COMMENT RESPONSE DOCUMENT (CRD) TO NOTICE OF PROPOSED AMENDMENT (NPA) 2009-04

DRAFT DECISION OF THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY

amending Decision No 2003/12/RM of the Executive Director of the European Aviation Safety Agency of 5 November 2003 on general acceptable means of compliance for airworthiness of products, parts and appliances ('AMC-20')

'Airworthiness Approval and Operational Criteria for on-board equipment related to Area Navigation for Global Navigation Satellite System approach operation to Localiser Performance with Vertical guidance minima using a Satellite Based Augmentation System'

Explanatory Note

I. General

1. The purpose of the Notice of Proposed Amendment (NPA) 2009-04, dated 19 March 2009, was to propose an amendment to Decision 2003/12/RM of the Executive Director of 5 November 2003 on general acceptable means of compliance for airworthiness of products, parts and appliances ('AMC-20'). It proposed the introduction of a new AMC-20 related to the Airworthiness Approval and Operational Approval criteria for on-board equipment related to approach operations using Global Navigation Satellite System to Localiser Performance with Vertical guidance minima using a Satellite Based Augmentation System.

II. Consultation

2. The draft Executive Director Decision amending Decision No 2003/12/RM for general acceptable means of compliance for airworthiness of products, parts and appliances ('AMC-20') was published on the web site (http://www.easa.europa.eu) on 23 March 2009.

   By the closing date of 23 June 2009, the European Aviation Safety Agency (hereafter referred to as the 'Agency') had received 150 comments from 26 National Aviation Authorities, professional organisations and private companies.

III. Publication of the CRD

3. All comments received have been acknowledged and incorporated into this Comment-Response Document (CRD) with the responses of the Agency.

4. In responding to comments, a standard terminology has been applied to attest the Agency's acceptance of the comment. This terminology is as follows:

   - **Accepted** – The comment is agreed by the Agency and any proposed amendment is wholly transferred to the revised text.
   - **Partially Accepted** – Either the comment is only agreed in part by the Agency, or the comment is agreed by the Agency but any proposed amendment is partially transferred to the revised text.
   - **Noted** – The comment is acknowledged by the Agency but no change to the existing text is considered necessary.
   - **Not Accepted** - The comment or proposed amendment is not shared by the Agency.

   The resulting text as shown in the Appendix B highlights the changes as compared to the NPA proposal.

5. The Executive Director Decision amending Decision 2003/12/RM will be issued at least two months after the publication of this CRD to allow for any reactions of stakeholders regarding possible misunderstandings of the comments received and answers provided.

6. Such reactions should be received by the Agency not later than 20 February 2012 and should be submitted using the Comment-Response Tool at http://hub.easa.europa.eu/crt.

IV. CRD table of comments, responses and resulting text

(General Comments)	-

comment	*29* comment by: *Honeywell* Honeywell understands that the AMC is advisory material, but we have been using a different approach to certify our systems, and we want to make sure that we can continue to use this approach after the AMC is published. The overall basis for certification in the current Honeywell FMS is to show compliance to AC 20-130, TSO C115, TSO 129 and DO-236B since the majority of operations are related to the RNP function. Honeywell has not sought FMS authorization to TSO C146a; however, compliance to elements of DO-229 applicable to the Final Approach Segment (FAS) are addressed in support of STC/ATC approvals for LPV. Honeywell intends to achieve the TSO-C145b/C146b authorization via GPS receiver upgrades separate from the FMS. In other words, the design of the Honeywell avionics suite is such that the FMS will be DO-236B RNP compliant throughout all phases of flight. The only exception is in the final approach segment of an LPV approach when the FMS will be DO-229D Class Gamma LPV compliant, with the following exceptions/deviations: DO-229D, 2.2.5.2.1 "5-Digit Channel Selection" The Honeywell FMS approach procedure is not selected by 5-digit channel but by selecting the LPV minima for Approach Type Identifier and Reference Path Identifier for desired LPV approach (i.e. LPV W-25A) on the ARRIVALS page. 2.2.5.7.2, "Exit Criteria", and 2.2.5.7.3, "Display Transition" The Honeywell FMS missed approach operation is designed per D-236B/AC90-101 TOGA to LNAV. Honeywell finds that this approach yields a safe and effective system with consistent operational characteristics over the variety of approach types.
response	*Noted* As recognised, this AMC is an acceptable means of compliance that demonstrates compliance with the requirements, but it is not the only possible method. Full compliance with the AMC will result in a presumption of compliance with the requirements and no further demonstration should be required. As stated, an applicant may elect to use an alternative means of compliance. However, that means of compliance must meet the objectives of this AMC and be acceptable to the Agency and to the competent authority. Further evaluation of the proposed alternative will be undertaken by the Agency on receipt of a formal application.

comment	*64* comment by: *Swedish Transport Agency, Civil Aviation Department (Transportstyrelsen, Luftfartsavdelningen)* The Swedish Transport Agency, Civil Aviation Department is supporting the content of the NPA 2009-04
response	*Noted* The Agency thanks you for your support.

comment	*153* comment by: *CAA-NL* CAA-NL agrees with this NPA
response	*Noted* The Agency thanks you for your support.

TITLE PAGE p. 1

comment	*124* comment by: *skyguide* LPV usually stands for "Localizer Performance with Vertical Guidance" (not Localizer Precision...). (See also pp. 8 & 24) We presume that this is an involuntary change of terminology and should therefore be corrected.
response	*Accepted* The text has been amended to define LPV as Localiser Performance with Vertical guidance.

A. Explanatory Note p. 3

comment	*122* comment by: *AOPA-Sweden* AOPA-Sweden recommends not using an acronym (LPV) with a different definition, which is already known by most of the world's pilots as 'lateral precision performance with vertical guidance'. Many pilots with a US license are flying in Europe and if there are different interpretations of the acronym, it will cause safety issues.

response	*Not accepted* The Agency is aware that the acronym LPV has also been used to mean 'Lateral Precision performance with Vertical guidance'. However, the meaning accepted by the industry is 'Localiser Performance with Vertical guidance' for ILS 'look alike' precision approaches using GNSS augmented by SBAS.

A. Explanatory Note - IV. Content of the draft opinion/decision p. 4

comment	*9* comment by: *REGA* Flight Crew should also include Single Pilot Operation (all certified aircraft)
response	*Not accepted* The use of the term Flight Crew in section IV was to advise the reader that the Agency's competence has been extended from the field of initial and continuing airworthiness and now includes Flight operations and ATM. Any restriction on single-pilot operations is detailed in the NPA associated with the FCL and OPS. It is not the intent of the AMC to introduce any additional operational restrictions.

comment	*104* comment by: *AIR FRANCE* There are too many AMC 20-xx! Why continue to propose new ones when we know that this rule material will have to find it's place in the future IRS. Suggest to, at least, state that the following rule material will end in OPS.SPA.xxx.SPN.
response	*Not accepted* AMC material contains detailed technical requirements that are a means to comply with a requirement such as an Implementing Rule. As Implementing Rules are intended to provide legally binding high-level requirements, the material presented in an AMC is unsuitable for the Implementing Rule text; therefore, AMC material will continue to be utilised where suitable and can be used as the means of compliance to the Implementing Rules.

A. Explanatory Note - V. Regulatory Impact Assessment p. 4-6

comment *1* comment by: *REGA*

In order to permit the LPV procedures also for helicopter, the approach procedures should also include Heliports, Helideck or any landing area which fulfils the ground infrastructure requirements.

response *Not accepted*

This AMC is applicable to airworthiness and operational requirements and does not address procedure design requirements. It is assumed that the procedures are consistent with ICAO Doc 8168.

comment *42* comment by: *AOPA-Sweden*

(ANSP), this acronym is wrong for Aeronautical Information Service Provider

response *Accepted*

The Acronym ANSP means Aeronautical Navigation Service Provider. The acronym has been changed.

comment *110* comment by: *AIR FRANCE*

"Further, it should be noted that many air transport category aircraft already carry capably RNAV systems, although they are not yet certified for RNAV GNSS operations. Such aircraft would be immediate candidates for certification." This is not true when it comes to SBAS augmentation. Many air transport category aircraft are capable of LNAV and LNAV/VNAV RNAV (GNSS) approaches but none of the major players (Airbus , Boeing,..) proposes an operational SBAS equipment.

response *Noted*

The Agency thanks you for your comment.

comment *132* comment by: *UK CAA*

Page No: 6

Paragraph No: 13 a. iii. Environmental

Comment: Under Option 2 (rulemaking) it is asserted that a positive benefit will accrue from this rulemaking as fuel gas emissions will be reduced. Nowhere in the text is this statement justified. Whilst a reduction in engine emissions might result from more direct approaches and constant descent final

approach (CDFA) procedures, these have not been directly associated unequivocally with all LPV operations. The introduction of LPV procedures, unless associated with other operational activities is more than likely to have the same effect as Option 1, in that they are both environmentally neutral.

Justification: An unjustified benefit has been introduced.

Proposed Text:

13. a. iii.

Option 1 (do nothing): Has no effect on environmental issues

Option 2 (rulemaking): Has no effect on environmental issues

OR:

13a. iii

Option 1 and Option 2 are environmentally neutral in their direct effect.

response *Partially accepted*

The use of an LPV approach procedure may not directly have impact on the engine emissions. However, the availability of a LPV approach to an airfield may reduce possible delays due to weather-induced holding and hence have a possible benefit in reducing overall engine emissions.

AMC 20-28 - 1. PURPOSE p. 8

comment *30* comment by: *FAA*

Comment: Paragraph does not mention LP line of minima

Rationale: As of the April 09 ICAO PBN Study Group 2 meeting, there is now a plan to include LPV and LP as part B to Chapter 5, "Implementing RNP APCH" in Doc 9613 (PBN manual), which is tentatively scheduled for revision in Spring 2010.

Recommendation: Suggest including or addressing LP.

response *Noted*

The Comment has been noted. The AMC was drafted before the ICAO PBN study group recommendation to include LPV & LP approach material. According to the information available to EASA, LP approaches are not planned for Europe. However, an aircraft which has been approved for LPV approaches in accordance with this AMC should be considered capable of performing LP approaches.

comment *125* comment by: *skyguide*

Same comment as for Title Page: LPV usually stands for "Localizer Performance

	with Vertical Guidance" (not Localizer Precision...)
response	*Accepted* Text amended.

AMC 20-28 - 2. BACKGROUND p. 8

comment	*31* comment by: *FAA* Comment: AMC 20-28 addresses criteria related to an aircraft system based on GNSS augmented by SBAS to conduct approach operations to LPV minima Rationale: Language is not harmonized. Recommendation: Consider harmonizing with draft part B to Chapter 5, "Implementing RNP APCH" in Doc 9613 (PBN manual) language which says that SBAS is "one means of compliance".
response	*Not accepted* This AMC is to provide a means to use GNSS augmented by SBAS to perform RNP-APCH operations to LPV minima. It does not prevent the use of an alternative means of vertical guidance to perform RNP-ACH operations.

AMC 20-28 - 3. SCOPE p. 8-9

comment	*32* comment by: *FAA* Comment: Paragraph 3 "Scope" does not mention LP minima. Rationale: **Operations to LP minima are not discussed in this AMC and no reason is given for why LP is excluded. However, the final paragraph in "Scope" explains that RNP APCH AR and basic RNP approaches are not covered.** Recommendation: Suggest explaining why LP minima is not mentioned in this AC in this paragraph.
response	*Not accepted* The AMC was drafted before the ICAO PBN study group recommendation to include LPV & LP approach material. According to the information available to the EASA, LP approaches are not planned for Europe. However, an aircraft which has been approved for LPV approaches in accordance with this AMC should be considered capable of performing LP approaches.

comment	*105* comment by: *AIR FRANCE* Wording is "the" major issue in RNAV matters. Please note that the words "LPV approach" do not exist in V3 of the PBN Manual for the moment. Operators need harmonization. Any new wording introduced by EASA should be agreed by the ICAO PBN WG.
response	*Noted* The term 'LPV approach' has been used in the context of this AMC to mean 'RNAV GNSS approach to LPV minima' in order to simplify the text. Once the ICAO has published an Amendment to the PBN manual containing the terminology for this type of approach, the Agency will initiate a task to update the AMC accordingly.

AMC 20-28 - 4. REFERENCE DOCUMENTS p. 9-10

comment	*33* comment by: *FAA* Comment: Remove ETSO-C129( ) and TSO-C129( ) from paragraphs 4.2.2 and 4.2.3 respectively. Rationale: **This document is for airworthiness approval of GNSS systems for LPV. ETSO-C129 and TSO-C129 equipment are not capable of performing LPV operations.** Recommendation: Remove any references to ETSO-C129( ) and TSO-C129( ) equipment from the document.
response	*Accepted* Reference deleted.

comment	*43* comment by: *Luftfahrt-Bundesamt* **page 10, 4.2.3** change reference AC 23-1309-1C to: AC 23-1309-1D or AC 23-1309-1()
response	*Accepted* Text amended to read 'AC 23-1309-1( )'.

comment	*48* comment by: *Luftfahrt-Bundesamt* **page 10, 4.2.4**

	add ED-80() / DO-254() Design Assurance Guidance for Airborne Electronic Hardware
response	*Accepted* Text added.

AMC 20-28 - 5. ASSUMPTIONS p. 10-12

comment	*17* comment by: *KLM* AMC 20-20 chapter 5.2 requires the missed approach to be based on RNAV or conventional design: This is very conservative and can have consequences for the benefits of SBAS over other type of systems. One of the advantages of SBAS design criteria is the narrow lateral protected airspace, in the final approach (as narrow as the ILS) and in the missed approach (narrower than the ILS missed approach, conventional NPA and RNAV missed approach). The limitation as indicated above minimises the benefits of SBAS compared to other types of approaches. The OCH of an approach procedure is the highest of the Final Approach and the Missed Approach. The narrower the final approach protected airspace, the lower the OCH and the more relevant becomes the width of the missed approach protected airspace. The wider the missed approach protected airspace the greater the likelihood that an obstacles become a controlling obstacle for the OCH. The OCH determines directly the operational minima (DA and RVR). Below some figures out of PANS-OPS are reproduced. Fig 1: Generic application of the turn radius and wind spiral. The width "a" is essential in the determination of the total width (b). Fig 2: Application of the generic method in case of a VOR or DME approach. Fig 3: Width origin turning missed approach, based on OAS surfaces. At least 6 km wide (3 km semiwidth), extending to greater width in case of a turn at an altitude above 1000 ft above the threshold. Fig 4: RNAV missed approach width at the waypoint is 7.4 km. Fig 5-7: In case of an SBAS guided missed approach the straight ahead segment prior to the turn is 3.8 km, much less than all other conventional and RNAV missed approach designs. The figures show the benefit of SBAS over the other type of approaches.

FIG 1: GENERAL CRITERIA TURNING MISSED APPROACH

FIG 2: WIDE LATERAL PROTECTED AIRSPACE DUE TO WIDE MISSED APPROACH AREA

FIG 3: ILS TURNING MISSED APPROACH, INITIAL WIDTH BASED ON OAS (MAX 3 Km SEMIWIDTH)

FIG 4: RNAV APPROACH LATERAL WIDTH MISSED APPROACH

FIG 5: SBAS SEMIWIDTH PARALLEL AT 1.9 KM (3.8 KM TOTAL WIDTH)

FIG 6: SBAS MISSED APPROACH PARALLEL WIDTH

FIG 7: SBAS SEMIWIDTH 3.8 KM PARALLEL

TURN AREA SIGNIFICANTLY NARROWER COMPARED TO RNAV, CONVENTIONAL NAV AIDS AND ILS

response *Noted*

The comment is correct with respect to the benefits of SBAS regarding the definition of the OCH. However, this AMC does not provide a means of compliance for procedure design. Neither the note in paragraph 5.2 nor the section on missed approach in paragraph 5.3 implies that missed approach procedure design has to be based on either RNAV or conventional navigation.

comment *34* comment by: *FAA*

Comment: paragraphs **5.2 and 5.3**, Basing the missed approach segment on a conventional navigation aid may prevent that LPV approach from obtaining the lowest possible minimums.

