European Aviation Safety Agency

Notice of Proposed Amendment 2018-02

Provision of airworthiness requirements in support of global performance-based navigation operations

RMT.0519

EXECUTIVE SUMMARY

This Notice of Proposed Amendment (NPA) addresses efficiency, proportionality and safety issues related to those aircraft whose airworthiness must be certified in order to perform global performance-based navigation (PBN) operations.

This NPA contains an update of the Certification Specifications for Airborne Communications, Navigation and Surveillance (CS-ACNS), which primarily incorporates the certification criteria related to the use of airworthiness and interoperability standards in support of performance-based navigation (PBN) implementation, as well as other minor amendments to the requirements published in Decision 2013/031/R. In particular, the main intent of this NPA is to propose new sections in Subpart C 'Navigation' (NAV), which is currently reserved.

The new sections are specifically dedicated to support global PBN operations and provide clear requirements in Book 1, as well as acceptable means of compliance (AMC) and guidance material (GM) in Book 2. These additions ensure conformity with the performance requirements and functionalities that stem from ICAO's RNP navigation specifications, i.e. RNP 4, RNP 2, RNP 1, advanced RNP (A-RNP), RNP approach (RNP APCH), RNP authorisation required (RNP AR), and RNP 0.3.

The specific objective is to provide a certification basis that will allow aircraft operators to benefit from the implementation of PBN routes and procedures. The proposed amendments are also expected to facilitate global PBN objectives and to simplify the certification process for both the applicants and the European Aviation Safety Agency (EASA).

Following the publication of Regulation (EU) 2016/1199, EASA published in 2016 a number of ED Decisions that transposed all PBN operational approval requirements from the AMC-20 material into the AMC/GM to Regulation (EU) No 965/2012. As the EASA's proposal incorporates all the PBN certification requirements into a single certification specification (CS), this NPA proposes to cancel AMC 20-4A, AMC 20-5, AMC 20-12, AMC 20-26, AMC 20-27A and AMC 20-28 for new applications. As regards RNAV 1, JAA TGL 10 Rev 1 will cease to be recognised by EASA for type certification after the publication of the updated CS-ACNS.

Action area:	Regular updates/review of rules		
Affected rules:	CS-ACNS; AMC-20		
Affected stakeholders:	Avionics and aircraft designers, installers and manufacturers		
Driver:	Efficiency/proportionality	**Rulemaking group:**	No
Impact assessment:	Light	**Rulemaking Procedure:**	Standard

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1. About this NPA

1.1. How this NPA was developed

EASA developed this NPA in line with Regulation (EC) No 216/2008[1] (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure[2].

This rulemaking activity is included in the EASA's 5-year Rulemaking Programme[3] under rulemaking task RMT.0519[4], with the purpose of updating the existing CSs for airborne CNS equipment in support of air traffic management (ATM) applications.

The text of this NPA has been developed by EASA and it is hereby submitted to all interested parties[5] for consultation.

1.2. How to comment on this NPA

Please submit your comments using the automated **Comment-Response Tool (CRT)** available at **http://hub.easa.europa.eu/crt/**[6].

The deadline for submission of comments is **30 April 2018.**

1.3. The next steps

Following the closing of the public consultation period, EASA will review all the comments received.

Based on the comments received, EASA will develop a decision amending CS-ACNS and the related AMC-20 material, which were respectively published with Decision 2013/031/R and Decision 2003/012/RM, as amended.

The comments received and the EASA responses thereto will be reflected in a comment-response document (CRD). The CRD will be annexed to the ED Decision.

1 Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1) (http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1467719701894&uri=CELEX:32008R0216).

2 EASA is bound to follow a structured rulemaking process as required by Article 52(1) of Regulation (EC) No 216/2008. Such a process has been adopted by the EASA Management Board (MB) and is referred to as the 'Rulemaking Procedure'. See MB Decision No 18-2015 of 15 December 2015 replacing Decision 01/2012 concerning the procedure to be applied by EASA for the issuing of opinions, certification specifications and guidance material (http://www.easa.europa.eu/the-agency/management-board/decisions/easa-mb-decision-18-2015-rulemaking-procedure).

3 http://easa.europa.eu/rulemaking/annual-programme-and-planning.php

4 https://www.easa.europa.eu/document-library/terms-of-reference/tor-rmt0519

5 In accordance with Article 52 of Regulation (EC) No 216/2008, and Articles 6(3) and 7) of the Rulemaking Procedure.

6 In case of technical problems, please contact the CRT webmaster (crt@easa.europa.eu).

2. In summary — why and what

2.1. Why we need to change the rules — issue/rationale

The initial issue of CS-ACNS was adopted with ED Decision 2013/031/R of 17 December 2013[7], after EASA had identified the need to ensure safety and interoperability for aircraft airborne communications, navigation and surveillance systems through a new set of CSs, that were published in Annex I to said Decision. This Decision entered into force on 1 January 2014.

In addition, some parts of the General Acceptable Means of Compliance for Airworthiness of Products, Parts and Appliances (AMC-20)[8] currently provide applicants with a basis to obtain an airworthiness (and operational) approval to conduct certain PBN operations, namely:

— AMC 20-4A 'Airworthiness Approval and Operational Criteria for the Use of Navigation Systems in European Airspace Designated for Basic RNAV Operations';

— AMC 20-5 'Airworthiness Approval and Operational Criteria for the use of the NAVSTAR Global Positioning System (GPS)';

— AMC 20-12 'Recognition of FAA Order 8400.12a for RNP 10 Operations';

— AMC 20-26 'Airworthiness Approval and Operational Criteria for RNP Authorisation Required (RNP AR) Operations';

— AMC 20-27A 'Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations';

— AMC 20-28 'Airworthiness Approval and Operational Criteria related to Area Navigation for Global Navigation Satellite System approach operation to Localiser Performance with Vertical guidance minima using Satellite Based Augmentation System'.

The initial issue of CS-ACNS did not include certification criteria for airborne systems related to navigation functions, which represents an opportunity to transpose the relevant material from the above AMC 20-XX into a single document with the purpose of enabling approval of RNP systems, as demanded by today's applications. However, the above documents do not cover all the existing RNP operations, so additional certification criteria are needed to provide for a comprehensive set of requirements.

Therefore, the main purpose of this NPA is to establish a simplified certification basis that will permit EASA to issue airworthiness approvals in respect of any of the RNP navigation specifications and functionalities defined by ICAO in its PBN Manual (Doc 9613), Fourth Edition[9].

Thus, the intent is to focus on and make available the necessary information to aircraft and avionics design and manufacture organisations through CS-ACNS, so that aircraft can be equipped, as required, to ensure safe PBN operations in accordance with the emerging routes and procedures.

[7] https://www.easa.europa.eu/document-library/certification-specifications/cs-acns-initial-issue

[8] https://www.easa.europa.eu/certification-specifications/amc-20-general-acceptable-means-compliance-airworthiness-products-parts

[9] ICAO Doc 9613-AN/937 'Performance-based Navigation (PBN) Manual', Fourth Edition, 2013.

Additionally, EASA proposes some other amendments to CS-ACNS resulting from implementation experience as follows:

— Subpart B, Section 1, where the voice communication system continuity requirements have been amended due to 'remote' being considered disproportionate for some aircraft;

— Subpart E, Section 1, where the alerts associated with terrain awareness and warning system (TAWS) together with testing guidance material have been amended to take into account approaches other than those served by an instrument landing system (ILS).

For more information about some of the issues addressed by this proposal, please refer to the RIA Section 4.1.

2.2. What we want to achieve — objectives

The overall objectives of the EASA system are defined in Article 2 of the Basic Regulation. This proposal will contribute to the achievement of the overall objectives by addressing the issues outlined in Section 2.1.

The main objective of this proposal is to develop CS-ACNS in order to:

— establish standards that permit the airborne community to comply with any of the RNP specifications and functionalities defined in the ICAO PBN Manual, Fourth Edition;

— alleviate the requirement for multiple approvals, certificates and EC declarations for parts and appliances and installation;

— take into account the lessons learned from the application of the PBN-related AMC-20s, i.e. AMC 20-4A, AMC 20-5, AMC 20-12, AMC 20-26, AMC 20-27A and AMC 20-28, and transpose the relevant RNP certification criteria into CS-ACNS.

Furthermore, the intention is also to cancel these parts from AMC-20 with the purpose of making CS-ACNS the only available means to facilitate certification of area navigation systems, thus avoiding duplication within EASA's framework. Similarly, JAA TGL 10 Rev 1 will no longer be used as guidance for RNAV 1 certification.

The additional CS-ACNS material shall be used for new applications for type certification of area navigation systems for PBN applications and, deliberately, does not specifically address RNAV navigation specifications. Today's navigation systems are commonly designed to meet RNP applications, and hence provide on-board performance monitoring and alerting[10]. Moreover, a careful review of the aircraft applicability requirements in the ICAO PBN Manual, the RTCA DO-229E MOPS for SBAS/GNSS receivers, the EUROCAE ED-75D MASPS for area navigation systems, FAA AC 20-138D and the EASA/JAA AMC/TGL material revealed that the requirements for aircraft qualification are similar across a significant number of PBN specifications. As a consequence, EASA considered that it is appropriate for an aircraft that will be type-certified in accordance with CS-ACNS for RNP X to also be recognised as having been type-certified for RNAV Y (where Y ≥ X), provided that both specifications are applicable to the same type of operations. For example:

[10] A gradual transition to RNP applications is expected, as the proportion of aircraft equipped with RNP systems gradually increases, which will enable airspace users to perform PBN operations in those volumes of the European airspace where an improvement on the integrity of the navigation function is deemed necessary.

— RNP 4 airworthiness type certification for remote continental/oceanic operations will also provide RNAV 10 airworthiness type certification;

— RNP 2 airworthiness type certification for en-route continental operations will also provide RNAV 5 airworthiness type certification for en-route continental operations;

— RNP 1 airworthiness type certification for arrival, approach and departure operations will also provide RNAV 1 airworthiness type certification for arrival, approach and departure operations.

An applicant that requests a type certification against RNAV specification(s) only may continue to file their application. EASA will work closely with the applicant to have the installation approved through the use of one or more special condition(s). Based on the EASA's experience with applications for approval of installation of area navigation systems, the number of such cases is expected to be very low and limited to the retrofit of area navigation systems on legacy aircraft that cannot be equipped with certified GNSS position sensors.

In fact, currently 88 % of all aircraft registered in the 28 EU MSs (plus Switzerland and Norway) and flying IFR in Europe are GNSS-equipped (results based on EUROCONTROL PRISME database[11]). 9 % of the non-equipped aircraft are 30 years old or more and 20.2 % are 25 years old or more.

The publication of the updated CSs does not invalidate the status of aircraft currently approved for compliance with AMC 20-4A, AMC 20-5, AMC 20-12, AMC 20-26, AMC 20-27A, AMC 20-28 and TGL-10. These approvals will continue to be recognised.

Additionally, the voice communication system continuity requirements are expressed in terms of classification of failure conditions and require that 'MAJOR' is considered for failures of the communications system in most of the cases, except for CS-23 Level 1 aircraft, if proved to be excessive.

Finally, the proposed amendments to the TAWS requirements are in line with the operational requirements considered in the AMC/GM to Regulation (EU) No 965/2012[12] on the provision of alerts related to excessive deviations below the glide path.

2.3. How we want to achieve it — overview of the proposals

2.3.1. Summary

The purpose of this NPA is to update CS-ACNS, as published with Decision 2013/031/R, with navigation-related airworthiness certification and interoperability standards.

2.3.2. Cancellation of PBN-related AMC-20 material

As proposed in NPA 2013-25[13] and following the publication of EASA Opinion No 03/2015[14], a number of ED Decisions, namely 2016/014/R, 2016/015/R, 2016/016/R, 2016/017/R, 2016/018/R, 2016/019/R,

[11] Based on IFR operations that took place between January and September 2017.

[12] Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council (OJ L 296, 25.10.2012, p. 1).

[13] NPA 2013-25 'Revision of operational approval criteria for performance-based navigation (PBN)' (RMT.0256 & RMT.0257 (MDM.062(A) & (B))) (https://www.easa.europa.eu/document-library/notices-of-proposed-amendments/npa-2013-25).

[14] https://www.easa.europa.eu/document-library/opinions/opinion-032015

2016/020/R and 2016/021/R, were published following the amendment of Regulation (EU) No 965/2012[15] by Regulation (EU) 2016/1199[16].

These ED Decisions amended the AMCs/GM to the annexes to the Air OPS Regulation by transposing all operational approval requirements from the AMC-20 references listed in Section 2.1. Moreover, NPA 2013-25 and EASA Opinion No 03/2015 also proposed the deletion of the transposed provisions from AMC-20, which would have resulted in those AMC-20s containing only provisions related to airworthiness. However, the AMC-20 material was not amended following the publication of the above-mentioned EASA Decisions, since EASA preferred to wait for this NPA and cancel the PBN-related AMC-20s in their entirety, once the airworthiness approval requirements had also been transposed into CS-ACNS.

2.3.3. Compatibility with the ICAO PBN Manual

The proposed airworthiness CSs are compatible with the aircraft requirements specified in the ICAO PBN Manual, Fourth Edition (2013), for the following PBN specifications:

— RNP 4,

— RNP 2,

— RNP 1,

— advanced RNP (A-RNP),

— RNP approach (RNP APCH),

— RNP approach authorisation required (RNP APCH AR),

— RNP 0.3.

The CS material is also compatible with the following optional or mandatory functionalities:

— radius to fix (RF),

— fixed radius transition (FRT),

— parallel offset,

— vertical navigation outside final approach,

— RNP scalability.

The time of arrival control (TOAC) functionality is not addressed, as the corresponding section of the ICAO PBN Manual still needs to be developed.

The following are the main differences between the proposed CSs and the requirements considered in ICAO's PBN Manual:

— The CSs are largely based on the EUROCAE ED-75D Minimum Aviation System Performance Standards (MASPS) for area navigation systems, which was published in 2014. The ICAO PBN

[15] Also known as the 'Air OPS Regulation'. See Section 5 for detailed information on the references provided.

[16] Commission Regulation (EU) 2016/1199 of 22 July 2016 amending Regulation (EU) No 965/2012 as regards operational approval of performance-based navigation, certification and oversight of data services providers and helicopter offshore operations, and correcting that Regulation (OJ L 198, 23.7.2016, p. 13).

Manual (Doc 9613, Fourth Edition) predates the MASPS, which introduces some differences between the CSs and the ICAO PBN Manual. The next edition of the ICAO PBN Manual, which is currently being updated by ICAO's PBN Study Group (PBNSG), is anticipated to incorporate these changes.

— The CSs also introduce new requirements for RNP AR departures. These are based on agreement reached by the PBNSG on the future aircraft qualification requirements for such procedures, which EASA considers mature enough to be already incorporated into the CSs. These requirements are also anticipated to be incorporated in the next update of the ICAO PBN Manual.

— The CSs also include a provision which would allow operators of smaller and relatively slow, general aviation aircraft to operate on procedures with radius to fix (RF) legs, without the need for an autopilot or flight director, provided that specific installation criteria are met. Similar to the RNP AR departure operations, this provision is based on an agreement reached by the PBNSG, which EASA considers mature enough for incorporation into the CSs.

— Other requirements are more stringent or demanding than the corresponding requirements of the ICAO PBN Manual. EASA considers that the ICAO PBN Manual sets out minimum requirements that Contracting States or regional aviation authorities may adapt to address issues with the specific regulatory and operational environments or safety culture in that particular State or region. Where this applies to the CSs, these requirements have been moved from the existing AMCs to CSs.

The CSs deliberately deviate from the ICAO PBN Manual in two particular aspects:

(a) The CSs refer to 'RNP value' whereas the ICAO PBN Manual uses the term 'navigation accuracy' and explicitly states that 'expressions such as RNP type and RNP value […] are not used under the PBN concept and are to be deleted in all ICAO material'. Although EASA appreciates the issues associated with the use of these terms, it also recognises the fact that in day-to-day operations, system designers, certification experts, pilots and other aviation professionals have become accustomed to the use of these terms. Moreover, EASA strives to draft the CSs in a manner that is easily understood by all stakeholders. Consequently, EASA has decided to keep the term 'RNP value'.

(b) EASA disagrees with the ICAO policy which states: 'Because specific performance requirements are defined for each navigation specification, an aircraft approved for a particular navigation specification is not automatically approved for any other navigation specification. Similarly, an aircraft approved for an RNP or RNAV specification having a stringent accuracy requirement (e.g. RNP 0.3 specification) is not automatically approved for a navigation specification having a less stringent accuracy requirement (e.g. RNP 4).' EASA has carefully reviewed the aircraft qualification requirements in the various PBN navigation specifications and found that these are, with few exceptions, similar. This conclusion is supported by the notion that aircraft are not equipped with specific equipment supporting a particular navigation specification. Instead, EASA concluded that the same systems (e.g. flight management system (FMS), displays, autopilot/flight director) support all the navigation specifications and that the differences are particularly related to the specific functions that the FMS supports (e.g. scalability).

2.3.4. Compatibility with FAA Advisory Circular AC 20-138D[17] including Changes 1 and 2

With few exceptions, the CSs are fully harmonised with the guidance offered by the FAA in their Advisory Circular (AC) 20-138D including Changes 1 and 2.

Notable differences include the following:

— For aircraft equipped with a Class A TAWS, the CS requires an alert for excessive downward deviation from the flight path on RNP approach procedures to localiser performance with vertical guidance (LPV) minima. This requirement is consistent with the requirements found in AMC1 CAT.IDE.A.150 and the former AMC 20-28. Contrary to the FAA, EASA concludes that the evident benefit to safety that this function provides outweighs the burden on industry to develop, install and certify the function. Moreover, EASA allows this function to be provided by another system than the TAWS, provided that it has the same effect as a TAWS Mode 5 alert.

— The requirements for RNP AR operations with regard to demonstration of performance in failure cases, as well as the requirements on continuity of function differ from those in the FAA's AC. These differences already existed between the FAA's AC and AMC 20-26 and relate to differing regulatory and operational environments. The situation in the United States allows aspects of RNP AR operations, such as mitigating the effects of failure conditions, to be addressed through the process of operational approval or other means. In the more fragmented regulatory and operational environment in Europe and elsewhere in the world, this is more difficult to achieve with an appropriate level of consistency. Consequently, EASA found that it is appropriate to address some of these aspects by putting more emphasis on the qualification of the aircraft.

2.3.5. Relationship with existing EASA regulations and decisions

The purpose of this regulatory proposal is to ensure the availability of approval criteria for aircraft system design and installation, as required by Regulation (EU) No 748/2012[18].

In particular, this NPA proposes the expansion of CS-ACNS, as initially published in Decision 2013/031/R, with new provisions in Subpart C 'Navigation' for PBN.

This proposal does not require recertification of aircraft; however, an applicant wishing to certify additional functionalities on already type-certified aircraft would have to apply on the basis of the proposed CS-ACNS.

It is essential that EASA provide a certification basis that is able to respond to stakeholders' needs, in particular with respect to the introduction of PBN as defined in the Annex to Commission Implementing Regulation (EU) No 716/2014 of 27 June 2014 on the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan[19] or the more recent EASA Opinion No 10/2016 'Performance-based navigation implementation in the European air traffic management network[20].

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[17] Airworthiness Approval of Positioning and Navigation Systems.

[18] Commission Regulation (EU) No 748/2012 of 3 August 2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations (OJ L 224, 21.8.2012, p. 1). See Section 5 for detailed information on the references provided.

[19] OJ L 190, 28.6.2014, p. 19. Also known as the 'PCP Regulation'. See Section 5 for detailed information on the references provided.

[20] https://www.easa.europa.eu/document-library/opinions/opinion-102016

These actions respond to the ICAO Assembly Resolution A37-11 'Performance-based navigation global goals' which 'urges all States to implement RNAV and RNP air traffic services (ATS) routes and approach procedures in accordance with the ICAO PBN concept laid down in the Performance-based Navigation (PBN) Manual (Doc 9613)'.

2.3.6. Structure of the proposed PBN Section of Subpart C 'Navigation'

The PBN Section is structured in subsections that the applicant can consult depending on their particular PBN certification needs. This is summarised in Table 1.

Table 1: Mandatory and optional airworthiness requirements

	Basic criteria	Supplementary criteria							
PBN specification	**Subsections 1 & 2** LNAV	**Subsection 3** LNAV in approach	**Subsection 4** Advisory VNAV	**Subsection 5** VNAV in final approach	**Subsection 6** RNP AR	**Subsection 7** Advanced-RNP	**Subsection 8** RF	**Subsection 9** FRT	**Subsection 10** Parallel offset
RNP 4	Required							*Optional*	Required
RNP 2	Required							*Optional*	*Optional*
RNP 1	Required		*Optional*				*Optional*		
RNP 0.3	Required		*Optional*				*Optional*		
RNP APCH	Required	Required	*Optional*	Required			*Optional*		
RNP AR	Required	Required		Required	Required		Required		
A-RNP	Required	Required	*Optional*	Required		Required	Required	Required	Required

The scope of the 10 subsections is detailed below:

Subsection 1: General applicability for performance-based lateral navigation

Subsection 2: Generic specifications for performance-based lateral navigation

Subsection 3: Supplementary specifications for lateral navigation in final approach

Subsection 4: Supplementary specifications for vertical navigation outside final approach

Subsection 5: Supplementary specifications for vertical navigation in final approach

Subsection 6: Supplementary specifications for RNP approach authorisation required

Subsection 7: Supplementary specifications for applications for advanced-RNP

Subsection 8: Supplementary specifications supporting radius to fix (RF)

Subsection 9: Supplementary specifications supporting fixed radius transition (FRT)

Subsection 10: Supplementary specifications supporting tactical parallel offset

Table 2 below shows which PBN specifications can be used for which type of operations.

Table 2: Operations supported by the existing navigation specifications

Navigation specification	*Operation*							
	En-route oceanic/remote	*En-route continental*	*Arrival*	*Approach*				*Departure*
				Initial	*Intermediate*	*Final*	*Missed*	
RNAV 10	Y							
RNAV 5		Y	Y					
RNAV 2		Y	Y					Y
RNAV 1		Y	Y	Y	Y		Y	Y
RNP 4	Y							
RNP 2	Y	Y						
RNP 1			Y	Y	Y		Y	Y
Advanced RNP (A-RNP)	Y	Y	Y	Y	Y	Y	Y	Y
RNP APCH				Y	Y	Y	Y	
RNP AR APCH				Y	Y	Y	Y	
RNP 0.3		Y	Y	Y	Y		Y	Y

2.4. What are the expected benefits and drawbacks of the proposal

The expected benefits of the proposal are summarised below. For the full impact assessment of the alternative options, please refer to Section 4.

— Simplification of the applicable certification basis that applicants should follow.

— One single process could be used to demonstrate compliance with the required navigation specifications.

— Harmonisation of the EASA certification criteria with those necessary to underpin global PBN operations.

— Qualification of aircraft to perform operations within an evolving PBN environment.

EASA did not identify any remarkable drawbacks.

3. Proposed amendments and rationale in detail

The text of the amendment is arranged to show deleted text, new or amended text as shown below:

— deleted text is ~~struck through~~;

— new or amended text is highlighted in grey;

— an ellipsis '[…]' indicates that the rest of the text is unchanged.

3.1. Draft certification specifications, acceptable means of compliance and guidance material — Amendments to CS-ACNS Book 1 and Book 2 (draft EASA decision)

The amendments proposed to CS-ACNS are described in this Section. It should be noted that Book 1 and Book 2 have been combined (compact format) to facilitate the reading of the proposed amendments; thus, each CS is followed by its corresponding AMC and GM.

The following is a list of provisions affected by the proposed amendments:

CS ACNS.A.GEN.001	Applicability	Amended
CS ACNS.A.GEN.005	Definitions	Amended
CS ACNS.A.GEN.015	Aircraft documentation	New
AMC1 ACNS.A.GEN.015(a)	Aircraft documentation	New
CS ACNS.A.GEN.020	Deviation from equipment standard	New
CS ACNS.B.VCS.030	Continuity	Amended
GM1 ACNS.B.VCS.030	Continuity	New
CS ACNS.C.PBN.XXXX	Subpart C — Navigation (NAV)	New
AMC/GM ACNS.C.PBN.XXXX	Subpart C — Navigation (NAV)	New
AMC1 ACNS.E.TAWS.035	Aural and visual alerts	Amended

Subpart A — General

CS ACNS.A.GEN.001 Applicability

~~These Certification Specifications are applicable to all aircraft for the purpose of compliance with equipage requirements with respect to on-board Communication, Navigation and Surveillance systems.~~

These Certification Specifications are intended to be applicable to aircraft for the purpose of complying with the communications, navigation and surveillance carriage requirements.

~~Furthermore, compliance with the appropriate section of these Certification Specifications ensures compliance with the following European regulations:~~

Compliance with the relevant sections of this Certification Specification ensures compliance with the following European regulations:

(a) Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council;

(b) Commission Implementing Regulation (EU) No 1207/2011~~,~~ of 22 November 2011 laying down requirements for the performance and the interoperability for surveillance for the single European sky; ~~and~~

(c) Commission Implementing Regulation (EU) No 1206/2011~~,~~ of 22 November 2011 laying down requirements on aircraft identification for surveillance for the single European sky;

(d) Commission Regulation (EC) No 29/2009 of 16 January 2009 laying down requirements on data link services for the single~~Single~~ European sky~~Sky~~; ~~and~~

(e) Commission Implementing Regulation (EU) No 1079/2012 of 16 November 2012 laying down requirements for voice channels spacing for the single~~Single~~ European sky~~Sky~~.

CS ACNS.A.GEN.005 Definitions

This point~~section~~ contains the definitions of terms used in these Certification Specifications~~ and not defined in CS-definitions.~~:

Accuracy means, in the context of PBN operations, the degree of conformance between the estimated, measured or desired position and/or the velocity of a platform at a given time, and its true position or velocity.

Advisory vertical navigation means an area navigation system function guiding the aircraft on a vertical path calculated by the area navigation system that is not based on a vertical path published on a State's aeronautical chart.

Area navigation (RNAV) means a method of navigation which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Area navigation system means a system that supports area navigation operations by integrating information from one or more positioning sensors and providing flight crew with the means to define any desired flight path.

