altitude
r)	CDI	Course deviation indicator
s)	CF	Course to a fix
t)	CNS/ATM	Communications, navigation, and surveillance/air traffic management
u)	OC	Operations circular (Spain)
v)	D/D	DME/DME
w)	D/D/I	DME/DME/IRU
x)	DF	Direct to a fix
y)	DOC	Designated operational coverage
z)	DME	Distance-measuring equipment

aa)	FD	Flight dispatcher
bb)	EASA	European Aviation Safety Agency
cc)	EHSI	Enhanced vertical status indicator
dd)	FAA	United States Federal Aviation Administration
ee)	FAF	Final approach fix
ff)	FAP	Final approach point
gg)	FD	Flight director
hh)	FM	Course from a fix to a manual termination
ii)	FMC	Flight management computer
jj)	FMS	Flight management system
kk)	FOM	Figure of merit
ll)	FTE	Flight technical error
mm)	GBAS	Ground-based augmentation system
nn)	GNSS	Global navigation satellite system
oo)	GLONASS	Global navigation satellite system
pp)	GPS	Global positioning system
qq)	GS	Ground speed
rr)	HAL	Horizontal alert limit
ss)	HSI	Horizontal status indicator
tt)	IF	Initial fix
uu)	IFR	Instrument flight rules
vv)	INS	Inertial navigation system
ww)	ILS	Instrument landing system
xx)	IRS	Inertial reference system
yy)	IRU	Inertial reference unit
zz)	LNAV	Lateral navigation
aaa)	LOA	Letter of authorisation/acceptance letter
bbb)	LOC	Locator
ccc)	MCDU	Multi-function control display
ddd)	MEL	Minimum equipment list
eee)	OIM	Operations inspector manual
fff)	MLS	Microwave landing system
ggg)	MP	Monitoring pilot
hhh)	MVA	Minimum vectoring altitude
iii)	NAVAIDS	Navigation aids
jjj)	NDB	Non-directional radio beacon
kkk)	NOTAM	Notice to airmen

lll)	NSE	Navigation system error
mmm)	ICAO	International Civil Aviation Organization
nnn)	OEM	Original equipment manufacturer
ooo)	OM	Operations manual
ppp)	OpSpecs	Operations specifications
qqq)	PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
rrr)	PBN	Performance-based navigation
sss)	PDE	Path definition error
ttt)	PEE	Position estimation error
uuu)	PF	Pilot flying
vvv)	PNF	Pilot not flying
www)	POH	Pilot operating handbook
xxx)	P-RNAV	Precision area navigation
yyy)	PSE	Path steering error
zzz)	RAIM	Receiver autonomous integrity monitoring
aaaa)	RNAV	Area navigation
bbbb)	RNP	Required navigation performance
cccc)	RNP APCH	Required navigation performance approach
dddd)	RNP AR APCH	Required navigation performance approval required approach
eeee)	RTCA	Radio Technical Commission for Aviation
ffff)	SBAS	Satellite-based augmentation system
gggg)	SID	Standard Instrument Departure
hhhh)	SL	Service letter
iiii)	STAR	Standard instrument arrival
jjjj)	TC	Type certificate
kkkk)	TF	Track to a fix
llll)	TGL	Transitional guidance material
mmmm)	TSE	Total system error
nnnn)	TSO	Technical standard order
oooo)	VA	Heading to an altitude
pppp)	VI	Heading to an intercept
qqqq)	VMC	Visual meteorological conditions
rrrr)	VM	Heading to a manual termination
ssss)	VOR	VHF omnidirectional radio range
tttt)	WAAS	Wide area augmentation system
uuuu)	WGS	World geodetic system
vvvv)	WPT	Waypoint

4. INTRODUCTION

4.1 On 1 November 2000, the European Joint Aviation Authorities (JAA) published transitional guidance material No. 10 (TGL-10) - Airworthiness and operational approval for precision RNAV (P-RNAV) operations in designated European airspace.

4.2 On 7 January 2005, the United States Federal Aviation Administration (FAA) published advisory circular (AC) 90-100 - U.S. En-route and terminal area navigation (RNAV) operations. This AC was superseded by AC 90-100A, published on 1 March 2007.

4.3 Although TGL-10 and AC 90-100A establish similar functional requirements, there are some differences between these documents.

4.4 The guidance material in this AC harmonises the European and the United States RNAV criteria under a single navigation specification called RNAV 1 and RNAV 2, in accordance with Doc 9613 – Performance based navigation (PBN) manual of the International Civil Aviation Organization (ICAO).

4.5 Operators approved under AC 90-100A meet the requirements of this AC, while operators approved under TGL-10 must confirm whether or not their aircraft systems meet the criteria set forth in this document (see Table 3-1 Appendix 6).

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

4.7 An operational approval issued by virtue of this document allows an operator to conduct RNAV 1 and RNAV 2 operations worldwide.

4.8 The RNAV 1 and RNAV 2 navigation specification applies to:

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

4.9 The final approach criteria, from the FAF to the runway threshold, along with the associated missed approach manoeuvre are not considered in this document and will be the subject of another AC.

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

4.11 The *basic RNP 1* navigation specification is expected to be used for similar operations but outside radar coverage.

4.12 It is foreseen that en-route RNAV 1 and RNAV 2 operations will be conducted in direct controller-pilot communication environments.

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

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

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

4.14 This AC does not include all of the requirements that may be specified for a particular operation. These requirements are established in other documents, such as, the aeronautical information publication (AIP) and ICAO Doc 7030 – Regional Supplementary Procedures.

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

4.16 The material described in this AC has been developed based on the following document:

- ✓ ICAO Doc 9613, Volume II, Part B, Chapter 3 – Implementing RNAV 1 and RNAV 2.

4.17 Where possible, this AC has been harmonised with the following documents:

- ✓ JAA TGL - 10 - Airworthiness and operational approval for precision RNAV operations in designated European airspace; y
- ✓ FAA AC 90-100A - U.S. Terminal and en route area navigation (RNAV) operations.