Rationale: Conventional navigation aids used for missed approach segments in most cases will require larger OCS protection surfaces than a missed approach based upon GNSS RNAV.

Recommendation: Add to note 1 in paragraph 5.2 and in the missed approach discussion in paragraph 5.3 that basing the missed approach on a conventional navigation aid will very likely cause higher LPV minimums than could be obtained with a GNSS-based RNAV missed approach segment.

response *Noted*

The comment is correct with respect to the benefits of SBAS regarding the definition of the OCH. However, this AMC does not provide a means of compliance for procedure design. Neither the note in paragraph 5.2 nor the section on missed approach in paragraph 5.3 implies that missed approach procedure design has to be based on either RNAV or conventional navigation.

comment	*44* comment by: *Luftfahrt-Bundesamt* **page 11, 5.3** lines 11 and 12: "If the missed approach segment is based on conventional means..." This sentence indicates that there might be another missed approach process which is NOT based on conventional means. If so, where is it described in this NPA ?
response	*Noted* Note 1 to paragraph 5.2 already indicates that a missed approach can be based on either conventional means or RNAV procedures. It is not the intent of this AMC to provide guidance with respect to procedure design.

comment	*54* comment by: *DSNA/DTI* § 5.1 Navaid infrastructure Subject : RAIM holes Rationale : I do not understand why in the AMC for LPV it is mentioned RAIM holes. How RAIM hole could impact LPV loss ? Recommendation : Suppress "(e.g. RAIM holes)"
response	*Accepted* Text amended.

comment	*106* comment by: *AIR FRANCE* Note 1: missed approach of an LPV should not be based on conventional segments. Aeroplanes with integrated navigation system capable of LPV will generally also be able to fly all missed approach based on RNP 1. Require an NDB or a DME for the missed approach is just introducing an un-necessary reason to be unable to fly the approach (when this conventional aid is not working).
response	*Noted* This AMC does not provide a means of compliance for procedure design. Neither the note in paragraph 5.2 nor the section on missed approach in paragraph 5.3 implies that missed approach procedure design has to be based on either RNAV or conventional navigation.

comment	*107* comment by: *AIR FRANCE* *"The instrument approach chart will identify LPV approach operation as RNAV(GNSS) and will indicate the associated LPV minima."* The FAA calls it RNAV (GPS), please harmonize through the PBN Workshop. RNAV (GNSS) seems the right wording in view of the implementation of Galileo.
response	*Noted* Your comment has been noted. EASA is aware that ICAO is currently working on harmonising the terminology, the term RNAV (GNSS) will be used until this harmonisation action is complete.

comment	*108* comment by: *AIR FRANCE* "*If the missed approach segment is based on conventional means, navaid facilities that are necessary to conduct the approach will be identified in the relevant publications.* " See previous comment: let the aeroplane equiped with integrated navigation systems (INS) get rid of the conventional means for the missed approach of an LPV approach. Suggest: "**For aircraft equiped with GNSS SBAS Stand alone navigation system,** if the missed approach segment is based on conventional means, navaid facilities that are necessary to conduct the approach will be identified in the relevant publications. For aircraft equipped with integrated navigation system incorporating a GNSS SBAS sensor these navaid facilities may be missing"
response	*Not accepted* Procedure design is not within the scope of this AMC.

comment	*109* comment by: *AIR FRANCE* "*The chart will provide sufficient data to support navigation database checking by the crew (including waypoint name, track, distance for each segment and vertical path angle).* " Why not mention the (WGS 84) coordinates? Checking of the coordinates by the flight crew shall not be mandatory but still possible. The chart should provide a table with the WPTs coordinates.
response	*Not accepted* Current charts may not always provide exact waypoint coordinates. It is not the intent of this AMC to address procedural design and charting issues.

comment	*133* comment by: *UK CAA* **Page No:** 11 **Paragraph No:** 5.1 final paragraph **Comment:** The acceptability of loss of LPV approach capability should be assessed by the Air Traffic Service Provider providing the LPV approach. **Justification**: It is the service provider's responsibility to ensure that the services it provides are suitably safe, it is the NAA's responsibility to ensure that this assessment is undertaken. **Proposed Text (if applicable):** The acceptability of the risk of loss…..will be considered by the air traffic service provider providing the approach.
response	*Accepted* Text amended.

comment	*134* comment by: *UK CAA* **Page No:** 11 **Paragraph No:** 5.2 note 1 **Comment:** It is not clear whether RNAV here is intended to include GPS/SBAS. **Justification:** The missed approach procedure should not rely on the same infrastructure as the approach in case the reason for the missed approach is failure of that infrastructure.
response	*Noted* It is the responsibility of the ANSP to define the appropriate infrastructure for a missed approach taking into consideration the possible cause of a missed approach and probable failures of the infrastructure. The ANSP should then publish the required equipage to undertake such procedure. It should be noted that this AMC is an acceptable means of compliance for aircraft airworthiness and operations. It is not intended to provide an acceptable means of compliance for the design of approach and missed approach procedures, reference to such procedures is provided as an assumption that they are designed and implemented correctly.

comment	*135* comment by: *UK CAA* **Page No:** 12 **Paragraph No:** 5.4 **Comment:** Obstacle clearance is also reliant on Instrument Approach Procedure design. **Proposed Text (if applicable**): Adequate obstacle clearance is achieved through aircraft performance, Instrument Approach Procedure Design and

	operating procedures.
response	*Accepted* Text amended.

AMC 20-28 - 6. AIRWORTHINESS CRITERIA - 6.1 General p. 12

comment	*18* comment by: *KLM* **General comments.** • The document does not mention APV I / II. This information should be mentioned also in the operational section. It must be clear to the pilot what one and the other mean. • There is no information mentioned related to Geodic Hondulation. o Unclear how this actually works in case of a SBAS, as the DA is based on the pressure altimeter, but the vertical guidance is based on (Augmented) GNSS and the ellipsoid. Isn't it necessary to give background information, if relevant? • Fall back can also be to LNAV/VNAV, not only to LNAV.
response	*Not accepted* With regards to the individual comments: • Flight Crews will not likely encounter the abbreviations APV I and APV II during normal operations. They will see an RNAV (GNSS) approach to LPV lines of minima; therefore, this AMC does not use these terms. • Geodetic undulation is considered in the procedure design requirement and has no airworthiness implications. • Fall-back to LNAV/VNAV is possible, however, it is not recommended due to the complexity of transitioning to a different operational procedure.

comment	*35* comment by: *FAA* Comment: AC 20-138A will soon be superseded by revision B. Rationale: AC 20-138B is in the first phase of the review/comment process and should complete the review phases for publication within the year. Recommendation: Suggest all document references use "(latest revision)" after the number to keep the references from becoming obsolete. This example should read: AC 20-138 (latest revision).

response	*Accepted* Text amended.

comment	*147* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* Since this AMC is consistent with FAA Advisory Circular AC 20-138A, Embraer understands that demonstration to this AMC would not be necessary for aircraft already compliant to FAA AC 20-138A. If the AMC has additional requirements to AC 20-138A, the AMC should identify means of compliance with the additional requirements.
response	*Not accepted* The requirements of this AMC are largely consistent with FAA AC 20-138(). However, due to differences, compliance with AC 20-138() does not imply acceptance of compliance with AMC 20-28 without further demonstration.

AMC 20-28 - 6. AIRWORTHINESS CRITERIA - 6.2 Equipment qualification and aircraft installation p. 12

comment	*19* comment by: *DFS* § 6.2.2. : add "at least" in sentense : The Integrated Navigation system should meet the performance requirements defined in Chapter 2.2 of RTCA DO-229C at least." (because the majority of GNSS/FMS SBAS equipment are developed with RTCA DO-229 requirements"
response	*Not accepted* The AMC already states the minimum required to comply with the certification requirements. This does not preclude demonstration to a higher standard where the minimum requirements are still being met.

comment	*20* comment by: *DFS* add "at least" in Note 1: Aircraft that have previously been demonstrated to comply with FAA AC 20-130A and ETSO C-115b (or subsequent versions), need only comply with the performance requirements of Chapter 2.3 of RTCA DO-229C at least. (because majortiy of GNSS/FMS SBAS equipment are developed with RTCA DO-229D requirements).

response	*Not accepted* The AMC already states the minimum required to comply with the certification requirements. This does not preclude demonstration to a higher standard where the minimum requirements are still being met.

comment	*21* comment by: *DFS* RTCA DO-229x is a performance document for equipment manufacturer. FBO and STC applicant is not familiar with this consistent document; precision for exact performance criteria to be demonstrated on aircraft integrator point of view will be appreciated. Therefore, chapters 2.2 & 2.3 of RTCA DO-229 have to be integrated to the AMC.
response	*Not accepted* It is not the intention of an AMC to repeat information contained in industry standards. It is assumed that applicants for airworthiness approval using this AMC have adequate knowledge of this RTCA standard.

comment	*22* comment by: *AIRBUS TRANSPORT INTERNATIONAL snc* We suggest to replace E/TSO-C145a by E/TSO-C145b, E/TSO-C146a by E/TSO-C146b and RTCA DO-229C by DO-229D. Reason: DO-229C is considered by the community as a first step to SBAS operations, mainly dedicated to the US SBAS service, i.e. WAAS. DO-229D takes more SBAS services into account, including EGNOS, and should therefore be more suitable as the minimum standard for AMC 20-28. Furthermore, DO-229D benefits from a lot of additional improvements compared to DO-229C (e.g. FAS Data Block protection required by §10.4.2 of this NPA).
response	*Partially accepted* EASA is not aware of technical issues in the RTCA DO-229C specification which would preclude the use of a system compliant with this standard within the EGNOS coverage, provided the requirements of FAA TSO-C145a/C146a have been considered. However, compliance with ETSO-C145c/ETSO-C146c will be required as these are currently the valid European standards.

comment	*36* comment by: *FAA* Comment: Paragraph 6.2.2, RTCA/DO-229D is the latest revision implemented by TSO. This section needs to use the same caveat as the previous sections when referring to RTCA/DO-229C. Also, Chapter 2.2 is the incorrect reference

	for Class Beta equipment. Rationale: Paragraphs 6.2.1 and 6.2.3 used the phrase: "...the equipment is at least compliant with RTCA DO-229C." Additionally, chapter 2.1 is the correct reference for Class Beta equipment. However, neither 6.2.1 nor 6.2.3 have a chapter reference so neither should 6.2.2. Recommendation: Change the first sentence in 6.2.2 to include the same caveat. The first sentence should read: "The integrated navigation system should at least meet the performance requirements defined in RTCA DO-229C.
response	*Partially accepted* Text amended to require compliance with ETSO-C145c/ETSO-C146c as these are currently the valid European standards.

comment	*51* comment by: *Gulfstream Aerospace Corporation Savannah* 6. Airworthiness Criteria. General. As TSO-c145a and TSO-c146a have been replaced by TSO-c145b and TSO-c146b respectively, recommend stating reference to the latest TSOs in this AMC.
response	*Partially accepted* Text amended to require compliance with ETSO-C145c/ETSO-C146c as these are currently the valid European standards.

comment	*55* comment by: *DSNA/DTI* All § 6.2 Subject : Reference to TSO or DO229 ? Rationale :In this paragraph, "should" is used. I understand that there are three different possibilities for LPV capability integration but for each case a "shall" is to be used. For example using DO 229C is acceptable as long as the SBAS sensor is in accordance with E/TSO C145, as some features are replaced by this E/TSO145. Recommendation : Use Shall in each of sub chapter and make reference to TSO.. instead of DO229..
response	*Not accepted* The AMC is an acceptable means of compliance, and consequently cannot include requirements. The use of 'shall' is therefore not appropriate.

comment	*56* comment by: *DSNA/DTI* §6.2

Subject : LPV 200ft

Rationale :

Are all these three LPV integration able to provide LPV 200ft ? ONe of the goal of the AMC 20-28 is to allow all possible LPV integration to achieve LPV 200ft. Is there any specific requirement to add to go down to LPV 200ft?

Recommendation : Clarify and add (if needed) specific requirement so that LPV 200ft is achieved with AMC 20-28 LPV integration.

response *Not accepted*

For the purpose of airworthiness approval, this AMC does not distinguish between higher and lower decision altitudes. There are no additional airworthiness requirements for approaches to LPV minima of 200 ft.

comment *100* comment by: *Thales Avionics*

What is the meaning of "E/TSO-C146a" ?

Proposed text : "ETSO-C146a or TSO-C146a"

Note: this issue appears in sections 6.2.1, 6.2.2, 6.2.3. 6.3.1 and Appendix 1 (three times).

response *Partially accepted*

This document now refers to ETSO standards as these are the valid European standards.

comment *101* comment by: *Thales Avionics*

The second sentence in the first paragraph of section 6.2.2 is not a requirement but seems to be an explanation relative to the previous sentence.

The proposal is to keep the first sentence of the first paragraph as a requirement and to put the second one in a note.

Proposed text:

"GNSS SBAS stand-alone equipment should be approved in accordance with ETSO-C146a or TSO-C146a (or subsequent version).

Note: Application of this standard should guarantee that the equipment is at least compliant with RTCA DO-229C."

Same issue in section 6.2.3

response *Partially accepted*

The text has been amended and second sentence of section 6.2.1 has been deleted.

comment *127* comment by: *Airbus S.A.S.*

AFFECTED PARAGRAPH:

§ 6.2.1, 6.2.2.

COMMENT:

DO-229C should be replaced by DO-229D; TSO-C145a and TSO-C146a should be replaced respectively by TSO-C145c and TSO-C146c.

JUSTIFICATION:

Several inconsistencies and issues have been solved in this version that is considered the most mature one.

In addition, current FAA applicable TSOs to use SBAS are TSO-C145c and TSO-C146c; RTCA DO-229 current issue applicable is rev D (RTCA DO-229D).

response *Partially accepted*

Compliance with ETSO-C145c/ETSO-C146c should be demonstrated as these are currently the valid European standards.

comment *141* comment by: *DGAC FRANCE*

Chapter 6 .2:

6.2.1:

Instead of

…. should be approved in accordance with E/TSO C146a (or subsequent version)

We propose:

…. should be approved in accordance with TSO C146a, TSO C146b or E/TSO C146c and subsequent version.

Justification:

ETSOC146a and ETSOC146b do not exist.

response *Partially accepted*

Compliance with ETSO-C145c/ETSO-C146c should be demonstrated as these are currently the valid European standards.

comment *143* comment by: *DGAC FRANCE*

Chapter 6.2

paragraph 6.2.1.

Instead of

Application of this standard guarantees that the equipment is at least compliant

with RTCA DO 229C

We propose:

Application of this standard guarantees that the equipment is at least compliant with RTCA DO229C and the MOPS modifications introduced in TSO C146a.

Justification:

Compliance with DO229C is not enough, modifications introduced in TSOC146a are necessary to be eligible to LPV operations.

consistently apply also similar comment on paragraph 6.2.2. and 6.2.3.

response *Partially accepted*

A note to that effect has been added.

AMC 20-28 - 6. AIRWORTHINESS CRITERIA - 6.2.3 Approach system incorporating class Delta GNSS SBAS equipment p. 12-13

comment *22* comment by: *AIRBUS TRANSPORT INTERNATIONAL snc*

We suggest to replace E/TSO-C145a by E/TSO-C145b, E/TSO-C146a by E/TSO-C146b and RTCA DO-229C by DO-229D.

Reason: DO-229C is considered by the community as a first step to SBAS operations, mainly dedicated to the US SBAS service, i.e. WAAS. DO-229D takes more SBAS services into account, including EGNOS, and should therefore be more suitable as the minimum standard for AMC 20-28.