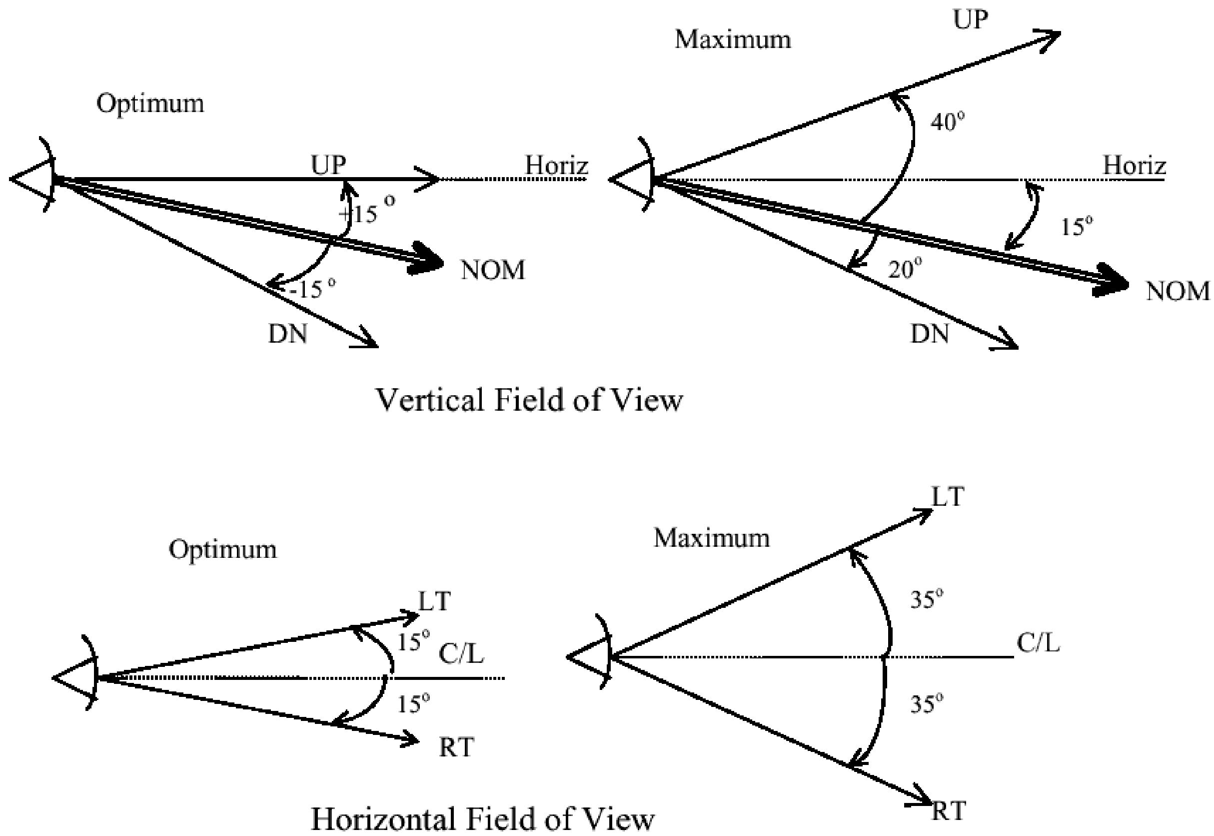
Aircraft-based augmentation system (ABAS) means an augmentation system that augments and/or integrates the information obtained from the GNSS elements with other information available on board the aircraft.

Continuity of function means, in the context of PBN operations, the capability of the system to perform its intended function without unscheduled interruptions.

Distance-measuring equipment (DME) means a ground–airborne positioning system based on interrogations from an airborne interrogator and replies from a ground-based transponder, that allows the aircraft to measure its slant range from the position of the ground-based DME transponder.

Field of view means either the optimum or maximum vertical and horizontal visual fields from the design eye reference point that can be accommodated with eye rotation only, as described in Figure 1.

Figure 1: Optimum and maximum fields of view



Flight plan means, in the context of PBN operations, a set of route segments and flight procedures defined and activated by the flight crew in the area navigation system, relative to an intended flight or portion of a flight of an aircraft.

Holding means a predetermined manoeuvre which keeps an aircraft within specified airspace.

Inertial navigation system/inertial reference unit (INS/IRU) means a stand-alone aircraft position sensor relying on accelerometers and gyroscopes to estimate position, direction and velocity.

Instrument landing system (ILS) means a system using ground-based transmitters and airborne receivers to provide lateral ('localiser') and vertical ('glide slope') guidance to the runway.

Lateral navigation (LNAV) means area navigation in the horizontal plane.

Mean sea level (MSL) means a reference for measuring and specifying altitudes in aeronautical information.

Navigation aid means a space- or ground-based facility that transmits signals that the aircraft's navigation system may use to determine its position.

Navigation functionality means the detailed capability of the navigation system required to meet the needs of the proposed operations in the airspace.

Navigation specification means a set of aircraft and aircrew requirements needed to support performance-based navigation operations within a defined airspace.

RNAV (X) specification means a navigation specification based on area navigation that does not include the requirement for on-board performance monitoring and alerting, designated by the prefix RNAV, where 'X' refers to the lateral navigation accuracy in nautical miles.

RNP (X) specification means a navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting, designated by the prefix RNP, where 'X' refers to the lateral navigation accuracy in nautical miles or the operation type.

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

Satellite-based augmentation system (SBAS) means a wide coverage augmentation system which monitors the GNSS constellation(s) and provides the user with augmentation information through a satellite-based transmitter.

Vertical navigation (VNAV) means a method of navigation based on a computed vertical path.

VHF omnidirectional range (VOR) means a ground–airborne positioning system based on signals in space transmitted by the VOR ground station to the aircraft VOR receiver to measure its angular position from the ground station.

[…]

CS ACNS.A.GEN.015 Aircraft documentation

(a) The aircraft flight manual (AFM) or similar documentation approved by EASA provides the list of aircraft capabilities for which the aircraft is certified in accordance with this CS.

(b) If there are deviations from this CS which result in limitation(s), they are to be clearly stated in the AFM or similar documentation approved by EASA.

AMC1 ACNS.A.GEN.015(a) Aircraft documentation

An acceptable means of compliance in the case of aircraft PBN capabilities is to specify in the documentation which of the following navigation specifications and functionalities the aircraft is certified for:

(a) RNAV 10,

(b) RNAV 5,

(c) RNAV 2,

(d) RNAV 1,

(e) RNP 4,

(f) RNP 2,

(g) RNP 1,

(h) RNP 0.3,

(i) A-RNP,

(j) RNP APCH,

(k) RNP AR (for approach and/or departures),

(l) RF (specify the associated navigation specifications),

(m) FRT,

(n) parallel offset.

CS ACNS.A.GEN.020 Deviation from equipment standards

Any deviations from the ETSO referenced in this CS and associated AMCs are to be evaluated to ensure compliance with the CS requirements.

Subpart B — Communications (COM)

SECTION 1 — VOICE CHANNEL SPACING (VCS)

[…]

CS ACNS.B.VCS.030 Continuity

~~The continuity of the voice communication system is designed to an allowable qualitative probability of 'remote'.~~

The voice communication system is designed so that the loss of radio communications is considered a 'MAJOR' failure condition for those aircraft foreseen to operate within an airspace where continuous air–ground voice communication is mandatory, except for CS-23 Level 1 aircraft, where this failure may be classified as 'MINOR'.

GM1 ACNS.B.VCS.030 Continuity

Information about Union requirements for continuous air–ground communications is provided in Commission Implementing Regulation (EU) No 923/2012 of 26 September 2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation. Specific requirements for the operation of radio equipment are placed in the respective States' aeronautical information publications (AIPs).

Subpart C — Navigation (NAV)

SECTION 1 — PERFORMANCE-BASED NAVIGATION (PBN)

Subsection 1 — Applicability — General

CS ACNS.C.PBN.101 Applicability

(See GM1 ACNS.C.PBN.101)

(a) Table 1 indicates the applicable airworthiness standards to be met by the airborne area navigation system installation in order to obtain certification credits for the RNP specifications addressed in this CS.

(b) Subsection 2 gives also certification credits for RNAV 10, RNAV 5, RNAV 2 and RNAV 1.

(c) The RNP 0.3 specification is applicable to helicopters.

Table 1: PBN specifications — Mandatory and optional airworthiness requirements

	Basic criteria	Supplementary criteria							
PBN specification	**Subsections 1 & 2** LNAV	**Subsection 3** LNAV in approach	**Subsection 4** Advisory VNAV	**Subsection 5** VNAV in final approach	**Subsection 6** RNP AR	**Subsection 7** Advanced-RNP	**Subsection 8** RF	**Subsection 9** FRT	**Subsection 10** Parallel offset
RNP 4	Required							*Optional*	Required
RNP 2	Required							*Optional*	*Optional*
RNP 1	Required		*Optional*				*Optional*		
RNP 0.3	Required		*Optional*				*Optional*		
RNP APCH	Required	Required	*Optional*	Required			*Optional*		
RNP AR	Required	Required		Required	Required		Required		
A-RNP	Required	Required	*Optional*	Required		Required	Required	Required	Required

Subsection 1: General applicability for performance-based lateral navigation

Subsection 2: Generic specifications for performance-based lateral navigation

Subsection 3: Supplementary specifications for lateral navigation in final approach

Subsection 4: Supplementary specifications for vertical navigation outside final approach

Subsection 5: Supplementary specifications for vertical navigation in final approach

Subsection 6: Supplementary specifications for RNP authorisation required (AR)

Subsection 7: Supplementary specifications for applications for advanced-RNP (A-RNP)

Subsection 8: Supplementary specifications supporting radius to fix (RF)

Subsection 9: Supplementary specifications supporting fixed radius transition (FRT)

Subsection 10: Supplementary specifications supporting parallel offset

GM1 ACNS.C.PBN.101 Applicability

Subpart C of CS-ACNS provides certification criteria for performance-based navigation. EASA has considered the current and future aircraft equipment and has assumed that most, if not all, aircraft are equipped with one or more GNSS receivers. Subpart C therefore focuses on compliance with RNP navigation specifications. Compliance with Subsection 2, however, also assures compliance with the RNAV 10, RNAV 5, RNAV 2 and RNAV 1 navigation specifications.

It should be noted that this Subpart does not address communication and surveillance considerations that are, in some cases, related to the implementation of a navigation specification (e.g. controller–pilot data link communications (CPDLC) and automatic dependent surveillance — contract (ADS-C) for RNP 4) within a particular airspace.

The ICAO PBN Manual (Doc 9613) contains 11 navigation specifications, each addressing specific operations by flight phase:

(a) RNAV 10, historically referred to as RNP 10, is applied for oceanic and remote continental navigation operations;

(b) RNAV 5, RNAV 2 and RNAV 1 are applied for continental en-route and terminal navigation operations;

(c) RNP 4 and RNP 2 (high continuity) are applied for oceanic and remote continental navigation operations;

(d) RNP 2 (low continuity), RNP 1 and advanced-RNP (A-RNP) are applied for continental en-route and terminal navigation operations;

(e) A-RNP, RNP APCH and RNP AR APCH are applied for initial, intermediate, final and missed approach navigation operations, and may include requirements for vertical navigation (VNAV);

(f) RNP 0.3 was specifically written to facilitate (low-level) en-route operations with rotorcraft.

Note: Detailed information is reflected in Table 2 (see AMC1 ACNS.C.PBN.2140).

Subpart C on performance-based navigation contains basic and supplemental certification criteria. The basic criteria must always be complied with, regardless of the navigation specification, and ensure compliance with the navigational requirements of the RNAV 10, RNAV 5, RNAV 2, RNAV 1, RNP 2, RNP 1 and RNP 0.3 criteria.

Some navigation specifications require compliance with supplemental criteria, e.g. compliance with Subsection 10 for parallel offsets for RNP 4.

The criteria for navigation specifications that include approach, i.e. A-RNP, RNP APCH and RNP AR, are more specific. Subsection 3 (‘LNAV in approach’) and Subsection 5 (‘VNAV in approach’) apply to these operations. Both RNP AR and A-RNP have their own specific criteria that need to be met, as described in Subsection 6 for RNP AR and Subsection 7 for A-RNP.

Subsection 4 addresses the use of advisory vertical navigation (VNAV) outside the approach part of the flight. Compliance with Subsection 4 supports continuous descent operations and is optional for RNP 1, RNP 0.3 and A-RNP.

Subsections 8, 9 and 10 contain criteria for specific functions. These functions (radius to fix, fixed radius transition, and parallel offset) are required for some applications and are optional for some others.

Example application of Table 1:

Question: An applicant wishes to apply for certification of an aircraft for RNP APCH. Which subsections of Subpart C should the applicant demonstrate compliance with?

Answer: Subsections 1 and 2, and the supplemental and the more stringent criteria provided in Subsections 3 and 5 for lateral and vertical navigation, respectively. The applicant may need to also demonstrate compliance with Subsection 8, which is optional, as the RF functionality could be used in the initial and intermediate approach segments, and in the final phase of the missed approach.

Additionally, Appendix A to Subpart C provides guidance material for the installation of equipment constituting the aircraft area navigation system and for testing the aircraft area navigation system.

Subsection 2 — Generic specifications for performance-based lateral navigation

APPLICABILITY

CS ACNS.C.PBN.201 Applicability

Subsection 2 provides the functional and performance criteria that are common to all PBN specifications for lateral navigation.

SYSTEM QUALIFICATION CRITERIA

CS ACNS.C.PBN.205 Area navigation system approval

(See AMC1 ACNS.C.PBN.205, GM1 ACNS.C.PBN.205, GM2 ACNS.C.PBN.205 and GM3 ACNS.C.PBN.205)

All equipment contributing to the area navigation function is approved.

AMC1 ACNS.C.PBN.205 Area navigation system approval

Where the area navigation system architecture is based on a stand-alone system, the area navigation system should be granted a European Technical Standard Order (ETSO) authorisation against ETSO-C146c operational class 1, 2 or 3.

Where the area navigation system architecture is based on a flight management system (FMS) receiving input from various sources of position, the FMS should be granted an ETSO authorisation against ETSO-C115d and, depending on the type of sources to determine position, it should be granted an ETSO authorisation against the following ETSO or be compliant with the following standards:

(a) GNSS position source against ETSO-C196a or ETSO-C145c operational class 1, 2 or 3;

(b) INS/IRU horizontal position source, whose functionality and performance are detailed in 0

(c) DME/DME horizontal position source based on a DME interrogator granted an ETSO authorisation against ETSO-2C66b;

(d) barometric vertical position source: ETSO-C106 A1.

With reference to CS ACNS.A.GEN.020, any deviations from the ETSOs should be evaluated against the relevant sections of EUROCAE ED-75D Minimum Aviation System Performance Standard (MASPS).

GM1 ACNS.C.PBN.205 Area navigation system approval

Subpart C of CS-ACNS is based on EUROCAE ED-75D (RTCA ED-236C and Change 1), except for RNP AR, and on the ICAO PBN Manual (Doc 9613).

The AMCs to Subpart C requirements encourage the installation of ETSO-authorised equipment, recognising the fact that many of the EUROCAE ED-75D requirements are covered through compliance with ETSO requirements. Recognition of ETSO authorisation generally limits the burden on the applicant that demonstrates compliance with the CS requirements.

GM2 ACNS.C.PBN.205 Area navigation system approval

ETSO-C145c and ETSO-C146c (operational class 1) support the following operations:

(a) oceanic/remote en route;

(b) continental en route;

(c) arrival;

(d) approach down to LNAV minima; and

(e) departure.

ETSO-C145c and ETSO-C146c (operational class 2) support, in addition, approach down to LNAV/VNAV minima.

ETSO-C145c and ETSO-C146c (operational class 3) support, in addition, approach down to LP and LPV minima.

ETSO-C146c (functional class D — operational class 4) only supports approach down to LP and LPV minima. Such equipment may meet the requirements of functional class B operational class 1, 2 and 3 (i.e. ETSO-C145c capabilities). Because of aircraft integration specificities of ETSO-C146c operational class 4 (see DO-229D § 1.4.2), the use of this equipment is not recognised as an AMC. Nevertheless, such equipment may be used by an applicant but would require specific architectural considerations for its approval. It is advised to contact EASA as early in the process as possible to discuss the applicable certification criteria.

The minimum system requirements may also depend on the intended airspace to be flown; hence, carriage of additional navigation systems could be required.

GM3 ACNS.C.PBN.205 Area navigation system approval

Integrated GNSS/INS position solutions reduce the rate of degradation after loss of position updating. For ‘tightly coupled’ GNSS/IRUs, RTCA Document DO-229D, Appendix R, provides additional guidance on ‘tightly coupled’ GNSS/IRUs.

CS ACNS.C.PBN.210 Position source

(See AMC1 ACNS.C.PBN.210)

The area navigation system uses global navigation satellite system (GNSS) as primary source of horizontal position.

AMC1 ACNS.C.PBN.210 Position source

If other horizontal position sources are available, they may be used to complement the GNSS-computed position provided that these sources do not degrade the GNSS-computed position.

If position is no longer available from a GNSS position source and if additional sources are available, the position should be computed using the best next available source, i.e. the source that provides the computed position with the highest integrity and accuracy.

Installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.215 Position estimation

(See AMC1 ACNS.C.PBN.215 and GM1 ACNS.C.PBN.215)

The area navigation system continuously estimates:

(a) the present position of the aircraft;

(b) the accuracy and integrity of the position.

AMC1 ACNS.C.PBN.215 Position estimation

Installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c operational class 1, 2 or 3 satisfies the requirement.

GM1 ACNS.C.PBN.215 Position estimation

(a) The estimated position accuracy is a measure based on a defined scale, in nautical miles, which conveys the current position estimation performance. The position accuracy can be related to the required navigation performance (RNP) value: if the position accuracy is less than the RNP value, there should be a fairly high level of confidence, but not a guarantee, that the system can meet the requirements of the intended PBN operation.

(b) The margin between position accuracy and the required performance should be an indication of the available margin. The position error is the radius of a circle, centred on the estimated position, such that the probability of the true position lying outside the circle without being detected is less than or equal to 10^{-5}/hour.

CS ACNS.C.PBN.220 Navigation source selection and reversion

(See AMC1 ACNS.C.PBN.220)

When a multi-sensor area navigation system is installed, it has the capability to automatically or manually select the source(s) that provides (provide) the highest position accuracy and integrity.

AMC1 ACNS.C.PBN.220 Navigation source selection and reversion

Installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

CS ACNS.C.PBN.225 Reasonableness check of distance-measuring equipment (DME)

(See AMC1 ACNS.C.PBN.225)

When the area navigation system uses DME, it has the capability to perform a reasonableness check of the radio navigation data.

AMC1 ACNS.C.PBN.225 Reasonableness check of distance-measuring equipment (DME)

Installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

CS ACNS.C.PBN.230 Flight plan management

(See AMC1 ACNS.C.PBN.230)

The area navigation system provides flight crew with the capability to create, review, modify and activate a flight plan. Activation of any new flight plan or modification of an existing flight plan requires positive action by the flight crew. Guidance output is not affected until the flight plan or its modification is activated. Once activated, the area navigation system has the capacity to execute the flight plan.

AMC1 ACNS.C.PBN.230 Flight plan management

(a) The area navigation system should be capable of displaying:

(1) the along-track distance between any flight plan waypoints;

(2) the distance to go to any waypoint selected by the flight crew;

(3) the actual waypoint details.

(b) The area navigation system should enable modification of any flight plan, or flight plan segment, including procedures that were loaded from the on-board navigation database, except for final approach segment (FAS) data blocks protected by a cyclic redundancy check (CRC) code.

(c) The area navigation system should allow the creation and insertion of pilot-defined fixes and related data.

(d) Consideration should be given to the number of fixes that a system allows to be stored during flight planning. It is recommended that sufficient storage for the anticipated flight plan be provided. This is intended to encourage systems to have the capacity to store a large, complex flight plan (e.g. a flight plan containing SIDs/DPs, the en-route segments, STARs, and approach procedures).

Installation of equipment with an ETSO authorisation against ETSO-C115d is considered to meet the criteria of (b), (c), and (d). It also supports item (a); however, the applicant should ensure the flight deck interface complies with the CS.

Installation of equipment with an ETSO authorisation against ETSO-C146c is considered to meet the criteria of (a) through (d).

CS ACNS.C.PBN.235 Automatic leg sequencing

(See AMC1 ACNS.C.PBN.235)

The area navigation system has the capability to automatically sequence legs and display the sequencing to the flight crew in a readily visible manner.

AMC1 ACNS.C.PBN.235 Automatic leg sequencing

Installation of equipment with an ETSO authorisation against ETSO-C115d and ETSO-C146c satisfies the requirement.

CS ACNS.C.PBN.240 Route/procedure extraction and loading

(See AMC1 ACNS.C.PBN.240)

The area navigation system has the capability to extract routes/procedures from the on-board navigation database, including all their characteristics, and to load them into the area navigation system's flight plan.

AMC1 ACNS.C.PBN.240 Route/procedure extraction and loading

Installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

The installation of equipment with an ETSO authorisation against ETSO-C146c largely satisfies the CS requirement; however, the applicant should ensure that both altitude and speed constraints are extracted from the database.

CS ACNS.C.PBN.245 Path definition and leg transition

(See AMC1 ACNS.C.PBN.245 and GM1 ACNS.C.PBN.245)

(a) The area navigation system allows flight crew to define the flight path for the intended route.

(b) The area navigation system has the capability to maintain tracks consistent with the following path terminators:

  (1) direct to fix (DF), track to a fix (TF), initial fix (IF), fix to an altitude (FA), and course to a fix (CF);

  (2) heading to an altitude (VA), heading to a manual termination (VM), and heading to an intercept (VI);

  (3) course to an altitude (CA), and from a fix to a manual termination (FM).

(c) The area navigation system has the capability to automatically execute leg transitions and maintain tracks consistent with the path terminators listed above, combined with the capability to execute fly-by turns.

(d) Unless otherwise specified in the on-board navigation database, the area navigation system constructs the flight path between waypoints in the same manner as a TF leg.

AMC1 ACNS.C.PBN.245 Path definition and leg transition

Installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirements.

Installation of equipment with an ETSO authorisation against ETSO-C146c satisfies the requirements of (a), (b)(1), (c) and (d).

Where the area navigation system does not support an automatic execution of VA, VM and VI path terminators, the applicant should demonstrate that the aircraft can be manually flown on a heading to intercept a course or to go direct to another fix after reaching a procedure-specified altitude.

Where the area navigation system does not support an automatic execution of CA and FM path terminators, the applicant should demonstrate that the area navigation system allows the flight crew to readily designate a waypoint and select a desired course to or from a designated waypoint.

GM1 ACNS.C.PBN.245 Path definition and leg transition

Path terminators and leg transitions are defined in Aeronautical Radio, Inc. (ARINC) 424 documents, and their application is described in more detail in EUROCAE ED-75D and ED-77 (RTCA documents DO-236B and DO-201A).

CS ACNS.C.PBN.250 'Direct-to' function

(See AMC1 ACNS.C.PBN.250)

The area navigation system has the capability to generate and execute a geodesic path to any designated fix, at any time, without 'S-turning' and without undue delay, known as 'direct-to' function.

AMC1 ACNS.C.PBN.250 'Direct-to' function

Installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c satisfies the requirement.

CS ACNS.C.PBN.255 Magnetic variation

(See AMC1 ACNS.C.PBN.255 and GM1 ACNS.C.PBN.255)

(a) The area navigation system has the capability to assign a magnetic variation (MAGVAR) at any location within the region where flight operations are conducted using magnetic north as reference.

(b) For paths defined by a course, the area navigation system uses the appropriate magnetic variation value available in the navigation database.

(c) The conditions under which the magnetic variation data is updated are included in the aircraft's Instructions for Continued Airworthiness (ICA).

AMC1 ACNS.C.PBN.255 Magnetic variation

Installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c satisfies the requirement; however, the applicant still needs to include the conditions for updating the magnetic variation table in the aircraft's Instructions for Continued Airworthiness (ICA).

GM1 ACNS.C.PBN.255 Magnetic variation

Further guidance on the application of magnetic variation can be found in EUROCAE ED-77/RTCA DO-201A.

The most accurate magnetic variation value is usually provided by the database. For flight path segments that require magnetic course information, a common source of magnetic variation or a standardised magnetic variation selection provide repeatability among aircraft for the flight paths flown.

CS ACNS.C.PBN.260 RNAV holding

(See AMC1 ACNS.C.PBN.260)

(a) The area navigation system has the capability to initiate, maintain and discontinue holding procedures at any point and at all altitudes. When a holding procedure is initiated, the area navigation system:

(1) changes automatic waypoint sequencing to manual;

(2) permits the flight crew to readily select a desired course to or from the holding waypoint;

(3) retains all subsequent waypoints in the active flight plan in the same sequence;

(4) permits the flight crew to readily initiate the return to automatic waypoint sequencing at any time prior to the holding waypoint and continue with the existing flight plan.

(b) The area navigation system allows for manual or automatic definition of the holding pattern.

AMC1 ACNS.C.PBN.260 RNAV holding

Installation of equipment with an ETSO authorisation against ETSO-C115d Class A satisfies the requirement to define the holding pattern (section (b)).

CS ACNS.C.PBN.265 User-defined routes and fixes

(See AMC1 ACNS.C.PBN.265 and GM1 ACNS.C.PBN.265)

The area navigation system provides a means to the flight crew to build a user-defined route by:

(a) entering unique waypoints extracted from the on-board navigation database;

(b) manually creating user-defined fixes.

AMC1 ACNS.C.PBN.265 User-defined routes and fixes

Installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c satisfies the requirement.

GM1 ACNS.C.PBN.265 User-defined routes and fixes

User-defined fixes are usually defined via the entry of latitude/longitude, place/along-track, place/bearing-place/bearing, and place/bearing/distance.

CS ACNS.C.PBN.270 Navigation accuracy

(See AMC1 ACNS.C.PBN.270)

(a) The area navigation system is capable of acquiring and setting the RNP value for each segment of a route or procedure flown from the on-board navigation database.

(b) When an aircraft flies an RNP route or procedure and the RNP value changes to a lower value, the area navigation system completes the change prior to reaching the leg with the lower RNP value, considering the latency of the monitoring and alerting function of the area navigation system.

AMC1 ACNS.C.PBN.270 Navigation accuracy

(a) The RNP value associated with a leg or segment should be assigned in the following order of precedence:

(1) Flight crew manually entered RNP value for the leg or segment;

(2) The RNP value coded in the on-board navigation database for the current leg or segment;

(3) The RNP value coded in the on-board navigation database for the current area;

(4) A system default RNP value if provided by the area navigation system.

(b) Installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c satisfies the requirement.