Note.- *Despite harmonisation efforts, operators must take note of the existing differences between this AC and the aforementioned documents when requesting an approval from the corresponding Administrations.*

5. GENERAL INFORMATION

5.1 Navigation aid infrastructure

a) This AC defines the criteria for the following RNAV systems:

- ➢ GNSS;
- ➢ DME/DME; and
- ➢ DME/DME/IRU.

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

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

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

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

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

Note.- *Most modern RNAV systems give priority to GNSS input and then DME/DME positioning. Although VOR/DME positioning is usually performed in the flight management computer (FMC) when there is no DME/DME positioning criteria, avionics and infrastructure variability pose serious challenges to standardisation and harmonisation. Therefore, this document only deals with GNSS, DME/DME, and DME/DME/IRU systems. This does not prevent the conduction of operations with systems that use VHF omni-directional radio range (VOR), provided they meet the criteria set forth in this AC.*

f) NAVAID infrastructure should be validated by modelling, while the expected performance should be assessed and verified through flight inspections. Assessments should consider the aircraft capabilities described in this AC. For example, a DME signal can be used if the aircraft is between 3 NM and 160 NM from the facility, below 40 degrees above the horizon (as seen from the DME facility) and if the DME/DME include angle is between 30 and 150 degrees.

g) The DME infrastructure assessment is simplified when using a screening tool which accurately matches ground infrastructure and aircraft performance, as well as an accurate representation of the terrain. Guidance material on this assessment can be found in Doc 8168, Volume II – PANS-OPS and Doc 8071 – Manual on testing of radio navigation aids.

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

i) Field strength below the minimum requirement or where co-channel or adjacent channel interference may exist, are considered receiver errors. Air navigation service providers (ANSPs) shall identify errors resulting from multiple DME signal paths. When these errors exist and are not acceptable to the operation, the ANSPs can identify such NAVAIDs as not appropriate for RNAV 1 and RNAV 2 applications (so that they can be inhibited by the flight crew) or, not authorise the use of DME/DME or DME/DME/IRU systems.

j) The individual components of the navigation infrastructure must meet the performance requirements described in Annex 10 to the Chicago Convention – Aeronautical Telecommunications. Navigation aids that do not meet the requirements of Annex 10 should not be published in the State AIPs. When significant performance differences are identified in a published DME facility, RNAV 1 and RNAV 2 operations in the airspace affected by such facility should be limited to GNSS.

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

l) Requirements and access methods to RAIM prediction tools shall be determined by Staets and published in the AIPs.

m) Prediction services can only be for receivers that meet the minimum performance of a technical standard order (TSO) or be specific to the receiver design. The prediction service shall use the current information from GNSS satellites and a horizontal alert limit (HAL) that is appropriate to the operation (1 NM for RNAV 1 and 2 NM for RNAV 2).

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

o) Since DME/DME and DME/DME/IRU systems must only use DME facilities identified in the AIPs of each State, the CAAs will list in such publications the facilities that are not appropriate for RNAV 1 and RNAV 2 operations, including facilities associated to an instrument landing system (ILS) or a microwave landing system (MLS) that uses a range offset.

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

Note 2.*- When temporary restrictions occur, the publication of restrictions on the use of DME should be accomplished by use of a notice to airmen (NOTAM) to identified the need to exclude the DME.*

5.2 ATS communications and surveillance

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

RNAV 1 and RNAV 2 navigation specification.

5.3 Obstacle clearance and route spacing

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

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

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

5.4 Publications

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

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

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

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

e) Any DME facility that is critical to RNAV 1 and RNAV 2 operations shall be identified in the relevant publications.

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

g) The navigation information published in the AIP for routes and NAVAIDs must meet the requirements set forth in Annex 15 – Aeronautical Information Services.

5.5 Additional considerations

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

  1) RNAV 1: 0.5 NM.

  2) RNAV 2: 1 NM

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

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

6. AIRWORTHINESS AND OPERATIONAL APPROVAL

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

5.5.1 the airworthiness approval, which is issued 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

5.5.2 the operational approval, which is issued by the State of the operator (see Paragraph 4.2.1 and Attachment F to Annex 6 Part I).

6.2 For general aviation operators, the State of registry will determine whether or not the aircraft meets the applicable RNAV 1 and RNAV 2 requirements and will issue the operational approval (*e.g.*, letter of authorisation – LOA) (see Paragraph 2.5.2.2 of Annex 6 Part II).

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

7. AIRWORTHINESS APPROVAL

7.1 Aircraft requirements

7.1.1 Description of the RNAV navigation system

a) **Lateral navigation (LNAV)**

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

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

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

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

Position data from other types of navigation sensors can be combined with GNSS data, provided they do not cause position errors that exceed total system precision requirements. Use of GNSS equipment approved by TSO-C129 () is limited to those systems that include the minimum system functions specified in Paragraph 7.4 of this AC. As a minimum, integrity should be provided by ABAS. In addition, TSO-C129 equipment must include the following additional functions:

- ✓ pseudo-range step detection; and
- ✓ health word checking.

5.5.2.2.2 DME/DME RNAV equipment that meets the criteria listed in Paragraph 7.3.2; and

5.5.2.2.3 DME/DME/IRU RNAV equipment that meets the criteria listed in Paragraph 7.3.4.

7.1.2 System performance, monitoring and alerting

a) **Accuracy**

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

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

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

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

d) **Signal-in-space**

1) **RNAV 1.-** If GNSS is used for operations in RNAV 1 designated airspace or routes, the aircraft navigation equipment must provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds 10^{-7} per hour (Annex 10, Volume I, Table 3.7.2.4.1).

2) **RNAV 2.-** If GNSS is used for operations in RNAV 2 designated airspace or routes, the aircraft navigation equipment must provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 4 NM exceeds 10^{-7} per hour (Annex 10, Volume I, Table 3.7.2.4.1).

7.2 **RNAV system eligibility**

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

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

7.2.3 **Aircraft that comply with TGL-10**.- Operators approved according to TGL-10 must confirm whether or not their aircraft systems meet the requirements set forth in this AC (see Table 3-1 of Appendix 6).