Furthermore, DO-229D benefits from a lot of additional improvements compared to DO-229C (e.g. FAS Data Block protection required by §10.4.2 of this NPA).

response *Partially accepted*

The EASA is not aware of technical issues in the RTCA DO-229C specification which would preclude the use of system compliant with this standard within the EGNOS coverage, provided the requirements of FAA TSO-C145a/C146a have been considered. However, compliance with ETSO-C145c/ETSO-C146c should be demonstrated as these are currently the valid European standards.

comment *128* comment by: *Airbus S.A.S.*

COMMENT:

In § 6.2.3, DO-229C should be replaced by DO-229D; TSO-C145a and TSO-C146a should be replaced respectively by TSO-C145c and TSO-C146c.

JUSTIFICATION:

Several inconsistencies and issues have been solved in this version that is

considered the most mature one.

In addition, current FAA applicable TSOs to use SBAS are TSO-C145c and TSO-C146c; RTCA DO-229 current issue applicable is rev D (RTCA DO-229D).

response *Partially accepted*

Compliance with ETSO-C145c and ETSO-C146c should be demonstrated as these are currently the valid European standards.

comment *142* comment by: *DGAC FRANCE*

Chapter 6 .2:

6.2.3:

Instead of

…. should be approved in accordance with E/TSO C146a (or subsequent version)

We propose:

…. should be approved in accordance with TSO C146a, TSO C146b or E/TSO C146c and subsequent version.

Justification:

ETSOC146a and ETSOC146b do not exist.

response *Partially accepted*

Compliance with ETSO-C145c and ETSO-C146c should be demonstrated as these are currently the valid European standards.

AMC 20-28 - 6. AIRWORTHINESS CRITERIA - 6.3.1. Navigational System Error (NSE) p. 13

comment *22* comment by: *AIRBUS TRANSPORT INTERNATIONAL snc*

We suggest to replace E/TSO-C145a by E/TSO-C145b, E/TSO-C146a by E/TSO-C146b and RTCA DO-229C by DO-229D.

Reason: DO-229C is considered by the community as a first step to SBAS operations, mainly dedicated to the US SBAS service, i.e. WAAS. DO-229D takes more SBAS services into account, including EGNOS, and should therefore be more suitable as the minimum standard for AMC 20-28.

Furthermore, DO-229D benefits from a lot of additional improvements compared to DO-229C (e.g. FAS Data Block protection required by §10.4.2 of this NPA).

response | *Partially accepted*

EASA is not aware of technical issues in the RTCA DO-229C specification which would preclude the use of a system compliant with this standard within the EGNOS coverage, provided the requirements of FAA TSO-C145a/C146a have been considered. However, compliance with ETSO-C145c/ETSO-C146c should be demonstrated as these are currently the valid European standards.

comment | *37* comment by: *FAA*

Comment: RTCA/DO-229C reference needs to include a caveat for later revisions implemented by TSO.

Rationale: As done in previous sections, this should include the phrase "at least" prior to RTCA/DO-229C.

Recommendation: Change sentence to read: "...weighted least squares solution at least in accordance with RTCA/DO-229C, Appendix J."

response | *Not accepted*

The AMC already states a minimum to comply with the requirements. This does not preclude demonstration to a higher standard where the minimum requirements are still being met.

comment | *129* comment by: *Airbus S.A.S.*

COMMENT:

In § 6.3.1, DO-229C should be replaced by DO-229D; TSO-C145a and TSO-C146a should be replaced respectively by TSO-C145c and TSO-C146c.

JUSTIFICATION:

Several inconsistencies and issues have been solved in this version that is considered the most mature one.

In addition, current FAA applicable TSOs to use SBAS are TSO-C145c and TSO-C146c; RTCA DO-229 current issue applicable is rev D (RTCA DO-229D).

response | *Partially accepted*

Second paragraph reworded as a note and does not require compliance with the latest European ETSO standards.

AMC 20-28 - 6. AIRWORTHINESS CRITERIA - 6.3.2. Flight Technical Error (FTE) p. 13

comment	*3* comment by: *REGA* In order to permit the LPV procedures also for helicopter, the approach procedures should also include Heliports, Helideck or any landing area which fulfils the ground infrastructure requirements.
response	*Noted* This AMC is applicable to the airworthiness and operational requirements and does not address procedure design. It is assumed that the procedures are consistent with ICAO Doc 8168.

comment	*11* comment by: *REGA* Flight Crew should also include Single Pilot Operation (all certified aircraft).
response	*Noted* The intent of this AMC is neither to address the number of Flight Crew nor to introduce additional operational restrictions. Any restriction on single-pilot operations are detailed in the Agency Opinions 04/2010 and 04/2011 associated with the FCL and OPS.

comment	*22* comment by: *AIRBUS TRANSPORT INTERNATIONAL snc* We suggest to replace E/TSO-C145a by E/TSO-C145b, E/TSO-C146a by E/TSO-C146b and RTCA DO-229C by DO-229D. Reason: DO-229C is considered by the community as a first step to SBAS operations, mainly dedicated to the US SBAS service, i.e. WAAS. DO-229D takes more SBAS services into account, including EGNOS, and should therefore be more suitable as the minimum standard for AMC 20-28. Furthermore, DO-229D benefits from a lot of additional improvements compared to DO-229C (e.g. FAS Data Block protection required by §10.4.2 of this NPA).
response	*Partially accepted* EASA is not aware of technical issues in the RTCA DO-229C specification which would preclude the use of a system that is compliant with this standard within the EGNOS coverage, provided the requirements of FAA TSO-C145a/C146a have been considered. However, compliance with ETSO-C145c/ETSO-C146c should be demonstrated as these are currently the valid European standards.

comment	*96* comment by: *Garmin International* Section 6.3.2.1 Note 2 states:

Note 2: 1/3 of the full scale deflection for lateral deviation corresponds to 50 microamps and 1/2 the full scale deflection for vertical deviation corresponds to 75 microamps when a standard display is used (with a full scale deflection of 150 microamps).

While true, it is not obvious what purpose this Note serves. Is it trying to convey that the flight crew must maintain FTE within 1/3 FSD laterally and 1/2 scale vertically? If so, it should be reworded to make this purpose plain.

Additionally, suggest removing the references to microamps as some systems will output lateral and vertical guidance deviation in ARINC 429 labels or another output format not based on microamps. See also additional comments regarding references to "microamps" in section 8.5.

response *Accepted*

Note deleted.

AMC 20-28 - 6. AIRWORTHINESS CRITERIA - 6.4 Integrity p. 14

comment *58* comment by: *Garmin International*

Section 6.4 states "Presenting simultaneously, misleading lateral, vertical and distance data, ...". To maintain harmonization with FAA AC 20-138A, suggest that the statement be modified to remove "distance" since distance is a normal field of view parameter per FAA AC 20-138A paragraph 18.d(2). See additional comments on AMC 20-28 paragraph 7 item 3.

response *Partially accepted*

Text amended for clarification.

comment *102* comment by: *Thales Avionics*

Concerning hardware failures, the classification of the Failure Condition as Hazardous will often prohibit single navigation systems. The system will generally involve several equipment pieces (for example GPS/SBAS receiver, navigation computer, control panels and displays) and in a number of airborne architectures the 10-7 objective during the approach exposure time will not be achievable with a single system due to hardware failures and will require to implement dual or monitored systems (at least for some elements of the system).

Is it the intent of this requirement to require a dual or monitored (or partially dual or monitored) system? If the intent is to consider that a single system complies with the requirement it should be specified.

Note 1: this issue is only related to hardware failures. Concerning the design it is clearly understood that this requirement implies Level B Design Assurance Level.

Note 2: on digital systems it is generally not possible to identify separately "simultaneous, misleading lateral, vertical and distance data". It is considered that a hardware failure can impact simultaneously all the outputs.

response *Not accepted*

It is not the intention of this AMC to prescribe design solutions. The 'hazardous' failure condition results from the fact than on an approach to LPV minima, the GNSS/SBAS signal may be the only means for the Flight Crew to determine the position of the aircraft on the approach path, contrary to ILS, a co-located DME or Marker Beacons may not be available to the Flight Crew.

Consequently, a dual, redundant system may be required to meet CS XX-1309 requirements for larger (e.g. CS-25 and CS-23 Class IV) aircraft. However, a single system could potentially satisfy the requirements for smaller (e.g. CS-23 Class I) aircraft.

comment *130* comment by: *Airbus S.A.S.*

COMMENT:

The comment is linked to the classification of the "pure" aircraft failure case "*Presenting simultaneously, misleading lateral, vertical and distance data, during an LPV approach is considered to be a hazardous failure condition (extremely remote)*".

As per CS25.1309 regulation, the criticality of any aircraft hazard shall take into account aircraft architecture and cues available to the crew (number of equipment involved, the alerts available, etc...).

The proposed draft AMC should request aircraft manufacturer to properly perform a safety assessment as per CS 25.1309. The failure case addressed in Section 6.4 should be part of this evaluation, but the classification has to be assessed during the certification exercise at aircraft manufacturer level.

Airbus propose to remove the "hazardous" classification associated to the aircraft failure case "Presenting simultaneously, misleading lateral, vertical and distance data, during an LPV approach" in the AMC.

JUSTIFICATION:

Classification of an aircraft failure condition must be assessed in light of aircraft integration and architecture, knowledge of human factors, operating procedures, training, flight test pilot experience, and others as per CS25.1309 regulation.

response *Not accepted*

The criticality of an operation is not necessarily dependent on an aircraft's architecture. Rather, a specific architecture can aid in the reduction of the risks associated with a particular operation.

comment 136 comment by: *UK CAA*

Page No: 14

Paragraph No: 6.4

Comment: A hazardous failure condition may be achieved by presenting any undetected misleading information.

Justification: If erroneous information is given in any one dimension e.g. height, then there is a risk of CFIT or loss of separation.

Proposed Text (if applicable): Presenting misleading lateral, vertical or distance data….

response *Accepted*

Text amended.

AMC 20-28 - 6. AIRWORTHINESS CRITERIA - 6.5 Continuity of function p. 14

comment 24 comment by: *Honeywell*

This section's wording (and Appendix 3, Section 1.3) implies that the only response to a loss of LPV approach capability is a missed approach and diversion to another airport. If the LPV approach is also an LNAV/RNAV approach with a published MDA then the operator should be allowed to continue the approach to the MDA using LNAV/RNAV capability. Recommend revising wording to clarify that a missed approach is only required when LPV capability is lost on an LPV-only approach, or when equipment failures or other limitations preclude falling back to another valid approach type.

response *Not accepted*

Although fall-back to an LNAV/VNAV procedure is theoretically possible, it is not recommended due to the complexity of transitioning to a different operational procedure.

comment 38 comment by: *FAA*

Comment: Loss of LPV capability can also be mitigated by reverting to an LNAV approach either at the destination airport (prior to the final approach fix, or for DO-229D compliant equipment, after the FAF) or an alternate airport. The mitigation is not solely reliant upon another navigation system.

Rationale: RTCA/DO-229D equipment has the capability to fail down to an LNAV approach if the aircraft has crossed the FAF. Both -229D and -229C equipment have the capability to alert the crew to select an LNAV/VNAV or LNAV approach if the loss of LPV occurs prior to the FAF. If the RNAV (GNSS) approach cannot be completed at the destination airport, pilots of SBAS equipped aircraft can flight plan an alternate airport based on an LNAV

procedure at the alternate then fly whatever approach (LPV, LNAV/VNAV, LNAV) the equipment indicates is supported at the alternate.

Recommendation: Change the sentence to read: "Loss of LPV approach capability is considered a minor failure condition. The operator can: 1) prior to the FAF, select an LNAV/VNAV or LNAV approach if available; 2) after the FAF, continue the approach to LNAV minimums if above required minimum altitudes (equipment compliant with DO-229D) or do a missed approach; 3) perform an RNAV (GNSS) approach at an alternate airport; or 4) conduct an approach using a different navigation system.

response *Not accepted*

Section 6 of this AMC is associated with airworthiness requirements. The proposed wording relates to operational procedures which the Flight Crew could apply in case of loss of LPV capability. This aspect is addressed in Appendix 3.

comment *59* comment by: *Garmin International*

Section 6.5 begins with the statement:

It shall be demonstrated that:

a) the probability of loss of all navigation information is Remote.

b) the probability of non-restorable loss of all navigation and communication functions is Extremely Improbable.

While this statement is certainly relevant to the aircraft navigation and communication functions, it doesn't seem to be particularly relevant to the discussion of LPV approach operations. Suggest removing this text or clarifying how these requirements are relevant to LPV approach operations.

response *Accepted*

Text has been deleted.

comment *95* comment by: *EUROCOPTER*

The meaning of the sentence "For LPV approach operation at least one system is required" is ambiguous. Does it mean that an onboard solution with just one SBAS system is considered as sufficient? If yes, there is no need for such a sentence as it means implicitely that 2 systems are not required and in any case, you need one.

Futhermore, this sentence appears in fact as design solution which is suggested to meet the requirements mentionned previously whereas it is normally the task of aircraft manufacturers to propose solutions in response to requirements.

response *Partially accepted*

The sentence has been deleted. However, please note that it is not the intention of this AMC to prescribe design solutions.

comment	*103* comment by: *Thales Avionics* The first paragraph: *"It shall be demonstrated that:* *a) the probability of loss of all navigation information is Remote.* *b) the probability of non-restorable loss of all navigation and communication functions is Extremely Improbable."* is not relevant to the LPV function. It deals with the basic aircraft navigation capability. Proposed resolution: to delete the first paragraph.
response	*Accepted* Text has been deleted.

comment	*137* comment by: *UK CAA* **Page No:** 14 **Paragraph No:** 6.5 **Comment**: It should be clarified whether the loss of LPV approach capability is considering loss of capability in an individual aircraft, i.e. equipment failure in that aircraft. If the general loss of capability is being considered e.g. loss of GPS signal then the impact to air traffic service providers may be more than minor. **Justification:** The affect on the air traffic service providers both at the airport and at a control centre if multiple aircraft are suddenly diverting to other destinations can only be assessed and deemed acceptable by the relevant service providers.
response	*Partially accepted* This comment is already addressed in paragraph 5.1. However, upon further review, the Agency has considered that for reasons of consistency, loss of the system which provides capability to perform an LPV approach at the level of a single aircraft should be raised to major, because such an event could potentially lead to a significant reduction of functional capabilities and safety margins and an increased crew workload. The text has been amended accordingly.

AMC 20-28 - 7. FUNCTIONAL CRITERIA p. 14-16

comment	*13* comment by: *REGA* Flight Crew should also include Single Pilot Operation (all certified aircraft).
response	*Accepted* The sentence states 'where the minimum Flight Crew is two', which does not preclude single-pilot operations.

comment	*28* comment by: *Dassault Aviation* In § 7.1 "Required Functions", Item 7 has been modified from previous version of AMC 20-28 (Draft V1.4 - 13 Oct 2008), and differs from DO 229C/D requirements: While the clarification for the specific TAWS mode of operation is a welcome one, this version of AMC 20-28 also removes the possibility to implement as an alternative means of compliance an altitude alert if the estimated position is lower than the desired FAP height by more than 50m + VAL. This suppression is an important modification putting additional constraints that may be excessive for some aircrafts, especially for retrofit. Enabling the use of the TAWS excessive downward deviations alert may not be practical, e.g., • because of avionics systems architecture constraints, or • for installation of stand-alone SBAS GPS, whereas the altitude alert is already a standard implementation on (some) SBAS GPS. This may lead to some delay for LPV implementation in Europe. Therefore Dassault Aviation propose to reintroduce the possibility to implement the altitude alert as in AMC 20.28 draft V1.4 as an alternative means of compliance: e.g. Dassault proposal for item 7 is to replace text of the NPA by the following one: Where operational regulations require the use of a Class A TAWS or a Class A TAWS is installed: - Prior to sequencing the FAP, capability to provide an altitude alert if the estimated position is lower than the desired FAP height by more than 50m + VAL, or -Capability to provide an appropriate output to an installed Terrain Awareness and Warning System (TAWS) enabling the use of the excessive downward deviation from a glideslope function.
response	*Not accepted* EASA has carefully considered verification of altitude, by means of an altitude alert at the FAP versus the benefits that TAWS Mode 5 protection would provide. The Agency considers that the intention of TAWS Mode 5 is not to prevent system failures, but rather to continuously monitor the position of the

aircraft on the glide path and provide an alert in case of piloting errors. The altitude alert at the FAP does not provide continuous monitoring. Additionally, the Agency considers that altitude verification at the FAP should be considered a standard procedure for the Flight Crew to perform on any approach.

comment

39 comment by: *FAA*

Comment: Page 15, paragraph 7.1, item 1, in note 1, there is a typographical error.