Display of navigation data

CS ACNS.C.PBN.275 Display and entry of navigation data — resolution

(See AMC1 ACNS.C.PBN.275)

The area navigation system displays and allows manual entry of navigation data with a resolution that supports the intended operation.

AMC1 ACNS.C.PBN.275 Display and entry of navigation data — resolution

Installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c satisfies the requirement.

CS ACNS.C.PBN.280 Deviation display

(See AMC1 ACNS.C.PBN.280 and AMC2 ACNS.C.PBN.280)

The area navigation system continuously displays, in each flight crew's optimum field of view, the defined path and the deviation from that path.

AMC1 ACNS.C.PBN.280 Deviation display

An acceptable means of compliance is to provide a non-numeric deviation display. The full-scale deflection of the non-numeric lateral deviation display should be:

(a) comparable with the applicable RNP value; and

(b) made available to the flight crew.

The full-scale deflection of the non-numeric deviation display should be set in the following manner and priority:

(a) automatically to a value obtained from the on-board navigation database; or

(b) automatically by default logic; or

(c) manually by flight crew procedure subject to human factor assessment performed by the applicant.

If the manually entered value is lower than the value obtained from the database, then the manually entered value should be applied.

Alternatively, subject to EASA agreement, a moving map display with appropriate map scales, and which provides sufficiently equivalent functionality to a non-numeric lateral deviation display, may be accepted. EASA agreement will be based on a human factor and workload assessment performed by the applicant.

AMC2 ACNS.C.PBN.280 Deviation display

When used to conduct a departure procedure off the runway, the area navigation system should display lateral deviations not later than when reaching 50 feet above the departure runway. Installation of equipment with an ETSO authorisation against ETSO-C115d supports this.

CS ACNS.C.PBN.285 Display of active waypoint

(See AMC1 ACNS.C.PBN.285 and AMC1 ACNS.C.PBN.285)

The area navigation system displays in the flight crew's maximum field of view:

(a) the identification of the active (To) waypoint;

(b) the distance, estimated time of arrival at and bearing to the active (To) waypoint.

AMC1 ACNS.C.PBN.285 Display of active waypoint

The installation of equipment with an ETSO authorisation against ETSO-C146c largely satisfies the CS requirement; however, the applicant should ensure that both distance to, and estimated time of arrival at, the active waypoint are available to the flight crew.

AMC2 ACNS.C.PBN.285 Display of active waypoint

Where the requirement for a display located in the maximum field of view is impracticable and subject to EASA agreement, the display of the data on a page on a multifunction control and display unit (MCDU), readily accessible to the flight crew, may be accepted for type-certification application against RNP 4 or RNP 2. EASA agreement will be based on a human factor and workload assessment performed by the applicant.

CS ACNS.C.PBN.290 Display of ground speed

(See AMC1 ACNS.C.PBN.290)

The area navigation system displays the ground speed in the flight crew's maximum field of view.

AMC1 ACNS.C.PBN.290 Display of ground speed

The installation of equipment in the flight crew's maximum field of view with an ETSO authorisation against ETSO-C146c satisfies the requirement.

CS ACNS.C.PBN.2100 Selected course

(See AMC1 ACNS.C.PBN.2100)

The selected course is:

(a) displayed in the flight crew's optimum field of view; and

(b) automatically slaved to the system computed path.

AMC1 ACNS.C.PBN.2100 Selected course

A moving map display is an acceptable means of compliance.

Where the requirement for a course selector slaved to the area navigation system is impracticable, and subject to EASA agreement, a course selector not slaved to the area navigation system associated with adequate operational procedures may be accepted for type-certification application against RNP 2, RNP 1 or RNP APCH. The applicant should provide a human factor and workload assessment.

Note: The alleviation provided above is intended to address particular concerns on small CS-23, Level 1, 2 and 3 aircraft.

CS ACNS.C.PBN.2105 Display of altitude/speed constraints

The area navigation system displays altitude and speed constraints to the flight crew in the maximum field of view.

CS ACNS.C.PBN.2110 Display of navigation aid frequencies and/or identifiers

The area navigation system has the capability to display on a page which is readily available to the flight crew:

(a) the GNSS constellation(s);

(b) the frequencies and/or identifiers of the ground positioning navigation aids selected;

(c) except where specified in the FAS data block for approach procedures, the SBAS service provider in use.

Navigation database

CS ACNS.C.PBN.2115 Use of navigation database

(See AMC1 ACNS.C.PBN.2115 and GM1 ACNS.C.PBN.2115)

The area navigation system uses an on-board navigation database which:

(a) is protected against flight crew modification of the stored data; and

(b) has a capacity appropriate for the intended operation.

AMC1 ACNS.C.PBN.2115 Use of navigation database

The installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146C largely satisfies the CS requirement. The applicant should ensure that the database capacity is appropriate for the intended operation and that it contains:

(a) aerodromes and their associated information (name, location, etc.);

(b) relevant ground navigation aids and their associated information (e.g. identifier, location, channel, frequency);

(c) relevant procedures for the intended operation (e.g. routes, standard instrument departure, standard instrument arrival route, approach procedures, holding patterns) and their associated information (e.g. coding of the desired path, designation of the RNP);

(d) waypoints included in the procedures mentioned above with their associated information (e.g. identifier, latitude and longitude) and altitude and/or speed constraints.

GM1 ACNS.C.PBN.2115 Use of navigation database

The on-board navigation database should have a capacity that is consistent with the intended use of the aircraft. The database of a regional aircraft may contain data for a given region only, whereas the database of a long-range aircraft may contain worldwide data.

CS ACNS.C.PBN.2120 Data quality requirements (DQRs)

(See AMC1 ACNS.C.PBN.2120)

The applicant ensures that the DQRs associated with the navigation database have been defined and are compatible with the intended function through formal arrangements signed with the corresponding data services provider(s) (DAT provider).

AMC1 ACNS.C.PBN.2120 Data quality requirements (DQRs)

Since database process assurance levels are normally addressed at equipment design level, the applicant should verify with the equipment manufacturer that the DQRs have been established and provided to the navigation database provider(s). Formal arrangements should also ensure that deficiencies and/or errors detected by the DAT provider can be reported to the applicant, whenever DQRs could be compromised.

Documentation that these data quality requirements are valid at aircraft level must be confirmed during the airworthiness approval.

CS ACNS.C.PBN.2125 Extraction and display of navigation data

(See AMC1 ACNS.C.PBN.2125)

The area navigation system has the means to:

(a) process the data with the resolution provided by the database;

(b) enable flight crew to:

 (1) verify the validity period of the on-board navigation database;

 (2) load from the on-board navigation database, by its unique identifier, the procedure(s) to be flown.

AMC1 ACNS.C.PBN.2125 Extraction and display of navigation data

The installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c satisfies the requirement.

Monitoring and alerting

CS ACNS.C.PBN.2130 Alerting associated with degradation of navigation

(See AMC1 ACNS.C.PBN.2130)

When the area navigation system is unable to maintain the RNP value, the area navigation system provides, without undue delay, an indication in the flight crew's optimum field of view.

AMC1 ACNS.C.PBN.2130 Alerting associated with degradation of navigation

The alerting requirement is largely satisfied by installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c; however, the applicant should ensure that the alert is appropriately indicated in the flight crew's optimum field of view, and assess any processing delays caused by the aircraft flight deck alerting system.

Where the requirement for an indication in the flight crew's optimum field of view is impracticable and subject to EASA agreement, display of the alert in the flight crew's maximum field of view may be accepted for type-certification application against RNP 4, RNP 2 or RNP 1. The applicant should support the deviation by providing a human factor and workload assessment.

Note: The alleviation provided above is intended to address particular concerns on smaller aircraft, for example, CS-23, Level 1, 2 and 3 aircraft.

CS ACNS.C.PBN.2135 Navigation accuracy alerting

(See AMC1 ACNS.C.PBN.2135)

The area navigation system provides an annunciation if a manually entered RNP value is greater than the RNP value associated with the current routes and procedures as defined in the on-board navigation database. Any subsequent reduction of the RNP value reinstates this annunciation.

AMC1 ACNS.C.PBN.2135 Navigation accuracy alerting

Installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the CS criteria; however, the applicant should ensure the flight deck interface complies with the CS.

This CS is typically not relevant for equipment with an ETSO authorisation against ETSO-C146c.

However, if equipment with an ETSO authorisation against ETSO-C146c provides a facility to the flight crew to enter the RNP value, then this alerting mechanism should be implemented as well.

Note: This functionality is not part of the functionalities specified in RTCA Document DO-229D (MOPS).

PERFORMANCE CRITERIA

Lateral performance

CS ACNS.C.PBN.2140 Lateral navigation accuracy

(See AMC1 ACNS.C.PBN.2140)

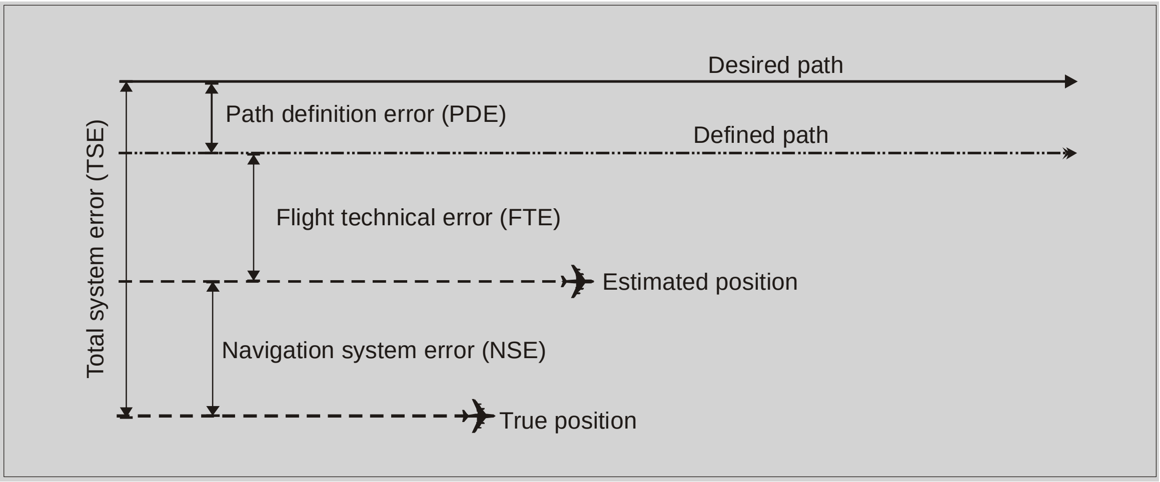
The lateral navigation accuracy provided by the area navigation system supports the intended operations.

AMC1 ACNS.C.PBN.2140 Lateral navigation accuracy

The lateral navigation accuracy is the lateral total system error (TSE) and should be calculated as the combination of the path definition error (PDE), the flight technical error (FTE) and the navigation system error (NSE) — see **Figure 2** below. Assuming that these three errors are Gaussian and independent, the distribution of TSE is also Gaussian with a standard deviation equal to the root sum square (RSS) of the standard deviations of these three errors:

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

Figure 2: Lateral errors



The cross-track and along-track lateral TSE of the aircraft area navigation system should be within ± one time the value (in NM) of the required navigation performance (RNP), which depends on the phase of flight (see **Table 2** below), for at least 95 % of the flight time.

Table 2: RNP values (in NM) by navigation specification

PBN navigation specification	*Flight phase*							
	En-route oceanic/remote	*En-route continental*	*Arrival*	*Approach*				*Departure*
				Initial	*Intermediate*	*Final*	*Missed*	
RNP 4	4							
RNP 2	2	2						
RNP 1			1	1	1		1	1
Advanced RNP (A-RNP)	2	2 or 1	1	1	1	0.3	1	1
RNP APCH				1	1	0.3	1	
RNP AR				1–0.1	1–0.1	0.3–0.1	1–0.1	1–0.3
RNP 0.3		0.3	0.3	0.3	0.3		0.3	0.3

Table 3 below indicates the allowable 'FTE credit' for various RNP operations when using autopilot, flight director, or manual flight control. The applicant may use these FTE values toward meeting TSE for the desired RNP operation without further demonstration or evaluation. The applicant may use different FTE values provided they can demonstrate:

(a) that the proposed FTE is achievable; and

(b) that the TSE performance criteria are met (see **Table 2** above).

Table 3: Lateral FTE credit

Targeted RNP value (TSE) in NM	FTE credit in NM	FTE Basis
0.3	0.125	Autopilot
	0.25	Flight director or manual operation
1.0	0.5	Autopilot or flight director
	0.5	Manual operation
2.0	1.0	Manual operation
4.0	1.0	Manual operation

The PDE may be neglected when the area navigation system internal resolution is equal to or better than the resolution of the path data source.

Otherwise, the PDE should be estimated by taking into account all sources of potential error (fix coordinates, radius values, course definition, magnetic variation resolution, altitude/height resolution, etc.) as described in EUROCAE ED-75D Section 3.2.

The flight time duration considered for demonstrating INS/IRU sensor lateral position accuracy performance (NSE) should be commensurate with the aircraft's maximum design range and taking into account automatic updates of position from other aircraft position sensors when available.

The area navigation system should estimate the NSE of DME/DME sensor based on the formula provided in DO-283B Appendix C § 3.1.2. As such, installation of equipment with an ETSO authorisation against ETSO-C115d is an acceptable means of compliance.

For systems integrating INS/IRU with GNSS, the flight time duration considered for demonstrating INS/IRU sensor lateral position accuracy performance (NSE) should consider the aircraft's maximum design range, taking into account automatic updates of position from other aircraft position sensors when available.

Note: On-board performance monitoring and alerting compliance does not imply automatic monitoring of FTE. The on-board monitoring and alerting function should at least consist of an NSE monitoring and alerting algorithm and a lateral deviation display that enables the flight crew to monitor the FTE.

CS ACNS.C.PBN.2145 Area navigation system design — integrity

(See AMC1 ACNS.C.PBN.2145)

The area navigation system, including position sensors, displays, etc., is designed to provide a level of integrity that supports the intended operation.

AMC1 ACNS.C.PBN.2145 Area navigation system design — integrity

The area navigation system, including position sensors, displays, etc., is designed to provide a level of integrity that supports the classification of failure conditions defined in Table 4 below.

Table 4: Area navigation system failure conditions — Integrity

Failure condition	Classification
Presentation of erroneous lateral position or guidance	MAJOR
Presentation of erroneous along-track distance	MINOR

CS ACNS.C.PBN.2150 Area navigation system design — continuity

(See AMC1 ACNS.C.PBN.2150)

The area navigation system, including position sensors, displays, etc., is designed to provide a level of continuity that supports the intended operation.

AMC1 ACNS.C.PBN.2150 Area navigation system design — continuity

Loss of the capability of the area navigation system to provide lateral position or guidance is considered a MAJOR failure condition.

Subsection 3 — Supplementary specifications for lateral navigation in final approach

APPLICABILITY

CS ACNS.C.PBN.301 Applicability

(See GM1 ACNS.C.PBN.301)

Subsection 3 provides the supplementary functional and performance criteria that are applicable to the lateral navigation function for the final approach segment; these criteria are necessary to obtain certification credit against the RNP specifications that support approach operations (i.e. A-RNP, RNP APCH and RNP AR APCH).

GM1 ACNS.C.PBN.301 Applicability

The lateral navigation capabilities of area navigation systems that are required to support initial, intermediate and missed approach segments of an approach procedure are described in Subsection 2.

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.305 Final approach intercept

(See AMC1 ACNS.C.PBN.305 and GM1 ACNS.C.PBN.305)

The area navigation system has the capability to intercept the final approach course at or before the final approach fix or the final approach point.

AMC1 ACNS.C.PBN.305 Final approach intercept

The installation of equipment with an ETSO authorisation against ETSO-C146c, Class Gamma, satisfies the requirement.

GM1 ACNS.C.PBN.305 Final approach intercept

The capability to intercept the final approach provides the pilot with the ability to capture the published final approach track following a period when the aircraft has been flown manually, or in autopilot/automatic flight control system heading mode, following ATC vectors to support final approach sequencing.

Display of navigation data

CS ACNS.C.PBN.310 Approach mode indication

The area navigation system provides unambiguous indications in the flight crew’s maximum field of view that enables the flight crew to readily identify:

(a) the applicable line of minima for the approach that has been selected; and

(b) whether the guidance is angular or linear.

CS ACNS.C.PBN.315 Lateral deviation display

(See AMC1 ACNS.C.PBN.315)

The area navigation system continuously displays on a non-numeric lateral deviation display, in each flight crew's optimum field of view, the extended flight path and the deviation from that path.

AMC1 ACNS.C.PBN.315 Lateral deviation display

The deviation indicators on the non-numerical lateral display should appear in a timely fashion to allow the flight crew to intercept the final approach segment.

CS ACNS.C.PBN.320 Non-numeric lateral deviation display scaling for approach

(See AMC1 ACNS.C.PBN.320)

The full-scale deflection of the non-numeric lateral deviation display supports the applicable track-keeping accuracy required for the approach.

AMC1 ACNS.C.PBN.320 Non-numeric lateral deviation display scaling for approach

(a) When linear lateral deviation is provided, the full-scale deflection of the non-numeric deviation display should not exceed two times the RNP value.

(b) When angular lateral deviation is provided:

  (1) installation of equipment with an ETSO authorisation against ETSO-C146c operational class 1, 2 or 3 satisfies the requirement; or

  (2) the full-scale deflection of the non-numeric deviation display should allow the aircraft to remain within the boundaries of (a) above.

CS ACNS.C.PBN.325 Display of distance to threshold

The area navigation system continuously displays in the flight crew's maximum field of view the along-track distance to the landing threshold point/fictitious threshold point (LTP/FTP) after passing the final approach fix/final approach point.

SUPPLEMENTARY PERFORMANCE CRITERIA

Horizontal performance

CS ACNS.C.PBN.330 Area navigation system design — integrity in final approach

(See AMC1 ACNS.C.PBN.330)

The area navigation system, including position sensors, displays, etc., is designed to provide a level of integrity that supports the intended operations.

AMC1 ACNS.C.PBN.330 Area navigation system design — integrity in final approach

The area navigation system, including position sensors, displays, etc., should be designed to provide a level of integrity that supports the classification of failure conditions defined in Table 5 below.

Table 5: Area navigation system failure conditions — integrity in final approach

Intended operations **Failure condition**	RNP APCH down to LNAV or LNAV/VNAV minima Classification (not RNP AR APCH)	RNP APCH down to LP or LPV minima Classification
Presentation of erroneous lateral position or guidance	MAJOR	HAZARDOUS
Presentation of erroneous along-track distance	MAJOR	MAJOR

Note: For RNP AR APCH, specific criteria apply; reference is made to Subsection 6.

Subsection 4 — Supplementary specifications for advisory vertical navigation

APPLICABILITY

CS ACNS.C.PBN.401 Applicability

(See GM1.ACNS.C.PBN.401)

This Subsection provides the supplementary requirements that support the use of advisory vertical navigation which is intended to reduce flight crew workload and may support continuous descent operations. The capability to provide advisory VNAV may optionally be associated with the following navigation specifications: RNP 1, RNP 0.3, RNP APCH and A-RNP.

GM1 ACNS.C.PBN.401 Applicability

(See CS ACNS.C.PBN.401)

Advisory vertical guidance does not provide approved vertical guidance deviation indications for operational credit. Advisory vertical guidance may be provided for en-route and terminal operations as well as on approaches without a published vertical path (i.e. approaches to LNAV or LP minima), whereas vertical guidance provided on approach procedures to LNAV/VNAV or LPV minima is approved for operational credit.

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.405 Vertical path

The area navigation system has the capability to define a vertical path to a fix.

CS ACNS.C.PBN.410 Altitude constraints

(See AMC1 ACNS.C.PBN.410)

Where barometric altimetry is used as the source for vertical guidance, the area navigation system has the capability to specify a vertical path between altitude constraints at two fixes in the flight plan.

AMC1 ACNS.C.PBN.410 Altitude constraints

The altitude constraints should be defined as follows:

(a) an ‘AT or ABOVE’ altitude constraint;

(b) an ‘AT or BELOW’ altitude constraint;

(c) an ‘AT’ altitude constraint; or

(d) a ‘WINDOW’ altitude constraint.

The installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

CS ACNS.C.PBN.420 Pressure settings

(See GM1 ACNS.C.PBN.420)

Where barometric altimetry is used as the source for vertical guidance, the area navigation system uses the same pressure-setting input as the aircraft altimetry system.

GM1 ACNS.C.PBN.420 Pressure settings

The aircraft system should utilise a single input for the altimeter-setting so as to prevent potential flight crew errors due to different altimeter settings in the aircraft altimeter system and area navigation system.

CS ACNS.C.PBN.425 Vertical navigation (VNAV) path transitions

(See AMC1 ACNS.C.PBN.425)

Where the area navigation system is capable of automatically intercepting a vertical path, it uses a fly-by technique with a normal acceleration factor of not less than 0.03g.

AMC1 ACNS.C.PBN.425 Vertical navigation (VNAV) path transitions

The installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

Display of navigation data

CS ACNS.C.PBN.430 Vertical deviation display

(See AMC1 ACNS.C.PBN.430)

The area navigation system continuously displays, in the flight crew's optimum field of view, the defined vertical path and the deviation from that path.

AMC1 ACNS.C.PBN.430 Vertical deviation display

A non-numerical vertical deviation display with a full-scale deflection of not more than ± 500 ft is an acceptable means of compliance.

Installation of equipment with an ETSO authorisation against ETSO-C115d supports the statement above; however, the applicant should ensure the display characteristics comply with the CS.

CS ACNS.C.PBN.435 Vertical navigation (VNAV) mode indication

(See AMC1 ACNS.C.PBN.435)

Where vertical guidance is provided on procedures with no published path, the area navigation system provides, in the flight crew's optimum field of view, an unambiguous indication that the vertical guidance is advisory.

AMC1 ACNS.C.PBN.435 Vertical navigation (VNAV) mode indication

The indication should be plain and easy to interpret. The use of typographic characters (e.g. '+' or '/') as the only means to distinguish whether the vertical guidance is advisory or is referenced to in a published procedure is not considered adequate.

The aircraft fight manual (AFM), pilot operating handbook (POH) or similar documents and supplements to these documents should contain a statement informing the flight crew that, during these operations, the primary barometric altimeter should be used as the primary reference for compliance with all altitude restrictions associated with the instrument approach procedure, including compliance with all associated step-down fixes.

SUPPLEMENTARY PERFORMANCE CRITERIA

Vertical performance

CS ACNS.C.PBN.440 Vertical accuracy

(See AMC1 ACNS.C.PBN.440 and AMC2 ACNS.PBN.440)

The accuracy of the vertical position that is provided by the area navigation system, when employing advisory VNAV, supports the intended operations.

AMC1 ACNS.C.PBN.440 Vertical accuracy

When supporting VNAV with barometric altitude, the vertical total system error (TSE_Z), once all the errors in the aircraft processing chain of the vertical guidance have been taken into account, should be lower than or equal to the values specified in **Table 6** below.

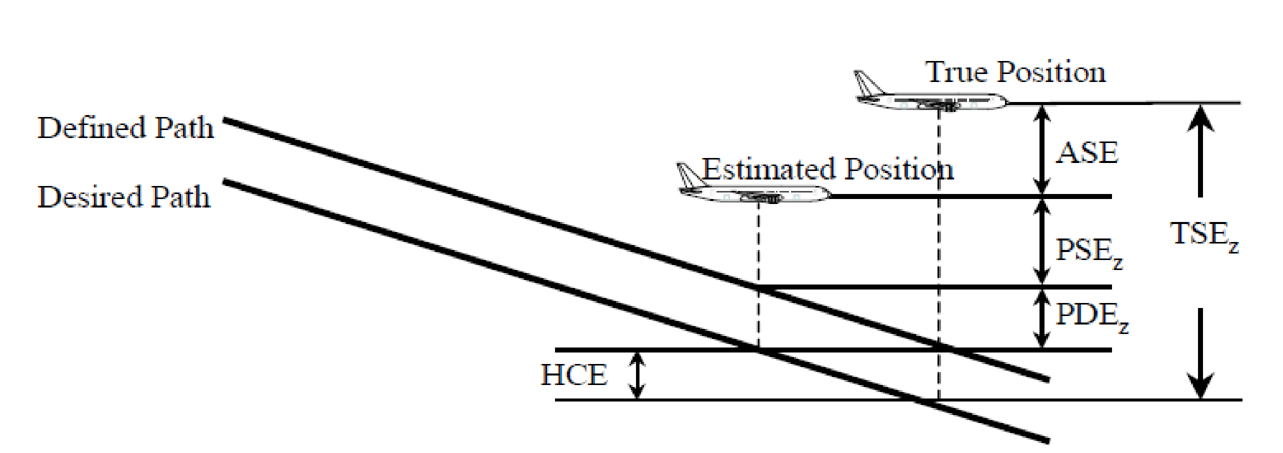
Table 6: Maximum vertical total system error (TSE_Z)

Altitude bands	Level flight segments & climb/descent intercept of clearance altitudes		Flight along specified vertical descent profile
At or below 5 000 ft MSL	150 ft		160 ft
Above 5 000 to 29 000 ft MSL	200 ft		210 ft
Above 29 000 to 41 000 ft MSL	200 ft		260 ft

TSE_Z should be calculated as the combination of the altimetry system error (ASE), the vertical path steering error (PSE_Z), the vertical path definition error (PDE_Z) and the horizontal coupling error (HCE) — see **Figure 3** below. The vertical navigation accuracy (TSEz) is expected to be achieved for at least 99.7 % of the flight time. Assuming that these four errors are Gaussian and independent, the distribution of TSE_z is also Gaussian with a standard deviation equal to the root sum square (RSS) of the standard deviations of the ASE, PSE_Z, PDE_Z, and HCE.

$$TSE_Z = \sqrt{ASE^2 + PSE_Z{}^2 + PDE_Z{}^2 + HCE^2}$$

Figure 3: Vertical errors



(a) Altimetry system error (ASE)

Altimetry system performance is demonstrated separately from the VNAV certification through the static pressure system certification process (e.g. CS XX.1325). Altimetry systems that meet such a requirement satisfy the ASE requirements for VNAV operations. No further demonstration or compliance is necessary, and the following formula should be used to calculate the ASE (in ft) as a function of the aircraft altitude H (in ft), representing the maximum value which is expected to be achieved for at least 99.7 % of the flight time.

$$ASE = -8.8 \times 10^{-8} \times H^2 + 6.5 \times H + 50$$

(b) Vertical path definition error (PDE_Z)

VNAV path definition error is the error associated to the vertical path computation. It includes path definition error (PDE) and the approximation made by the VNAV equipment for the vertical path construction, if any. This is addressed through equipment approval (ETSO).