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

7.2.5 **Aircraft with a statement by the manufacturer**.- Aircraft that have a statement by the manufacturer documenting compliance with the criteria of this AC or equivalent document meet the performance and functional requirements set forth in this document. This statement must include the substantiation of airworthiness compliance. The operator will determine compliance with RNAV system requirements described in Paragraph 7.3 and with the functional requirements described in Paragraph 7.4.

Note 1.- *Aircraft with demonstrated RNP capability will announce when they can no longer meet the performance requirements associated to the operations. However, for procedures based on DME/DME/IRU, the operator will determine whether or not it complies with the criteria set forth in Paragraphs 7.3.2 and 7.3.4 (DME/DME and DME/DME/IRU).*

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

7.2.6 **Aircraft flight manual, pilot operations handbook or avionics operating manual**

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

(b) **Aircraft in use.-** For aircraft in use that are already equipped with RNAV systems but for which the AFM or POH or avionics operating manual does not define or clarify the system capability, the operator can submit documentation or a statement by the manufacturer that meets the requirements of this AC in accordance with Paragraph 7.2.4 above.

7.3 **Criteria for the approval of RNAV 1 and RNAV 2 system**

7.3.1 **Criteria for GNSS**

a) The following systems meet the precision requirements of these criteria:

1) Aircraft with TSO-C129/C129a sensor (Class B or C) and FMS that meets the criteria established in TSO-C115b, installed for IFR use in accordance with AC 20-130A;

2) Aircraft with TSO-C145 () sensor and FMS that meets the criteria established in TSO-C115b, installed for IFR use in accordance with AC 20-130A or AC 20-138A;

3) Aircraft with Class A1 TSO-C129/C129a (without deviation from the functional requirements described in Paragraph 8.4 of this document), installed for IFR use in accordance with AC 20-138 or AC 20-138A; and

4) Aircraft with TSO-C146 () (without deviation from the functional requirements described in Paragraph 7.4 of this document), installed for IFR use in accordance with AC 20-138A.

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

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

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

7.3.2 **Criteria for the RNAV DME/DME system**

The criteria for assessing the DME/DME RNAV system are described in Appendix 1 to this document.

7.3.3 **Criteria for the RNAV DME/DME/IRU system**

The DME/DME/IRU RNAV system must comply with Appendix 2 to this document.

7.4 **Functional requirements – Navigation displays and functions**

The requirements contained in Appendix 3 help to guarantee that the aircraft RNAV system performance complies with the design criteria of the procedure.

7.5 **Continued airworthiness**

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

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

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

1) Maintenance control manual (MCM);

2) Illustrated parts 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 1 and RNAV 2 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 1 and RNAV 2 initial approval, must be forwarded and reviewed by the CAA 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 CAA 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 1 and RNAV 2 application;

3) equipment involved in a RNAV 1 and RNAV 2 operation; and

4) MEL use.

8. OPERATIONAL APPROVAL

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

Concerning commercial air transport, the assessment of an application for RNAV 1 and RNAV 2 operational approval is done by the State of the operator, in accordance with standing operating rules supported by the criteria described in this AC.

For general aviation, the assessment of an application for RNAV 1 and RNAV 2 operational approval is carried out by the State of registry, in accordance with standing operating rules supported by the criteria described in this AC.

8.1 Requirements to obtain operational approval

8.1.1 In order to obtain RNAV 1 and RNAV 2 approval, the applicant or operator will take the following steps, taking into account the criteria established in this paragraph and in Paragraphs 9, 10, 11, and 12:

a) *Airworthiness approval*.- aircraft shall have the corresponding airworthiness approvals, pursuant to Paragraph 7 of this AC.

b) *Application*.- The operator shall submit the following documentation to the CAA:

1) *RNAV 1 and RNAV 2 operational approval application;*

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

3) *Airworthiness documents related to aircraft eligibility*.- The operator shall submit relevant documentation, acceptable to the CAA, showing that the aircraft is equipped with RNAV systems that meet the RNAV 1 and RNAV 2 requirements set forth in this AC, as described in Paragraph 7, for example, the parts of the AFM or AFM supplement that contain the airworthiness statement.

4) *Training programme for flight crews and flight dispatchers (FD)*

(a) Commercial operators must submit to the CAA the RNAV 1 and RNAV 2 training syllabus to show that the operational procedures and practices and the training aspects described in Paragraph 10 have been included in the initial, promotional or periodic training programmes for flight crews and FDs.

Note.- *It is not necessary to establish a separate training programme if the RNAV 1 and RNAV 2 training identified in Paragraph 10 has already been included in the training programme of the operator. However, it must be possible to identify what aspects of RNAV are covered in the training programme.*

(b) Private operators shall be familiar with and demonstrate that they will perform their operations based on the practices and procedures described in Paragraph 10.

5) *Operations manual and checklists*

(a) Commercial operators must review the operations manual (OM) and the checklists in order to include information and guidance on the standard operational procedures detailed in Paragraph 9 of this AC. The appropriate manuals must contain the operation instructions for navigation equipment and contingency procedures. The manuals and checklists must be submitted for review along with the formal application in Phase two of the approval process.

(b) Private operators must operate their aircraft based on the practices and procedures identified in Paragraph 9 of this AC.

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

7) *Maintenance*.- The operator will submit for approval a maintenance programme for the conduction of RNAV 1 and RNAV 2 operations.

8) *Training programme for maintenance personnel*.- Operators will submit the training curriculum that corresponds to maintenance personnel in accordance with Paragraph 7.5 e).

9) *Navigation data validation programme*.- Operators will present details about the navigation data validation programme as described in Appendix 4 to this AC.

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

d) *Validation flight*.- The CAA may deem it advisable to perform a validation flight before granting the operational approval. Such validation can be performed on commercial flights..

e) *Issuance of the approval to conduct RNAV 1 and RNAV 2 operations*.- Once the operator has successfully completed the operational approval process, the CAA will grant the operator approval to conduct RNAV 1 and RNAV 2 operations.

9. OPERATING PROCEDURES

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

a) **Pre-flight planning**

1) Operators and pilots intending to conduct operations on RNAV 1 and RNAV 2 routes must fill out the appropriate boxes in the ICAO flight plan.