Recommendation: "none" should be "non".

response

Accepted

Text amended.

comment

49 comment by: *Gulfstream Aerospace Corporation Savannah*

7.1 Required Functions. Item 3. Proposed text, "Capability to continuously display the distance to the Landing Threshold Point/Fictitious Threshold Point (LTP/FTP) or the Flight Plan distance to the next waypoint.

response

Partially accepted

The text has been amended to state that from passing the FAP the distance to the LTP/FTP should be displayed. The display of the distances to waypoints prior to and including the FAP is covered under different navigation specifications.

comment

50 comment by: *Gulfstream Aerospace Corporation Savannah*

7.1 Required Functions. Item 1. Replace the word "none" with "non".

response

Accepted

Text amended.

comment

52 comment by: *Gulfstream Aerospace Corporation Savannah*

7.1 Required Functions. Item 6. Recommend adding a note that states the following (or similar type wording): "Note: During an LPV failure/unavailable condition it is permissible to continue to display the vertical-deviation scale as long as it is marked with a red-X indicating that the scale is not to be used for navigation." This follows the same philosophy and display logic as implemented in ILS approach for the Gulfstream GIV-X and GV-SP models.

response | *Not accepted*

Item 6 does not require the applicant to remove the scale, rather it requires the guidance to be removed (or invalidated). The Gulfstream design seems to be consistent with the requirement. However, upon further review, this requirement has been amended to state that the invalid guidance cues are to be removed (or invalidated).

comment | *60* comment by: *Garmin International*

Section 7.1 item 2 requires:

"Capability to display the GNSS Approach mode (e.g., LPV, LNAV/VNAV, LNAV ...) in the primary field of view."

The requirement to display GNSS approach mode in the primary field of view is inconsistent with FAA AC 20-138A paragraph 18.d(2) which says the "… approach mode annunciation, … should be located within the pilot's normal field of view." Suggest changing this to "… in the normal field of view."

Additionally, the primary field of view requirement is problematic for retrofit equipment like Garmin 400W/500W as it requires a separate approach mode annunciation in the primary field of view that not only indicates the equipment is in approach mode but also indicates the type of approach. While Garmin's 400W/500W has the capability to output the approach mode type on an ARINC 429 bus, the 429 bus is the only externally accessible source for this information. Other than an EFIS, Garmin is not aware of any external approach mode annunciator equipment that uses the 429 bus to display the type of approach as part of the approach mode annunciation. Garmin's 400W/500W equipment displays the approach mode type on its own display, which will appear in the normal field of view when installed in accordance with the installation instructions.

response | *Partially accepted*

Although the Agency considers that the approach mode should be displayed in the primary field of view, it is recognised that for some installation this may be impractical. Therefore, the note has been amended to state that indication of approach mode may be located outside of the primary field of view, but within the normal field of view, subject to the Agency agreement.

comment | *61* comment by: *Garmin International*

The last sentence of the note in section 7.1 item 2 states:

"It permits also to detect a level of service degradation (e.g. downgrade from LPV to LNAV)."

While a display of GNSS approach mode in the primary field of view might assist the crew with detecting a level of service degradation (e.g., downgrade from LPV to LNAV), this indication is already provided by other means in the primary field of view; specifically a vertical deviation flag without a concurrent lateral deviation flag. This further supports maintaining harmonization with FAA

AC 20-138A paragraph 18.d(2) requirements that the approach mode indication should be located in the normal field of view.

response *Partially accepted*

Please see response to comment 60.

comment *62* comment by: *Garmin International*

Section 7.1 item 3 includes a Note with the phrase:

"... located in the primary field of view (+/- 15 degrees from the normal line of sight) ..."

The requirement to display distance in the primary field of view is inconsistent with FAA AC 20-138A paragraph 18.d(2) which requires display of distance to active waypoint in the normal field of view.

Additionally, there are no primary field of view distance display requirements for an ILS approach, which is quite similar in nature. So it doesn't seem appropriate to require distance display in the primary field of view for LPV.

To maintain harmonization with FAA AC 20-138A, suggest changing the distance display requirement to the normal field of view. See additional comments on AMC 20-28 paragraph 6.4.

response *Partially accepted*

A note is not a requirement in itself. However, upon further review, the requirement has been revised to state that display of distance should be in the primary field of view, with the note stating that deviations from this requirement may be acceptable subject to the Agency agreement.

comment *63* comment by: *Garmin International*

Section 7.1 item 1 sub-item 3) includes the following text:

"The lateral and vertical Full Scale Deflections are angular and associated to the lateral and vertical definitions of the FAS contained in the FAS Data Block."

When a VTF approach has not been selected, RTCA/DO-229C and RTCA/DO-229D paragraph 2.2.5.4.2 include an option for a lateral FSD that is not angular and not associated to the lateral definition of the FAS; specifically:

a. Prior to the FAWP, the deviation shall be either:

i. Prior to 2 nm from the FAWP, the deviation shall be linear, with FSD for a cross-track error of +/- 1 nm. Between 2 nm from the FAWP and the FAWP, the deviation sensitivity shall gradually change to the final approach segment lateral deviation sensitivity (Figure 2-16a); or

Garmin's TSO-C146a equipment implements the quoted DO-229 2.2.5.4.2 requirement. Consequently, the quoted AMC 20-28 section 7.1 item 1 sub-item 3) text is not consistent with what DO-229 allows nor how fielded equipment actually functions.

response | *Noted*

It should be considered that the scope of this AMC is limited to the final approach section as defined in paragraph 2.

comment | *65* comment by: *Garmin International*

Section 7.1 item 4 contains the following text:

Although data may be stored or transmitted in different ways, the data has to be organized in data blocks for the purpose of computing the CRC. This format provides integrity protection for the data it contains. Consequently, each Final Approach Segment is defined by a specific "FAS Data block" containing the necessary lateral and vertical paramenters depicting the approach to be flown.

Once the FAS Data Block has been decoded, the equipment shall apply the CRC to the data block to determine if the data is valid. If the FAS Data Block does not pass the CRC test, the equipment shall not allow activation of the LPV approach operation.

As this is already required by TSO-C146a (and later revisions) and RTCA/DO-229C/D, it doesn't seem to add value from either an operator's point of view or a manufacturer's point of view. Suggest the quoted text be removed.

response | *Partially accepted*

The text has been converted into a note. Although the information may not be of value to the equipment manufacturers, the Agency believes that the text provides added value to the installers and may be informative to the operators.

comment | *66* comment by: *Garmin International*

Section 7.1 item 6 contains the following text:

"Indication of the Loss Of Integrity (LOI)/... in the primary field of view ..."

The requirement to display Loss of Integrity (LOI) in the primary field of view is inconsistent with FAA AC 20-138A paragraph 18.d(2) which requires LOI display in the normal field of view.

Additionally, per the following note in DO-229C/D 2.2.5.6.2, the LOI requirements only apply prior to sequencing the FAP:

Note: Although this requirement is stated for LPV and LP approaches, its applicability is limited to outside the FAWP since a loss of integrity monitoring after sequencing the FAWP is defined to be a loss of navigation as described in Section 2.2.5.6.3.

To maintain harmonization with AC 20-138A and consistency with the intent of LOI only being applicable prior to the FAP, suggest changing the LOI display requirement to the normal field of view.

response | *Partially accepted*

Although the Agency considers that the Loss Of Integrity should be displayed in the primary field of view, it is recognised that for some installation this may be impractical. Therefore, the note has been amended to state that indication of approach mode may be located outside of the primary field of view, but within the normal field of view, subject to the Agency agreement.

comment | *67* comment by: *Garmin International*

Section 7.1 item 6 ends with the phrase:

"... and the removal of all guidance clues."

Removal of all guidance clues is not possible in all installations. For example, many mechanical CDI/HSI instruments are unable to "hide" the deviation "needle" for LPV (or ILS for that matter).

Additionally, requiring the removal of all guidance clues is inconsistent with FAA AC 20-138A paragraph 18.e(3) that states:

Presentation of a failure/status annunciation (flag or integrity annunciation) does not require removal of navigation information from the navigation display.

It is also inconsistent with the note in DO-229C/D 2.2.5.6.3 that states:

Note: A loss of navigation alert does not require removal of navigation information from the navigation display. It is acceptable to continue to display navigation information concurrent with the failure/status annunciation when conditions warrant.

Suggest removing this phrase or changing it to a suggestion rather than a requirement.

response | *Noted*

With respect to removal of guidance cues, the AMC is a means of compliance, but may not be the only means of compliance.

comment | *68* comment by: *Garmin International*

Section 7.1 item 7 includes the following text:

"Capability to provide an appropriate output to ..."

The need to provide an "output" to an installed TAWS for excessive downward deviation from glideslope function depends on the level of integration of the aircraft equipment. For example, equipment that is integrated such that the LPV and Class A TAWS functions are performed within the same LRU does not require such an "output".

Suggest revising this text to "Capability to interface with ..." or "Capability to support ...".

response | *Partially accepted*

The text has been amended to account for this comment.

comment | *93* comment by: *EUROCOPTER*

Item 3 "Capability to continously display the distance to the Landing Threshold Point / Fictitious Threshold Point (LTP/FTP)" is too much related to the standard ILS approach. An LPV is basically a RNAV approach for which distance to next waypoint shall be displayed. In a LPV procedure, The FAF is a (RNAV) waypoint whereas glideslope interception on ILS procedure is not. This means item 3 requirement should be replaced by "Capability to continuously display the distance to the next waypoint in the procedure".

response | *Partially accepted*

The text has been amended to state that from passing the FAP, the distance to the LTP/FTP should be displayed. The distances to waypoints prior to and including the FAP are covered under different navigation specifications.

comment | *97* comment by: *Garmin International*

Section 7.1 item 8 includes the following text:

"Capability to immediately provide track deviation indications ..."

Suggest revising the phrase "track deviation" to "course deviation" within this text.

response | *Partially accepted*

The text has been amended to state: 'Capability to immediately provide deviations from the intended flight path relative to the extended final approach segment'.

comment | *111* comment by: *AIR FRANCE*

Item 2: this function is necessary but not implemented on the existing fleet.

response | *Noted*

Thank you for your comment, it has been duly noted.

comment | *138* comment by: *UK CAA*

Page No: 15

Paragraph No: 7.1 Item 1 Second line of Note 1

Comment: The phrase "none flying crew member" has been used.

Justification: Apparent typographical error

Proposed Text: "…… the non-flying crew member ….. "

response *Accepted*

Text amended.

comment *140* comment by: *Pilatus*

response

1.1 Approach mode display in the primary field of view

1.1.1 NPA 2009-04 Requirement

The NPA 2009-04 (AMC 20-28) section 7.1 contains of a table with requirements applicable to LPV approach functionality. Item 2 from the "Required Functions" table is shown below:

2. Capability to display the GNSS Approach mode (e.g. LPV, LNAV/VNAV, LNAV …) in the primary field of view.

   Note: This annunciation indicates to the crew the active approach mode in order to correlate it with the corresponding line of minima on the approach chart. It permits also to detect a level of service degradation (e.g. downgrade from LPV to LNAV).

1.1.2 Pilatus Aircraft Ltd. Comment

The minimum operational performance standards for the GNSS equipment are given in RTCA/DO-229D [2]. According to this document the GNSS equipment is categorised in the following classes:

Class Beta. Equipment consisting of a GPS/SBAS sensor that determines position (with integrity) and provides position and integrity data to an integrated navigation system (e.g. flight management system, multi-sensor navigation system). This equipment also provides integrity in the absence of the SBAS signal through the use of Fault Detection and Exclusion (FDE).

Class Gamma. Equipment consisting of both GPS/SBAS position sensor (defined by Class Beta) and navigation function, so that the equipment provides path deviations relative to a selected path. The equipment provides the navigation function required of a stand-alone navigation system. This equipment also provides integrity in the absence of the SBAS signal through the use of FDE. In addition, this class of equipment requires a database, display outputs and pilot controls.

Class Delta. Equipment consisting of both the GPS/SBAS position sensor (defined by Class Beta) and navigation function, so that the equipment provides path deviations relative to a selected final approach path, similar to Class Gamma. However, not all of the functions provided by Class Gamma equipment are available from Class Delta. In particular, Class Delta does not provide an RNAV capability and is not required to provide a FAS database or direct pilot controls. It is understood that Class Delta equipment provides means to be controlled. The Delta class of equipment is only applicable to Class

4 that is intended to provide an ILS alternative. Aircraft that install Delta class equipment are expected to have a separate RNAV capability up to the Final Approach Waypoint (FAWP) and for the missed approach (after the Landing Threshold Point/Fictitious Threshold Point) [2].

1.1.2.1 Requirements for Class Gamma equipment

The RTCA/DO-229D has following requirement for the Class Gamma equipment regarding approach mode indication:

Section 2.2.1.7 Mode Switching Requirements

In approach mode the current approach type shall be continuously annunciated in accordance with the database (see section 2.2.4.5.1 and 2.2.5.5.1) and switches to LNAV during fail-down from LNAV/VNAV or LPV. [2]

This requirement must be fulfilled by stand alone GNSS equipment with Gamma classification. Such system provides the ability for manual or automatic selection of the available approach type (e.g. LPV, LNAV/VNAV, LNAV …). The automatic selection is based on the current GNSS equipment performance.

In case of automatic selection the pilot is not actively in the loop and must be informed which type of approach is selected by the system (applicable minima). See RTCA/DO-229D, paragraph 2.2.5.2.4, reference below.

Selection of the Approach Type

The equipment shall provide a means to select which type of approach will be conducted (LPV or LP, LNAV/VNAV or LNAV). This selection may be manual or automatic.

For automatic selection, the equipment shall select either Approach (LPV or LP), Approach (LNAV/VNAV), or Approach (LNAV) when entering approach mode. The automatically-selected approach type shall be most accurate approach where the alert limit(s) are predicted to be supported, and where a minimum is published for the selected procedure. The order of precedence is LPV or LP, LNAV/VNAV, then LNAV. If LPV or LP is both published and predicted to be available, the equipment shall indicate that it is available. If LPV or LP is published and is not predicted to be available, the equipment shall indicate that it is not available and shall indicate the approach type that is available (e.g., "LPV not available – Use LNAV/VNAV minima"). A prediction for Approach (LNAV) is not necessary. Once annunciated, the equipment shall not change from Approach (LPV) to Approach (LNAV/VNAV) or from Approach (LP) to Approach (LNAV) unless the approach is reselected or the pilot selects a different approach type.

For manual selection, when entering approach mode the equipment shall indicate if the manually-selected approach type is not predicted to be available. [2]

As shown above the NPA 2009-04 requirements for the display of the GNSS approach mode will be applicable to GNSS Class Gamma equipment in accordance with RTCA/DO-229D.

