ADVISORY CIRCULAR

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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. RELEVANT SECTIONS OF THE LATIN AMERICAN AERONAUTICAL REGULATIONS (LAR) OR EQUIVALENTS

LAR 91: Sections 91.1015 and 91.1640 or equivalents

LAR 121: Section 121.995 (b) or equivalent

LAR 135: Section 135.565 (c) or equivalent

3. 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 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	U.S. Terminal and en route area navigation (RNAV) operations
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)

Spain DGAC CO 03/01 Aprobaciones de aeronavegabilidad y operacionales para operaciones RNAV de precisión (P-RNAV) en el espacio aéreo Europeo designado

4. 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.*

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has been deleted from the Annexes to the Convention on International Civil Aviation because the RNP concept has been replaced by the PBN concept.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

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.

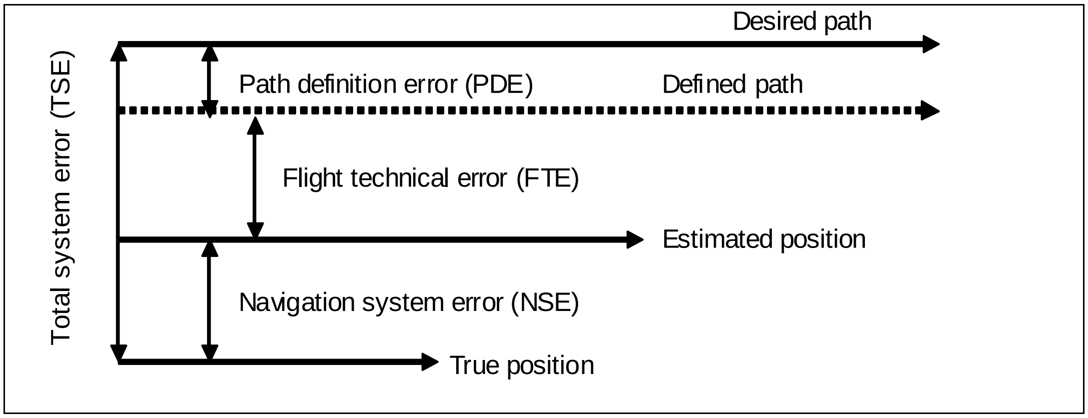
r) **Standard instrument arrival (STAR)**.- A designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

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 (FAA)
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)	LAAS	Local area augmentation system
aaa)	LAR	Latin American Aeronautical Regulations
bbb)	LNAV	Lateral navigation
ccc)	LOA	Letter of authorisation/acceptance letter
ddd)	LOC	Locator
eee)	MCDU	Multi-function control display
fff)	MEL	Minimum equipment list
ggg)	OIM	Operations inspector manual
hhh)	MLS	Microwave landing system
iii)	MP	Monitoring pilot
jjj)	MVA	Minimum vectoring altitude

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

vvvv)	VM	Heading to a manual termination
wwww)	VOR	VHF omnidirectional radio range
xxxx)	WAAS	Wide area augmentation system
yyyy)	WGS	World geodetic system
zzzz)	WPT	Waypoint

5. INTRODUCTION

5.1 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.

5.2 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.

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

5.4 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).

5.5 Operators approved under AC 90-100A meet the requirements of this CA, 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).

5.6 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.

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

5.8 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).

5.9 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.

5.10 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.

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

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

5.13 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.*

5.14 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.

5.15 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.

5.16 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.

5.17 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.*

6. GENERAL INFORMATION

6.1 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) ANSPs shall guarantee that operators of aircraft equipped with GNSS and, where applicable, with satellite-based augmentation system (SBAS), have access to a means of predicting the availability of fault detection using the aircraft-based augmentation system (ABAS) (*e.g.,* RAIM). This prediction system can be provided by an ANSP, airborne equipment manufacturers or other entities.

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.

6.2 **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.

6.3 **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.

6.4 **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.

6.5 **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.

7. AIRWORTHINESS AND OPERATIONAL APPROVAL

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

a) 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

b) 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).

7.2 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).

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

8. AIRWORTHINESS APPROVAL

8.1 Aircraft requirements

8.1.1 Description of the RNAV navigation system

a) **Lateral navigation (LNAV)**

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).*

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):

(a) 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 8.4 of this CA. 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.

(b) DME/DME RNAV equipment that meets the criteria listed in Paragraph 8.3.2; and

(c) DME/DME/IRU RNAV equipment that meets the criteria listed in Paragraph 8.3.4.

8.1.2 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).

8.2 **RNAV system eligibility**

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

8.2.2 **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.

8.2.3 **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).

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

8.2.5 **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 8.3 and with the functional requirements described in Paragraph 8.4.

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 8.3.2 and 8.3.4 (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 CA. The operator must assess such equipment in accordance with the performance and functional requirements set forth in this document.*

8.2.6 **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 or that the aircraft has RNP 1 capability or better.

(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 8.2.4 above.

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

8.3.1 **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 8.4 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.

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

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

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

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

8.4 **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.

8.5 **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.

9. OPERATIONAL APPROVAL

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

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

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

9.1 Requirements to obtain operational approval

9.1.1 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 10, 11, 12, and 13:

a) *Airworthiness approval*.- aircraft shall have the corresponding airworthiness approvals, pursuant to Paragraph 8 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 CA, as described in Paragraph 8, 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 (*e.g.*, LAR 121 and LAR 135 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 11 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 11 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 (*e.g.*, LAR 91 operators) shall be familiar with and demonstrate that they will perform their operations based on the practices and procedures described in Paragraph 11.

5) *Operations manual and checklists*

(a) Commercial operators (*e.g.*, LAR 121 and 135 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 10 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 (*e.g.*, LAR 91 operators) must operate their aircraft based on the practices and procedures identified in Paragraph 10 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 8.5 e).

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

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. The validation flight will be carried out according to the provisions of Chapter 13, Volume II, Part II of the SRVSOP Operations Inspector Manual (MIO).

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.

1) LAR 121 and/or 135 operators.- For LAR 121 and/or LAR 135 operators, the CAA will issue the corresponding operations specifications (OpSpecs) that will reflect the RNAV 1 and RNAV 2 approval.

2) *LAR 91 operators*.- For LAR 91 operators, the CAA will issue a letter of authorisation (LOA).

10. OPERATING PROCEDURES

10.1 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 position relative to the path) must be limited to ± ½ the navigation precision associated with the route or flight procedure (*e.g.*, 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 (*e.g.*, 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.

11. TRAINING PROGRAMME

11.1 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 CA;

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 8.4 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.

12. 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.

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

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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 CA.

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. For LAR 121 and 135 operators, the CAA will issue the OpSpecs, and for LAR 91 operators, a LOA.

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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 TG-10 approval	Needs to confirm the following RNAV 1 and RNAV 2 performance capabilities in connection with this CA	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	

*http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/afs410/policy_guidace/

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