2) On-board navigation data must be current and appropriate for the region of intended operations and will include NAVAIDS, WPTs, and the relevant ATS route codes for arrivals, departures, and alternate aerodromes. RNAV STAR procedures can be designated using multiple runway transitions. Operators that lack this function will provide an alternate means of compliance (for example, a navigation database adjusted for these operations). If there is no alternate means of compliance to fly an RNAV designated procedure that contains multiple runway transitions, operators will not submit or accept an approval for these procedures.

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

3) The availability of the navigation infrastructure required for the intended routes, including any non-RNAV contingency, must be confirmed for the foreseen period of the operation, using all available information. Since Annex 10 Volume I requires GNSS integrity (RAIM or SBAS), it is also necessary to confirm adequate availability of these devices.

4) **Aircraft not equipped with GNSS.-** Aircraft not equipped with GNSS shall be capable of updating the DME/DME and DME/DME/IRU position for RNAV 1 and RNAV 2 routes and for SIDs and STARs.

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

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

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

7) RAIM (ABAS) availability

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

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

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

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

8) DME availability

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

b) **General operating procedures**

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

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

3) At system initialization, pilots must:

(a) confirm that the navigation database is up-to-date;

(b) verify the current position of the aircraft;

(c) verify the appropriate entry of the assigned ATC route once they receive the initial clearance, and of any subsequent change in route; and

(d) ensure that the sequence of WPTs as depicted in their navigation system matches the route drawn in the appropriate charts and the assigned route.

4) Pilots shall not fly an RNAV 1 or RNAV 2 SID or STAR, unless it can be retrieved from the on-board navigation database using the name of the procedure, and coincides with the procedure in the chart. However, the route can be modified afterwards by inserting or deleting specific WPTs in response to ATC clearance. Manual entry or the creation of new WPTs through manual insertion of latitude and longitude or rho/theta values is not permitted. Likewise, pilots must not change any RNAV SID or STAR database WPT type from a fly-by WPT to a flyover WPT or *vice versa*.

5) Whenever possible, RNAV 1 or RNAV 2 routes must be obtained from the database as a whole, instead of individually loading the route WPTs from the database to the flight plan. However, the individual selection and insertion of designated fixes and WPTs from the navigation database is permitted, provided all the fixes along the published route to be flown are inserted. Likewise, the route can be modified afterwards through the insertion or deletion of specific WPTs in response to ATC clearance. Manual entry or the creation of new WPTs through the manual insertion of latitude and longitude or rho/theta values is not permitted.

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

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

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

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

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

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

11) All pilots are expected to follow the route centreline, as represented on the on-board lateral deviation indicators and/or flight guidance, during all RNAV 1 and RNAV 2 operations, unless cleared by the ATC to deviate or due to an emergency. For normal operations, the cross-track error/deviation (the difference between the RNAV system computed path and the aircraft estimated position relative to that path, i.e. FTE) must be limited to ± ½ the navigation precision associated with the route or flight procedure (i.e., 0.5 NM for RNAV 1 and 1.0 NM for RNAV 2). Small lateral deviations from this requirement are allowed (*e.g.*, overshooting or undershooting the path) during or immediately after an en-route turn/procedure, up to a maximum of 1 times (1xRNP) the navigation precision (i.e., 1 NM for RNAV 1 and 2 NM for RNAV 2).

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

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

13) Manual selection of functions that limit the banking angle of the aircraft can reduce the ability of the aircraft to maintain its desired track and is not recommended. Pilots should acknowledge that manual selection of functions that limit the banking angle of the aircraft could reduce their ability to meet ATC path expectations.

14) Pilots operating aircraft with RNP approval in accordance with the provisions of this AC do not need to modify the predetermined RNP values of the manufacturer established in the FMC.

c) **RNAV SIDs specific requirements**

1) Before beginning take-off, the pilot must verify that the airborne RNAV system is available and operating correctly, and that the appropriate aerodrome and runway data have been loaded. Before the flight, pilots must verify that the airborne navigation system is operating correctly and that the appropriate runway and departure procedure (including any applicable en-route transition) have been loaded and are duly displayed. Pilots assigned to an RNAV departure procedure and subsequently receive a change of runway, procedure or transition, must verify that the appropriate changes have been entered and are available for navigation before take-off. A final check of proper runway entry and correct route depiction, shortly before take-off, is recommended.

2) *Altitude for connecting the RNAV equipment*.- The pilot must be capable of connecting the RNAV equipment in order to follow the flight guidance in the RNAV lateral navigation mode before reaching 153 m (500 ft) above the aerodrome elevation. The altitude at which the RNAV guidance on a route begins can be higher (*e.g*., climb to 304 m (1 000 ft) then direct to…)

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

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

5) *DME/DME/IRU aircraft.-* Pilots of aircraft without GNSS that use DME/DME RNAV systems with an IRU (DME/DME/IRU) must make sure that the position in the inertial navigation system (INS) is within 304 m (1 000 ft/0.17 NM) from a known position at the starting point of the take-off roll. This is usually achieved through the use of a manual or automatic runway updating function. The navigation chart can also be used to confirm the position of the aircraft if the pilot procedures and the display resolution allow compliance with the 304 m (1 000 ft) tolerance requirement.

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

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

d) **RNAV STARs specific requirements**

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

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

2) The creation of new WPTs by the flight crew through manual entries into the RNAV system will invalidate any route, and is not permitted.

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

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

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

6) Although a specific method has not been established, any altitude or speed constraints shall be observed.

e) **Contingency procedures**

1) The pilot must notify the ATC of any loss of RNAV capability, together with the proposed course of action. If it is not possible to meet the requirements of an RNAV route, pilots must notify the ATS as soon as possible. Loss of RNAV capability includes any failure or event that causes the aircraft to be unable to meet the RNAV requirements of the route.