1.1.2.2 Requirements for Class Delta-4 equipment

The RTCA/DO-229D (section 2.3) has no specific requirements regarding the approach type selection (auto/manual) or approach type display (LNAV, LNAV/VNAV, or LPV) for the Class Delta-4 equipment.

The behaviour of the Flight Management System (FMS) (TSO-C115) with integrated GNSS Sensor (TSO-C145/146, class Beta-3/Delta-4) during approach operation is different to the GNSS Class Gamma equipment. The

system may only distinguish between FMS approach operation (LNAV or LNAV/VNAV baro-based) and GNSS approach operation (LPV or LP). In this case the operation of Class Delta-4 equipment is similar to an ILS approach. Since the pilot is always in the loop and must select the desired approach mode, only the availability of the manual selected approach type must be displayed. This can be done by a dedicated "LPV" status indication. This indication will not revert to LNAV/VNAV or LNAV since this mode must be manually selected by the pilot. Subsequently the pilot will know what type of approach is selected (applicable minimum).

Furthermore such a system is not designed to support the GNSS based vertical guidance for LNAV/VNAV type of approaches, see Class Delta-4 specification [2]. For LNAV/VNAV approach type the vertical guidance is based on the barometric pressure. Therefore the system can not automatically determine if the current integrity limits are sufficient to perform a baro-based LNAV/VNAV approach since the eventual limitations (e. g. outside temperature) must be checked by the pilot.

The information above shows that the requirements from NPA 2009-04 may not be met by a FMS system with integrated GNSS Class Beta-3/Delta-4 equipment.

1.1.2.3 Requirement to display the approach type in the pilot primary field of view:

The FAA AC 20-138A has following requirements regarding use of Navigation Displays, refer to [5]:

d. Navigation Display.

(1) The horizontal (and vertical) deviation(s) display(s) and failure annunciation should be located within the pilot's primary field of view, as should any indication requiring immediate aircrew action. For the purpose of this AC, the primary field of view is within 15 degrees of the pilot's primary line of sight.

(2) Displays used for loss of integrity monitoring, waypoint sequencing, start of a turn, turn anticipation, active waypoint, distance to active waypoint, desired track and actual track (track angle error), TO/FROM indication, approach mode annunciation, and automatic mode switching should be located within the pilot's normal field of view. The normal field of view is such that the pilot would notice an annunciation during normal aircraft operation. Guidelines for the normal field of view include: the lateral normal field of view is from the center of the airspeed indicator to and including the equipment if installed in the center radio stack. Alternatively, if the equipment is installed to the left of the airspeed indicator, the lateral normal field of view is the center of the altimeter to and including the equipment. The vertical normal field of view includes immediately above and below the basic "T" instruments (may also be anywhere within the lateral field of view). [5]

According to the requirements above only the horizontal (and vertical) deviation display and the failure annunciation (Integrity warning) should be displayed in pilot's primary field of view. All other navigation information can be displayed in pilot's normal field of view.

Consequently the manufacturers of the GNSS equipment propose to use an external annunciation unit, if the navigation display is installed outside the pilot's primary field of view, refer to Garmin GNS430W Installation Manual [4]. In most of the cases the external annunciators do not display the approach type which is active on the GNSS equipment (Mid-Continent Annunciation Control Unit MD41-1408A) . The NPA 2009-04 requirement can cause potential

problems for retrofit programs.

The GNSS Class Gamma equipment can be designed to automatically select the available approach type, as specified in RTCA/DO-229D. Once selected the approach type can only be changed by the pilot, see RTCA/DO-229D [2], paragraph 2.2.5.2.4. The degradation from LPV or LNAV/VNAV to LNAV approach type after Final Approach Fix (FAF) is indicated trough the removal of vertical guidance information (identical to ILS operation) and annunciation of integrity warnings. In this case the pilot will be well aware that the LPV or LNAV/VNAV minimum can not be flown even if the changed minimum (LNAV) is not displayed in the primary field of view.

1.2 TAWS Class A requirements

1.2.1 NPA 2009-04 Requirement

The NPA 2009-04 section 7.1 contains the requirement for the TAWS and GNSS equipment regarding excessive glide slope deviation, as shown below:

7. Capability to provide an appropriate output to an installed Terrain Awareness and Warning System (TAWS) enabling the use of the excessive downward deviation from a glideslope function.

   Note: This is only applicable where operational regulations require the use of a Class A TAWS or a Class A TAWS is installed.

1.2.2 Pilatus Aircraft Ltd. comment

Excessive downward deviation from an ILS glideslope is a capability of TAWS Class A mode 5 equipment. The TSO C151b (Terrain Awareness and Warning System) does not have any requirements for the TAWS to use the LPV glideslope deviation for mode 5 functionality. Also DO-229D and FAA AC 20-138a do not have the requirements for the GNSS equipment to provide specific glideslope deviation signal to the TAWS class A unit.

Requirement to carry TAWS Class A are summarised below [3]:

ICAO Annex 6 Part 1 (International Commercial Air Transport) SARPs require that TAWS Class A shall be carried in all aircraft with an MTOM (maximum take-off mass) greater than 5700kg or authorised to carry 10 or more passengers. TAWS Class A is recommended for carriage in the case of aircraft authorised to carry 6-9 passengers.

ICAO Annex 6 Part 2 (International General Aviation) SARPs require carriage of either TAWS Class A or TAWS Class B in all aircraft with an MTOM greater than 5700kg or authorised to carry 10 or more passengers

For EU and EEA States, the public transport requirement is actioned under the requirements of EU-OPS 1.665 which has the effect of mandating TAWS Class A:

"(a) An operator shall not operate a turbine powered aeroplane having a maximum certificated take-off mass in excess of 5 700 kg ... or a maximum approved passenger seating configuration of more than 9 unless it is equipped with a ground proximity warning system that includes a predictive terrain hazard warning function (Terrain Awareness and Warning System – TAWS).

(b) The ground proximity warning system must automatically provide, by means of aural signals, which may be supplemented by visual signals, timely and distinctive warning to the flight crew of sink rate, ground proximity, altitude loss after take-off or go-around, incorrect landing configuration and downward glide slope deviation.

(c) The terrain awareness and warning system must automatically provide the

flight crew, by means of visual and aural signals and a Terrain Awareness Display, with sufficient alerting time to prevent controlled flight into terrain events, and provide a forward looking capability and terrain clearance floor." [3]

Pilatus Aircraft Ltd. is concerned that above mentioned requirement will cause issues with retrofit programs. The current TAWS and GNSS systems are not designed to provide mode 5 functionality during LPV approach operation. Many existing systems will require major design changes to be able to provide this functionality.

2 Conclusion

1) Pilatus Aircraft Ltd. proposes to distinguish between GNSS equipment with automatic selection (Class Gamma) and manual selection of the approach type (class Delta-4). The indication of the approach type, paragraph 1.1, should only be applicable to the equipment with automatic selection capability (Class Gamma).

2) Pilatus Aircraft Ltd. proposes to review the requirement regarding display of the active approach type in the primary field of view (as shown in 1.1.2.3.).

3) Pilatus Aircraft Ltd. proposes to review the requirements for the TAWS class A equipment since this is not standardised at the moment, refer to 1.2.

response *Not accepted*

Reference is made to commenter's conclusions:

1) Manual selection on the RNAV equipment alone may not be the only action the Flight Crew will need to perform before the guidance and steering signals for the selected approach will be provided to the instruments and/or flight guidance systems. The Agency therefore disagrees with commenter's position.

2) Reference is made to the response to comment 66.

3) Issues with standardisation and technical implementation difficulties have been considered when the requirement was drafted. The Agency however believes that the safety benefits of the requirement justify the additional burden on the equipment manufacturers and installers and has decided to maintain the requirement.

comment *146* comment by: *Thales Avionics*

In order to allow the crew to comply with the operational requirement in appendix 3 1.1 b) second paragraph, a requirement should be added in section 7.1 for a means to display "approach procedures (including alternate aerodromes) as extracted by the system (e.g. CDU flight plan page) or presented graphically on the NAV display, in order to confirm the correct loading and the reasonableness of the procedure content..."

response *Not accepted*

The requirement in Appendix 3 does not imply that the crew must verify the reasonableness of the content. It should be considered that the approach is defined in a uniquely identified and CRC protected FAS Data Block, thereby

providing a means to verify correct loading of the procedure. The SBAS channel number or other approach identifier is expected to always be verifiable.

comment

148 comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

In item 7 of the table, Embraer understands that the interface between LPV and TAWS should be recommended for aircraft affected by operational regulations requiring the use of Class A TAWS. Since there are no operational regulations requiring the use of Class A TAWS, Embraer believes that an option to operate LPV without TAWS should be provided.

This would not limit operators to use LPV functionality for aircraft with stand alone equipment.

response

Not accepted

The requirement applies only to aircraft that are required by operational regulation (currently Commission Regulation (EC) N° 859/2008, OPS 1.665) to have a TAWS Class A installed and those aircraft where TAWS Class A has been installed voluntarily.

comment

151 comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

In the item 03 of the table, Embraer understands that this item goes beyond what is required for the ILS approach that uses information from localizer and glideslope. For the display of information for ILS it is not necessary for the presentation of distance to appear in the primary field of vision, despite having the same level of importance.

response

Noted

The commentator is correct.

comment

154 comment by: *Bombardier Aerospace*

"1. Item 7 of section 7.1 'Required Functions' imposes a new functionality requirement on the TAWS, i.e., Mode 5 capability during SBAS LPV approaches. The TAWS equipment is required to meet TSO C-151b and the aircraft installation is certified using JAA TGL 12 'Certification Considerations for the Terrain Awareness Warning System: TAWS' as guidance material. Both of these documents should be updated to reflect the new functionality imposed on the TAWS by Item 7. Industry should have the opportunity to comment on these updates. Item 7 should be withdrawn until the updated TSO and TGL have been released."

response

Not accepted

Issues with non-availability of ETSO and AMC material have been considered

when the requirement was drafted. However, it is not a prerequisite to have an ETSO or AMC to design such a function. The Agency believes that the safety benefits of the requirement justify the additional burden on the equipment manufacturers and installers and has decided to maintain the requirement.

AMC 20-28 - 8. AIRWORTHINESS COMPLIANCE p. 17-19

comment *45* comment by: *Luftfahrt-Bundesamt*

page 17, 8.2

sentence 5: add "..., confirmation of appropriate software and complex electronic hardware design assurance level,..."

response *Accepted*

Text amended accordingly.

comment *46* comment by: *Luftfahrt-Bundesamt*

page 18, 8.4

c) 2nd bullet: instead of "dual equipage": "multiple (or redundant) equipment"

add 3rd bullet: adequate means to switch off (deactivate) the failed system (e.g. C/B...)

response *Accepted*

Text amended accordingly.

comment *69* comment by: *Garmin International*

Section 8.4 item a), second bullet states:

"clear annunciation of the selected approach system on or near the display;"

It is not entirely clear which "display" is being referred to in this context (e.g., guidance display of lateral and vertical deviations; FMS or multi-function display, etc.). Suggest changing "display" to "guidance display".

response *Accepted*

Text amended accordingly.

comment *70* comment by: *Garmin International*

Section 8.4 item f) third bullet states:

"Use of context sensitive help capability ..."

is an essential design consideration.

While a laudable goal, previously certified equipment like the Garmin TSO-C146a 400W, 500W, and G1000 do not have such capabilities nor is such a capability required by TSO-C146 and RTCA/DO-229C/D. Suggest removing "context sensitive help capability".

response *Noted*

The Agency reminds the commenter that an essential design consideration does not constitute a requirement.

comment *71* comment by: *Garmin International*

Section 8.5 item d) first bullet contains the following text:

"(i.e. within +/-50 microamps deviation)"

Suggest changing "+/- 50 microamps deviation" to "+/- 1/3 Full Scale Deflection" as some systems will output lateral guidance deviation in an ARINC 429 label or other output format not based on microamps.

response *Partially accepted*

References to deviations have been removed from the text.

comment *72* comment by: *Garmin International*

Section 8.5 item d) second bullet contains the following text:

"(i.e. within +/-75 microamps deviation)"

Suggest changing "+/- 75 microamps deviation" to "+/- 1/2 Full Scale Deflection" as some systems will output vertical guidance deviation in an ARINC 429 label or other output format not based on microamps.

response *Partially accepted*

References to deviations have been removed from the text.

comment *73* comment by: *Garmin International*

Section 8.5 item d) Note 1 states:

"Note 1: Compatibility with ILS display systems can be achieved by converting the lateral and vertical deviation to microamps based upon a Full Scale Display (FSD) at 150 microamps."

If the previous suggestions about using % FSD are used for section 8.5 item d)

	first and second bullets, then it seems like this text should be removed or revised to be consistent as some ILS display systems may use ARINC 429 labels or some other input format not based on microamps. Additionally, if the text "Full Scale Display (FSD)" is retained, it should be revised to "Full Scale Deflection (FSD)" to be consistent with other uses within AMC 20-28.
response	*Partially accepted* Following a review of this requirement and changes introduced to paragraph 6.3.2, the referenced paragraph has been deleted.

comment	*94* comment by: *EUROCOPTER* In paragraph 8.4, the requirement for "a system source selector as the only mean of selection" should not be required for legacy avionic systems to be upgraded in SBAS. Indeed, applying such requirement to legacy installations would require a complete redesign of the source selection system which is technically complex, expensive and induces regression risks. Having more than one mean of selection should be considered acceptable provided the indications in the primary field of view are such that a mistake is as unlikely as mistaking a source.
response	*Not accepted* The Agency is aware of the difficulties which certain aircraft architectures present. However, the AMC presents an acceptable means of compliance, but not the only means.

comment	*149* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* In the item 8.5(a), Embraer understands that the AMC should reference a minimum number of approaches for FTE performance evaluation for LPV approach operation avoiding general terms as “several”.
response	*Partially accepted* The number of approaches may depend on specific design and aircraft architecture considerations. Specifying a number of approaches would be inappropriate. However, the paragraph has been reworded to improve clarity.

comment	*150* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.* In the item 8.5(d), Embraer understands that the AMC should present the deviation values in full scale deflection for better comprehension. Although the correspondence from microamps into full scale deflection is already presented on item 6.3, Embraer believes that it should be presented on this requirement

	or a reference to item 6.3 should be included.
response	*Accepted* The requirements of item 8.5.d have been transferred to paragraph 6.3.2 and on review have been amended for clarity.

AMC 20-28 - 9. AIRCRAFT FLIGHT MANUAL/PILOT OPERATING HANDBOOK p. 19

comment	*23* comment by: *AIRBUS TRANSPORT INTERNATIONAL snc* In §9.a), although only a suggestion ("may"), the amount of information related to "descriptions" and "introductions" to insert in the AFM/POH is inconsistent with the principles set forth in CS 25.1581 and its AMC. Indeed, this AMC states: "(…) the systems descriptions and procedures provided in the AFM for most large aeroplanes should be limited to that which is uniquely related to aeroplane safety or airworthiness". We would therefore suggest to keep only the compliance statements in the AFM, and to insert the descriptions (even "very brief") in other operating and training manuals (except for aircraft where the AFM serves as the sole operating manual, iaw CS 25.1581 & AMC). Reason: The AFM/POH should be kept manageable without unnecessary information, iaw CS 25.1581. Detailed descriptions and procedures should be placed in separated dedicated manuals.
response	*Not accepted* Although the suggestion that the AFM should be kept manageable is an appreciated principle, not all aircraft types have the same range of manuals.

comment	*47* comment by: *Luftfahrt-Bundesamt* **page 19, 9.** first sentence: "..., whichever is applicable,..." statement too weak. Text should clearly indicate, that -whenever there is an AFM- the information should be included in the AFM.
response	*Not accepted* The Agency has accepted that a Pilot Operating Handbook could be equivalent to an AFM for particular types of aircraft.

comment	*74* comment by: *Garmin International*

Section 9 item a) includes the following text:

"including the airborne equipment software version,"

A minimum software version should be sufficient to avoid having to update the AFM or POH due solely to a software version change.

response *Not accepted*

The Agency is of the opinion that software part-numbering conventions allow for minor changes to be accomplished without having to roll the part number.

comment *75* comment by: *Garmin International*

Section 9 item b) third bullet includes the following text:

"Abnormal Procedures - including actions in response to a Loss of Integrity/Loss of Navigation ..."