(c) Horizontal coupling error (HCE)

HCE (vertical error component of along-track positioning error) is a function of the horizontal NSE and is directly reflected in the along-track tolerance offset used in BARO-VNAV procedure design criteria. The HCE should only be taken into account in the final approach segment.

HCE is expected to be achieved for at least 99.7 % of the flight time and, in this context, may be assumed to be equal to 24 ft on a vertical path of 3°.

(d) Vertical path steering error (PSE_Z)

PSE_Z is the vertical path steering performance which varies depending on how operations are conducted (manual, flight director, or autopilot). Use of a flight director or autopilot may be required to support the PSE_Z requirement in certain conditions. In this case, the area navigation system coupling to the flight director and/or autopilot should be unambiguously displayed in the flight crew's primary field of view. This should also be documented in the AFM.

(e) Vertical path error at final approach fix (FAF) due to the vertical fly-by transition

Error due to the capture of the vertical path starting from the FAF altitude should be limited. This momentary deviation below the published procedure minimum altitude at the FAF is acceptable provided the deviation is limited to no more than 50 feet (assuming no VNAV equipment error).

Further guidance can be found in ED-75D § 1.7.2.2, pertaining to vertical components of navigation error terms.

AMC2 ACNS.C.PBN.440 Vertical accuracy

When using SBAS/GNSS geometric altitude sources, the installation of equipment with an ETSO authorisation against ETSO-C146c, Class Gamma, satisfies the requirement.

CS ACNS.C.PBN.445 Advisory vertical navigation (VNAV) in final approach

Where vertical guidance is provided for procedures with no published vertical path:

(a) the advisory vertical guidance is selectable prior to the final approach fix (FAF);

(b) after the FAF, the area navigation system does not automatically transition from one source of altitude to another (e.g. from barometric altitude to SBAS/GNSS geometric altitude);

(c) the advisory vertical guidance is readily deselectable.

Subsection 5 — Supplementary specifications for vertical navigation in final approach

APPLICABILITY

CS ACNS.C.PBN.501 Applicability

(See GM1 ACNS.C.PBN.501)

Subsection 5 provides the supplementary functional and performance criteria that are applicable to vertical navigation function for final approach.

GM1 ACNS.C.PBN.501 Applicability

This Subsection sets out the certification specifications for systems that use either a barometric source of vertical position (BARO-VNAV) or a GNSS space-based augmented source of vertical position (SBAS-VNAV) on procedures where vertical guidance is based on a published vertical path to LNAV/VNAV or LPV minima respectively.

The vertical performance of systems that comply with CS ACNS.C.PBN.565 is not adequate to support RNP AR APCH operations, but the requirements contained in CS ACNS.C.PBN.660 should be applied instead.

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.505 Vertical path

The area navigation system has the capability to define a vertical path to a fix.

CS ACNS.C.PBN.510 Altitude constraints

(See AMC1 ACNS.C.PBN.510)

The area navigation system has the capability to specify a vertical path between altitude constraints at two fixes in the flight plan.

AMC1 ACNS.C.PBN.510 Altitude constraints

The altitude constraints should be defined as follows:

(a) an 'AT or ABOVE' altitude constraint;

(b) an 'AT or BELOW' altitude constraint;

(c) an 'AT' altitude constraint; or

(d) a 'WINDOW' altitude constraint.

AMC1. ACNS.C.PBN.510 Altitude constraints

The installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

CS ACNS.C.PBN.515 Pressure settings

(See GM1 ACNS.C.PBN.515)

Where barometric altimetry is used as the source for vertical guidance, the area navigation system uses the same pressure-setting input as the aircraft altimetry system.

GM1 ACNS.C.PBN.515 Pressure settings

The aircraft system should utilise a single input for the altimeter-setting so as to prevent potential flight crew errors due to different altimeter settings in the aircraft altimeter system and area navigation system.

CS ACNS.C.PBN.520 Glide path intercept

(See AMC1 ACNS.C.PBN.520 and GM1 ACNS.C.PBN.520)

The area navigation system has the capability to automatically intercept the final approach glide path.

AMC1 ACNS.C.PBN.520 Glide path intercept

The area navigation system should allow the final approach fix (FAF) to be intercepted using a fly-by technique with a normal acceleration factor of not less than 0.03g.

The installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

GM1 ACNS.C.PBN.520 Glide path intercept

The capability to intercept the final approach provides the flight crew with the ability to rejoin the published final approach track following a period when the aircraft has been flown manually, or in autopilot /automatic flight guidance system heading mode, following ATC vectors to support final approach sequencing.

CS ACNS.C.PBN.525 Temperature compensation

(See AMC1 ACNS.C.PBN.525)

Except for systems that are intended to operate equivalent to an instrument landing system (ILS), area navigation systems that use a barometric source for vertical position provide:

(a) a selectable means to enable cold temperature compensation automatically from the initial approach fix to the missed approach holding fix;

(b) a clear and distinct indication to the flight crew when this function is activated.

AMC1 ACNS.C.PBN.525 Temperature compensation

The area navigation system should provide a temperature compensation capability for the vertical path. The area navigation system should comply with EUROCAE ED-75D, Appendix H.2.

The capability to provide automatic temperature compensation is not required to obtain an ETSO authorisation against ETSO C115d. Consequently, the applicant should ensure that this function has been implemented into the area navigation system.

Display of navigation data

CS ACNS.C.PBN.530 Vertical deviation display

(See GM1 ACNS.C.PBN.530)

The area navigation system continuously displays, on the non-numeric vertical deviation display located in the flight crew's optimum field of view, the defined vertical path and the deviation from that path.

GM1 ACNS.C.PBN.530 Vertical deviation display

Deviations from the defined path should be displayed in a timely fashion to support the flight crew to intercept the final approach segment.

CS ACNS.C.PBN.535 Resolution and full-scale deflection of the vertical deviation display

(See AMC1 ACNS.C.PBN.535)

The vertical deviation display has a resolution and a full-scale deflection that suitably supports the monitoring and bounding of the vertical deviation.

AMC1 ACNS.C.PBN.535 Resolution and full-scale deflection of the vertical deviation display

Installation of equipment with an ETSO authorisation against ETSO-C115d or ETSO-C146c supports the requirement of the CS; however, the applicant should ensure that the display characteristics comply with the CS.

The area navigation system should provide a non-numerical vertical deviation display with a full-scale deflection of ± 150 ft. In addition, the display should provide the flight crew with an easy way to readily identify a path deviation of 75 ft using the vertical deviation display alone, i.e. provide clear markings at + 75 ft and at – 75 ft.

Note: Subject to EASA agreement, the use of a scale of other than ± 150 ft may be accepted provided that the scaling is suitable to control the aircraft on the intended path and the 75-ft deviation can be easily identified by the flight crew. The applicant should provide a human factor and workload assessment as well as relevant operating procedures that ensure that the aircraft's deviation from the path can be monitored and bounded within the ± 75-ft interval, supporting this deviation.

Systems that use angular vertical scaling should meet the following:

(a) The deviation scaling suitably supports the flight technical error (FTE) monitoring and bounding (75-ft deviation);

(b) The deviation limits are equivalent to the operational limits for glideslope deviations during an ILS approach.

It may be required to limit the length of the approach to exclude operating where the angular deviations no longer support monitoring and bounding of the FTE.

Vertical deviation displays that rely on the flight crew to assess the deviation based on whether or not the pointer still touches a marker are not considered acceptable.

A vertical situation display is not considered to satisfy the requirements.

CS ACNS.C.PBN.540 Barometric altitude

When the approach is supported by barometric altitude sources, the aircraft displays the barometric altitude from two independent altimetry sources:

(a) one in each of the flight crew's optimum field of view, if the required minimum flight crew is two; or

(b) one in the flight crew's optimum field of view and the other visible from the flight crew's normal position, if the required minimum flight crew is one.

CS ACNS.C.PBN.545 Active approach mode display

The area navigation system provides an unambiguous indication in the flight crew's maximum field of view that enables the flight crew to identify the active source for the vertical guidance, barometric altitude or SBAS/GNSS geometric altitude.

Monitoring and alerting

CS ACNS.C.PBN.550 Glide path alerting

(See AMC1 ACNS.C.PBN.550)

For approaches to LPV minima, aircraft equipped with a Class A TAWS provide an alert for excessive deviation below the glide path.

AMC1 ACNS.C.PBN.550 Glide path alerting

The excessive-deviation-below-the-glide-path alert may be provided by another system other than the TAWS. If this is the case, the alert should have equivalent effect to the Mode 5 alert provided by a Class A TAWS system.

SUPPLEMENTARY PERFORMANCE CRITERIA

Vertical performance

CS ACNS.C.PBN.555 Vertical accuracy when using barometric altitude sources

(See AMC1 ACNS.C.PBN.555)

The accuracy of the vertical position that is provided by the area navigation system when using a barometric vertical position source supports the intended operations.

AMC1 ACNS.C.PBN.555 Vertical accuracy when using barometric altitude sources

When supporting VNAV, the vertical total system error (TSE_Z), taking into account all the errors in the aircraft processing chain of the vertical guidance, should be lower than or equal to the values specified in **Table 7** below.

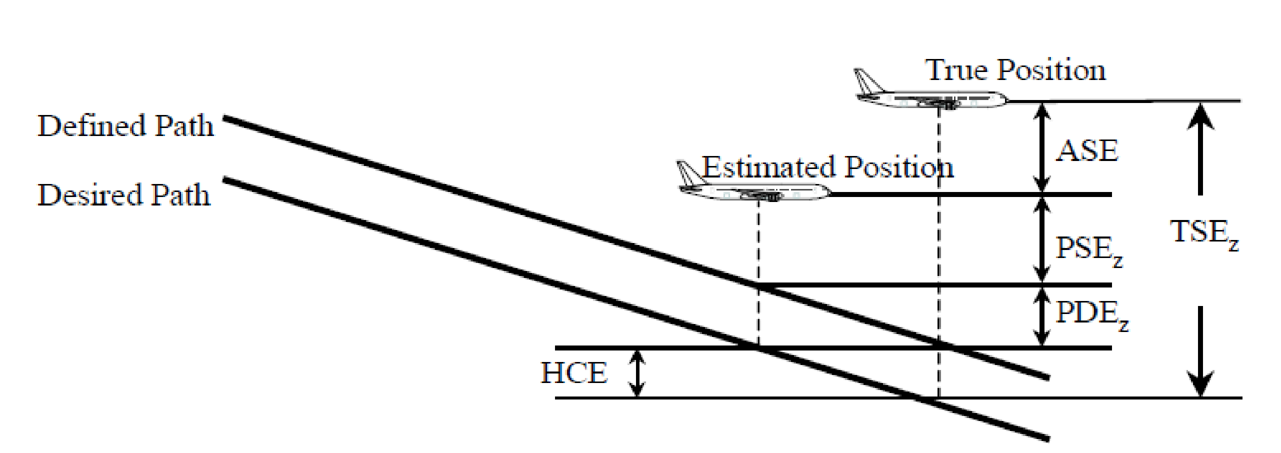
Table 7: Maximum vertical total system error (TSE_Z)

Altitude bands	Level flight segments & climb/descent intercept of clearance altitudes	Flight along specified vertical descent profile
At or below 5 000 ft MSL	150 ft	160 ft
Above 5 000 to 29 000 ft MSL	200 ft	210 ft
Above 29 000 to 41 000 ft MSL	200 ft	260 ft

TSE_Z should be calculated as the combination of the altimetry system error (ASE), the vertical path steering error (PSE_Z), the vertical path definition error (PDE_Z) and the horizontal coupling error (HCE) — see **Figure 4** below. Vertical navigation accuracy (TSE_Z) is expected to be achieved for at least 99.7 % of the flight time. Assuming that these four errors are Gaussian and independent, the distribution of TSE_z is also Gaussian with a standard deviation equal to the root sum square (RSS) of the standard deviations of the ASE, PSE_Z, PDE_Z, and HCE.

$$TSE_Z = \sqrt{ASE^2 + PSE_Z{}^2 + PDE_Z{}^2 + HCE^2}$$

Figure 4: Vertical errors



(a) Altimetry system error (ASE)

Altimetry system performance is demonstrated separately from the VNAV certification through the static pressure system certification process (e.g. CS XX.1325). Altimetry systems that meet such a requirement satisfy the ASE requirements for VNAV operations. No further demonstration or compliance is necessary, and the following formula should be used to calculate the ASE (in ft) as a function of the aircraft altitude H (in ft), representing the maximum value which is expected to be achieved for at least 99.7 % of the flight time.

$$ASE = -8.8 \times 10^{-8} \times H^2 + 6.5 \times H + 50$$

(b) Vertical path definition error (PDE_Z)

VNAV path definition error is the error associated to the vertical path computation. It includes path definition error (PDE) and the approximation made by the VNAV equipment for the vertical path construction, if any. This is addressed through equipment approval (ETSO).

(c) Horizontal coupling error (HCE)

HCE (vertical error component of along-track positioning error) is a function of the horizontal NSE and is directly reflected in the along-track tolerance offset used in BARO-VNAV procedure design criteria. The HCE should only be taken into account in the final approach segment.

HCE is expected to be achieved for at least 99.7 % of the flight time and, in this context, may be assumed to be equal to 24 ft on a vertical path of 3°.

(d) Vertical path steering error (PSE_Z)

The vertical path steering performance varies depending on how operations are conducted (manual, flight director or autopilot). The use of a flight director or autopilot may be required to support the PSE_Z requirement in certain conditions. In this case, the area navigation system coupling to the flight director and/or autopilot should be unambiguously displayed in the flight crew's primary field of view. This should also be documented in the AFM.

(e) Vertical path error at final approach point (FAP) due to the vertical fly-by transition

The error due to the capture of the vertical path starting from the FAP altitude should be limited. A momentary deviation below the published procedure minimum altitude at the FAP is acceptable, provided the deviation does not exceed the values provided in **Table 8** below (assuming no VNAV equipment error).

Table 8: Maximum vertical path error at final approach point (FAP)

Ground speed (kt)	Height loss (ft)
150	23
200	40
250	63
300	91
350	124

Further guidance can be found in ED-75D, § 3.2.8.5.

CS ACNS.C.PBN.560 Vertical accuracy when using SBAS/GNSS geometric altitude sources

(See AMC1 ACNS.C.PBN.560 and GM1 ACNS.C.PBN.560)

When supporting approach operations down to LNAV/VNAV or LPV minima using SBAS/GNSS vertical position source, the accuracy of the area navigation system is demonstrated to be suitable for the intended operation.

AMC1 ACNS.C.PBN.560 Vertical accuracy when using SBAS/GNSS geometric altitude sources

The vertical total system error (TSE_Z) is dependent on the navigation system error (NSE), the path definition error (PDE_Z) and the flight technical error (FTE_Z).

(a) Navigation system error (NSE)

The NSE should be within the accuracy requirements of ICAO Annex 10, Volume 1, paragraph 3.7.2.4, to the Chicago Convention (signal-in-space performance). These NSE requirements are considered to be fulfilled without any demonstration if the equipment has been granted an ETSO authorisation against ETSO-C146c, Class Gamma.

(b) Flight technical error (FTE_Z)

FTE_Z is considered to be equivalent to the ILS approach if the angular deviations are displayed to the flight crew on the existing or comparable display, and the system meets the integration criteria of paragraph 7(a) of Appendix A to Subpart C of this CS and the SBAS/GNSS receiver has been granted an ETSO authorisation against ETSO-C146c, Class Gamma.

For flight guidance systems, the FTE_Z performance is considered acceptable if it meets the criteria of paragraph 7(a) of Appendix A to Subpart C of this CS and the SBAS/GNSS receiver has been granted an ETSO authorisation against ETSO-C146c, Class Gamma.

(c) Path definition error (PDE_Z)

For approaches to LPV minima, there are no performance or demonstration requirements for PDE_Z. PDE_Z is considered negligible based on the requirements for the FAS data block generation process.

For approaches to LNAV/VNAV minima, the applicant may assume that the PDE_Z is negligible provided that the area navigation system's internal resolution is equal to or better than the resolution provided for the path definition.

GM1 ACNS.C.PBN.560 Vertical accuracy when using SBAS/GNSS geometric altitude sources

The lateral and vertical full-scale deflection requirements detailed in RTCA DO-229D, which is the basis for ETSO-C145c/C146c, ensure an ILS 'lookalike' presentation. The deflection may be fully angular with no limitation or angular but bounded at a certain value (e.g. bounded at ± 1 NM laterally and ± 150 m vertically).

CS ACNS.C.PBN.565 Area navigation system design — integrity in final approach

(See AMC1 ACNS.C.PBN.565)

The integrity of the vertical guidance provided by the aircraft's area navigation system supports the intended operations.

AMC1 ACNS.C.PBN.565 Area navigation system design — integrity in final approach

The area navigation system, including position sensors, displays, etc., should be designed to provide a level of integrity that supports the classification of failure conditions defined in **Table 9** below.

Table 9: Area navigation system failure conditions — integrity in final approach

Intended operations **Failure condition**	RNP APCH down to LNAV or LNAV/VNAV minima Classification (not RNP AR APCH)	RNP APCH down to LP or LPV minima Classification
Presentation of erroneous vertical position or guidance	MAJOR	HAZARDOUS
Presentation of erroneous vertical and horizontal position or guidance	HAZARDOUS	HAZARDOUS

Note: For RNP AR APCH, specific criteria apply; reference is made to Subsection 6.

CS ACNS.C.PBN.570 Area navigation system design — continuity

(See AMC1 ACNS.C.PBN.570)

The continuity of vertical guidance provided by the area navigation system supports the intended operation.

AMC1 ACNS.C.PBN.570 Area navigation system design — continuity

Loss of the capability of the area navigation system to provide vertical guidance is considered a MAJOR failure condition.

Note: For RNP AR APCH, specific criteria apply; reference is made to Subsection 6.

Subsection 6 — Supplementary specifications for RNP authorisation required (RNP AR)

APPLICABILITY

CS ACNS.C.PBN.601 Applicability

Subsection 6 provides the supplementary functional and performance criteria that are applicable to obtain certification credit for RNP AR APCH. Criteria for RNP AR departures (RNP AR DP) are provided consistently with the ICAO Navigation Specification for RNP AR departures.

The criteria of this Subsection only apply to operations on RNP AR procedures designed in accordance with the requirements of ICAO Doc 9905 'Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual.

GM1 ACNS.C.PBN.601 Applicability

Compliance demonstration of aircraft eligibility for RNP AR approval is often a long and very demanding process. It requires full and unrestricted access to the aircraft's safety (i.e. the data used to support compliance with CS XX.1309), aerodynamics and performance data. Furthermore, the applicant should have, as a minimum, access to a representative simulator for prolonged periods of time. Occasionally, access to the aircraft for flight testing will be required.

An applicant that meets the conditions above and intends to apply for RNP AR approval is encouraged to contact EASA at the earliest opportunity to discuss the details of the technical and compliance demonstration.

More stringent criteria may apply to aircraft that operate with special or proprietary procedures which are not designed to conform to ICAO Doc 9905. An applicant that applies for RNP AR approval is encouraged to contact EASA at the earliest opportunity to discuss the technical details of the compliance demonstration.

SUPPLEMENTARY SYSTEM QUALIFICATION

CS ACNS.C.PBN.605 System performance demonstration

(See AMC1 ACNS.C.PBN.605 and GM1 ACNS.C.PBN.605)

The performance (including the RF function) of the aircraft's system is demonstrated under a variety of operational, meteorological and failure conditions, commensurate with the intended operation.

Criteria for assessing RNP significant failures under design limit performance conditions are the following:

(a) the lateral excursions observed as a result of probable failures are contained within a 1 × RNP corridor;

(b) the lateral excursions observed as a result of one-engine-inoperative (OEI) are contained within a 1 × RNP corridor;

(c) the lateral excursions observed as a result of remote failures are contained within a 2 × RNP corridor;

(d) a demonstration is made that the aircraft remains manoeuvrable and a safe extraction can be flown for all extremely remote failures.

For criteria (a), (b) and (c) above, the vertical excursion does not exceed 75 feet below the desired path.

AMC1 ACNS.C.PBN.605 System performance demonstration

The applicant should demonstrate the aircraft capability in terms of performance under design limit operational conditions (e.g. tailwinds and crosswinds, centre-of-gravity (CG) limits, temperature limits), and on representative procedures that include RF legs of varying radii. The applicant should also assess the effects of configuration changes (e.g. gear and flap extension and retraction).

The applicant should conduct a safety impact assessment based on the aircraft's system safety assessments (SSAs) and identify all failure conditions that could potentially impact on performance. The failure hazard analysis and system safety assessment of all the aircraft's systems that support RNP AR operations (RNAV systems, flight controls systems, flight guidance systems, displays, etc.) should therefore be revisited to identify these failures. System failures should include latent failures ('integrity') and detected failures ('continuity'). For the detected failures, the monitor limit of the alert, the time to alert, the flight crew reaction time, and the aircraft response should all be taken into account and verified to ensure that the aircraft does not exit the obstacle clearance volume.

Analogous to demonstration of robustness for systems that support autoland, the intent of this requirement is to ensure robustness of the aircraft and its systems to failure conditions. Consequently, performing a safe extraction is not an acceptable means of demonstrating compliance against the criteria of CS ACNS.C.PBN.605(a), (b) and (c). These demonstrations rely on crew action to intervene and place the aircraft back on the target track, even if in an operational environment, the crew is expected to initiate a missed approach procedure when the lateral or vertical criteria are exceeded. For compliance demonstration purposes however, executing a missed approach is not considered appropriate for demonstration of compliance with these criteria.

(a) With reference to CS ACNS.C.PBN.605(a), any failure that is classified as 'probable' and supports the RNP AR operation should be assessed. Those failures that would require the flight crew to act or intervene should be assessed in a representative environment and design limit operational conditions by the applicant's flight test pilots. The impact of the failure and the flight crew intervention should be such that the aircraft can be maintained within the 1 × RNP value and within –75 ft altitude deviation.

(b) With reference to CS ACNS.C.PBN.605(b), the same requirements apply for the case of an engine failure.

(c) With reference to CS ACNS.C.PBN.605(c), the same requirements apply, except that for the case of failures classified as 'remote' but not 'extremely remote', the impact of the failure and the flight crew intervention should be such that the aircraft can be maintained within the 2 × RNP value and within –75 ft altitude deviation.

(d) With reference to CS ACNS.C.PBN.605(d), the applicant should demonstrate that no 'extremely remote' failure limits the flight crew's ability to:

— intervene and place the aircraft back on the target track contained within the alert threshold; or

— safely extract the aircraft through manual intervention.

Safe extraction is defined as within 2 × RNP for the applicable approach and missed approach procedure. The RNP for the missed approach procedure is usually higher than the RNP for the continued approach. For extremely remote navigational failure conditions (e.g. all flight management computers (FMCs) failed), the flight crew must be able to reasonably navigate the aircraft free of obstacles by using other navigational means to follow the missed approach procedure.

For departure procedures with close-in RF legs at or just beyond the departure end of the runway, and for missed approach procedures with close-in RF legs, the retraction of the landing gear and flaps and subsequent rapid acceleration may affect the area navigation system's ability to conduct accurate turn anticipation. An inaccurate turn anticipation calculation may result in an overshoot of a close-in RF turn. When this performance characteristic is present, the applicant should consider including a limiting airspeed for the initial phase of the departure or the missed approach in the AFM. The airspeed limit should not be lower than the best-climb airspeed with one-engine-inoperative.

The severity level of the above demonstrations (failure conditions in combination with the RNP approach containment requirements), as assessed by the test pilot, must still match the probability of the applicable failure condition (ref.: CS 25.1309).

Specific evaluations should be conducted to assess path excursions upon failures and the resulting RNP levels. Results should be documented in the AFM, AFM Supplement, or any appropriate aircraft operational support document which is approved by EASA and made available to the operator. In other words: If, for example, the worst-case result of the assessments that have been conducted to demonstrate compliance for ‘remote’ failures shows that the aeroplane diverts 0.40 NM from the published track, then EASA expects that the applicant would limit the authorised RNP to 0.20 NM.

GM1 ACNS.C.PBN.605 System performance demonstration

As regards applications for RNP AR approval, the involvement of flight test pilots in this exercise has shown to be crucial. Flight crew intervention is an essential aspect of these demonstrations and on occasion it has been proven difficult for flight crews to timely recognise the failure and intervene adequately. An appropriate level of specific training for RNP AR operations may be assumed.

CS ACNS.C.PBN.610 Source of horizontal position

(See GM1 ACNS.C.PBN.610)

The area navigation system utilises the global navigation satellite system (GNSS) as primary source of horizontal position and is backed by an appropriate inertial position source.

GM1 ACNS.C.PBN.610 Source of horizontal position

Integrated global positioning system/inertial navigation system (GPS/INS) or global positioning system/inertial reference unit (GPS/IRU) position solutions reduce the rate of degradation after loss of position updating. For ‘tightly coupled’ GPS/inertial systems, RTCA/DO-229D Appendix R provides additional guidance.

INS or IRU are generally not considered suitable as a sole source of horizontal position for RNP AR applications described herein. However, it is recognised that many multi-sensor navigation systems utilise INS or IRU within their navigation calculations to provide continuity when the other higher accuracy sensor(s) is (are) momentarily unavailable.

Attitude and heading reference systems (AHRSs), including an AHRS with inputs from air-data computers, are not considered to provide a level of performance that would be adequate to support RNP AR operations.

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.615 Autopilot/Flight director

Means are provided to couple the area navigation system with the autopilot or flight director.

CS ACNS.C.PBN.620 Reversion

(See GM1 ACNS.C.PBN.620)

If the RNP cannot be maintained during a radius to fix (RF) leg, the flight guidance mode remains in lateral navigation.

GM1 ACNS.C.PBN.620 Reversion

This requirement is intended to support the flight crew in extracting the aircraft from the procedure.

CS ACNS.C.PBN.625 Go-around and missed approach

(See GM1 ACNS.C.PBN.625)

Upon initiating a go-around or missed approach, both area navigation system and the autopilot or flight director remain in lateral navigation guidance mode and continue to guide the aircraft along the lateral path of the procedure until completion of the approach and missed approach procedure.

GM1 ACNS.C.PBN.625 Go-around and missed approach

Loss of the RNP capability is considered as a condition that would require the initiation of a missed approach.