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

10. TRAINING PROGRAMME

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

a) information about this AC;

b) the meaning and proper use of aircraft equipment and navigation suffixes;

c) the characteristics of procedures, as determined in chart displays and in the text description;

d) the representation of the types of WPTs (fly-by and fly-over) and ARINC 424 path terminations provided in Paragraph 7.4 and any other type used by the operator, as well as those associated with the aircraft flight paths;

e) the navigation equipment required to operate in RNAV 1 and RNAV 2 routes, SIDs and STARs (*e.g.*, GNSS, DME/DME and DME/DME/IRU).

f) specific information on the RNAV system:

1) levels of automation, annunciation modes, changes, alerts, interactions, reversals, and degradation;

2) integration of functions with other aircraft systems;

3) the meaning and convenience of en-route discontinuities, as well as procedures related to the flight crew;

4) pilot procedures consistent with the operation;

5) types of navigation sensors (*e.g.*, GNSS, DME, IRU) used by the RNAV system and establishment of priorities, weighting, and consistency with associated systems;

6) turns anticipation taking into account the effects of speed and altitude;

7) interpretation of electronic displays and symbols;

8) understanding aircraft configuration and the operating conditions required to support RNAV operations, *e.g.*, appropriate selection of CDI scale (lateral deviation display scale);

g) operating procedures for RNAV equipment, as applicable, including how to carry out the following:

1) verify currency and integrity of aircraft navigation data;

2) verify the successful completion of RNAV system self-test;

3) initialize RNAV system position;

4) retrieve and fly a SID or STAR with the appropriate transition;

5) adhere to speed and altitude constraints associated with a SID or STAR;

6) select the appropriate SID or STAR for the active runway and become familiar with the procedures to deal with a runway change;

7) perform a manual or automatic update (with take-off point shift, if applicable);

8) verify the WPTs and flight plan programming;

9) fly direct to a WPT;

10) fly a course/track to a WPT;

11) intercept a course/track;

12) fly radar vectors and return to an RNAV route from a “heading” mode;

13) determine cross-track errors and deviations;

14) resolve en-route discontinuities (insert and delete/eliminate en-route discontinuities);

15) remove or reselect the navigation sensor inputs;

16) when required, confirm the exclusion of a specific NAVAID or any type of navigation aid;

17) when required by the CAA, performs gross navigation errors checks using conventional NAVAIDs;

18) change the arrival and alternate aerodromes;

19) perform parallel offset functions if that capability is available. Pilots must know how offset are applied, the functionality of the particular RNAV system, and the need to advise the ATC if this functionality is not available; and

20) perform RNAV holding functions (*e.g.*, insert or delete a holding pattern).

h) levels of automation recommended by the operator for each flight phase and workload, including the methods to minimise cross-track error that permit the aircraft to follow the route centreline;

i) radiotelephony phraseology used for RNAV applications; and

j) contingency procedures for RNAV failures.

11. NAVIGATION DATABASE

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

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

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

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

e) Systems must not use the facilities indicated by the CAA as inappropriate for RNAV 1 and RNAV 2 operations in the AIP, or facilities associated with an ILS or MLS that uses a range offset. This can be done excluding the specific DME facilities known to have a detrimental effect on the navigation solution from the aircraft database, when RNAV routes are within the receiving range of such DME facilities.

12. OVERSIGHT, INVESTIGATION OF NAVIGATION ERRORS, AND WITHDRAWAL OF RNAV 1 and RNAV 2 APPROVAL

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

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

c) Information attributing multiple errors to a pilot in particular may call for additional training or a license review for that pilot.

d) Repetitive navigation errors attributed to the equipment or a specific part of the navigation equipment or to operating procedures can be the cause of cancellation of an operational approval (withdrawal of RNAV 1 and RNAV 2 operational authorisation or withdrawal of the LOA in the case of private operators).

APPENDIX 1

CRITERIA FOR THE APPROVAL OF RNAV SYSTEMS THAT USE DME

(DME/DME RNAV SYSTEM)

1. PURPOSE

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

2. MINIMUM REQUIREMENTS FOR DME/DME RNAV SYSTEMS

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

Paragraph	Criteria	Explanation
d)	DME facilities relative angles	When it is necessary to generate a DME/DME position, the RNAV system must use, as a minimum, DMEs with a relative angle between 30° and 150°.
e)	Use of DMEs through the RNAV system	The RNAV system may use any valid (listed in the AIP) DME facility, regardless of its location. A valid DME facility: 1) issues a precise signal that identifies the facility; 2) meets the minimum signal intensity requirements; and 3) is protected against interference from other DME signals, in accordance with co-channel and adjacent channel requirements. When needed to generate a DME/DME position, as a minimum, the RNAV system must use an available and valid low altitude and/or high altitude DME anywhere within the following region around the DME facility: 1) greater than or equal to 3 NM from the facility; and 2) less than 40° above the horizon when viewed from the DME facility and at a distance of 160 NM. ***Note.-*** *The use of a figure-of-merit (FOM) in approximating the designated operational coverage (DOC) of particular facilities is acceptable, provided precautions are taken to ensure that the FOM is coded in such a way that the aircraft can use the facility anywhere within the DOC. The use of DMEs associated with ILS or MLS is not required..*
f)	No requirement to use VOR, NDB, LOC, IRU or AHRS	There is no requirement to use VOR, non-directional radio beacon (NDB), localizer (LOC), IRU or attitude and heading reference system (AHRS) during normal operation of the DME/DME RNAV system.
g)	Position estimation error (PEE)	When using a minimum of two DME facilities that meet the criteria contained in Paragraph e) above and any other valid facility that does not meet such criteria, the position estimation error during 95% of the time must be better than or equal to the following equation: $$2\sigma_{DME/DME} \leq 2\frac{\sqrt{(\sigma^2{}_{1,air}+\sigma^2{}_{1,sis})+(\sigma^2{}_{2,air}+\sigma^2{}_{2,sis})}}{\sin(\alpha)}$$ where: σ_{sis} = 0.05 NM σ_{air} is MAX {(0.085 NM, (0.125% of the distance)} α = angle of inclusion (30^o to 150^o) ***Note.-*** *This performance requirement can be met by any navigation system that uses two DME facilities simultaneously, limits the DME inclusion angle between 30° and 150° and uses DME sensors that meet TSO-C66c precision requirements. If the RNAV system uses DME facilities outside of the published designated operational coverage, it can still be assumed that the DME signal-in-space error of valid facilities is* σ_{gorund} *= 0.05 NM.*
h)	Preventing	The RNAV system must ensure that the use of facilities