Actions in response to Loss of Integrity and Loss of Navigation may not be the same. Suggest separating these by a comma rather than a slash.

response *Partially accepted*

Text amended to include an 'or'.

AMC 20-28 - 10. OPERATIONAL CRITERIA p. 20-22

comment *4* comment by: *REGA*

In order to permit the LPV procedures also for helicopter, the approach procedures should also include Heliports, Helideck or any landing area which fulfils the ground infrastructure requirements.

response *Noted*

This AMC is applicable to the airworthiness and operational requirements and does not address procedure design. It is assumed that the procedures are consistent with ICAO Doc 8168.

comment *15* comment by: *REGA*

Flight Crew should also include Single Pilot Operation (all certified aircraft).

response *Not accepted*

The use of the term Flight Crew is generic. Any restriction on single pilot-

operations are detailed in the Agency Opinions 04/2010 and 04/2011 associated with the FCL and OPS. It is not the intent of the AMC to introduce additional operational restrictions.

comment *16* comment by: *REGA*

Use aircraft instead of airplane (including helicopter).

response *Accepted*

Text amended where appropriate.

comment *76* comment by: *Garmin International*

Section 10, fifth paragraph begins with the statement:

"Depending on the aircraft capability, an LPV approach may be conducted with either a flight director or autopilot mode engaged."

Suggest modifying this statement to "When the GNSS equipment is installed with a compatible flight director/autopilot, …" Otherwise, as presently written, this statement could leave the reader with the impression that installations without FD/AP, i.e. manual operations, are not allowed, which is inconsistent with paragraph 8.5 item c) of this AMC.

response *Not accepted*

The use of the phrase 'may be conducted' does not imply that manual approaches are prohibited.

comment *77* comment by: *Garmin International*

Section 10.2, first paragraph includes the abbreviation "STD". This abbreviation is not included in Appendix 1, so its meaning isn't defined.

Section 10.2, last paragraph, last sentence begins with the phrase "An example of training syllabus ...". The word "of" can be deleted from this phrase.

response *Accepted*

Text reworded for clarity.

comment *78* comment by: *Garmin International*

Section 10.4.2 second paragraph contains the following phrase "... while Transport Canada (TCCA) is issues an ...". The word "is" can be deleted from this phrase.

response	*Accepted* Typo corrected.

comment	*79* comment by: *Garmin International* Section 10.4.3 item e) begins with the phrase "Loss of Integrity (LOI) function ...". Suggest that "annunciation" is a more appropriate word than "function" to use in this context.
response	*Accepted* Text amended accordingly.

comment	*98* comment by: *Garmin International* Section 10.4.2 contains the following Note: Note 1: The LPV approach is characterised in the navigation database by the FAS Data Block protected by a CRC. The FAS Data Block contains the lateral and vertical parameters, which define the approach to be flown. Those parameters have been calculated, validated and promulgated by the Air Navigation Service Provider. In addition, each FAS Data Block ends with a CRC, which wraps around the approach data. Consequently, the integrity is ensured when the airborne equipment making use of the data successfully passes the CRC on the data block. While all of this information is correct, it doesn't seem to add value from either an operator's point of view or a manufacturer's point of view. Suggest the quoted text be removed.
response	*Not accepted* The information is considered valuable background information for operators.

comment	*112* comment by: *AIR FRANCE* *Prior to LPV approach operation, the operator needs to be **authorised** by their competent authority for such operations.* EU OPS (annex 3 Reg 3922/91) OPS § 1.003 gives two definitions : accepted/acceptable or approved. "Authorised" is not clear and not defined in EU OPS. Suggest to use "approved". One reason is that foreign Authorities will require a copy of our "approval" to conduct LPV approaches on their aerodromes.
response	*Partially accepted*

Text has been amended to include the option for approval.

comment *123* comment by: *AOPA-Sweden*

10: AOPA-Sweden requires the text shall be more general than suited just for commercial flights, most smaller GA-aircraft does not have an AFM, just a Pilot Operational Handbook and they are not required to have an MMEL/MEL.

AOPA-Sweden does not see any need for the pilot to be special authorized by a competent authority to be able to fly a "European LPV-approach", the presentation for the pilot is the same as an ILS-approach.

The agency should carefully consider the applicable requirements that FAA has for private pilots flying "US-LPV approaches". Today, in the USA, there are as far as we know, more GNSS based approaches than ILS. The position of AOPA Sweden is that Private and commercial pilots in Europe also should be able to be approved to fly LPV approaches in the non-complicated manner as in the US. If extra administrational requirements are put to European pilots, Europe will loose in competitiveness without further gain in flight safety. It should be better that pilots fly LPV approaches than fly NDB or marginal VFR operations. The cost burden for starting to fly LPV approaches should be as low as for any other type of approach.

10, 5th paragraph: AOPA-Sweden suggests an addition to clarify the use of approach flight guidance.

"Depending on the aircraft capability, an LPV approach may be conducted with either a flight director or autopilot mode engaged. In this case the "approach" flight guidance mode should be used, *when installed and available to the crew in case the approach guidance is not available, the crew should not have to operate*"

10.1:

This rule is mainly directed to the "operator" as a business entity. However, many aircraft are not flown under an operator, i.e. privately owned aircraft etc and single pilot. Therefore the regulations should also be proportional to these aircraft since a few requirements are not really applicable for private operations. I.e. 10.2 and 10.3. If a pilot-owner is flying his aircraft - shall he then approve himself for his training and also fly according an extra syllabus? A private pilot as an operator does not have an Operations Manual!

AOPA-Sweden strongly opposes that all the changed checklists and procedures are to be sent to the authority for approval. Today, the checklists of many smaller aircraft do not have to be sent to the authority. The cost is not motivated. This regulation will cost extra money for both the authority and the involved operators. The gain in terms of flight safety is not demonstrated, nor motivated, since most operators already are subject to Approvals and have established routines for changing procedures & checklists. A calculation for example: If 25 000 aircraft will need 1 hour of authority work and each hour costs EUR100, the cost for this requirement would be EUR 2 500 000. The win in terms of accidents etc must be presented before this expensive suggestion is considered.

10.2: AOPA-Sweden's position is that these requirements mainly should be adopted into Part FCL as appropriate. Extra requirements and documentation should not be put into this Part, rather into Part OPS or Part FCL to reach consistency. The Part FCL already gives the IR holders privileges to fly

approaches down to DH of 200ft. Therefore these extra requirements are in conflict with Part FCL, if the are applicable to other than operators under Part OPS (the former JAR-OPS 1 or 3). AOPA-Sweden proposes that, if the agency wants to require extra requirements for LPV approaches with DH of 200ft or more, these should be included there. According to Swedish regulations, an operator can also be a single person operating an aircraft. Some of the proposed rulemaking does not make sense for a single pilot to fulfill.

10.3: The last sentence, "the designated crew shall have a validated competence". How should this be presented? AOPA-Sweden suggests that all relevant qualifications and requirements are to be handled within Part FCL under IR and Class/type ratings. A pilot having a valid IR and type/class rating should be considered current unless part FCL states otherwise. For operators under Part OPS (JAR-FCL 1 and 3) of course there can be other require

10.4.2: Quality monitoring and to some extent Data monitoring are both not practicable to perform as a private owner of an airplane

10.4.3: There is already other EU legislation taking care of reportable events. This regulation would be a "double regulation" and therefore not desired according EASA rulemaking policy. From user perspective it would be better to put the reporting rules as a change of present reporting legislation, if needed.

response *Partially accepted*

Where considered appropriate, the text has been amended to address AOPA's comments.

The Agency is fully aware of AOPAs general concerns regarding authorisation and training requirements, and will shortly be initiating a rulemaking task to address these issues.

With regards to AOPA's comments to paragraph 10.4.3, the Agency emphasises that an AMC is not a mandatory regulation; however, in order to maintain the highest level of safety, private pilots are strongly encouraged to report events to the appropriate authority.

comment *155* comment by: *Transport Canada Civil Aviation Standards Branch*

EASA's NPA 2009-04 section 10 Operational Criteria requires that the competent authority needs to authorize such operations.

Transport Canada would recommend that amendments to approved COM, SOPs, training programs and MELs may be sufficient to meet the operational criteria."

response *Noted*

EASA agrees in principle with Transport Canada, but is of the opinion that approval of listed documents could constitute authorisation.

AMC 20-28 - 11. AVAILABILITY OF DOCUMENTS p. 22

comment	*80* comment by: *Garmin International* Section 11, first paragraph describes how to obtain JAA documents. As there are no JAA documents referenced within AMC 20-28, it is unclear whether this information is necessary.
response	*Not accepted* Reference is made in paragraph 4.1 to JAR-OPS 3.

comment	*113* comment by: *AIR FRANCE* *JAA documents are available from the JAA publisher Information Handling Services (IHS).* *Information on prices, where and how to order is available on the JAA website: www.jaa.nl* Can probably be deleted. JAA farewell is behind us.
response	*Noted* Until such time that the operational rules prepared by the Agency come into force, JAA documents are still considered valid.

AMC 20-28 - APPENDIX 1: GLOSSARY p. 23-25

comment	*5* comment by: *REGA* In order to permit the LPV procedures also for helicopter, the approach procedures should also include Heliports, Helideck or any landing area which fulfils the ground infrastructure requirements.
response	*Noted* This AMC is applicable to the airworthiness and operational requirements and does not address procedure design. It is assumed that the procedures are consistent with ICAO Doc 8168.

comment	*40* comment by: *FAA* Comment: page 24, "LPV". AMC 20-28 defines LPV as "Localiser Precision with Vertical guidance". Rationale: This is a different description that the MOPS, 229D which defines LPV as "Localizer Performance with Vertical guidance". Recommendation: Consider harmonizing with the Minimum Operational

	Performance Standards for GPS/WAAS, RTCA DO-229D.
response	*Accepted* Text amended accordingly.

comment	*81* comment by: *Garmin International* Consideration should be given to removing unused terms from Appendix 1. E.g., ABAS, Basic GNSS Operation, TSO-C129 Class A, and TSO-C129 Class B are not used within AMC 20-28.
response	*Accepted* Text has been amended to delete all unused terms in the AMC.

comment	*114* comment by: *AIR FRANCE* *LPV: Localiser Precision with Vertical guidance.* Insuffisant! LPV **means SBAS** so there is no better place than here to state it. Suggest: LPV: Localiser Precision with Vertical guidance (**using SBAS**) LPV approach operation: RNAV GNSS approach operation **using SBAS** and conducted down to LPV minima. LPV approach procedure: RNAV GNSS approach procedure **using SBAS** and containing LPV minima.
response	*Not accepted* LPV is not defined as associated with SBAS. It is an operational procedure. Reference is made to the full title of the AMC.

comment	*126* comment by: *skyguide* Same comment as for Title Page and page 8: LPV usually stands for "Localizer Performance with Vertical Guidance" (not Localizer Precision...).
response	*Accepted* Text has been amended accordingly.

comment	*131* comment by: *Airbus S.A.S.*

COMMENT:

TSO C146( ) Delta class definition is missing. Airbus suggest to put definition from RTCA DO-229, quoted here below.

JUSTIFICATION:

Delta Class defines an equipment having the following characteristics quoted from RTCA DO-229:

"Equipment consisting of both the GPS/SBAS position sensor (defined by Class Beta) and a navigation function, so that the equipment provides path deviations relative to a selected final approach path, similar to Class Gamma. However, not all of the functions provided by Class Gamma equipment are available from Class Delta. In particular, Class Delta does not provide an RNAV capability and is not required to provide a FAS database or direct pilot controls. It is understood that Class Delta equipment does provide a means to be controlled. The Delta class of equipment is only applicable to Class 4 that is intended to provide an ILS alternative. Aircraft that install Delta class equipment are expected to have a separate RNAV capability, as RNAV (GPS) approaches assume an RNAV capability up to the Final Approach Waypoint (FAWP) and for the missed approach (after the LTP/FTP). The integration of these systems is outside the scope of this document."

This class defines implementation of equipment behaving like an ILS equipment.

response *Partially accepted*

The text has been amended to refer to CS-ETSO.

comment *152* comment by: *Gulfstream Aerospace Corp*

Attachment #1

Gulfstream Aerospace offer the attached as comments to this NPA.

response *Accepted*

With reference to the Glossary: The referenced sentence has been removed.

The other comments have been addressed separately.

AMC 20-28 - APPENDIX 2: OPERATIONAL CHARACTERISTICS OF THE PROCEDURE AND ITS OPERATIONAL USE p. 26

comment *6* comment by: *REGA*

In order to permit the LPV procedures also for helicopter, the approach procedures should also include Heliports, Helideck or any landing area which fulfils the ground infrastructure requirements.

response *Noted*

This AMC is applicable to the airworthiness and operational requirements and does not address procedure design. It is assumed that the procedures are consistent with ICAO Doc 8168.

comment *82* comment by: *Garmin International*

A lot of Appendix 2 doesn't seem to be relevant to a Part 91 operator. It also seems out-of-scope with respect to the type of operation being performed. E.g., does similar guidance exist for Cat I ILS? If not, why is the effort required for an operator to use LPV approaches greater than that required for Cat I ILS when the two approach types have similar characteristics?

response *Accepted*

Clarification has been added to the introduction of the Appendix. However, there is no equivalent Part 91 operation in Europe.

comment *83* comment by: *Garmin International*

Appendix 2 first paragraph states:

"The operator should show evidence that consideration has been given to the evaluation of any new or modified LPV approach procedures. Particular attention should be paid to procedures:"

The guidance in this paragraph and its sub-bullets seems to be based on RNP SAAAR approaches and is excessive for LPV approaches. Are there similar requirements for ILS operations? If not, why is this necessary for LPV approaches? Consideration also should be given to how writing this AMC impacts Part 91 operators and the burden that this implies.

response *Partially accepted*

EU-OPS contain similar requirements. However, clarification has been added to the introduction of the Appendix.

comment *84* comment by: *Garmin International*

Appendix 2 last paragraph states:

"The operational evaluation of a LPV approach procedure showing evidence of the above mentioned operational characteristics may include, at operator discretion, an approach conducted with the aircraft in VMC or the use of a full flight simulator (FFS) in order to evaluate if the procedure is correctly executed

	by the navigation system and fly-able with the aircraft type." The way this paragraph and the entire appendix is written, it appears that such an evaluation may be required for every LPV approach procedure in the database that is new or modified. Is this required for Cat I ILS? If not, then why for LPV?
response	*Not accepted* The addition 'at operator's discretion' already implies that this is not a requirement as such.

comment	*99* comment by: *Garmin International* Appendix 2, fifth bullet contains the following phrase "have a missed approach trajectories ...". The word "a" can be deleted from this phrase.
response	*Accepted* Thank you, typo corrected.

comment	*115* comment by: *AIR FRANCE* *The operational evaluation of a LPV approach procedure showing evidence of the above mentioned operational characteristics may include,* ***at operator discretion****, an approach conducted with the aircraft in VMC or the use of a full flight simulator (FFS) in order to evaluate if the procedure is correctly executed by the navigation system and fly-able with the aircraft type*. **At operator discretion :** is it acceptable to leave it at the operator discretion? If the approach is in mountainous environment (or one of the other mentioned criteria), it should be mandatory.
response	*Not accepted* The approach proposed by Air France is appreciated, but is deemed too restrictive to be applied to all types of operations.

comment	*116* comment by: *AIR FRANCE* *The operational evaluation of a LPV approach procedure showing evidence of the above mentioned operational characteristics may include, at operator discretion, an approach conducted with the aircraft in VMC or the use of a* ***full flight simulator (FFS)*** *in order to evaluate if the procedure is correctly executed by the navigation system and fly-able with the aircraft type*. Experience shows that present FFS have no reliable "visuals" when it comes to operational evaluation of RNAV approaches. FFS allows to verify flyability but is not reliable for obstacle clearance verification.

response | *Noted*

The FFS is not intended to be used for obstacle clearance verification.