CS ACNS.C.PBN.630 Radius to fix (RF) leg transition

(See AMC1 ACNS.C.PBN.630)

The area navigation system has the capability to execute the radius to fix (RF) leg transitions and to consistently maintain tracks, as specified in Subsection 8.

AMC1 ACNS.C.PBN.630 Radius to fix (RF) leg transition

The demonstration of the RF capability should be undertaken considering:

(a) limit wind speed;

(b) turn radius;

(c) configuration changes;

(d) failure conditions.

With reference to failure conditions (d), the unique requirements on demonstration of performance under failure conditions of CS ACNS.C.PBN.605 apply.

CS ACNS.C.PBN.635 Navigation accuracy for RNP AR operations

(See AMC1 ACNS.C.PBN.635)

The area navigation system is capable of acquiring the RNP value associated with the intended operation.

AMC1 ACNS.C.PBN.635 Navigation accuracy for RNP AR operations

If the area navigation system offers multiple RNP values associated with lines of minima on an RNP AR approach procedure, the system should allow the flight crew to select the appropriate line of minima for use on the final approach segment. The system should then acquire the associated RNP value(s) for the procedure from the navigation database.

CS ACNS.C.PBN.640 RNP AR departures

The area navigation system provides the following capabilities to support RNP AR departure procedures:

(a) The area navigation system allows loading and execution of a flight plan where the initial fix of the RNP AR DP defined path is placed at or near the approach end of the take-off runway.

(b) The area navigation system provides lateral path guidance not later than when reaching 50 feet above the departure runway.

(c) The area navigation system is capable of executing an RF leg where the first fix defining the RF leg begins at the departure end of the runway.

(d) The area navigation system provides a means for the flight crew to confirm availability of GNSS for aircraft positioning immediately prior to take-off.

(e) The INS position is automatically updated upon pressing the take-off/go-around (TOGA) button or during the take-off roll.

AMC1 ACNS.C.PBN.640 RNP AR departures

The installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement (b) of CS ACNS.C.PBN.640.

Display of navigation data

CS ACNS.C.PBN.645 Display of aircraft track

The area navigation system displays the desired and current aircraft track in the flight crew's optimum field of view.

CS ACNS.C.PBN.650 Lateral deviation display

(See AMC1 ACNS.C.PBN.650)

The full-scale deflection of the non-numeric lateral deviation display supports the intended operation.

AMC1 ACNS.C.PBN.650 Lateral deviation display

The full-scale deflection of the non-numeric lateral deviation display should not be greater than two (2) times the applicable RNP.

Navigation database

CS ACNS.C.PBN.655 Use of a navigation database

(See AMC1 ACNS.C.PBN.655)

The area navigation system uses an on-board navigation database which provides sufficient data resolution to ensure that the area navigation system achieves the required accuracy to support RNP AR operations.

AMC1 ACNS.C.PBN.655 Use of a navigation database

Waypoint resolution error should be less than or equal to 60 feet, including both the data storage resolution and the area navigation system computational resolution used internally for the construction of flight plan waypoints.

The navigation database should contain vertical angles (flight path angles) stored to a resolution of hundredths of a degree, with equivalent computational resolution.

SUPPLEMENTARY PERFORMANCE CRITERIA

Lateral performance

CS ACNS.C.PBN.660 Area navigation system design — RNP AR integrity

(See AMC1 ACNS.C.PBN.660)

The integrity of the lateral guidance provided by the aircraft area navigation system supports the intended RNP AR operations.

AMC1 ACNS.C.PBN.660 Area navigation system design — RNP AR integrity

The area navigation system, including position sensors, displays, etc., should be designed to provide a level of integrity that supports the classification of failure conditions defined in **Table 10** below.

Table 10: Area navigation system failure conditions — RNP AR integrity

Intended operations **Failure condition**	Approach or departure with RNP ≥ 0.3 NM and missed approach with RNP ≥ 1.0 NM	Approach or departure with RNP < 0.3 NM or missed approach with RNP < 1.0 NM
Presentation of erroneous lateral position or guidance	MAJOR	HAZARDOUS
Presentation of erroneous along-track distance	MAJOR	MAJOR

CS ACNS.C.PBN.665 Area navigation system design — RNP AR continuity

(See AMC1 ACNS.C.PBN.665)

The continuity of lateral guidance provided by the area navigation system supports the intended RNP AR operation.

AMC1 ACNS.C.PBN.665 Area navigation system design — RNP AR continuity

The area navigation system, including position sensors, displays, etc., should be designed to provide a level of continuity that supports the classification of failure conditions defined in **Table 11** below, depending on the intended operation.

Table 11: Area navigation system failure conditions — RNP AR continuity

Intended operations **Failure condition**	RNP AR approach or departure with RNP ≥ 0.3 NM and missed approach with RNP ≥ 1.0 NM	RNP AR approach or departure with RNP < 0.3 NM and missed approach with RNP < 1.0 NM
Loss of lateral guidance	MAJOR	HAZARDOUS
Loss of along-track distance	MAJOR	MAJOR

Vertical performance

CS ACNS.C.PBN.670 Vertical accuracy

(See AMC1 ACNS.C.PBN.670 and AMC2 ACNS.C.PBN.670)

The vertical position accuracy supports the intended RNP AR operations.

AMC1 ACNS.C.PBN.670 Vertical accuracy

When the vertical position is provided by BARO-VNAV and the aircraft performs stabilised constant descent path, the area navigation system should ensure that 99.7 % of the system error in the vertical position is equal to or less than the vertical error budget (VEB) attributed to the aircraft, as defined by (in feet):

$$VEB_{aircraft} = \sqrt{ANPE^2 + WPR^2 + FTE^2 + ASE^2}$$

Where:

ANPE = actual navigation performance error which can be computed as follows:

$$ANPE = 6076.115 \times 1.225 \times RNP \times tan(\theta)$$

WPR = waypoint precision error which can be computed as follows:

$$WPR = 60 \times tan(\theta)$$

FTE = flight technical error which can be assumed to be 75 feet with autopilot or flight director coupled.

ASE = altimetry system error which can be computed as follows:

$$ASE = -8.8.10^{-8} \times (h + \Delta h)^2 + 6.5.10^{-3}(h + \Delta h) + 50$$

Using:

— ‘θ’ as the vertical navigation (VNAV) path angle;

— ‘h’ as the height in feet of the local altimetry reporting station; and

— ‘Δh’ as the height in feet of the aircraft above the reporting station.

Note: $VEB_{aircraft}$ contains the elements out of the minimum obstacle clearance (MOC) equation in Appendix 1 to ICAO Document 9905 ‘Required Navigation Performance Authorization Required Procedure Design Manual’, which are attributed to the aircraft. The applicant should not apply the other elements of the MOC equation, i.e. body geometry (bg) error or international standard atmosphere temperature deviation (isad), in support of demonstration of vertical accuracy.

AMC2 ACNS.C.PBN.670 Vertical accuracy

The installation of equipment with an ETSO authorisation against ETSO-C146c that supports a 50-m vertical alert limit (VAL) satisfies the requirement for operations down to RNP 0.23.

The installation of equipment with an ETSO authorisation against ETSO-C146c that supports a 35-m VAL satisfies the requirement for operations down to RNP 0.1.

CS ACNS.C.PBN.675 Area navigation system design — RNP AR integrity

(See AMC1 ACNS.C.PBN.675)

The integrity of the vertical guidance provided by the aircraft area navigation system supports the intended operations.

AMC1 ACNS.C.PBN.675 Area navigation system design — RNP AR integrity

The area navigation system, including position sensors, displays, etc., should be designed to provide a level of integrity that supports the classification of failure conditions defined in **Table 12** below, depending on the intended operation.

Table 12: Allowable failure condition of the vertical guidance provided by the area navigation system

Intended operations **Failure condition**	Approach or departure with RNP ≥ 0.3 NM and missed approach with RNP ≥ 1.0 NM	Approach or departure with RNP < 0.3 NM or missed approach with RNP < 1.0 NM
Presentation of erroneous vertical position or guidance	MAJOR	HAZARDOUS
Simultaneous presentation of erroneous vertical and horizontal position or guidance	HAZARDOUS	HAZARDOUS

CS ACNS.C.PBN.680 Continuity of vertical guidance

(See AMC1 ACNS.C.PBN.680)

The continuity of the vertical guidance provided by the aircraft area navigation system supports the intended operations.

AMC1 ACNS.C.PBN.680 Continuity of vertical guidance

Loss of the capability of the area navigation system to provide vertical guidance is considered a MAJOR failure condition.

Subsection 7 — Supplementary specifications for applications for advanced-RNP (A-RNP)

APPLICABILITY

CS ACNS.C.PBN.701 Applicability

Subsection 7 provides the supplementary functional and performance criteria that are applicable to obtain certification credit for applications for advanced-RNP (A-RNP).

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.705 Leg transition

The area navigation system has the capability to execute the following leg transitions and to maintain tracks consistent with:

(a) radius to fix (RF), as specified in Subsection 8;

(b) holding to manual terminator (HM).

CS ACNS.C.PBN.710 Parallel offset

The area navigation system has the capability to implement parallel offset (as specified in Subsection 10).

CS ACNS.C.PBN.715 RNP scalability

The area navigation system has the capability to operate with RNP values (selectable from 0.3 to 1.0 NM in tenth(s) of NM). The RNP value is either retrievable automatically from the on-board navigation database or manually selectable by the flight crew.

CS ACNS.C.PBN.720 Fixed radius transitions

The area navigation system has the capability to execute fixed radius transitions (FRTs), as specified in Subsection 9.

Display of navigation data

CS ACNS.C.PBN.725 Display of aircraft track

The area navigation system displays the current aircraft track (or track angle error) in the flight crew's optimum field of view.

Subsection 8 — Supplementary specifications supporting radius to fix (RF)

APPLICABILITY

CS ACNS.C.PBN.801 Applicability

Subsection 8 provides the supplementary functional and performance criteria that are applicable to obtain certification credit for the capability to execute radius to fix (RF) path terminators.

The RF functionality is mandatory to obtain A-RNP and RNP AR certification credits and can be optionally associated with RNP 1, RNP 0.3 and RNP APCH.

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.805 RF functional requirements

(See AMC1 ACNS.C.PBN.805 and GM1 ACNS.C.PBN.805)

The area navigation system coupled with an autopilot or a flight director is capable of:

(a) executing the radius to fix (RF) leg transitions;

(b) commanding and achieving a bank angle of up to 30 degrees above 400 feet above ground level (AGL) and up to 8 degrees below 400 feet AGL.

AMC1 ACNS.C.PBN.805 RF functional requirements

The applicant should perform an evaluation of the navigation system on a representative set of procedure designs under all foreseen operating conditions. The evaluation should address maximum assumed crosswind and maximum altitude with the aircraft operating in the range of expected airspeeds for the manoeuvre and operating gross weights and CG conditions (i.e. forward/aft). Procedure design constraints should include sequencing multiple, consecutive RF leg segments of varying turn radii, including consecutive RF leg segments reversing the direction of turn (i.e. reversing from a left-hand RF turn to a right-hand RF turn).

When evaluating flight technical error on RF legs, the effect of rolling into and out of the turn should be considered.

Within the demonstration, the applicant should be seeking to confirm that the FTE is commensurate with the identified RNP navigation accuracy and that the RF turn entry and exit criteria are satisfied.

Where applicable, the ability of the aircraft to maintain an appropriate FTE after a full or partial failure of the autopilot and/or flight director should also be demonstrated.

Any limitations identified during the compliance demonstration should be documented. Flight crew procedures should be assessed, including identification of any limitations which surround the use of pilot selectable or automatic bank angle limiting functions and confirmation of those related to go-around or missed approach from an RF leg segment.

Test procedures for aircraft capability to perform RF legs in approach and departure should make use of the RF leg demonstration templates described in Appendix C to Subpart C.

GM1 ACNS.C.PBN.805 RF functional requirements

The test procedure is designed to provide 5 degrees of manoeuvrability margin to enable the aircraft to get back on the desired track after a slight overshoot at the start of the turn.

Industry standards for RF defined paths can be found in EUROCAE ED-75D (RTCA DO-236C Change 1).

CS ACNS.C.PBN.810 RNP failure

If the RNP cannot be achieved during a radius to fix (RF) leg, the flight guidance mode remains in lateral navigation.

CS ACNS.C.PBN.815 Autopilot/Flight director

(See AMC1 ACNS.C.PBN.815)

The use of autopilot or flight director is required to execute radius to fix (RF) leg transitions, except for non-type-rated CS-23 Level 1, 2 and 3 aircraft performing RNP 1 and RNP APCH operations with an RNP value of not less than 1, and at speeds of 200 knots or less, provided that, in addition to the requirement stated in CS ACNS.C.PBN.820, the aircraft is equipped with an appropriately scaled course deviation indicator (CDI).

AMC1 ACNS.C.PBN.815 Autopilot/Flight director

The applicant should perform an evaluation to demonstrate that the aircraft can be maintained on the desired path, without excessive deviations, under all foreseen operating conditions. The demonstrations should be performed on a representative set of procedure designs.

Display of navigation data

CS ACNS.C.PBN.820 Display of computed path

The area navigation system displays the intended path on an appropriately scaled moving map display in the flight crew's maximum field of view.

Subsection 9 — Supplementary specifications supporting fixed radius transition (FRT)

APPLICABILITY

CS ACNS.C.PBN.901 Applicability

Subsection 9 provides the supplementary functional and performance criteria that are applicable to obtain FRT certification credit.

The FRT functionality is required for advanced RNP and can be optionally associated with RNP 2 and RNP 4 specifications.

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.905 Fixed radius transition (FRT) requirements

(See AMC1 ACNS.C.PBN.905 and GM1 ACNS.C.PBN.905)

The area navigation system is capable of defining, executing and maintaining a track consistent with an FRT between flight path segments, using a 0.1-NM resolution for the radius value.

AMC1 ACNS.C.PBN.905 Fixed radius transition (FRT) requirements

The installation of equipment with an ETSO authorisation against ETSO-C115d satisfies the requirement.

GM1 ACNS.C.PBN.905 Fixed radius transition (FRT) requirements

FRT requirements are defined in Aeronautical Radio, Inc. (ARINC) 424, and their application is described in more detail in EUROCAE documents ED-75D (RTCA DO-236C Change 1).

Display of navigation data

CS ACNS.C.PBN.910 Display of the computed path

The area navigation system displays the computed curved path of the FRT on an appropriately scaled moving map display in the flight crew's maximum field of view.

Subsection 10 — Supplementary specifications supporting parallel offset

APPLICABILITY

CS ACNS.C.PBN.1001 Applicability

Subsection 10 provides supplementary functional and performance criteria that are applicable to obtain certification credit for parallel offset which enables the aircraft to fly a path parallel to, but offset left or right from, the original active route (parent route). Parallel offset is applicable only for en-route segments and is not foreseen to be applied on standard instrument departures (SIDs), standard instrument arrivals (STARs) or approach procedures.

The parallel offset functionality is mandatory to obtain RNP 4 and A-RNP certification credits and can be optionally associated with RNP 2 specifications.

SUPPLEMENTARY FUNCTIONAL CRITERIA

Area navigation system

CS ACNS.C.PBN.1005 Parallel offset capabilities

(See AMC1 ACNS.C.PBN.1005)

(a) The area navigation system has the capability to:

(1) define a path offset from the parent track and transit to and from the offset track maintaining an intercept angle of 30 degrees;

(2) manually initiate and cease the parallel offset path;

(3) automatically cancel the offset path:

(i) following an amendment of the active flight plan by executing a ‘direct-to’;

(ii) approaching the first fix of an instrument approach procedure (initial approach fix (IAF), initial fix (IF) or final approach fix (FAF));

(iii) approaching the commencement of a segment which is not compatible with the offset:

(A) at the fix where a course change exceeds 90 degrees;

(B) if the route segment ends at a hold fix.

An advance notice of the automatic cancellation is given to the flight crew and the area navigation system allows sufficient time for the aircraft to return to the parent track before the commencement of the incompatible leg or the first fix of the instrument approach procedure.

(b) When executing a parallel offset, the area navigation system applies to the offset route all performance requirements and constraints of the original route, as defined in the active flight plan.

AMC1 ACNS.C.PBN.1005 Parallel offset capabilities

The installation of equipment with an ETSO authorisation against ETSO-C115d, Class A, satisfies the requirement.

For area navigation systems that have not been granted an ETSO authorisation against ETSO-C115d, Class A, the requirements of ED-75D (RTCA DO-236C Change 1) Section 3.7.2.2.4 'Parallel Offsets' apply, with the following additions:

(a) The area navigation system should have the capability to define the offset path from the parent track using an increment of at least 1 NM, left or right and with a total offset of at least 20 NM. Where the area navigation system supports the definition of a single, pre-planned parallel offset using specific start and end fixes, the area navigation system should:

(1) provide automatic initiation and cessation of the offset at the start and end waypoint;

(2) begin transition to the offset path at the start waypoint on the original path to join the intercept path;

(3) begin the return to the original path such that the return transition ends at the end waypoint on the original path.

(b) When executing a parallel offset, the area navigation system computes the offset reference points using the same resolution that the parent route reference points have. Where FRTs are applied, the offset track should be flown with the same turn radius as the parent track.

Display of navigation data

CS ACNS.C.PBN.1010 Indication of parallel offset status

When in offset mode, the area navigation system provides:

(a) lateral guidance parameters relative to the offset path;

(b) distance and estimated time of arrival information relative to the offset reference points;

(c) a continuous indication of the parallel offset status and of the offset value in the flight crew's maximum field of view;

(d) the cross-track deviation indication during the operation of the offset referred to the offset track.

Appendix A — Installation and testing guidance

(1) Introduction

(a) This Appendix provides guidance on the installation and testing of area navigation systems. Depending on the applicable airworthiness standards, the applicant should consider the following paragraphs as detailed below:

(i) Paragraphs (2), (3) and (4) of this Appendix should always be considered.

(ii) When Subsection 3 'Supplementary specifications for lateral navigation in final approach' is applicable, paragraph (5) 'Supplementary testing for lateral navigation in final approach' of this Appendix should be considered.

(iii) When Subsection 4 'Supplementary specifications for advisory vertical navigation' is applicable, paragraph (6) 'Supplementary testing for vertical navigation outside final approach' of this Appendix should be considered.

(iv) When Subsection 5 'Supplementary specifications for vertical navigation in final approach' is applicable, paragraph (7) 'Supplementary testing for vertical navigation in final approach' of this Appendix should be considered.

(v) When Subsection 7 'Supplementary specifications for applications for advanced-RNP' is applicable, paragraph (8) 'Supplementary testing for applications for advanced RNP' of this Appendix should be considered as well as Appendix C 'RF leg demonstration templates'.

(2) Equipment installation

(a) The applicant should mostly use equipment that has been granted ETSO authorisation and in that case should strictly follow the equipment manufacturer installation guide.

(b) For each of the equipment installed, the applicant should verify and assess all switching and transfer functions, including electrical bus switching and failure modes under partial or complete loss of electrical power, loss of signal reception, loss of equipment interfaced with the area navigation system, etc. Under such failure conditions, the applicant should:

(i) evaluate the aircraft's system response to ensure that the switch is accomplished as expected;

(ii) verify that the switch is clearly enunciated and that any warning associated with the loss of equipment is commensurate with the requirements of CS XX.1322;

(iii) verify that the switching itself does not induce any inaccurate guidance and that the autopilot/flight director response is appropriate.

(c) For multi-sensor installation, under sensor failure conditions, the applicant should verify the following:

(i) the GNSS is used as a primary source of navigation;

(ii) the appropriate switching mode and annunciation;

(iii) the switch is clearly enunciated and that any warning associated with the loss of equipment is commensurate with the requirements of CS XX.1322;

(iv) the switching itself does not induce any inaccurate guidance and that the autopilot/flight director response is appropriate;

(v) the remaining navigation sensors are appropriately reflected in the positioning computation of the area navigation system.

(d) Initial certification of systems, including multiple (scanning) DME sensors, that have not been previously certified must be based upon a demonstration of system accuracy by recording (at not greater than 15-minute intervals) the DME/DME sensor position and comparing it to the actual position during evaluation flights. The latest revisions of AC 25-7 and AC 23-8 provide guidance on test distances from VOR and DME navigation aids. Recorded data should include sufficient signal parameters and sensor performance data to provide a clear indication of satisfactory sensor performance. The particular flight paths should be selected based upon an analysis of critical signal characteristics, station geometry, signal coverage (including limited station availability with acceptable range), aircraft movement, etc. The system should demonstrate its ability to detect poor signal conditions, inadequate navigation capability, recovery from in-flight power failure, etc. The auto-tune logic should be reviewed and tested to verify that ground stations are identified and tuned correctly.

(e) Inertial systems that satisfy the criteria of 0do not need further evaluation.

(f) As regards GNSS sensors that have been granted an ETSO authorisation against ETSO-C146 (Class Gamma equipment), it is stipulated that the equipment will support installations with the ability to compensate for the navigation centre to antenna offset. If applicable, the applicant should confirm that the antenna to aircraft centre of navigation offset is appropriate to the installation for GNSS SBAS equipment supporting LPV.

Note: The fact that the GNSS antenna is top-mounted can result in several feet of vertical difference between the antenna and the aircraft centre of navigation, significantly greater than for ILS antennas. The centre-of-navigation to wheel-crossing height should be evaluated for each installation. For most installations, a fixed vertical offset is adequate.

(g) The applicant should evaluate the accessibility of all controls pertaining to the installation of the area navigation system.

(h) The applicant should evaluate the visibility of display(s) and annunciator(s) pertaining to the installation of the area navigation system during day and night lighting conditions. No distracting cockpit glare or reflections may be introduced.

(3) Sensor interference testing

(a) GNSS equipment is particularly susceptible to out-of-band SATCOM emissions and in-band inter-modulation between multiple channel SATCOM installations. GNSS equipment should not be installed in aircraft with multiple SATCOM channels unless absence of interference with the GNSS sensor is demonstrated.

(b) Improperly used or installed GNSS re-radiators can present misleading information to GNSS equipment. Equipment manufacturers may provide mitigation against the use of erroneous data for GNSS position and navigation solutions. Possible measures include: implementing or enabling cross-checks of GNSS sensor data against independent position sources and/or other detection monitors using GNSS signal metrics or data. It is left to the applicant to determine that the method chosen by the equipment manufacturer is adequate for the aircraft integration.

(c) The lack of interference from VHF radios should be demonstrated on the completed installation of navigation sensors (GNSS, DME where applicable, etc.) by tuning each VHF transmitter to the frequencies listed below and transmitting for a period of 30 seconds while observing the signal status of each satellite being received. Degradation of individually received satellite signals below a point where the satellite is no longer available will require additional isolation measures to be taken:

(i) 121.150 MHz; 121.175 MHz; 121.200 MHz; 131.250 MHz; 131.275 MHz; and 131.300 MHz (for radios with 25-kHz channel spacing); and

(ii) 121.185 MHz; 121.190 MHz; 130.285 MHz and 131.290 MHz (for radios with 8.33-kHz channel spacing);

(d) For installations on rotorcraft, the applicant should ensure that the rotor blades do not interfere with the received signals. This problem has been experienced in some rotorcraft and varies with the rotation rate.

(e) The applicant should perform an evaluation to determine satisfactory electromagnetic compatibility (EMC) between the installation of the area navigation system and other on-board equipment (this test may be partially accomplished as a ground test).

(4) Generic testing for performance-based lateral navigation

(a) The applicant should evaluate the navigation parameters displayed on cockpit instruments (such as HSI, CDI, distance display, electronic flight instrument system, moving maps, FMSs, etc.) against the relevant criteria. In particular, the parameters displayed should be consistent across the cockpit, especially the aircraft heading or track reference (magnetic or true), the aircraft altitude (feet or metres), and the aircraft speed (knots or km/h).

(b) The applicant should verify that the area navigation system continuously provides to the flight crew:

(i) an estimation of the present position, the position accuracy and integrity;

(ii) the computed desired path and the deviation from that path; in particular, the applicant should:

(1) evaluate the sensitivity of the deviation display;

(2) verify that the full-scale setting is appropriate for the intended operation;

(3) when applicable, verify that when the full-scale setting changes, the display of the updated deviation is appropriate;

(iii) the identification of the active TO waypoint;

(iv) the distance, bearing and time to the active TO waypoint;

(v) the aircraft ground speed.

This behaviour should be evaluated for different flight phases, altitudes, and under various normal aircraft manoeuvring (e.g. bank angles of up to 30 degrees and pitch angles associated with take-off, departures, approaches, landing and missed approaches as applicable).

(c) The applicant should verify that the course selector and the area navigation system are properly integrated. The behaviour of the system and the display of the aircraft heading and selected course should be appropriate and consistent when the aircraft follows the area navigation system’s flight plan but also when the aircraft is manually flown.

(d) The automatic and manual selection/deselection of sensor type and positioning aid should be verified:

(i) The appropriate automatic sensor selection should be verified, and where a multi-sensor system is installed, the applicant should check that the automatic selection is consistent with GNSS being the primary source of horizontal position;

(ii) Where a multi-sensor system is installed, the appropriate automatic reversion when one or several sensors fail should be verified;

(iii) The appropriate automatic selection and tuning of positioning navigation aids should be verified. Where DME is installed, the automatic selection and tuning should be evaluated where multiple DME can be received from the aircraft, for different flight phases and different altitudes. For each sensor, the applicant should verify the continuous aircraft position estimations for different flight phases, altitudes, and various normal aircraft manoeuvring (e.g. bank angles of up to 30 degrees and pitch angles associated with take-off, departures, approaches, landing and missed approaches as applicable);

(iv) The capability to manually override the selection or deselection of a positioning sensor type and positioning navigation aids should be checked.

(e) The applicant should verify the capability to create, review, modify and activate a flight plan. In particular, the applicant should verify the capability to extract and load procedures from the navigation database into the area navigation system. During the extraction, all procedures' characteristics (sequence of waypoints, speed and/or altitude constraint, etc.) should be loaded into the flight plan.

(f) The applicant should evaluate the following issues when the area navigation system is interfaced with an autopilot and/or a flight director. If some issues are raised, the area navigation system may still be installed, but either should not be connected to the autopilot or have an appropriate aircraft flight manual supplement/rotorcraft flight manual supplement (AFMS/RFMS) limitation that mitigates the issue.

(i) The applicant should evaluate the steering response while the flight director and/or autopilot are/is coupled to the area navigation system during a variety of different track and mode changes while operating at the maximum and minimum operating speeds. This evaluation should include, as applicable:

(1) transition from en route through the approach to missed approach modes and then back to en route;

(2) intercept and track to and from a waypoint on a selected course.