Paragraph	Criteria	Explanation
	erroneous guidance from other facilities	outside the service volume (where field intensity and common or adjacent interference requirements cannot be met) do not cause misguidance. This could be achieved by including reasonableness checks when initially tuning on a DME facility, or by excluding a DME facility when there is a co-channel DME within line-of-sight.
i)	Preventing erroneous VOR signals-in-space	The RNAV system can use a VOR. However, the RNAV system must make sure that an erroneous VOR signal-in-space does not affect the position error when the system is within DME/DME coverage. This can be achieved by monitoring the VOR signal with DME/DME to make sure that it does not mislead position results (*e.g.*, through reasonableness checks).
j)	Ensuring RNAV systems use operational facilities	The RNAV system must use operational DME facilities. DME facilities listed in the NOTAMs as inoperative (for example, being tested or undergoing maintenance) could still reply to on-board interrogation. Consequently, inoperative facilities must not be used. An RNAV system can exclude inoperative DME facilities by verifying the identification code or inhibiting the use of facilities identified as inoperative.
k)	Operational mitigation	Operational mitigations, such as the monitoring by pilots of the sources to update the RNAV navigation system, or time scheduling, or the exclusion of multiple DME facilities, should be performed before any period of intensive workload or any critical flight phase. ***Note.-*** *The exclusion of individual facilities listed in the NOTAMS as out of service and/or the programming of a route/procedure defined as critical DME is acceptable when such mitigation does not require action by the pilot during a critical phase of the flight. Likewise, a programming requirement does not imply that the pilot should manually enter the DME facilities that are not in the navigation database.*
l)	Reasonableness checks	Many RNAV systems perform reasonableness checks to verify the validity of DME measurements.- Reasonableness checks are very effective against database errors or erroneous system inputs (such as, inputs from co-channel DME facilities) and normally can be divided into two classes: 1) the ones the RNAV system uses after a new DME has been captured, where the system compares the aircraft's position before using the DME with the range of the aircraft to that DME; and 2) the ones the RNAV system continuously uses, based on redundant information (for example, additional DME signals or IRU information). **General requirements** Reasonableness checks are intended to prevent navigation aids from being used for navigation updating in areas where data can lead to errors in the radio position fix due to co-channel interference, multipath, and direct signal screening.

Paragraph	Criteria	Explanation
		Instead of using the service volume of NAVAIDs, the navigation system must provide checks that preclude the use of duplicate frequencies of the NAVAIDs within range, over-the-horizon NAVAIDs, and NAVAIDs with poor geometry. **Assumptions.-** Under certain conditions, reasonableness checks can be invalid. 1) A DME signal will not remain valid just because it was valid when captured. 2) *Additional DME signals might not be available.* The intent of this specification is to support operations where infrastructure is minimal (for example, when only two DMEs are available for en-route segments). ***Use of stressing conditions to test the effectiveness of the verification***.- When a reasonableness check is used to meet any requirement of these criteria, the effectiveness of the check must be tested under extreme conditions. An example of this condition is when a DME signal, valid when captured, becomes distorted during the test, when there is only one supporting DME or two signals of equal strength.

3. PROCESS TO CONFIRM THE PERFORMANCE OF RNAV SYSTEMS THAT USE DME

New systems may demonstrate compliance with these criteria as part of the airworthiness approval. For existing systems, operators shall determine compliance with the equipment and aircraft criteria set forth in this AC based on the information provided by aircraft and equipment manufacturers. Manufacturers that have achieved compliance with the requirements of paragraph (8.3.2) above and of this paragraph (8.3.3) shall provide this information through a letter to their customers. Operators may use this approval as the basis for their operations. Manufacturers will also be required by the CAA to provide a copy of the aforementioned letter in order to facilitate making this information available to all operators. Guidance is provided below for aircraft and FMS and DME manufacturers.

a) **Aircraft manufacturers (type certificate (TC) holders that incorporating FMS and DME/DME positioning).-** The manufacturer shall review the available data on the integrated navigation system and shall obtain additional data, as appropriate, to determine compliance with the criteria set forth in this AC. Manufacturers that have achieved compliance with these criteria shall provide this information by letter to their customers. Manufacturers are also requested to provide a copy of this letter to the CAA in order to facilitate making this information available to all operators.

b) **Equipment manufacturers (normally individual DME and/or FMS TSO holders)**

1) **DME sensor**.- The only requirement in this paragraph (8.3.3) that needs to be considered for a DME sensor is accuracy. DME sensors have been tested for a variety of performance requirements of TSO-C66 – Distance-measuring equipment (DME) that operates within the radio frequency range of 960-1215 megahertz and documents of the Radio Technical Commission for Aeronautics (RTCA).

(a) TSO-C66 performance standards have evolved as follows:

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

(2) TSO-C66a: (September 1965) RTCA/DO151, accuracy requirement of a total error of 0.1 NM attributed to the ground facility, an accuracy of 0.5 NM for

airborne equipment or 3% distance, whichever is greater, with a maximum of 3 NM.

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

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

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

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

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

(2) **Accomplishing new testing.**- New tests must be conducted under the same conditions used to demonstrate compliance with the original TSO-C66 standard.

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

2) **Multi-sensor systems.-** The manufacturer shall review the data on the integrated navigation system and obtain additional data, as appropriate, to comply with the criteria contained in Paragraphs 8.3.2 and 8.3.3 of this AC. Manufacturers that have achieved compliance with such criteria shall provide this information in a letter to their customers, along with any operational limitation (for example, if the pilot must manually inhibit the use of facilities listed as unavailable in the NOTAM). The certification of the manufacturer may limit compliance to specific DME systems, or may reference any DME to TSO-C66c requirements. Manufacturers shall also provide a copy of the letter to the CAA.