AMC 20-28 - APPENDIX 3: LPV APPROACH OPERATIONAL PROCEDURES p. 27-29

comment | *8* comment by: *REGA*

In order to permit the LPV procedures also for helicopter, the approach procedures should also include Heliports, Helideck or any landing area which fulfils the ground infrastructure requirements.

response | *Noted*

This AMC is applicable to the airworthiness and operational requirements and does not address procedure design. It is assumed that the procedures are consistent with ICAO Doc 8168.

comment | *25* comment by: *Honeywell*

Similar to comment made in Section 6.5, the wording "After sequencing the FAP, the procedure must be discontinued..." implies that a missed approach is the only acceptable response to loss of LPV capability. Recommend clarifying that it is also acceptable to continue to the MDA if the approach is LPV and another type, e.g. LNAV/RNAV, and the crew and equipment supports the other approach capability.

response | *Accepted*

Text amended to account for the comment.

comment | *41* comment by: *FAA*

Comment: Page 29, paragraph 1.3, "After sequencing the FAP, the procedure must be discontinued unless the flight crew have in sight the visual references required to continue the approach…"

Rationale: In some cases the FAA provides an additional option.

Recommendation: Consider including the note "unless the airspace authority does not require such requirement (e.g. FAA permits fail-down to LNAV-only operations in some cases)."

response | *Accepted*

Please see response to comment 25.

comment	*53* comment by: *DSNA/DTI* § 1.3 During the procedures Subject : A distance/altitude check should be done by pilot around 1000ft. Rationale: This is an outcome from the SBAS LPV and GBAS Cat I Safety analysis conducted by DSNA and Eurocontrol. Indeed, to limit the risk of altimeter mis setting, a first distance/altitude check is commonly done by pilot around the FAP. After, along the final segment, the pilot uses horizontal and vertical deviation computed from GPS and EGNOS signal with respect to FAS DB. Last of all, the DH is based on altimeter information. In order to reduce the risk of altimeter mis setting (due to temperature, pilot error…), a distance altitude check should also be done before arriving to the DH. About 1000ft, pilot are asked to check RVR. It could be worth to ask them to do a distance/altitude check around this point. Information will be provided on the RNAV GNSS chart with a table distance/altitude. Recommendation : A distance/altitude check should be done by pilot around 1000ft.
response	*Not accepted* The altitude verification at the FAP is considered adequate to detect gross errors. The glide path and guidance provided is based on a protected FAS data block and integrity is inherent to the system design.

comment	*57* comment by: *DSNA/DTI* Appendix 3, §1.3 Subject : Rationale : What is the meaning of "lateral or vertical deviation are excessive" ? Is it more than a ½ FSD ? In the previous version of AMC this third bullet was dealing with FTE. I checked the AMC 20-27. It is mentioned "If lateral or vertical (if provided) FTE is excessive" Recommendation : Please clarify.
response	*Not accepted* Excessive is already being defined as when the Flight Crew cannot timely correct the deviation.

comment	*85* comment by: *Garmin International* A lot of the information in Appendix 3 seems more appropriate in a training syllabus than in an operational manual. Is similar operational procedure documentation required for Cat I ILS operations? If not, why is the effort required for an operator to use LPV approaches greater than that required for Cat I ILS when the two approach types have similar characteristics?
response	*Noted* The Agency will continue to keep the requirements of this Appendix under review and amend these as required based on in service experience.

comment	*86* comment by: *Garmin International* Appendix 3 section 1.1 item b) second paragraph ends with the statement: "The vertical path of the LPV approach procedure could be checked as extracted from the navigation database on the system Man Machine Interface (e.g. CDU)." Garmin's TSO-C146 equipment does not display the vertical path and there is no DO-229 requirement to provide such a capability, so it is unclear how this can be accomplished with equipment that has already been certified by the FAA for LPV operations in the US.
response	*Noted* The use of the phrase 'could check' implies that this is optional, but recommended where possible.

comment	*87* comment by: *Garmin International* Appendix 3 section 1.2 third bullet indicates the crew must check: "The vertical path angle." Garmin's TSO-C146 equipment does not display the vertical path angle and there is no DO-229 requirement to provide such a capability, so it is unclear how this can be accomplished with equipment that has already been certified by the FAA for LPV operations in the US.
response	*Accepted* Text amended to state: Where the system permits.

comment	*88* comment by: *Garmin International* Appendix 3, section 1.3 contains the following statement:

"Prior to sequencing the FAP, the procedure must be discontinued if there is:"

Suggest changing "Prior to sequencing the FAP," to "When the FAP is the active waypoint," to ensure there is no confusion with other situations that are "Prior to sequencing the FAP" like an LOI that could occur when the initial approach waypoint or an intermediate approach waypoint is the active waypoint.

response *Not accepted*

Text amended to state: Where the system permits.

comment *89* comment by: *Garmin International*

Appendix 3, section 1.3 indicates that prior to sequencing the FAP, the procedure must be discontinued if there is:

"Loss of integrity/Loss of Navigation is indicated by a warning annunciation, absence of power, equipment failure)."

AMC 20-28 repeatedly links LOI with LON as if navigation equipment will provide a single annunciation mechanism. This is an incorrect linkage as FAA AC 20-138A paragraph 18.e(4) states:

A unique annunciation of the loss of integrity monitoring should be provided.

Also as per the following note in DO-229C/D 2.2.5.6.2, the LOI requirements only apply prior to sequencing the FAP:

Note: Although this requirement is stated for LPV and LP approaches, its applicability is limited to outside the FAWP since a loss of integrity monitoring after sequencing the FAWP is defined to be a loss of navigation as described in Section 2.2.5.6.3.

A LOI will result in the same annunciation as LON only after the FAP is sequenced.

Additionally, Garmin TSO-C146a equipment will automatically reduce the service level from LPV to LNAV for RNAV (GNSS) approaches that have both minima when HPLsbas or VPLsbas exceeds the LPV approach HAL or VAL, respectively. In cases where LNAV guidance is still possible, the vertical deviation will be flagged but the lateral deviation will not be flagged. As presently written, this is too restrictive for downgrade cases where the crew could continue the approach to LNAV minima in similar fashion to an ILS approach losing glideslope and the crew continuing the approach to LOC only minima.

response *Accepted*

Loss of Navigation is obviously detectable without requiring specific annunciation. The requirement has been removed where appropriate.

comment *90* comment by: *Garmin International*

Appendix 3, section 1.3 indicates that after sequencing the FAP, the procedure

must be discontinued if there is:

- Loss of integrity/Loss of Navigation is indicated by a warning annunciation;
- Loss of vertical guidance is indicated (even if lateral guidance is displayed);

Garmin TSO-C146a equipment will automatically reduce the service level from LPV to LNAV for RNAV (GNSS) approaches that have both minima when HPLsbas or VPLsbas exceeds the LPV approach HAL or VAL, respectively. In cases where LNAV guidance is still possible, the vertical deviation will be flagged but the lateral deviation will not be flagged. As presently written, this is too restrictive for downgrade cases where the crew could continue the approach to LNAV minima in similar fashion to an ILS approach losing glideslope and the crew continuing the approach to LOC only minima.

response *Noted*

Text has been amended accordingly.

comment *91* comment by: *Garmin International*

Appendix 3, section 2, first bullet contains the following phrase:

"(e.g., failures of the flight director or autopilot)"

This should only be applicable if the FD/AP is engaged.

response *Noted*

The Agency considers that this is obvious.

comment *117* comment by: *AIR FRANCE*

The instrument approach chart should clearly identify the LPV approach operation as RNAV(GNSS) ***or equivalent*** *(e.g. RNAV(GNSS) RWY 27,…).*

Delete "or equivalent": we need clarity, "clearly identify" doesn't match with "or equivalent".

Suggest

The instrument approach chart should clearly identify the LPV approach operation as RNAV(GNSS) (e.g. RNAV(GNSS) RWY 27,…).

The operator should determine in accordance with the promulgated OCA(H) and the operational requirement (e.g. EU-OPS 1.430) the Decision Altitude/Height (DA(H)) and **publish it under a "LPV line of minima".**

response *Accepted*

The text has been amended accordingly.

comment	*118* comment by: *AIR FRANCE* To be logic, suggest: The flight crew should ensure sufficient means are available to navigate and land at the destination or at an alternate aerodrome in the case of loss of LPV airborne capability. In particular, the flight crew should check that: · a non RNAV GNSS based procedure is available at the alternate (where a destination alternate is required) **or at the destination (if an LPV approach is used to select the destination alternate)** unless the airspace authority does not require such requirement (e.g. FAA within WAAS coverage);
response	*Partially accepted* The text has been improved for clarity.

comment	*119* comment by: *AIR FRANCE* *If the missed approach procedure is based on conventional means (e.g. VOR, DME) the appropriate airborne equipment required to fly this procedure must be available and serviceable onboard the aircraft. The associated ground-based navigation aids must also be operational.* Should only be mandatory for GNSS SBAS Stand-alone Navigation systems. Missed approach based on conventional means should only be an option for stand alone systems. Integrated Navigation systems should always fly a RNAV RNP based missed approach. Suggest: **For GNSS SBAS Stand-alone Navigation systems,** if the missed approach procedure is based on conventional means (e.g. VOR, DME) the appropriate airborne equipment required to fly this procedure must be available and serviceable onboard the aircraft. The associated ground-based navigation aids must also be operational.
response	*Not accepted* This AMC does not address procedure design.

comment	*120* comment by: *AIR FRANCE* *The final approach segment should be intercepted **no later** than the FAP in order for the aircraft to be correctly established on the final approach course before starting the descent (to ensure terrain and obstacle clearance).* Suggest to replace no later by "before". It is inconsistant to forbid "direct to the FAP" in §1.2 and allow radar vertoring to the same FAP.
response	*Accepted* Text amended.

comment	*121* comment by: *AIR FRANCE* . *Reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and mileage of the final approach segment. Note: As a minimum, this check could be a simple inspection of a suitable map display.* · *The vertical path angle.* Pilots need clear procedures. In that case they need the value of an acceptable error margin. Suggest: . Reasonableness of the tracks **(+/- 1 deg**) and distances **(+/- 0,1 Nm**) of the approach legs, and the accuracy of the inbound course and mileage of the final approach segment. Note: As a minimum, this check could be a simple inspection of a suitable map display. · The vertical path angle **(+/- 0,1 deg)**.
response	*Not accepted* The precise definition of operating procedures is dependent on specific features of the design of the RNAV and display systems. It is not the intention of an AMC to regulate operating procedures with the suggested level of detail.

comment	*144* comment by: *DGAC FRANCE* **<u>Appendix 3: LPV approach procedure</u>** **paragraph 1.3 : During the procedure** <u>Comment:</u> Reversion should be authorised after the FAP but not after 1000ft which is the "gate" to get the minima. Indeed, if the reversion from LPV to LNAV is well integrated in the cockpit, pilot should be authorised to continue the approach after the FAP and fly the LNAV procedure. After 1000ft the recommended solution in case of vertical guidance loss is the go around except if the visual references have been acquired. <u>Proposal:</u> Add the reversion possibility to 1000' in case of vertical guidance loss, when the reversion mode from LPV to LNAV is correctly integrated in the cockpit. Add the reversion management case in the training section (appendix 4).
response	*Accepted* Text amended.

comment	*145* comment by: *DGAC FRANCE* **<u>Appendix 3: LPV approach procedure</u>** **Paragraph 1.3 : During the procedure** <u>Comment</u>: lateral and vertical deviations are excessive and cannot be timely corrected: => Clarify what is an excessive deviation.
response	*Not accepted* Excessive is already being defined as when the Flight Crew cannot timely correct the deviation.

AMC 20-28 - APPENDIX 4: FLIGHT CREW TRAINING SYLLABUS p. 30-31

comment	*92* comment by: *Garmin International* Appendix 4, section 2, items i) and j) state: i) Abnormal procedures j) Contingency procedures The difference between abnormal procedures and contingency procedures should be clarified.
response	*Accepted* Terms have been added to Appendix 1.

Appendix A – Resulting text

AMC 20-28 Airworthiness Approval and Operational Criteria for RNAV GNSS approach operation to LPV minima using SBAS

1. PURPOSE

This AMC provides an acceptable means that can be used to obtain airworthiness approval for an Area Navigation (RNAV) approach system based on Global Navigation Satellite System (GNSS) augmented by a Satellite Based Augmentation System (SBAS) in order to conduct approach operations to Localiser ~~Precision~~ Performance with Vertical guidance (LPV) minima. This AMC also defines the operational criteria necessary to conduct safely such approach operations in designated European airspace.

An applicant may elect to use an alternative means of compliance. However, that means of compliance must meet the objectives of this AMC and be acceptable to the Agency and the competent authority. Compliance with this AMC is not mandatory. Use of the terms *shall* and *must* apply only to an applicant who elects to comply with this AMC in order to obtain airworthiness approval or to demonstrate compliance with the operational criteria.

2. BACKGROUND

This document addresses and defines airworthiness and operational criteria related to an aircraft system based on GNSS augmented by SBAS in order to conduct RNAV GNSS approach operation to LPV minima. ~~It relates to the implementation of area navigation within the context of the Single European Sky[1], in particular in relation to the verification of conformity of the airborne constituents, per Article 5 of EC Regulation 552/2004~~. It addresses certification considerations of stand-alone and multi-sensor systems on board an aircraft, including their functional requirements, accuracy, integrity, continuity of function and limitations, together with operational considerations. Operational compliance with these requirements must be addressed through national operational regulations, and may require a specific operational approval in some cases.

RNAV GNSS approaches conducted down to LPV minima are characterised by a Final Approach Segment (FAS). A FAS is the approach path which is defined laterally by the Flight Path Alignment Point (FPAP) and Landing Threshold Point/Fictitious Threshold Point (LTP/FTP) and defined vertically by the Threshold Crossing Height (TCH) and Glide Path Angle (GPA). The FAS of such approaches may be intercepted by an approach transition (e.g. Precision Area Navigation (P-RNAV) or initial and intermediate segments of an RNP APCH approach) or through vectoring (e.g. interception of the extended FAS).

3. SCOPE

This AMC is to be used to show compliance with the applicable Airworthiness Codes and functional criteria as define in paragraph 4.1 and 7.1. These are related to systems based on a stand-alone receiver or multi-sensor systems including at least one GNSS SBAS sensor. It also

~~[1] Regulation (EC) No 549/2004 of the European Parliament and of the Council of 10 March 2004 laying down the framework for the creation of the single European sky (the framework Regulation), OJ L 96, 31.3.2004, page 1.~~

defines the operational approval criteria for the intended use under Instrument Flight Rules, including Instrument Meteorological Conditions, in designated European airspace.

Section 4.2 of this AMC refers to documents which contribute to the understanding of an RNAV GNSS approach operation to LPV minima using SBAS and which may support an application for approval. However, it is important that an applicant evaluates the aircraft systems and the proposed operational procedures against the criteria of this AMC.

Compliance with this AMC does not, by itself, constitute an operational authorisation to conduct RNAV GNSS approach operation to LPV minima using SBAS. Aircraft operators should apply to their competent authority. Since this AMC has been harmonised with other implementation and operational criteria outside of Europe, i.e. USA/FAA, it is expected to facilitate interoperability and ease the effort in obtaining operational authorisation by operators.

In this AMC, "LPV approach" wording has been used in lieu of "RNAV GNSS approach to LPV minima" for simplification purposes.