(ii) The applicant should evaluate:

(1) the steering response during the automatic sequencing of various flight plan legs and transition; and

(2) the appropriate display of this sequencing to the flight crew.

In particular, the capability to execute fly-by, fly-over and RNAV holding should be evaluated for different altitudes, wind conditions, aircraft speeds and configurations.

(iii) The applicant should verify that the lateral manoeuvre anticipation supplied by the area navigation system is appropriate for the aircraft type. The applicant should verify that an appropriate annunciation of impending waypoint crossing is provided.

(iv) The applicant should verify that execution of the 'direct-to' and 'direct-to' with intercept function with a resultant aircraft heading change do not overshoot and do not cause 'S' turns.

(v) The applicant should evaluate that the autopilot response to the area navigation system fault by simulating a representative fault consistent with the equipment architecture (e.g. pulling the circuit breaker). This test should be done under various navigation modes.

(vi) The applicant should verify that modification of the flight plan does not impact on the aircraft guidance until the flight plan and its modification is activated. This behaviour should be evaluated for various kinds of flight plan modifications (lateral revision, constraint insertion/deletion, etc.) and for different procedure types (departure procedures, en route, manually inserted segment, arrival procedures, etc.).

(g) If the equipment uses barometric input, the applicant should verify that the equipment properly interprets the barometer reading. Special consideration should be given to manually entering barometric corrections.

(h) A flight crew workload analysis when operating the area navigation system in association with other piloting requirements should be conducted by the applicant during all phases of flight and operations supported by the area navigation system and found to be acceptable, including those non-normal procedures that can be evaluated in flight.

(i) The applicant should verify that the flight technical error (FTE) does not exceed the FTE credits. This test may not be necessary if the FTE has been previously established for the aircraft concerned. One acceptable way of assessing FTE is to monitor the measured cross-track deviation while either flying under autopilot control or flying manually using the navigation display provided.

(j) The applicant should validate the navigational accuracy of multi-sensor equipment in each operating mode. In addition to overall system navigation performance, particular test requirements for navigational accuracy will vary depending upon the particular sensors integrated in the multi-sensor equipment and whether sensor accuracy performance data has previously been obtained. The performance of each navigation sensor should be evaluated separately and in combination with other sensors as applicable.

(5) Supplementary testing for lateral navigation in final approach

(a) For installations where the autopilot has not been modified and the area navigation system provides ILS-like deviations, the applicant should conduct several approaches:

(i) while flying raw data, flight director and coupled to the autopilot, as applicable;

(ii) while intercepting before and after the final approach fix (FAF),

and check that the autopilot response is appropriate and that the displays are appropriate and consistent within the cockpit.

The objective of this test is not to verify approach performance but to ensure that the area navigation system interfaces are compatible with the aircraft. In addition, the autopilot approach functionality should be evaluated in order to ensure compatibility with the gain scheduling employed by some autopilots during approaches.

(b) For installations where the autopilot has been modified, the autopilot lateral control channel performance has not been assessed, or non-standard deviations are provided (not ILS-like), then the approach performance will need to be evaluated per the latest revision of AC 23-17C, AMC1 to CS 25.1329, or AC 29-2C.

(c) For manual control to the approach flight path, the appropriate flight display(s) must provide sufficient information to maintain the approach path and align with the runway or go-around without excessive reference to other cockpit displays.

(d) In order to ensure the system operates properly, the lateral full-scale deflection should be evaluated by the applicant while on approach.

(e) The applicant should evaluate how distance to go, course, bearing, etc., are displayed on all flight deck presentations during approach procedures when step-down fixes are included in the navigation database.

(6) Supplementary testing for vertical navigation outside final approach

(a) The applicant should evaluate the autopilot response to the insertion of various altitude constraints into the area navigation system's flight plan:

(i) 'AT or BELOW' altitude constraint;

(ii) 'AT or ABOVE' altitude constraint;

(iii) 'AT' altitude constraint;

(iv) 'WINDOW' altitude constraint.

The autopilot response should be evaluated under various conditions (different aircraft configurations and speeds, different lateral paths and transitions at the altitude constraint, etc.).

(b) Where the area navigation system is capable of automatically intercepting a vertical path, the vertical fly-by and the autopilot response should be evaluated under different configurations and winds.

(c) If the equipment uses barometric input, the applicant should verify that the equipment properly interprets the barometer reading. Special consideration should be given to manually entering barometric corrections.

(7) Supplementary testing for vertical navigation in final approach

(a) For installations where the autopilot has not been modified and the area navigation system provides ILS-like deviations, the applicant should conduct several approaches:

(i) while flying raw data, flight director and coupled to the autopilot, as applicable;

(ii) while intercepting before and after the final approach fix (FAF),

and check that the autopilot response is appropriate and that the displays are appropriate and consistent within the cockpit.

The objective of this test is not to verify approach performance, but to ensure that the area navigation system interfaces are compatible with the aircraft. In addition, the autopilot approach functionality should be evaluated in order to ensure compatibility with the gain scheduling employed by some autopilots during approaches. For example, some autopilots depend upon a radio altimeter or middle marker beacon passage inputs to enable a 'glideslope extension' function to reduce oscillating or aerodynamic instability when coupled to a glideslope signal during the final approach phase. But PBN approaches do not have middle marker beacons, so the autopilot response needs to be evaluated when incorporating the PBN capability.

(b) For installations where the autopilot has been modified, the autopilot lateral control channel performance has not been assessed, or non-standard deviations are provided (not ILS-like), then the approach performance will need to be evaluated per the latest revision of AC 23-17b, AMC1 to CS 25.1329, or Appendix B of CS-29/AC 29.1329 contained in AC 29-2 (or equivalent means).

(c) For manual control to the approach flight path, the appropriate flight display(s) must provide sufficient information to maintain the approach path and align with the runway or go-around without excessive reference to other cockpit displays.

(d) In order to ensure the system operates properly, the vertical full-scale deflection should be evaluated by the applicant while on approach.

(e) A flight crew workload analysis when operating the area navigation system in association with other piloting requirements should be conducted by the applicant during all phases of flight and found to be acceptable, including those non-normal procedures that can be evaluated in flight.

(f) The applicant should evaluate the autopilot response to the insertion of various altitude constraints into the area navigation system's flight plan:

(i) 'AT or BELOW' altitude constraint;

(ii) 'AT or ABOVE' altitude constraint;

(iii) 'AT' altitude constraint;

(iv) 'WINDOW' altitude constraint.

The autopilot response should be evaluated under various conditions (different aircraft configurations and speeds, different lateral paths and transitions at the altitude constraint, etc.).

(g) Where the area navigation system is capable of automatically intercepting a vertical path, the vertical fly-by and the autopilot response should be evaluated under different configurations and winds.

(h) If the equipment uses barometric input, the applicant should verify that the equipment properly interprets the barometer reading. Special consideration should be given to manually entering barometric corrections.

(i) When a Class A TAWS is installed and LPV minima are foreseen to be used, the applicant should verify the interface between the TAWS and the area navigation system by checking the excessive downward deviation from the glide path.

(j) When temperature compensation is enabled, the applicant should ensure that the display of corrected altitude(s) is consistent on all displays in the cockpit.

(8) Supplementary testing for applications for advanced RNP

(a) The applicant should evaluate the aircraft response to the insertion of a hold to a manual termination. This evaluation should be performed at different altitudes, under different wind conditions, and for different aircraft operating speeds.

(b) RF legs should be evaluated as detailed in Appendix C.

(c) The use of different navigation accuracies (RNP values) between 0.3 and 1 NM should be evaluated. The applicant should particularly evaluate the aircraft response to navigation accuracy changes and should check that:

(i) the display update following the navigation accuracy change is appropriate;

(ii) the display of the updated navigation accuracy is consistent with all displays in the cockpit;

(iii) the steering response while the flight director and/or autopilot are/is coupled to the area navigation system during the navigation accuracy change is appropriate.

(9) Navigation error test

(a) The initial certification of each BARO-VNAV system to be used for IFR approach operations should be based on a system performance demonstration by recording the BARO-VNAV equipment vertical guidance and comparing it to the actual aircraft position along a pre-established vertical flight path. This evaluation can be made by using the actual coded path and appropriate path definition.

(b) Data should be gathered using a variety of descent rates, angles, and lateral navigation source inputs available to the BARO-VNAV system.

Note: GNSS SBAS LNAV/VNAV most closely emulates BARO-VNAV performance.

(c) The data should demonstrate that the appropriate accuracy criteria of CS ACNS.C.PBN.2140 are met on a 99.7 % probability basis.

(d) Tests should verify proper operation of caution indications and lateral navigation interface.

(e) Normal flight manoeuvres should not cause loss of system sensor inputs and the system dynamic response should be confirmed.

(f) The applicant should evaluate any unusual flight technical errors or errors from using the autopilot and flight director.

Appendix B — INS/IRU standard performance and functionality

(1) Introduction

(a) This Appendix provides the performance and functionality criteria that an airborne INS/IRU position source should meet to support PBN operations.

(2) INS/IRU position source standard performance and functionality

(a) The equipment should support an unambiguous display in the flight crew’s optimum field of view an indication when its outputs are invalid.

(b) The navigation function of the equipment should be designed commensurate with a ‘MAJOR’ failure condition.

(c) The alignment, updating, and navigation computer functions of the system must not be invalidated by normal aircraft power interruptions and transients.

(d) The equipment should provide or support the following functions and displays:

(i) valid ground and in-air alignment capability at all latitudes appropriate for the intended use of the installation;

(ii) a display of alignment status;

(iii) the present position of the aeroplane in suitable coordinates.

(e) The circular error of the equipment should be lower than or equal to 2 nautical miles per flight hour on a 95-per-cent basis.

Appendix C — RF leg demonstration templates

AppC-1 — Introduction

(1) Applicants must demonstrate the aircraft's capability to perform all types of RF legs that can be published on instrument procedures as per the procedure design criteria. This Appendix provides templates that are an acceptable method to demonstrate an aircraft's capability to perform RF legs. Applicants may use engineering simulations and/or aircraft for the flight test demonstrations. The templates depict the various RF legs that procedure designers may use when constructing actual initial, intermediate, missed approach, or final approach segments for RNP approaches along with SIDs and STARs. Applicants may use the templates to create one or more approach procedures at the desired aerodrome for flight test demonstration purposes in visual meteorological conditions only. The intent of such demonstrations is to streamline the airworthiness approval for conducting RF legs.

(2) The demonstration procedures need to include the depicted RF leg types shown in **AppC-2**. To increase flight test efficiency, it is acceptable for applicants to link the individual RF legs that are depicted in the figures by using straight segments to create 'mega procedures' for demonstrating the aircraft's capability. However, the reflex curve legs ('S' turns) and decreasing radius turns must not have a straight segment between the path terminators (see **Figure 1** below for an example). The point is to demonstrate the aircraft is capable of flying the various types of turns including turns of minimum radius.

Note: Figure 1 is only an example and is not intended as the only possible combination for creating efficient flight profiles.

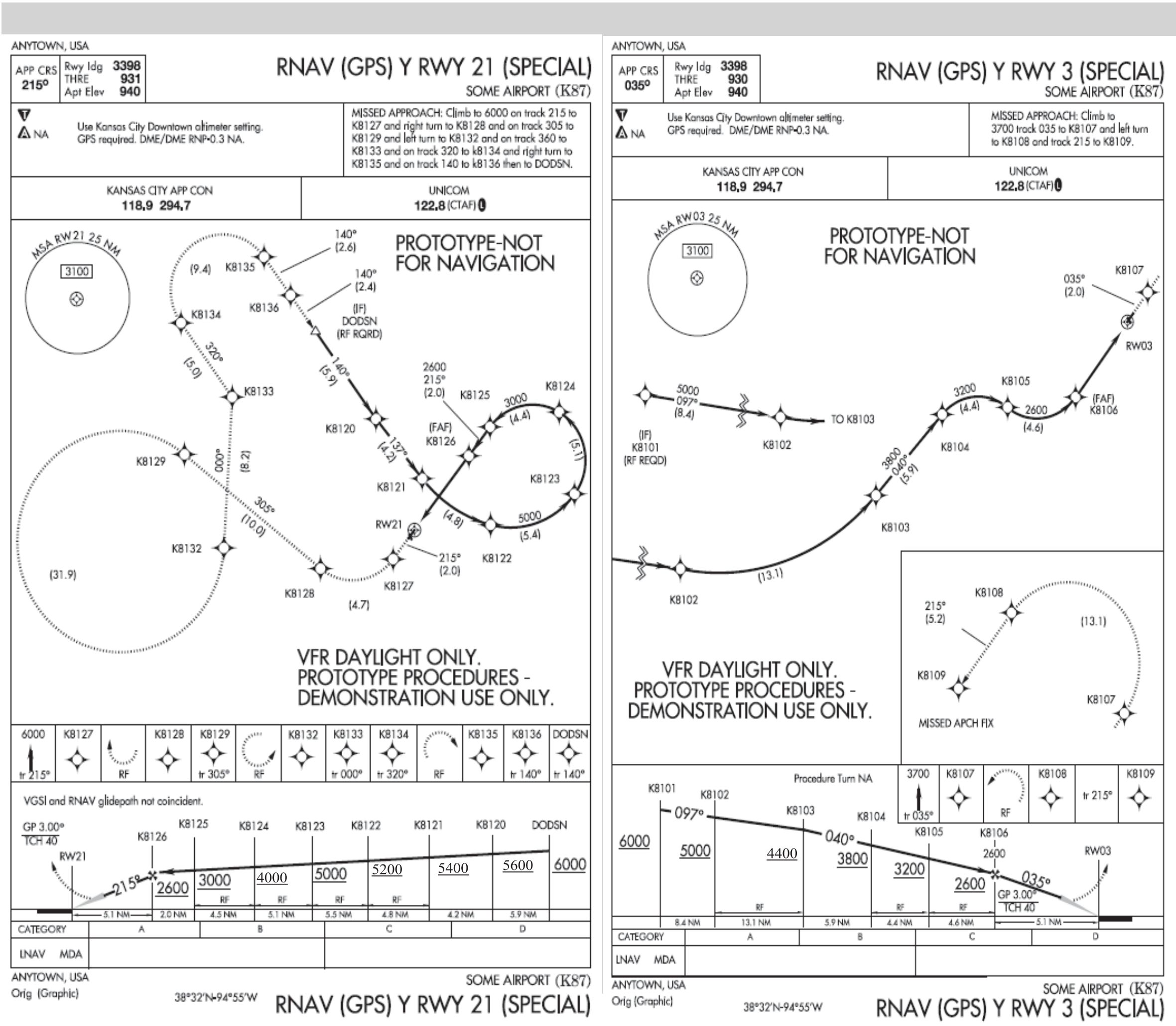


Figure 1: Example procedure profiles

(3) It should be noted that the templates are designed for use on both RNP AR and standard RNP approach procedures with RF legs. In addition, the procedures created from the templates intend to provide some 'stressing' situations as a consequence of the procedure design criteria applied. For example, several RF leg radii were intentionally reduced to approach the 25-degree RNP AR flight guidance system bank angle limits, given the design wind criteria and aircraft approach category C/D in terms of aircraft speeds (121–165 knots).

(4) **AppC-2** provides a basic description, illustration, and waypoint information for the RF legs. A 'test guide' in **AppC-3** lists a recommended testing regimen and considerations for test conduct, but the applicant can tailor the test regimen as needed.

(5) The test procedures are designed for an aerodrome with an elevation of approximately 1 500 ft MSL. All turn radii were computed using expected ground speeds and altitudes based upon the 1 500-ft MSL aerodrome elevation. The turn radii were adjusted so that the required bank angle, given the adverse wind input, would approach the bank angle limitation noted in the procedure design criteria. The waypoint and navigation leg data is provided so that the procedures can be 'translated' to a location suitable to the applicant. However, the elevation of the selected location should be within the range of 1 000–2 000 ft MSL to ensure that the designed turn radii and bank angles do not change significantly. If the location used has an elevation outside the 1 000–2 000-ft MSL range, it is the applicant's responsibility to ensure the procedures offer adequate obstacle clearance and meet the bank angle limits in the RF leg design criteria.

AppC-2 — Description of test procedures

Each of the procedures is described in this section along with an image for illustration.

AppC-2.1 — Departures

(1) Design criteria for departures are currently being developed. Subsequently, two procedures were designed using known criteria in addition to criteria features that are likely to be incorporated. One of the procedures mimics a conventional design at Boston Logan that has proven difficult for some high-performance aircraft to use. Due to environmental restrictions on the ground track, the previous conventional procedure incorporates a series of short track-to-fix (TF) legs that, when viewed from a larger perspective, 'looks' like a series of RF legs when considering that each of the waypoints are 'fly-by'. However, in the conventional format, some FMSs have difficulty with the short leg segments and therefore annunciate an inability to capture a subsequent leg. The resolution to this issue is the RF leg or a series of RF legs that ensure conformance to the desired ground path. The 'Alpha departure' shown in **Figure 2** incorporates an RF leg shortly after take-off followed by a straight climbing segment to a series of two back-to-back RF legs with reducing radii. Waypoint information is shown in **Table 1**.

Figure 2: Alpha departure

Runway Transition Data - Northwest1 DEP

DB	Waypoint	Distance	Leg	FO/FB	Latitude	Longitude	TC	MC	Altitude	Speed	MEA	Arc Center Lat (D° M' S.ss")	Arc Center Lon (D° M' S.ss")	Arc Radius (NM)
NACO: FULL	*DER RW13*				N38 03 35.48	W097 51 17.61								
	WP10 WP	1.00	CF	FB	N38 02 50.65	W097 50 27.06	138.28	132.28	+2043					
	WP12 WP	4.71	RF		N38 02 36.01	W097 45 05.27						N38 04 50.54	W097 47 36.91	3.00
	WP14 WP	10.03	TF	FB	N38 09 15.81	W097 35 35.10	48.37	42.37		230				
	WP15 WP	18.36	RF		N38 08 14.76	W097 14 40.04						N38 00 29.33	W097 25 46.14	11.70
	WP17 WP	9.23	RF		N37 59 56.88	W097 15 19.74				250		N38 04 21.38	W097 20 14.52	5.87

Waypoint Data

DB	Waypoint	Arc Center	Lat-Long (DMS.S)	Latitude (Deg)	Longitude (Deg)	Latitude (D°, M.mm')	Longitude (D°, M.mm')	Latitude (D° M' S.ss")	Longitude (D° M' S.ss")
	WP10 WP		380250.65N-0975027.06W	N 38.0474016	W 97.8408493	N38 02.844	W97 50.451	N38 02 50.65	W097 50 27.06
	WP12 WP		380236.01N-0974505.27W	N 38.0433368	W 97.7514634	N38 02.600	W97 45.088	N38 02 36.01	W097 45 05.27
	WP13 WP	Y	380450.54N-0974736.91W	N 38.0807058	W 97.7935850	N38 04.842	W97 47.615	N38 04 50.54	W097 47 36.91
	WP14 WP		380915.81N-0973535.10W	N 38.1543916	W 97.5930830	N38 09.263	W97 35.585	N38 09 15.81	W097 35 35.10
	WP15 WP		380814.76N-0971440.04W	N 38.1374327	W 97.2444558	N38 08.246	W97 14.667	N38 08 14.76	W097 14 40.04
	WP16 WP	Y	380029.33N-0972546.14W	N 38.0081485	W 97.4294845	N38 00.489	W97 25.769	N38 00 29.33	W097 25 46.14
	WP17 WP		375956.88N-0971519.74W	N 37.9991334	W 97.2554842	N37 59.948	W97 15.329	N37 59 56.88	W097 15 19.74
	WP18 WP	Y	380421.38N-0972014.52W	N 38.0726064	W 97.3373679	N38 04.356	W97 20.242	N38 04 21.38	W097 20 14.52

No FAA checks included.

Database Effective Dates

Database	Date
NFDC	10/20/2011
JEPPESEN	N/A
IFP_OFFLINE	N/A
AVNIS	12/15/2011
benefits	N/A
NACO	N/A

Table 1: Alpha departure waypoints

(2) The 'Bravo departure' shown in **Figure 3** consists of an RF leg shortly after take-off followed by a brief straight segment, then two back-to-back RF legs with a turn direction reversal. The turn radii also vary as the aircraft climbs and increases performance. Waypoint information is shown in **Table 2**.

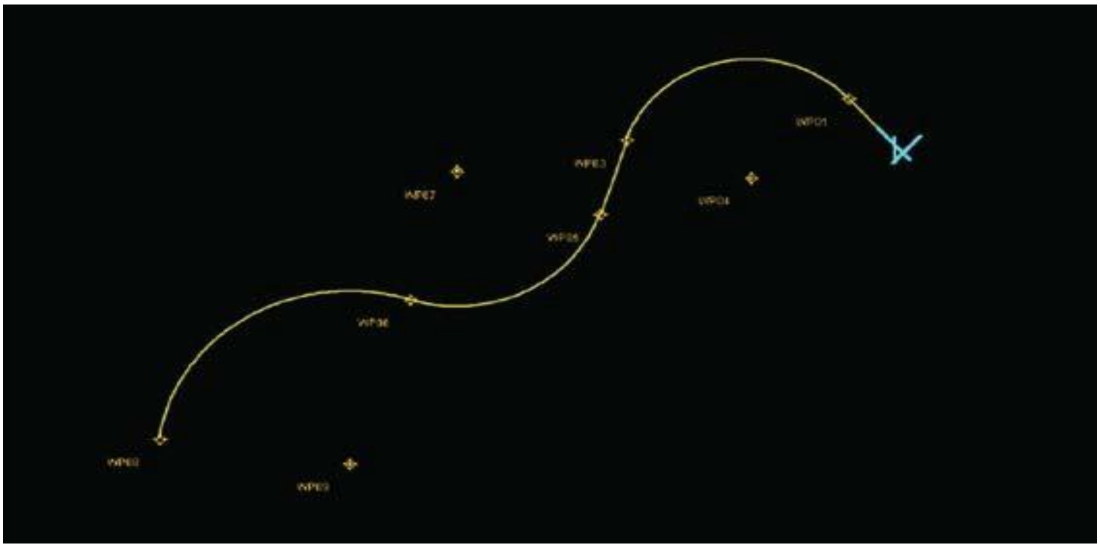


Figure 3: Bravo departure

Runway Transition Data - Southwest1 DEP

DB	Waypoint	Distance	Leg	FO/FB	Latitude	Longitude	TC	MC	Altitude	Speed	MEA	Arc Center Lat (D° M' S.ss")	Arc Center Lon (D° M' S.ss")	Arc Radius (NM)
NACO: FULL	*DER RW31*				N38 04 27.15	W097 52 15.90								
	WP01 WP	1.00	CF	FB	N38 05 11.97	W097 53 06.49	318.27	312.27	+2043					
	WP03 WP	6.40	RF		N38 04 07.23	W097 59 40.21						N38 03 09.74	W097 55 59.72	3.06
	WP05 WP	2.00	TF	FB	N38 02 13.13	W098 00 27.73	198.23	192.23						
	WP06 WP	5.53	RF		N37 59 58.37	W098 06 05.17				230		N38 03 19.16	W098 04 41.65	3.52
	WP08 WP	7.86	RF		N37 56 19.81	W098 13 30.08				250		N37 55 41.30	W098 07 51.90	4.50

Waypoint Data

DB	Waypoint	Arc Center	Lat-Long (DMS.S)	Latitude (Deg)	Longitude (Deg)	Latitude (D°, M.mm')	Longitude (D°, M.mm')	Latitude (D° M' S.ss")	Longitude (D° M' S.ss")
	WP01 WP		380511.97N-0975306.49W	N 38.0866586	W 97.8851359	N38 05.200	W97 53.108	N38 05 11.97	W097 53 06.49
	WP03 WP		380407.23N-0975940.21W	N 38.0686757	W 97.9945032	N38 04.121	W97 59.670	N38 04 07.23	W097 59 40.21
	WP04 WP	Y	380309.74N-0975559.72W	N 38.0527067	W 97.9332567	N38 03.162	W97 55.995	N38 03 09.74	W097 55 59.72
	WP05 WP		380213.13N-0980027.73W	N 38.0369801	W 98.0077039	N38 02.219	W98 00.462	N38 02 13.13	W098 00 27.73
	WP06 WP		375958.37N-0980605.17W	N 37.9995476	W 98.1014351	N37 59.973	W98 06.086	N37 59 58.37	W098 06 05.17
	WP07 WP	Y	380319.16N-0980441.65W	N 38.0553211	W 98.0782353	N38 03.319	W98 04.694	N38 03 19.16	W098 04 41.65
	WP08 WP		375619.81N-0981330.08W	N 37.9388359	W 98.2250232	N37 56.330	W98 13.501	N37 56 19.81	W098 13 30.08
	WP09 WP	Y	375541.30N-0980751.90W	N 37.9281393	W 98.1310840	N37 55.688	W98 07.865	N37 55 41.30	W098 07 51.90

No FAA checks included.

Database Effective Dates

Database	Date
NFDC	10/20/2011
JEPPESEN	N/A
IFP_OFFLINE	N/A
AVNIS	12/15/2011
benefits	N/A
NACO	N/A

Table 2: Bravo departure waypoints

AppC-2.2 — Arrival

(1) A single arrival was designed which is similar to a previously studied design at Fargo, ND. As the aircraft descends and decelerates, it follows a path that consists of a series of RF legs with a reversal of the turn direction after the first turn. The second directional turn consists of two back-to-back RF legs with decreasing radii. The arrival is shown in **Figure 4** and waypoint information is shown in **Table 3**.