(a) **FMS accuracy.-** FMS accuracy depends on a number of factors, including latent effects, the selection of DME facilities, the method of combining information from multiple DMEs, and the effects of other sensors used for positioning. For FMSs that use two or more DMEs at the same time and that limit the DME inclusion angle to between 30° and 150°, the precision requirement can be met if the DME sensors meet the precision requirements of TSO-C66c. For FMSs that lack these characteristics, precision shall be assessed under inadequate DME geometry scenarios and shall consider the demonstrated precision of the DME sensor. Inadequate geometry scenarios may include angles at the previously specified limits, with or without additional DME facilities available outside these conditions.

(b) **Identification of conditions.-** The conditions that might prevent compliance with precision requirements and the means to avoid them shall be identified.

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APPENDIX 2

CRITERIA FOR APPROVAL OF RNAV SYSTEMS THAT USE DME AND IRU

(DME/DME/IRU RNAV SYSTEM)

1. PURPOSE

This paragraph defines the minimum performance for the DME/DME/IRU (D/D/I) RNAV system. Performance standards for DME/DME positioning are detailed in Appendix 1. The minimum requirements set forth in Appendix 1 are applicable to this appendix and, thus, are not repeated, unless additional performance is required.

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

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

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APPENDIX 3

FUNCTIONAL REQUIREMENTS – NAVIGATION FUNCTIONS AND DISPLAYS

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

Paragraph	Functional requirements	Explanation
		operations where the minimum flight crew is two pilots, means will be provided for the pilot not flying (PNF) the aircraft or monitoring pilot (MP) to check the desired path and the position of the aircraft relative to that path; 2) A navigation database containing current navigation data officially issued for civil aviation, which can be updated in accordance with the aeronautical information regulation and control (AIRAC) cycle and from which ATS routes can be retrieved and loaded into the RNAV system. The stored resolution of the data must be sufficient to achieve negligible path definition error (PDE). The database must be protected against flight crew modification of the stored data; 3) The means to display to the flight crew the period of validity of the navigation database; 4) The means to retrieve and display the data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the flight crew to verify the route to be flown; and 5) The capability to load on the RNAV system, from the navigation database, the complete RNAV segment of the SIDs or STARs to be flown. ***Note.-*** *Due to variability in RNAV systems, this document defines the RNAV segment from the first occurrence of a named WPT, track or course up to the last occurrence of a named WPT, track or course. Legs or segments prior to the first named WPT or after the last named WPT must not be loaded from the navigation database.*
c)	The means to show the following items, either on the primary field of view of the pilots, or on a readily accessible page display [*e.g.*, on a multi-function control display unit (MCDU)]:	1) The active navigation sensor type; 2) The identification to the active (TO) waypoint; 3) The ground speed or time to the active (TO) waypoint; and 4) The distance and bearing to the active (TO) waypoint. ***Note.-*** *When the CDU/MCDU is used to support precision checks by the pilot, said CDU/MCDU must have the capability of displaying lateral deviation with a resolution of at least 0.1 NM.*
d)	The capability to execute the “direct to” function.	
e)	The capability for automatic leg sequencing, displaying the sequence to the flight	

Paragraph	Functional requirements	Explanation
	crew.	
f)	The capability of executing ATS routes retrieved from the on-board database, including the capability of performing fly-by and flyover turns.	
g)	The aircraft must have the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent: ➢ Initial fix (IF); ➢ Course to a fix (CF); ➢ Direct to a fix (DF); and ➢ Track to a fix (TF).	***Note 1.-*** *Path terminators are defined in ARINC 424 specification, and their application is described in more detail in RTCA documents DO-236B and DO-201A and in EUROCAE ED-75B and ED-77* ***Note 2.****- Numeric values for courses and tracks must be automatically loaded from the RNAV system database.*
h)	The aircraft must have the capability to automatically execute leg transitions consistent with the following ARINC 424 path terminators: heading to an altitude (VA), heading to a manual termination (VM), and heading to an intercept (VI), or must be capable of being manually flown on a heading to intercept a course or to fly direct to another fix after reaching an altitude of a specified procedure.	
i)	The aircraft must have the capability to automatically execute leg transitions consistent with the following ARINC 424 path terminators: course to an altitude (CA) and course from a fix to a manual termination (FM), or the RNAV system must permit the pilot to readily designate a waypoint and select a desired course to or from a designated waypoint.	
j)	The capability to load an	

Paragraph	Functional requirements	Explanation
	RNAV ATS route from the database into the RNAV system by its name is a recommended function. However, if all or part of an RNAV route (not SID or STAR) is entered by manual entry of WPTs from the database, the paths between the manual entry of WPTs and the preceding or subsequent WPTs must be flown in the same way as a TF leg in terminal airspace.	
k)	The capability of showing an indication of RNAV system failure, including the associated sensors, in the primary field of view of the pilots.	
l)	For multi-sensor systems, the capability for automatic reversion to an alternate RNAV sensor if the primary RNAV sensor fails. This does not preclude the provision of a means for manual selection of the navigation source.	
m)	Database integrity	Navigation database suppliers must comply with RTCA DO-200/EUROCAE document ED 76 - Standards for processing aeronautical data. A Letter of acceptance (LOA) issued by the appropriate regulatory authority to each of the participants in the data chain shows compliance with this requirement. Discrepancies that invalidate a route must be reported to database providers, and the affected routes must be prohibited through a notice from the operator to its flight crews. Aircraft operators must consider the need to conduct periodic checks of the navigation databases in order to meet the requirements of the existing safety system.
n)	It is recommended that the RNAV systems provide lateral guidance so that aircraft remain within the lateral boundaries of the fly-by transition area.	

APPENDIX 4

NAVIGATION DATA VALIDATION PROGRAMME

1. INTRODUCTION

The information stored in the navigation database defines the lateral and longitudinal guidance of the aircraft for RNAV1 and RNAV 2 operations. Navigation database updates are carried out every 28 days. The navigation data used in each update are critical to the integrity of every RNAV 1 and RNAV 2 route, SID, and STAR. This appendix provides guidance on operator procedures to validate the navigation data associated with the RNAV 1 and RNAV 2 operations.

2. DATA PROCESSING

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

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

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

3. INITIAL DATA VALIDATION

3.1 The operator must validate every RNAV 1 and RNAV 2 route, SID and STAR before flying under instrument meteorological conditions (IMC) to ensure compatibility with the aircraft and to ensure that the resulting paths are consistent with the published routes, SIDs and STARs. As a minimum, the operator must:

a) compare the navigation data of RNAV 1 and RNAV 2 routes, SIDs, and STARs to be loaded into the FMS with valid charts and maps that contain the published routes, SIDs, and STARs.

b) validate the navigation data loaded for RNAV 1 and RNAV 2 routes, SIDs, and STARs, either on the flight simulator or on the aircraft, under visual meteorological conditions (VMC). RNAV 1 and RNAV 2 routes, SIDs, and STARs outlined on a chart display must be compared to the published routes, SIDs, and STARs. Complete RNAV 1 and RNAV 2 routes, SIDs, and STARs must be flown in order to ensure that the paths can be used, that they have no apparent lateral or longitudinal discrepancies, and that they are consistent with the published routes, SIDs, and STARs.

c) Once the RNAV 1 and RNAV 2 routes, SIDs, and STARs are validated, a copy of the validated navigation data shall be kept and maintained in order to compare them with subsequent data updates.

4. DATA UPDATING

After receiving a navigation data update and before using such data on the aircraft, the operator must compare the update with the validated routes. This comparison must identify and resolve any discrepancy in the navigation data. If there are significant changes (any change affecting route path or performance) in any part of a route and if those changes are verified through the initial data, the operator must validate the amended route in accordance with the initial validation data.

5. NAVEGATION DATA SUPPLIERS

Navigation data suppliers must have a letter of acceptance (LOA) in order to process these data (*e.g.*, FAA AC 20-153 or the document on the conditions for the issuance of letters of acceptance to navigation data providers by the European Aviation Safety Agency – EASA (EASA IR

21 Subpart G) or equivalent documents). A LOA recognises the data supplier as one whose data quality, integrity and quality management practices are consistent with the criteria set forth in document DO-200A/ED-76. The operator´s database supplier must have a Type 2 LOA and its respective suppliers must have a Type 1 or 2 LOA. The CAA may accept a LOA issued to navigation data suppliers or issue its own LOA.

6. AIRCRAFT MODIFICATIONS (DATABASE UPDATE)

If an aircraft system necessary for RNAV 1 and RNAV 2 operations is modified (*e.g.*, change of software), the operator is responsible for validating the RNAV 1 and RNAV 2 routes, SIDs, and STARs with the navigation database and the modified system. This can be done without any direct assessment if the manufacturer confirms that the modification has no effect on the navigation database or on path calculation. If there is no such confirmation by the manufacturer, the operator must perform an initial validation of the navigation data with the modified system.

APPENDIX 5

RNAV 1 and RNAV 2 APPROVAL PROCESS

a) The RNAV 1 and RNAV 2 approval process consists of two types of approvals, airworthiness and operational. Although the two have different requirements, they must be considered in one single process.

b) This process is an orderly method used by the CAA to make sure that the applicants meet the established requirements.

c) The approval process is made up by the following phases:

1)	Phase one:	Pre-application
2)	Phase two:	Formal application
3)	Phase three:	Documentation evaluation
4)	Phase four:	Inspection and demonstration
5)	Phase five:	Approval

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

1) the contents of the formal application;

2) the review and evaluation of the application by the aviation administration;

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

4) conditions under which the RNAV 1 and RNAV 2 approval could be cancelled.

e) In *Phase two – Formal Application*, the applicant or operator submits the formal application along with all the relevant documentation, as established in paragraph 9.1.1 b) of this AC.

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

g) In *Phase four – Inspection and demonstration*, the operator will provide training to its personnel and will carry out the validation flight, if required.

h) In *Phase five* - Approval, the CAA issues the RNAV 1 and RNAV 2 approval once the operator has met the airworthiness and operational requirements.

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APPENDIX 6

TRANSITION ROUTE TO RNAV 1 AND RNAV 2 OPERATIONS

a) The following steps identify the transition route to obtain RNAV 1 and RNAV 2 approval:

1) **Operators with no RNAV 1 and RNAV 2 approval.-** An operator wishing to operate in RNAV 1 and RNAV 2 designated airspace:

(a) must obtain the RNAV 1 and RNAV 2 approval based on this AC or equivalent document.

(b) An operator approved based on the criteria of this AC is eligible to operate in RNAV 1 and RNAV 2 routes in the United States and in European P-RNAV routes. No additional approval is required.

(c) An operator wishing to operate in P-RNAV designated airspace must obtain a P-RNAV approval in accordance with TGL-10.

2) **Operators with P-RNAV approval.-** An operator that maintains a P-RNAV approval according to TGL-10:

(a) is eligible to operate in the routes of any State where routes are based on TGL-10 criteria; and

(b) must obtain an RNAV 1 and RNAV 2 operational approval, with evidence of compliance with the differences that exist between TGL-10 and this AC or equivalent document, in order to operate in RNAV 1 and RNAV 2 designated airspace. This can be achieved by using Table 3-1.

Table 3-1 – Additional requirements to obtain an RNAV 1 and RNAV 2 approval based on a TGL-10 approval

Operator holding a TGL-10 approval	**Needs to confirm the following RNAV 1 and RNAV 2 performance capabilities in connection with this AC**	**Notes**
If the approval includes use of DME/VOR equipment (the DME/VOR equipment may be used as the only positioning input where is explicitly allowed)	RNAV 1 does not include any DME/VOR RNAV-based route	RNAV system performance must be based on GNSS, DME/DME or DME/DME/IRU. However, DME/VOR input must not be inhibited or deselected
If approval includes use of DME/DME	No action is required if the RNAV system performance meets the specific navigation service criteria of this AC: DME/DME or DME/DME/IRU	The operator can ask the manufacturer or check the *FAA website for the system compliance list
RNAV SID specific requirement for with DME / DME aircraft	RNAV guidance available before reaching 500 ft above field elevation (AFE)	The operator must add this operational requirement
If approval includes use of GNSS	No action is required	

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