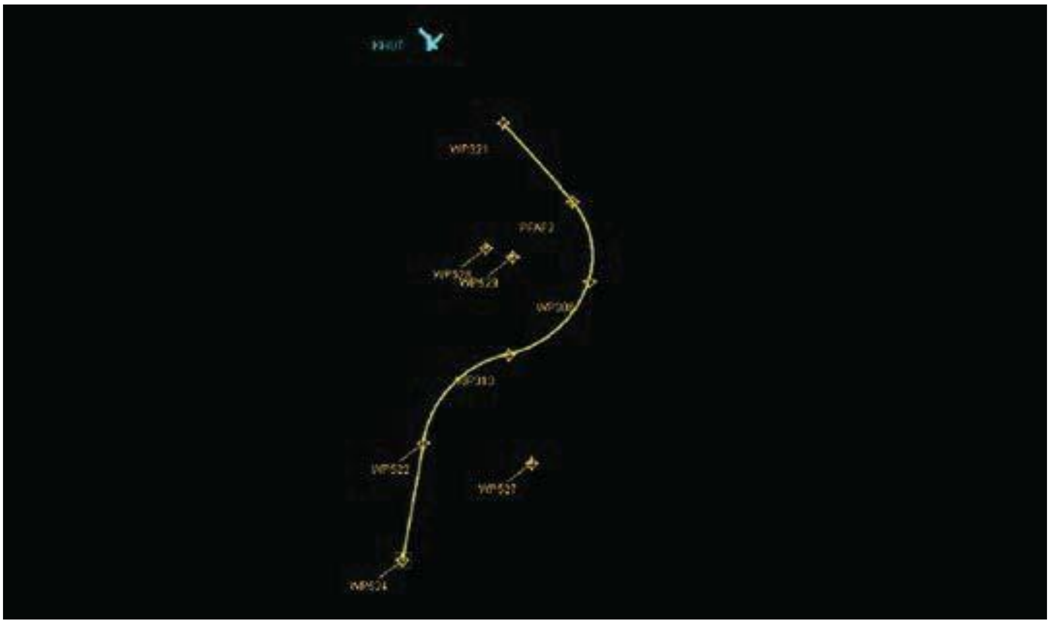


Figure 4: Arrival

Runway Transition Data - South RNAV STAR

DB	Waypoint	Distance	Leg	FO/FB	Latitude	Longitude	TC	MC	Altitude	Speed	MEA	Arc Center Lat (D° M' S.ss")	Arc Center Lon (D° M' S.ss")	Arc Radius (NM)
	WP524 WP		IF		N37 40 27.46	W097 53 15.62								
	WP522 WP	5.40	TF	FB	N37 45 46.51	W097 52 03.10	10.23	4.23						
	WP313 WP	5.91	RF		N37 49 46.57	W097 47 09.39						N37 44 52.99	W097 45 51.24	5.00
	WP306 WP	5.19	RF		N37 53 05.51	W097 42 30.19						N37 54 37.47	W097 48 27.02	4.95
	PFAF2 WP	3.86	RF		N37 56 42.35	W097 43 28.16						N37 54 14.09	W097 46 56.16	3.69
	WP321 WP	4.70	TF	FB	N38 00 12.21	W097 47 26.74	318.04	312.04						

Waypoint Data

DB	Waypoint	Arc Center	Lat-Long (DMS.S)	Latitude (Deg)	Longitude (Deg)	Latitude (D°, M.mm')	Longitude (D°, M.mm')	Latitude (D° M' S.ss")	Longitude (D° M' S.ss")
	PFAF2 WP		375642.35N-0974328.16W	N 37.9450982	W 97.7244900	N37 56.706	W97 43.469	N37 56 42.35	W097 43 28.16
	WP306 WP		375305.51N-0974230.19W	N 37.8848637	W 97.7083862	N37 53.092	W97 42.503	N37 53 05.51	W097 42 30.19
	WP313 WP		374946.57N-0974709.39W	N 37.8296033	W 97.7859430	N37 49.776	W97 47.157	N37 49 46.57	W097 47 09.39
	WP321 WP		380012.21N-0974726.74W	N 38.0033911	W 97.7907609	N38 00.203	W97 47.446	N38 00 12.21	W097 47 26.74
	WP522 WP		374546.51N-0975203.10W	N 37.7629185	W 97.8675290	N37 45.775	W97 52.052	N37 45 46.51	W097 52 03.10
	WP524 WP		374027.46N-0975315.62W	N 37.6742955	W 97.8876734	N37 40.458	W97 53.260	N37 40 27.46	W097 53 15.62
	WP527 WP	Y	374452.99N-0974551.24W	N 37.7480540	W 97.7642320	N37 44.883	W97 45.854	N37 44 52.99	W097 45 51.24
	WP528 WP	Y	375437.47N-0974827.02W	N 37.9104090	W 97.8075046	N37 54.625	W97 48.450	N37 54 37.47	W097 48 27.02
	WP529 WP	Y	375414.09N-0974656.16W	N 37.9039145	W 97.7822680	N37 54.235	W97 46.936	N37 54 14.09	W097 46 56.16

No FAA checks included.

No TERPS Surfaces included.

Database Effective Dates

Database	Date
NFDC	10/20/2011
JEPPESEN	N/A
IFP_OFFLINE	N/A
AVNIS	12/15/2011
benefits	N/A
NACO	N/A

Table 3: Arrival waypoints

AppC-2.3 — Approaches

(1) Three approaches are provided to assess avionics guidance capability through a series of RF leg approach designs. These templates are acceptable for demonstrating the aircraft's capability to perform both RNP AR and standard RNP APCH approach procedures.

(2) As shown in **Figure 5**, Approach 1 is a teardrop procedure that incorporates a descending RF right turn to final, rolling out at the final approach fix. Note that there is no straight segment 2 NM prior to the final approach fix which will be stressing for RNP APCH final approach guidance due to the reduced scaling transition from terminal mode to approach mode. This path requires the aircraft to descend, decelerate, and then configure for landing all during the RF leg. The missed approach also contains an RF leg en route to the missed approach hold. Waypoint information is shown in **Table 4** and vertical error budget information is shown in **Table 5**.

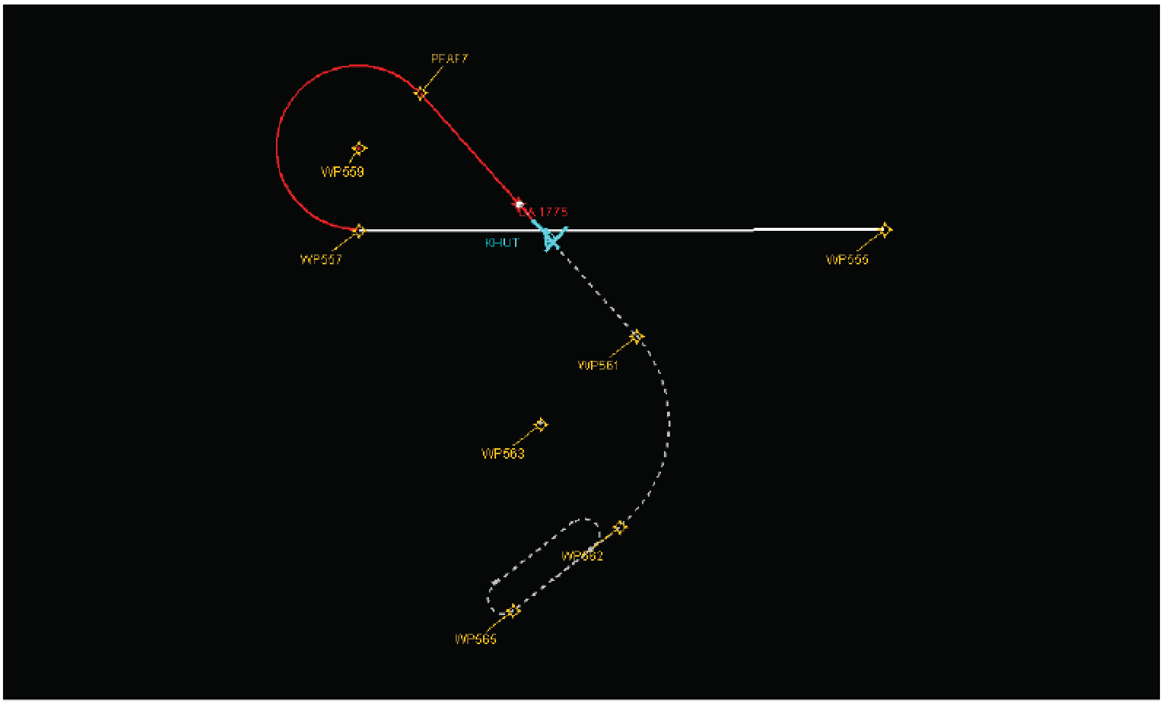


Figure 5: Approach 1

Leg Table 1

Segment	Leg Type	Start	End	Turn Type	Glide Path End Alt	Min Obs./ ATC End Alt	Max End Alt	Turn Radius Comp Alt	Descent Grad	Climb Grad	End Spd	Turn Radius Comp Spd	RNP	Turn Dir
Intermediate	IF	*WP555*	*WP555*	FB	10129			10129.22	0.0			300.0	1.0	
Intermediate	TF	*WP555*	*WP557*	FB	6235			6235.10				165.0	1.0	LEFT
Final	RF	*WP557*	*PFAF7*	FB	3172			6235.10				165.0	0.3	RIGHT
Final	TF	*PFAF7*	*KHUT:RW13:AER*	FB	1580			1580.00				165.0	0.3	
Missed	TF	DA 1775	*WP561*	FB				4337.40				265.0	1.0	RIGHT
Missed	RF	*WP561*	*WP562*	FB				4873.04				265.0	1.0	RIGHT
Missed	TF	*WP562*	*WP565*	FB				6881.69				265.0	1.0	
Missed	HM	*WP565*	*WP565*	FB				8890.33				265.0	1.0	RIGHT

Leg Table 2

Segment	Leg Type	Start	End	Turn Type	Leg Length (NM)	Leg Length (FT)	Start Course Magnetic	End Course Magnetic	Course Change	RF/Flyby Leg Radius	RF/Flyby Turn Bank Angle	Tailwind	RF Leg Arc Center
Intermediate	IF	*WP555*	*WP555*	FB	0.00	0.00000							
Intermediate	TF	*WP555*	*WP557*	FB	15.58	94644.27202	264.04	263.84					
Final	RF	*WP557*	*PFAF7*	FB	9.62	58427.49136	263.86	131.96	228.10	2.4156	19.95	59.35	WP559
Final	TF	*PFAF7*	*KHUT:RW13:AER*	FB	5.00	30380.57743	131.96	132.00	0.00		n/a	30.00	
Missed	TF	DA 1775	*WP561*	FB	5.22	31746.48819	131.96	132.00					
Missed	RF	*WP561*	*WP562*	FB	6.30	38255.73029	132.00	226.20	94.20	3.8294	24.89	56.65	WP563
Missed	TF	*WP562*	*WP565*	FB	4.02	24409.52927	226.16	226.12					
Missed	HM	*WP565*	*WP565*	FB	4.02	24409.52927	226.16						

Waypoint Data

DB	Waypoint	Latitude (Deg)	Longitude (Deg)	Latitude (Deg, Decimal Min)	Longitude (Deg, Decimal Min)	Latitude (D° M' S.ss")	Longitude (D° M' S.ss")
	PFAF7 WP	N 38.1361836	W 97.9417593	N38 8.171	W97 56.506	N38 08 10.26	W097 56 30.33
	WP555 WP	N 38.0691650	W 97.6507673	N38 4.150	W97 39.046	N38 04 08.99	W097 39 02.76
	WP557 WP	N 38.0688801	W 97.9795143	N38 4.133	W97 58.771	N38 04 07.97	W097 58 46.25
	WP559 WP	N 38.1091856	W 97.9796419	N38 6.551	W97 58.779	N38 06 33.07	W097 58 46.71
	WP561 WP	N 38.0170377	W 97.8059367	N38 1.022	W97 48.356	N38 01 01.34	W097 48 21.37
	WP562 WP	N 37.9237951	W 97.8164481	N37 55.428	W97 48.987	N37 55 25.66	W097 48 59.21
	WP563 WP	N 37.9742701	W 97.8659231	N37 58.456	W97 51.955	N37 58 27.37	W097 51 57.32
	WP565 WP	N 37.8826581	W 97.8832395	N37 52.959	W97 52.994	N37 52 57.57	W097 52 59.66

PFAF

	LAT	LON
LTP/FTP	N38 04 27.15	W097 52 15.90
Runway True Bearing	138.00	
FAF Altitude	6235.10	
LTP/FTP Elevation	1525.00	
TCH	55.00	
Glidepath Angle	3.00	
GPI	1049.46	
FAF Distance From LTP/FTP	88808.07 Feet	
	14.62 NM	
	LAT	LON
PFAF	N38 04 07.97	W097 58 46.25

RNAV (RNP)Z RW13

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Created : Fri Jan 06 09:13:34 EST 2012 in TARGETS vTARGETS 4.8 Beta 01/06/2012 (r23735), NACO effective date 1003

Table 4: Approach 1 waypoint information

RNP Value	0.30
LTP MSL Elevation	1525.00
Distance (ft) LTP to PFAF	88808.07
MSL PFAF Altitude	6235.10
Glidepath Angle	3.00
TCH	55.00
Delta ISA (dISA)	0.00
Semispan	131.00

Max Glidepath Angle	3.50
PFAF Elevation	6235.10
LTP Elevation	1525.0
ACT	0.00

Min Glidepath Angle	3.10	
NA Below	11.95 (C)	53.51 (F)
NA Above	46.85 (C)	116.32 (F)

Dist (ft) LTP to OCS ORIGIN	3324.78
OCS Slope (run:rise)	19.15:1
VEB ROC @ PFAF	72.14

Error Components	(Enter Bank Angle, WPR, FTE, and ATIS values below)		@ 250 ft	@ PFAF
ISAD	(dh x dISA)/288 + dISA - 0.5 x .00198 x [dh+h])		0.00	0.00
BG	40.48	semispan x sin (Bank Angle)	40.48	40.48
ANPE	1.225 x rnp x tan(a)		117.03	117.03
VAE	D x (tan(a) - tan(a - .01)) D=250/tan(a)		0.83	15.73
WPR	60.00	WPR x tan(a)	3.14	3.14
FTE	75.00		75.00	75.00
ASE	-8.8 x 10^-8 x (h + D x tan(a))^2 + 6.5 x 10^-3 x (h + D x tan(a)) + 50		61.26	87.11
ATIS	20.00		20.00	20.00

Table 5: Approach 1 vertical error budget (VEB)

(3) Approach 2, as shown in **Figure 6**, is also a descending right turn to final but has a series of four RF legs with differing radii. Similar to Approach 1 in **Figure 5**, this path will require the aircraft to descend and decelerate during the RF leg. Waypoint information is shown in **Table 6** and vertical error budget information is included in **Table 7**.

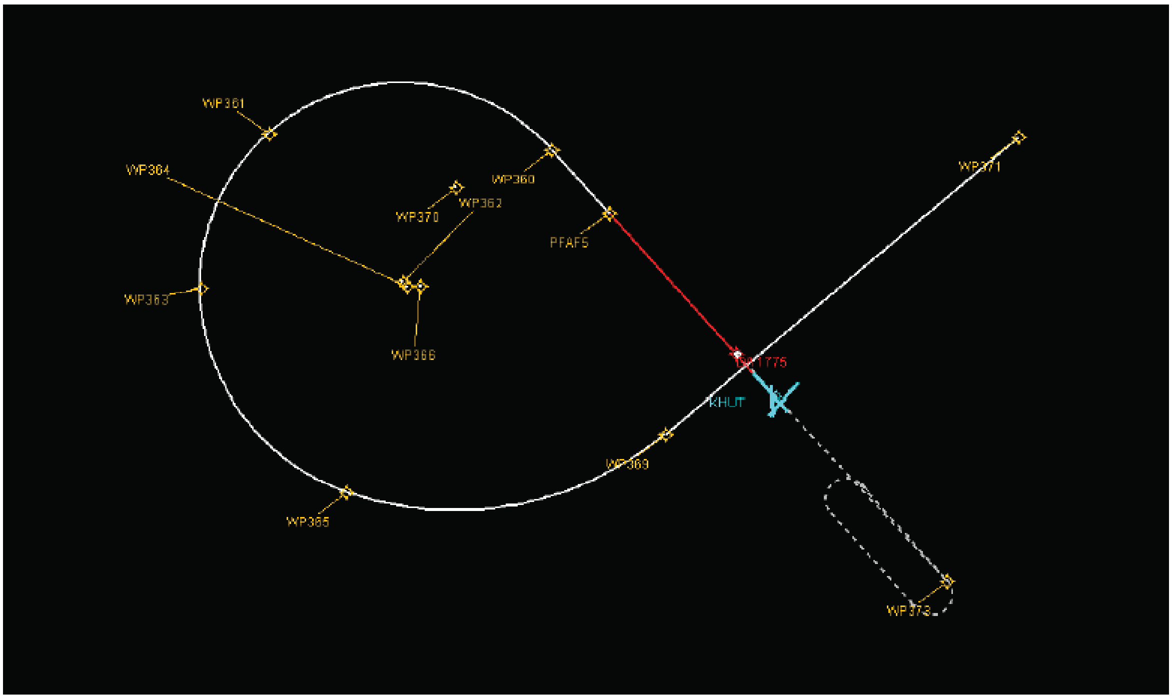

Figure 6: Approach 2

Leg Table 1

Segment	Leg Type	Start	End	Turn Type	Glide Path End Alt	Min Obs./ ATC End Alt	Max End Alt	Turn Radius Comp Alt	Descent Grad	Climb Grad	End Spd	Turn Radius Comp Spd	RNP	Turn Dir
Intermediate	IF	*WP371*	*WP371*	FB	12677			12676.98	0.0			300.0	1.0	
Intermediate	TF	*WP371*	*WP369*	FB	10009			10009.28				300.0	1.0	RIGHT
Intermediate	RF	*WP369*	*WP365*	FB	8044			10009.28				300.0	1.0	RIGHT
Intermediate	RF	*WP365*	*WP363*	FB	6499			8043.55				250.0	1.0	RIGHT
Intermediate	RF	*WP363*	*WP361*	FB	5486			6499.25				250.0	1.0	RIGHT
Intermediate	RF	*WP361*	*WP360*	FB	3672			5486.00				250.0	1.0	RIGHT
Intermediate	TF	*WP360*	*PFAF5*	FB	3172			3172.36				165.0	1.0	RIGHT
Final	TF	*PFAF5*	*KHUT:RW13:AER*	FB	1580			1580.00				165.0	0.3	
Missed	TF	DA 1775	*WP373*	FB				5312.04				265.0	1.0	
Missed	HM	*WP373*	*WP373*	FB				3725.00				265.0	1.0	RIGHT

Leg Table 2

Segment	Leg Type	Start	End	Turn Type	Leg Length (NM)	Leg Length (FT)	Start Course Magnetic	End Course Magnetic	Course Change	RF/Flyby Leg Radius	RF/Flyby Turn Bank Angle	Tailwind	RF Leg Arc Center
Intermediate	IF	*WP371*	*WP371*	FB	0.00	0.00000							
Intermediate	TF	*WP371*	*WP369*	FB	10.67	64836.91202	223.80	223.70					
Intermediate	RF	*WP369*	*WP365*	FB	7.86	47776.01926	223.70	283.59	59.89	7.5100	19.36	66.82	WP370
Intermediate	RF	*WP365*	*WP363*	FB	6.18	37533.45966	283.59	353.36	69.76	5.0700	19.68	62.93	WP366
Intermediate	RF	*WP363*	*WP361*	FB	4.05	24626.59378	353.36	42.16	48.81	4.7600	19.79	59.87	WP364
Intermediate	RF	*WP361*	*WP360*	FB	7.25	44079.45700	42.16	132.22	90.05	4.6200	19.65	57.86	WP362
Intermediate	TF	*WP360*	*PFAF5*	FB	2.00	12152.23097	132.22	132.23	0.02		n/a	30.00	
Final	TF	*PFAF5*	*KHUT:RW13:AER*	FB	5.00	30380.57743	132.23	132.28	1.16		n/a	30.00	
Missed	TF	DA 1775	*WP373*	FB	7.17	43590.52964	131.07	131.14					
Missed	HM	*WP373*	*WP373*	FB	4.00	24304.46194	131.07						

Waypoint Data

DB	Waypoint	Latitude (Deg)	Longitude (Deg)	Latitude (Deg, Decimal Min)	Longitude (Deg, Decimal Min)	Latitude (D° M' S.ss")	Longitude (D° M' S.ss")
	PFAF5 WP	N 38.1364523	W 97.9413803	N38 8.187	W97 56.483	N38 08 11.23	W097 56 28.97
	WP360 WP	N 38.1613379	W 97.9695326	N38 9.680	W97 58.172	N38 09 40.82	W097 58 10.32
	WP361 WP	N 38.1673998	W 98.1073560	N38 10.044	W98 6.441	N38 10 02.64	W098 06 26.48
	WP362 WP	N 38.1099519	W 98.0422797	N38 6.597	W98 2.537	N38 06 35.83	W098 02 32.21
	WP363 WP	N 38.1073598	W 98.1408183	N38 6.442	W98 8.449	N38 06 26.50	W098 08 26.95
	WP364 WP	N 38.1082105	W 98.0403093	N38 6.493	W98 2.419	N38 06 29.56	W098 02 25.11
	WP365 WP	N 38.0285723	W 98.0696613	N38 1.714	W98 4.180	N38 01 42.86	W098 04 10.78
	WP366 WP	N 38.1082629	W 98.0337635	N38 6.496	W98 2.026	N38 06 29.75	W098 02 01.55
	WP369 WP	N 38.0510922	W 97.9138308	N38 3.066	W97 54.830	N38 03 03.93	W097 54 49.79
	WP370 WP	N 38.1466107	W 98.0164594	N38 8.797	W98 0.988	N38 08 47.80	W098 00 59.25
	WP371 WP	N 38.1661249	W 97.7418454	N38 9.967	W97 44.511	N38 09 58.05	W097 44 30.64
	WP373 WP	N 37.9941400	W 97.7766721	N37 59.648	W97 46.600	N37 59 38.90	W097 46 36.02

PFAF

	LAT	LON
LTP/FTP	N38 04 27.15	W097 52 15.90
Runway True Bearing	138.00	
FAF Altitude	3172.36	
LTP/FTP Elevation	1525.00	
TCH	55.00	
Glidepath Angle	3.00	
GPI	1049.46	
FAF Distance From LTP/FTP	30380.58 Feet	
	5.00 NM	
	LAT	LON
PFAF	N38 08 11.23	W097 56 28.97

Table 6: Approach 2 waypoints

RNP Value	0.30
LTP MSL Elevation	1525.00
Distance (ft) LTP to PFAF	30380.58
MSL PFAF Altitude	3172.36
Glidepath Angle	3.00
TCH	55.00
Delta ISA (dISA)	0.00
Semispan	131.00

Dist (ft) LTP to OCS ORIGIN	3324.90
OCS Slope (run:rise)	19.15:1
VEB ROC @ PFAF	216.86

Max Glidepath Angle	3.50
PFAF Elevation	3172.36
LTP Elevation	1525.0
ACT	0.00

Min Glidepath Angle	3.10	
NA Below	11.95 (C)	53.51 (F)
NA Above	45.68 (C)	114.23 (F)

Error Components	(Enter Bank Angle, WPR, FTE, and ATIS values below)		@ 250 ft	@ PFAF
ISAD	(dh x dISA)/288 + dISA - 0.5 x .00198 x [dh+h])		0.00	0.00
BG	25.00	semispan x sin (Bank Angle)	25.00	25.00
ANPE	1.225 x rnp x tan(a)		117.03	117.03
VAE	D x (tan(a) - tan(a - .01)) D=250/tan(a)		0.83	5.50
WPR	60.00	WPR x tan(a)	3.14	3.14
FTE	75.00		75.00	75.00
ASE	-8.8 x 10^-8 x (h + D x tan(a))^2 + 6.5 x 10^-3 x (h + D x tan(a)) + 50		61.26	69.73
ATIS	20.00		20.00	20.00

Table 7: Approach 2 vertical error budget (VEB)

(4) Approach 3 is shown in **Figure 7**. This procedure uses an RF leg early in the procedure followed by a brief straight segment, then two back-to-back RF legs with a turn direction reversal. The second RF leg terminates at the final approach fix. As on the other approaches, the aircraft will be required to descend, decelerate and configure for landing during the series of RF legs. The missed approach also includes an RF leg to the missed approach hold. Waypoint information is shown in **Table 8** and vertical error budget information is included in **Table 9**.

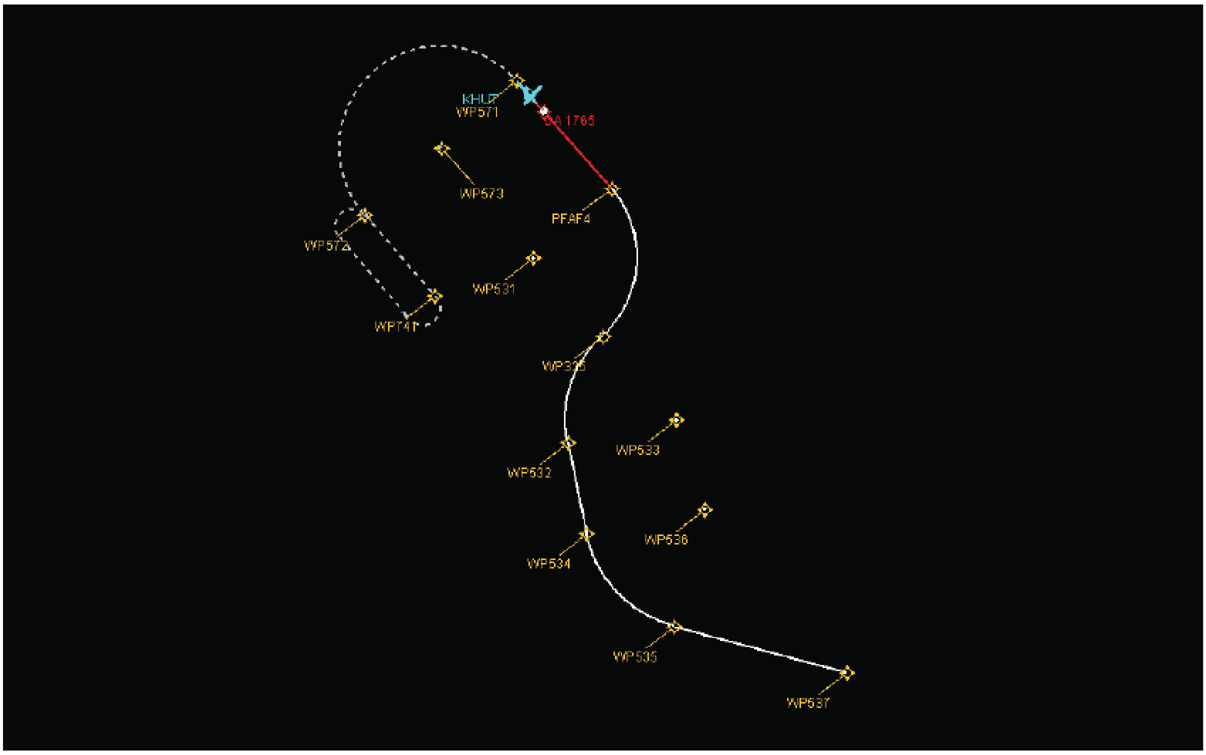

Figure 7: Approach 3

Leg Table 1

Segment	Leg Type	Start	End	Turn Type	Glide Path End Alt	Min Obs./ ATC End Alt	Max End Alt	Turn Radius Comp Alt	Descent Grad	Climb Grad	End Spd	Turn Radius Comp Spd	RNP	Turn Dir
Intermediate	IF	*WP537*	*WP537*	FB	10584			10583.57	0.0			300.0	1.0	
Intermediate	TF	*WP537*	*WP535*	FB	8641			8641.47				250.0	1.0	RIGHT
Intermediate	RF	*WP535*	*WP534*	FB	7193			8641.47				250.0	1.0	RIGHT
Intermediate	TF	*WP534*	*WP532*	FB	6193			6192.56				250.0	1.0	RIGHT
Intermediate	RF	*WP532*	*WP325*	FB	4937			6192.56				250.0	1.0	RIGHT
Intermediate	RF	*WP325*	*PFAF4*	FB	3162			4936.79				250.0	1.0	LEFT
Final	TF	*PFAF4*	*KHUT:RW31:AER*	FB	1570			1570.00				165.0	0.3	
Missed	TF	DA 1765	*WP571*	FB				2615.00				265.0	0.5	LEFT
Missed	RF	*WP571*	*WP572*	FB				8536.36				265.0	1.0	LEFT
Missed	TF	*WP572*	*WP741*	FB				10854.65				265.0	1.0	LEFT
Missed	HM	*WP741*	*WP741*	FB				13172.95				265.0	1.0	RIGHT

Leg Table 2

Segment	Leg Type	Start	End	Turn Type	Leg Length (NM)	Leg Length (FT)	Start Course Magnetic	End Course Magnetic	Course Change	RF/Flyby Leg Radius	RF/Flyby Turn Bank Angle	Tailwind	RF Leg Arc Center
Intermediate	IF	*WP537*	*WP537*	FB	0.00	0.00000							
Intermediate	TF	*WP537*	*WP535*	FB	7.77	47201.70006	278.82	278.72					
Intermediate	RF	*WP535*	*WP534*	FB	5.80	35214.94480	278.72	342.26	63.54	5.2220	19.55	64.11	WP536
Intermediate	TF	*WP534*	*WP532*	FB	4.00	24304.46194	342.26	342.25					
Intermediate	RF	*WP532*	*WP325*	FB	5.02	30520.94148	342.25	42.26	60.00	4.7980	19.44	59.26	WP533
Intermediate	RF	*WP325*	*PFAF4*	FB	7.10	43126.52487	42.26	312.31	89.95	4.5209	19.67	56.77	WP531
Final	TF	*PFAF4*	*KHUT:RW31:AER*	FB	5.00	30380.57743	312.31	312.27	0.00		n/a	30.00	
Missed	TF	DA 1765	*WP571*	FB	1.80	10937.00787	312.31	312.29					
Missed	RF	*WP571*	*WP572*	FB	13.64	82894.71614	312.29	133.02	179.27	4.3623	24.99	63.90	WP742
Missed	TF	*WP572*	*WP741*	FB	4.64	28172.46233	133.02	133.06					
Missed	HM	*WP741*	*WP741*	FB	4.64	28172.46233	133.02						

Waypoint Data

DB	Waypoint	Latitude (Deg)	Longitude (Deg)	Latitude (Deg, Decimal Min)	Longitude (Deg, Decimal Min)	Latitude (D° M' S.ss")	Longitude (D° M' S.ss")
	PFAF4 WP	N 37.9975785	W 97.7847137	N37 59.855	W97 47.083	N37 59 51.28	W097 47 04.97
	WP325 WP	N 37.8911180	W 97.7924249	N37 53.467	W97 47.545	N37 53 28.02	W097 47 32.73
	WP531 WP	N 37.9473859	W 97.8558480	N37 56.843	W97 51.351	N37 56 50.59	W097 51 21.05
	WP532 WP	N 37.8151083	W 97.8240457	N37 48.906	W97 49.443	N37 48 54.39	W097 49 26.56
	WP533 WP	N 37.8313647	W 97.7252214	N37 49.882	W97 43.513	N37 49 52.91	W097 43 30.80
	WP534 WP	N 37.7497614	W 97.8069336	N37 44.986	W97 48.416	N37 44 59.14	W097 48 24.96
	WP535 WP	N 37.6831652	W 97.7273613	N37 40.990	W97 43.642	N37 40 59.39	W097 43 38.50
	WP536 WP	N 37.7674351	W 97.6994648	N37 46.046	W97 41.968	N37 46 02.77	W097 41 58.07
	WP537 WP	N 37.6501154	W 97.5696846	N37 39.007	W97 34.181	N37 39 00.42	W097 34 10.86
	WP571 WP	N 38.0746550	W 97.8715595	N38 4.479	W97 52.294	N38 04 28.76	W097 52 17.61
	WP572 WP	N 37.9784995	W 98.0097230	N37 58.710	W98 0.583	N37 58 42.60	W098 00 35.00
	WP741 WP	N 37.9200757	W 97.9456813	N37 55.205	W97 56.741	N37 55 12.27	W097 56 44.45
	WP742 WP	N 38.0262098	W 97.9402549	N38 1.573	W97 56.415	N38 01 34.36	W097 56 24.92

PFAF

	LAT	LON
LTP/FTP	N38 03 35.48	W097 51 17.61
Runway True Bearing	318.00	
FAF Altitude	3162.36	
LTP/FTP Elevation	1515.00	
TCH	55.00	
Glidepath Angle	3.00	
GPI	1049.46	
FAF Distance From LTP/FTP	30380.58 Feet	
	5.00 NM	
	LAT	LON
PFAF	N37 59 51.28	W097 47 04.97

Table 8: Approach 3 waypoints

RNP Value	0.30
LTP MSL Elevation	1515.00
Distance (ft) LTP to PFAF	30380.58
MSL PFAF Altitude	3162.36
Glidepath Angle	3.00
TCH	55.00
Delta ISA (dISA)	0.00
Semispan	131.00

Max Glidepath Angle	3.50
PFAF Elevation	3162.36
LTP Elevation	1515.0
ACT	0.00

Min Glidepath Angle	3.10	
NA Below	11.97 (C)	53.55 (F)
NA Above	45.70 (C)	114.27 (F)

Dist (ft) LTP to OCS ORIGIN	3324.27
OCS Slope (run:rise)	19.15:1
VEB ROC @ PFAF	216.83

Error Components	(Enter Bank Angle, WPR, FTE, and ATIS values below)		@ 250 ft	@ PFAF
ISAD	(dh x dISA)/288 + dISA - 0.5 x .00198 x [dh+h])		0.00	0.00
BG	25.00	semispan x sin (Bank Angle)	25.00	25.00
ANPE	1.225 x rnp x tan(a)		117.03	117.03
VAE	D x (tan(a) - tan(a - .01)) D=250/tan(a)		0.83	5.50
WPR	60.00	WPR x tan(a)	3.14	3.14
FTE	75.00		75.00	75.00
ASE	-8.8 x 10^-8 x (h + D x tan(a))^2 + 6.5 x 10^-3 x (h + D x tan(a)) + 50		61.20	69.68
ATIS	20.00		20.00	20.00

Table 9: Approach 3 vertical error budget (VEB)

AppC-3 — Test guide

(1) **AppC-3** provides guidance that may be used to conduct development and/or airworthiness RF leg testing for new equipment hardware/software, or updates to existing equipment hardware/software. The guidance is designed to be used together with the templates described in **AppC-2** to create 'FOR TEST ONLY' terminal area instrument procedures (departures, arrivals and approaches). The intent of this regimen is to provide a set of rigorous instrument procedures that the applicant can use to demonstrate that the RF leg airworthiness approval criteria are met.

(2) The test instrument procedures are designed and located at an aerodrome with an elevation of approximately 1 500-ft MSL. The waypoint and navigation leg data is provided so that the procedures can be 'translated' to another location suitable to the applicant. However, the new aerodrome elevation should be within the range of 1 000–2 000-ft MSL to ensure that the designed turn radii and bank angles do not change significantly (see **AppC-1**). The applicant will be required to obtain a navigation database for their respective navigation system that contains the test procedures.

(3) The information in the following paragraphs describes test conditions such as generic aircraft performance parameters, desired atmospheric conditions, and considerations to assist the applicant with creating a detailed test plan. Applicants are encouraged to use these recommended guidelines. However, amendments may be made as required to accommodate unique equipment designs, test environment, testing methods or other considerations.

AppC-3.1 — Initial set-up

(1) Configure the aircraft for individual trials using two gross weight conditions:

(a) nominal heavy weight resulting in lower accelerations to climb speed and higher speeds on approach;

(b) nominal light weight resulting in higher accelerations to climb speed and lower speeds on approach.

(2) The test should be performed in representative operational conditions in terms of speeds, flap and gear settings, etc.

(3) Verify that a navigation database with the 'FOR TEST ONLY' terminal procedures is loaded in the area navigation system.

(4) Verify that desired data parameters will be recorded (if data recording capability is available).

Note: In addition to the desired data parameters, the lateral path definition (desired path) and lateral path 'cross-track error' (distance from the path's centre line) should be included in the recorded data parameters to monitor/review path maintenance performance.

(5) Configure the simulation (if practical) for trials using two atmospheric conditions:

(a) standard day, with standard lapse rate;

(b) 35 °C outside air temperature, with standard lapse rate.

(6) If practical, simulated wind direction should be set to a tailwind for each turn entry. Below 2 000-ft AGL, the wind velocity should be fixed at 30 kt. At 2 000-ft AGL and above, the wind velocity in knots (V_{KTW}) should be calculated as a function of the altitude in feet (A) in accordance with the formula:

$$V_{KTW} = 0.00198 \times A + 47$$

If impractical (i.e. when the simulator cannot model variable winds and various levels), select the wind direction and velocity that most effectively simulates the worst-case tailwind for the procedure.

AppC-3.2 — Airborne test conditions

(1) Record aircraft configuration:

(a) verify that the simulation is 'conformed' with correct avionics hardware and software;

(b) record aircraft performance parameters (gross weight, etc.);

(c) record aircraft configuration and changes to the configuration (flap, gear and thrust setting, etc.).

(2) Select the procedure to be tested, load the procedure into the route of flight, and verify the procedure is in the active route.

(3) Ensure the correct RNP values correspond to the appropriate value for the respective route/procedure segment.

(4) Engage lateral and vertical path guidance where applicable.

(5) Engage autopilot/flight director (as soon as practical after take-off) and verify the autopilot/flight director is providing guidance to the lateral path.

(6) Fly the programmed route and observe that the lateral cross-track deviation does not exceed the FTE for the respective RNP level as follows:

RNP	FTE
1.0	0.5 NM
0.3	0.25 NM with flight director / 0.125 NM with autopilot
< 0.3	Agreed allowable FTE value to achieve TSE ≤ 1 × RNP value

Table 10: FTE value versus RNP value

(7) Perform steps (1) through (6) for each aircraft gross weight configuration and for each test procedure.

Subpart E — Others

SECTION 1 — TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)

[…]

CS ACNS.E.TAWS.035 Aural and visual alerts

(See AMC1 ACNS.E.TAWS.035)

(a) The TAWS provides suitable aural and visual alerts for each of its functions.

(b) Aural and visual alerts are initiated simultaneously, except when suppression of aural alerts is necessary to protect pilots from nuisance aural alerting.

(c) Each aural alert identifies the reason for the alert.

(d) The system is capable of accepting and processing aeroplane performance related data or aeroplane dynamic data and providing the capability to update aural and visual alerts at least once per second.

(e) The aural and visual outputs are~~is~~ compatible with the standard cockpit displays and auditory systems.

(f) The visual display of alerting information is continuously displayed until the situation is no longer valid.

AMC1 ACNS.E.TAWS.035 Aural and visual alerts

(a) The testing of the TAWS system integration within the aircraft should address the provision of the alerts listed in Table 1 below. In addition to this minimum set, other implemented optional voice alerts should be tested.

Alert Condition	Caution	Warning
[…]	[…]	[…]
Ground Proximity Excessive Glide Slope or Glide Path Deviation Class A equipment	**<u>Visual Alert</u>** Amber text message that is obvious, concise, and must be consistent with the Aural message **<u>Aural Alert</u>** ‘Glide Slope’	**<u>Visual Alert</u>** None required **<u>Aural Alert</u>** None Required
[…]	[…]	[…]

TAWS INSTALLATIONS TESTING GUIDANCE MATERIAL

General Testing:

[…]

GPWS Testing:

(a) Flight testing to verify the proper operation of Basic GPWS functions can be conducted in any area where the terrain elevation is known to the flight crew. The following information provides an example of guidance for conducting flight tests to verify the proper operation of each GPWS function.

[…]

(5) Excessive Downward Deviation from a~~n ILS Glideslope~~ glide slope or glide path. ~~This test should be conducted during an ILS approach. This test will verify the proper operation of the ILS Glideslope input to TAWS~~. These tests should be conducted, as applicable, during:

a. an ILS approach to verify the proper operation of the ILS glide slope input to TAWS;

b. an RNP approach to LPV minima to verify the proper operation of the glide path input from the GNSS receiver or FMS to the TAWS;

c. a GBAS approach to verify the proper operation of the GBAS glide path input to TAWS.

[…]

3.2. Draft decision amending Decision No 2003/12/RM of the Executive Director of the European Aviation Safety Agency of 5 November 2003 on Acceptable Means of Compliance for airworthiness of products, parts and appliances (« AMC-20 »)

The following AMC-20 standards are deleted from the table of contents.

CONTENTS

AMC-20

GENERAL ACCEPTABLE MEANS OF COMPLIANCE FOR AIRWORTHINESS OF PRODUCTS, PARTS AND APPLIANCES

4. Impact assessment (IA)

4.1. Issues to be addressed

The main issue this NPA is addressing is the lack of a comprehensive set of certification specifications that permit EASA to issue airworthiness type certificates related to all RNP navigation specifications[21] and their associated functionalities defined in the ICAO PBN Manual (Doc 9613), Fourth Edition — adapting though the ICAO requirements to the European context (see Section 2.3.3).

In addition, fragmentation of the certification basis also represents an issue, and consequently it is important that EASA simplify the number of PBN references by gathering all the necessary information that applicants need in one single document, i.e. CS-ACNS.

4.1.1. Certification processes

As regards PBN, the objective of this proposal is to ensure harmonisation and standardisation of aircraft certification processes, otherwise the cost of equipment and certification would be disproportionate in respect of the benefits that could be gained from a global implementation of PBN routes and procedures, being the objective to achieve a higher level of harmonisation of the EASA/JAA certification criteria with those applied in other countries.

In order to ensure interoperability, the use of a common reference to establish the certification framework is key, so it is essential that airworthiness approval processes take into account the performance requirements and functionalities included in the ICAO PBN Manual, Fourth Edition.

Therefore, in order to fly PBN routes and procedures, aircraft have to be equipped appropriately, i.e. to be granted an airworthiness type certificate corresponding to the performance and functionality required by ICAO, as a minimum.

At present, airworthiness material published by EASA in AMC-20 does not cover all the possible navigation specifications, which results in the need to develop certification review items (CRIs) for those specifications not addressed yet. The same limitation applies to other guidance material used as a basis for type certification, e.g. JAA TGL Rev 1.

Therefore, availability of a single certification process that addresses any combination of navigation specifications instead of one type-certification process per each of them is expected to have a positive impact in terms of process simplification, limiting the administrative burden on applicants. Thus, the same documentation provided by applicants could be considered for type certification against multiple PBN specifications, making the process more efficient and promoting cost-efficiency.

4.1.2. Affected stakeholders

Aircraft and avionics manufacturers and design organisations that are involved in the development or installation of area navigation systems and related avionics integration.

[21] It is expected that applications for aircraft type certification related to RNAV specifications only will be limited to a very small number of cases consisting in retrofitting the area navigation systems of aircraft that cannot be equipped with GNSS sensors.

4.1.3. The drivers

According to the evolution of the ATM Master Plan and the ICAO Global Air Navigation Plan (GANP)[22], whose first priority is PBN implementation, an increase in the number of PBN operations, not just in Europe but in the whole world, is anticipated.

However, if the current situation remains as it is, it will be difficult to achieve the performance improvements expected from the application of Regulation (EU) No 716/2014 on the establishment of the Pilot Common Project (PCP) that supports the implementation of the European ATM Master Plan and, in particular, of enhanced terminal airspace requirements, which stipulate the implementation of SIDs and STARs based on RNP 1 with the use of radius-to-fix (RF) path terminators, as well as RNP APCH with vertical guidance (APV) at the 24 high-density terminal manoeuvring areas (TMAs).

Rulemaking task RMT.0519 has therefore been identified as key to supporting the achievement of the corresponding parts of the 2016 Deployment Programme, which was delivered by the SESAR Deployment Manager to the European Commission[23].

Furthermore, EASA Opinion No 10/2016 proposes the extension of the implementation of PBN requirements beyond the 24 aerodromes, as required by the PCP Regulation, in order to mitigate the risks associated with the non-harmonised implementation of PBN operations. The said Opinion proposes which navigation specifications and additional functionalities should be implemented in the European airspace, promoting a smooth transition to PBN operations.

In conclusion, the non-availability of proper certification specifications that cover all RNP airworthiness and interoperability requirements puts an unnecessary burden on both applicants and EASA as it complicates compliance demonstration and results in duplications. As a consequence, this may result in aircraft not being certified to access the more efficient PBN routes and procedures that are envisaged to be implemented in the EATMN and globally at ICAO level. The realisation of the performance-improvement objectives aimed through such implementations could therefore be delayed.

4.2. Options

Table 3: Selected policy options

Option No	*Short title*	**Description**
0	Do nothing	Baseline option (no change to the CS-ACNS; risks remain as outlined in the issue analysis).
1	Amend CS-ACNS	The provision of a comprehensive Certification Specification for airborne area navigation installations that can be used to ensure compliance with any of the RNP navigation specifications defined in the ICAO PBN Manual (Fourth Edition, 2013).

[22] ICAO 2016-2030 Global Air Navigation Plan, Fifth Edition, 2016 (Doc 9750-AN/963).

[23] 2016 Deployment Programme, 30 September 2016.

4.3. Analysis of the impacts

4.3.1. Safety impact

It is essential that EASA ensure that published routes and flight procedures can be flown by properly equipped aircraft. In particular, RNP navigation systems incorporate the requirement for on-board performance monitoring and alerting, which brings about a safety improvement through a higher level of integrity and allows operations to be conducted safer.

In terms of airworthiness safety benefits, the same goal could be achieved through both options albeit prolongation of the use of the current fragmented guidance could likely result in aspects being missed or overlooked.

Option 1, the application of CS-ACNS for the type certification of aircraft area navigation systems, would enable safe and consistent PBN operations.

4.3.2. Environmental impact

The airworthiness type certification of aircraft that are able to fly fuel-efficient PBN routes and approach procedures would be easier with Option 1 than with Option 0.

4.3.3. Social impact

There would be no social impact difference between the two options. It should be noted that CSs are applied on a voluntary basis. Furthermore, no potential social impact has been identified, neither for Option 0 nor for Option 1.

4.3.4. Economic impact

Option 0: This option would require the development/application of certification review items (CRIs) or special conditions (SCs) for the PBN specifications that are not currently addressed by the existing AMC 20 documents with the drawback to increasing the administrative burden and associated costs both for EASA and applicants, so it certainly represents a cumbersome process to obtain type certification of aircraft in relation to RNP navigation specifications, which is not in line with the objectives to achieve a better regulatory environment.

Option 1: This option would provide the necessary transparency with respect to the required certification standards, so the implementation of the airworthiness type-certification process would be more cost-efficient for both applicants and EASA:

— No need to develop CRIs or SCs for specifications not addressed in AMC 20 documents;

— A single certification process addressing any combination of RNP specifications instead of one type-certification process per specification;

— Standardisation of documentation provided by applicants when applying for type certification against multiple PBN specifications.

By reducing the costs and delays to obtain airworthiness type-certification against any RNP navigation specifications, Option 1 would significantly facilitate the aircraft certification process for RNP systems compared to Option 0. Therefore, it would accelerate the realisation of the performance benefits expected from the implementation of RNP routes and procedures in the EATMN and globally.

Additionally, Option 1 provides a higher level of harmonisation of EASA's certification requirements with those applied in other countries, in particular FAA AC 20-138D. Inter alia, it would aim to resolve inconsistencies in the integrity and continuity specifications between AMC 20-28, the ICAO PBN Manual and the FAA criteria. It would support all RNP navigation specifications and functionalities that are being implemented in EATMN and globally whilst still supporting the PBN specifications already in place.

4.3.5. Proportionality issues

With Option 0, applicants will only be sure of the applicable requirements when applying for a type certificate against a PBN specification for which an AMC 20 already exists (e.g. RNP APCH BARO/VNAV and AMC 20-27) and will be unsure of the requirements for a type certification related to a PBN specification for which there is currently no certification basis (e.g. RNP 1 with RF). Furthermore, the continued application of the former JAA TGL material for RNAV 1 type certification would not be transparent to all stakeholders.

Option 1 provides full transparency with respect to the applicable certification standard for any of the RNP specifications. Therefore, Option 1 would ensure that all applicants are treated equally and proportionately, which may not be the case with Option 0. Furthermore, in order to facilitate the type-certification process for small-/medium-sized design organisations, CS-ACNS includes guidance in Appendix 1 of Book 2 in this regard.

4.4. Conclusion

4.4.1. Comparison of options

With Option 0, obtaining an aircraft type certificate for RNP would be achieved at higher costs with a longer certification process for both applicants and EASA.

The application of PBN routes and procedures in the EATMN is required/proposed by:

— Regulation (EU) No 716/2014 on the establishment of the Pilot Common Project (PCP) supporting the implementation of the European ATM Master Plan and, in particular, PBN in high-density TMAs;

— EASA Opinion No 10/2016 on performance-based navigation implementation in the European air traffic management network (EATMN), which is expected to broaden the scope of the PCP Regulation requirements and ensure a harmonised usage and deployment of PBN throughout Europe.

Furthermore, at global level, the ICAO Assembly Resolution A37-11 on performance-based navigation global goals provides a common objective. All these initiatives require that aircraft be properly equipped and certified.

Through the application of a single, transparent and standardised process for the initial airworthiness certification of aircraft against any of the ICAO RNP specifications and in accordance with Regulation (EU) No 748/2012, Option 1 would facilitate timely RNP type certification of aircraft (RNP 4, RNP 2, RNP 1, RNP 0.3, advanced RNP, RNP APCH, RNP AR, and in particular functionalities like RF or FRT) to gain benefits from the implementation of PBN routes and procedures in the EATMN and globally.

In addition, Option 1 would ensure the completeness of CS-ACNS by incorporating the currently missing navigation aspects in the field of PBN.

Therefore, EASA concludes that Option 1 is the preferred one.

5. References

5.1. Related regulations

— Commission Regulation (EU) No 748/2012 of 3 August 2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations (OJ L 224, 21.8.2012, p. 1)

5.2. Affected decisions

— Decision 2013/031/R of the Executive Director of the Agency of 17 December 2013 adopting Certification Specifications for Airborne Communications Navigation and Surveillance (CS ACNS) — CS-ACNS Initial Issue

— ED Decision 2003/12/RM of the Executive Director of the Agency of 5 November 2003 on general acceptable means of compliance for airworthiness of products, parts and appliances (« AMC-20 »)

5.3. Related decisions

— Executive Director Decision 2016/014/R of 29 July 2016 amending the Acceptable Means of Compliance and Guidance Material to Part-ARO of Regulation (EU) No 965/2012 (AMC and GM to Part-ARO — Issue 3, Amendment 3)

— Executive Director Decision 2016/015/R of 29 July 2016 amending the Acceptable Means of Compliance and Guidance Material to Part-CAT of Regulation (EU) No 965/2012 (AMC and GM to Part-CAT — Issue 2, Amendment 6)

— Executive Director Decision 2016/016/R of 29 July 2016 amending the Guidance Material to Annex I (Definitions) of Regulation (EU) No 965/2012 (GM to Annex I (Definitions) — Amendment 4)

— Executive Director Decision 2016/017/R of 29 July 2016 amending the Acceptable Means of Compliance and Guidance Material to Part-NCC of Regulation (EU) No 965/2012 (AMC and GM to Part-NCC — Amendment 5)

— Executive Director Decision 2016/018/R of 29 July 2016 amending the Acceptable Means of Compliance and Guidance Material to Part-NCO of Regulation (EU) No 965/2012 (AMC and GM to Part-NCO — Issue 2, Amendment 3)

— Executive Director Decision 2016/019/R of 29 July 2016 amending the Acceptable Means of Compliance and Guidance Material to Part-ORO of Regulation (EU) No 965/2012 (AMC and GM to Part-ORO — Issue 2, Amendment 8)

— Executive Director Decision 2016/020/R of 29 July 2016 amending the Acceptable Means of Compliance and Guidance Material to Part-SPA of Regulation (EU) No 965/2012 (AMC and GM to Part-SPA — Amendment 3)

— Executive Director Decision 2016/021/R 2016/021/R of 29 July 2016 amending the Acceptable Means of Compliance and Guidance Material to Part-SPO of Regulation (EU) No 965/2012 (AMC and GM to Part-SPO — Amendment 5)

5.4. Other reference documents

- Commission Implementing Regulation (EU) No 716/2014 of 27 June 2014 on the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan (OJ L 190, 28.6.2014, p. 19)
- Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council (OJ L 296, 25.10.2012, p. 1)
- ICAO Assembly Resolution A37-11 — Performance-based navigation global goals, November 2010
- ICAO Doc 9613 — Performance-Based Navigation (PBN) Manual, Fourth Edition, 2013
- ICAO Doc 9750 —ICAO 2016-2030 Global Air Navigation Plan, Fifth Edition, 2016
- EASA Opinion No 03/2015 Revision of operational approval criteria for Performance-Based Navigation (PBN). Related NPA/CRD: 2013-25 — RMT.0256 & RMT.0257 (MDM.062(A) & (B)) — 31.3.2015
- EASA Opinion No 10/2016 Performance-based navigation implementation in the European air traffic management network. Related NPA/CRD: 2015-01 — RMT.0639 — 28.7.2016