This document is only applicable to RNAV GNSS approaches conducted down to LPV minima. It does not address RNP approaches with Authorisation Required (RNP AR APCH) nor Basic RNP approaches (RNP APCH). These types of approaches are addressed by AMC 20-26 and AMC 20-27.

4. REFERENCE DOCUMENTS

4.1 Related Requirements

- CS 25.1301, 25.1302, 25.1307, 25.1309, 25.1316, 25.1321, 25.1322, 25.1329, 25.1431, 25.1581.
- CS 23.1301, 23.1309, 23.1311, 23.1321, 23.1322, 23.1329, 23.1335, 23.1431, 23.1581.
- CS 27.1301, 27.1309, 27.1321, 27.1322, 27.1329, 27.1581.
- CS 29.1301, 29.1307, 29.1309, 29.1321, 29.1322, 29.1329, 29.1431, 29.1581.
- EU-OPS[2] 1.035, 1.220, 1.225, 1.243, 1.290, 1.295, 1.297, 1.400, 1.420, 1.430, 1.845, 1.865, 1.870 and 1.975.
- JAR-OPS 3.243, 3.845, 3.865.
- National operating regulations.

4.2 Related Material

4.2.1. ICAO

Annex 10	International Standards and Recommended Practices- Aeronautical Telecommunications.
Doc 7030/4	Regional Supplementary Procedures.
Doc 9613	Manual on Performance Based Navigation (PBN).

[2] Commission Regulation (EC) N° 859/2008 of 20 August 2008 amending Council Regulation (EEC) N° 3922/91 as regards common technical requirements and administrative procedures applicable to commercial transportation by aeroplane (OJ L 245, 20.9.2008, p. 1).

Doc 8168	PANS OPS (Procedures for Air Navigation Services-Aircraft Operations).

4.2.2. EASA

AMC 25-11	Electronic Display Systems.
AMC 20-26	Airworthiness Approval and Operational Criteria for RNP Authorisation Required (RNP AR) Operations.
AMC 20-27	Airworthiness approval and Operational Criteria for RNP APPROACH (RNP APCH) operations Including APV BARO-VNAV Operations.
ETSO- C115( )	Airborne area Navigation Equipment using Multi-sensor Inputs.
~~ETSO-C129( )~~	~~Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS).~~
ETSO-C145~~( )~~c	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System.
ETSO-C146~~( )~~c	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System.
EASA OPINION Nr. 01/2005	Conditions for Issuance of Letters of Acceptance for Navigation Database Suppliers by the Agency (i.e. an EASA Type 2 LoA).

4.2.3. FAA

AC 25-11( )	Electronic Display Systems.
AC 20-138( )	Airworthiness Approval of GNSS equipment.
AC 20-130A	Airworthiness approval of navigation or flight management systems integrating multiple navigation sensors.
AC 23-1309-1~~C~~( )	Equipment, systems, and installation in Part 23 airplanes.
AC 20-153	Acceptance of data processes and associated navigation data bases.
~~TSO-C115( )~~	~~Airborne area Navigation Equipment using Multi-sensor Inputs.~~
~~TSO-C129( )~~	~~Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS).~~
~~TSO-C145( )~~	~~Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System.~~
~~TSO-C146( )~~	~~Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System.~~

4.2.4. EUROCAE / RTCA and ARINC

ED-76 / DO-200A	Standards for Processing Aeronautical Data.
ED-12( ) / DO-178( )	Software considerations in airborne systems and equipment certification.
ED-80( ) / DO-254( )	Design assurance guidance for airborne electronic hardware.
ED-77 / DO-201A	Standards for Aeronautical Information.

DO-229( )	Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne equipment.
ARINC 424	Navigation System Data Base.

5. ASSUMPTIONS

Applicants should note that this AMC is based on the following assumptions:

5.1 ~~Navaid~~ Navigation Aid infrastructure

GNSS augmented by SBAS is the primary navigation system to support LPV approach operations. The navigation system shall be:

(1) Provisioned by a Navigation Service Provider certified according to Article 7 of Regulation 550/2004[3]; or

(2) Comply with Annex 10[4] Volume 1 to the Convention on International Civil Aviation (Chicago Convention[5]).

The acceptability of the risk of loss of LPV approach capability for multiple aircraft due to satellite failure or SBAS system failure, loss of the on board monitoring and alerting function ~~(e.g. RAIM holes)~~ or radiofrequency interference, will be considered by the air navigation service provider providing the approach ~~responsible airspace authority~~.

5.2 Obstacle clearance

Detailed guidance on obstacle clearance is provided in PANS-OPS (ICAO Doc 8168, Volume II).

Note 1: Missed approach procedure may be supported by either RNAV or conventional (e.g. based on NDB, VOR, DME) segments.

5.3 Publication

All LPV Approach procedures are:

(1) Published by an Aeronautical Information Service Provider certified according to Article 7 of Regulation 550/2004; or

(2) Consistent with the relevant parts of PANS OPS (ICAO Doc 8168).

The instrument approach chart will identify LPV approach operation as RNAV(GNSS) and will indicate the associated LPV minima.

Charting will follow the standards of Annex 4[6] to the Chicago Convention for the designation of an RNAV procedure where the vertical path is specified by a glide path angle. The charting designation will remain consistent with the current convention and will be promulgated as a LPV OCA(H).

If the missed approach segment is based on conventional means, navaid facilities that are necessary to conduct the approach will be identified in the relevant publications.

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[3] Regulation (EC) No 550/2004 of the European Parliament and of the Council of 10 March 2004 on the provision of air navigation services in the single European sky (the service provision Regulation), OJ L 96, 31.3.2004, page 10.

[4] Annex 10 to the Convention on International Civil Aviation - Aeronautical Telecommunications - Radio Navigation Aids

[5] The Convention on International Civil Aviation, sign in Chicago on 7 December 1944 (the Chicago Convention)

[6] Annex 4 to the Convention on International Civil Aviation - Aeronautical ~~Charts~~

The navigation data published in the applicable Aeronautical Information Publication (AIP) for the procedures and supporting navigation aids will meet the requirements of Annex 15[7] and Annex 4 to the Chicago Convention (as appropriate). The chart will provide sufficient data to support navigation database checking by the crew (including waypoint name, track, distance for each segment and vertical path angle).

All procedures will be based upon WGS 84 coordinates.

The LPV FAS will be promulgated using the FAS Data Block process. This specific on board navigation database element defines the LPV FAS and is called "FAS Data Block". This FAS Data Block contains the lateral and vertical parameters, which define the approach to be flown. Each FAS Data Block ends with a Cyclic Redundancy Check (CRC), which wraps around the approach data.

5.4 Communication and ATS surveillance

RNAV GNSS approach operation to LPV minima using SBAS does not include specific requirements for communication or ATS surveillance. Adequate obstacle clearance is achieved through aircraft performance, Instrument Approach procedure design and operating procedures. Where reliance is placed on the use of radar to assist contingency procedures, its performance will be shown to be adequate for that purpose, and the requirement for a radar service will be identified in the AIP.

RT phraseology appropriate to such approach operations will be promulgated.

The particular hazards of ~~a~~ terminal and approach areas and the impact of contingency procedures following multiple loss of aircraft LPV approach capability will be assessed.

6. AIRWORTHINESS CRITERIA

6.1 General

The following airworthiness criteria are applicable to the installation of the airborne system intended for IFR approach operation, certified according to CS-23, -25, -27 and -29.

~~This AMC is consistent with FAA Advisory Circular AC 20-138A (LPV approach operation airworthiness approval section).~~

This AMC is to be used to show compliance with the applicable Airworthiness codes and functional criteria.

6.2 Equipment qualification ~~and aircraft installation~~

6.2.1 GNSS SBAS Stand-alone Navigation system

GNSS SBAS stand-alone equipment should be approved in accordance with E~~/~~TSO-C146ac ~~(or subsequent version)~~ Class Gamma, operational class 3. ~~Application of this standard should guarantee that the equipment is at least compliant with RTCA DO-229C~~.

~~The equipment should be a Class Gamma, operational class 3 and the aircraft installation should comply with requirements of sections 6 to 9 of this AMC.~~

6.2.2 Integrated Navigation system incorporating a GNSS SBAS sensor

~~The Integrated Navigation system should meet the performance requirements defined in Chapter 2.2 of RTCA DO-229C.~~ The ~~system~~ equipment should ~~also~~ incorporate a GNSS SBAS

[7] Annex 15 to the Convention on International Civil Aviation - Aeronautical Information Services

sensor approved in accordance with E~~/~~TSO-C145ac ~~(or subsequent versions)~~ Class Beta, operational class 3 ~~and should comply with requirements of sections 6 to 9 of this AMC.~~

Note ~~1~~: Aircraft that have previously been demonstrated to comply with FAA AC 20-130A and ETSO C-115b (or subsequent versions), need only comply with the performance requirements of Chapter 2.3 of RTCA DO-229C.

6.2.3 Approach system incorporating class Delta GNSS SBAS equipment

The equipment should be approved in accordance with E~~/~~TSO-C146ac ~~(or subsequent version)~~ Class Delta operational class 4. ~~This standard should guarantee that the equipment is at least compliant with RTCA DO-229C~~.

~~The equipment should be a Class Delta 4 and the aircraft installation should comply with requirements of sections 6 to 9 of this AMC.~~

Note Equipment approved to ETSO-C145/146 could be eligible for acceptance provided that a positive deviation of compliance with RTCA DO-229C including the amendments of Appendix 1 to FAA TSO-C145a/C146a has been documented in the DDP.

6.3 Accuracy

The lateral and vertical Total System Error is dependent on the Navigation System Error (NSE), Path Definition Error (PDE) and Flight Technical Error (FTE).

6.3.1. Navigational System Error (NSE)

Navigational System Error should be within the accuracy requirements of Annex 10 volume 1 paragraph 3.7.2.4 to the Chicago Convention (Signal In Space performance requirements).

Note NSE requirements are fulfilled without any demonstration if the equipment complies with the requirements of paragraph 6.2 computes the three-dimensional position using a linear weighted least square solution in accordance with RTCA DO-229C Appendix J. Equipment compliant with E~~/~~TSO-C145ac/C146ac ~~(or subsequent version)~~ are satisfying the accuracy requirements of Annex 10 to the Chicago Convention.

6.3.2. Flight Technical Error (FTE)

~~6.3.2.1 Manual flight~~

~~For manual control to the approach flight path, the appropriate flight display(s) must provide sufficient information without excessive reference to other cockpit displays, to enable a suitably trained flight crew to maintain the approach path, make alignment with the runway or to go-around~~.

FTE should be contained within the following criteria:

- Lateral guidance from 1 000 ft HAT to DA(H) should be stable within 1/3 FSD where FS is defined as a 2 degree wedge with the origin located 305 m past the MAWP.
- Vertical guidance from 700 ft HAT to DA(H) should be stable within 1/2 FSD where FSD=±0.25(glide path angle).

~~FTE performance is considered acceptable if the lateral and vertical display full scale deflections are compliant with the Non-Numeric lateral cross-track and vertical deviation requirements of RTCA DO-229C (or subsequent version)~~

Note ~~1~~: FTE is considered to be equivalent to the ILS approach if the angular display to the Flight Crew is comparable and the equipment complies with the requirements of paragraph 6.2.

~~Note 2: ⅛ of the full scale deflection for lateral deviation corresponds to 50 microamps and ½ the full scale deflection for vertical deviation corresponds to 75 microamps when a standard display is used (with a full scale deflection of 150 microamps).~~

~~6.3.2.2 Flight Guidance System~~

Note For flight guidance systems, the FTE performance ~~is~~ may be considered acceptable if the approach mode of the Flight Guidance System is used during such approach. For more information see paragraph 8.5 of this AMC.

6.3.3. Path Definition Error (PDE)

There are no performance or demonstration requirements for PDE. PDE is considered negligible based upon the process of path specification to data specification and associated quality assurance that is included in the FAS Data Block generation process which is a standardised process. The responsibilities for FAS Data Block generation lie with the Air Navigation Service Provider. Operator's responsibilities associated to the navigation database management aspect are described in paragraph 10.4 of this AMC.

6.4 Integrity

Presenting ~~simultaneously~~, misleading lateral or vertical ~~and distance data~~ guidance, ~~during an LPV approach~~ is considered to be a hazardous failure condition ~~(extremely remote)~~.

Presenting misleading distance data is considered to be a major failure condition.

Note 1 Probability terms are defined in AMC 25.1309, FAA AC 23.1309-1( ), AC 27-1B or AC 29-2C.

Note 2 Where LPV approach capability is added to an aircraft having ILS capability, the integrity of the existing ILS display(s) or course deviation indicator(s) used for LPV approach operation are considered acceptable.

6.5 Continuity of function

~~It shall be demonstrated that:~~

~~a) the probability of loss of all navigation information is Remote.~~

~~b) the probability of non-restorable loss of all navigation and communication functions is Extremely Improbable~~.

Loss of the system that provides LPV approach capability is considered a major ~~minor~~ failure condition ~~if the operator can revert to a different navigation system and proceed to a suitable airport~~. ~~For LPV approach operation at least one system is required.~~

~~Note 1: The operator should develop contingency procedure for the loss of the approach capability during the approach.~~

~~Note 2: Probability terms are defined in AMC 25.1309, FAA AC 23.1309-1( ), AC 27-1B or AC 29-2C.~~

7. FUNCTIONAL CRITERIA

Functional criteria provided in this paragraph are those applicable to the LPV approach operation only. These criteria are therefore limited to the LPV Final Approach Segment and to the interception of the extended Final Approach Segment.

If the installed system (e.g. RNAV system) is also able to fly the initial, intermediate and missed approach segments of the approach it must be approved in accordance with the corresponding requirement (e.g. AMC 20-27 RNP APCH).

7.1 Required Functions

Item	Functional Description
1	LPV approach guidance must be continuously displayed on a lateral and vertical deviation display (HSI, EHSI, CDI/VDI) including a failure indicator and must meet the following requirements: 1) This display must be used as primary means of guidance during the approach. 2) The display must be visible to the Flight Crew and located in the primary field of view (± 15 degrees from the normal line of sight) when looking forward along the flight path. 3) The deviation display must have a suitable full-scale deflection based on the required track keeping accuracy. The lateral and vertical Full Scale Deflections are angular and associated to the lateral and vertical definitions of the FAS contained in the FAS Data Block. Note 1: Where the minimum required Flight Crew is two, it must be possible for the ~~none~~ non-flying Flight Crew member to verify the desired path and the aircraft position relative to the path.
2	Capability to display the GNSS Approach mode (e.g. LPV, LNAV/VNAV, LNAV …) in the primary field of view. Note 1: This annunciation indicates to the crew the active approach mode in order to correlate it with the corresponding line of minima on the approach chart. It permits also to detect a level of service degradation (e.g. downgrade from LPV to LNAV). Note 2: The display may be located in the normal field of view subject to Agency agreement.
3	Capability to continuously display the distance to the Landing Threshold Point/Fictitious Threshold Point (LTP/FTP) from passing the Final Approach Point in the primary field of view. Note: ~~The display must be visible to the flight crew and located in the primary field of view (± 15 degrees from the normal line of sight) when looking forward along the flight path.~~ The display may be located in the normal field of view subject to Agency agreement.

Item	Functional Description
4	The navigation database must contain all the necessary data/information to fly the published LPV approach procedure (Final Approach Segment). Note: Although data may be stored or transmitted in different ways, the data has to be organised in data blocks for the purpose of computing the CRC. This format provides integrity protection for the data it contains. Consequently, each Final Approach Segment is defined by a specific "FAS Data block" containing the necessary lateral and vertical parameters depicting the approach to be flown. Once the FAS Data Block has been decoded, the equipment shall apply the CRC to the data block to determine if the data is valid. If the FAS Data Block does not pass the CRC test, the equipment shall not allow activation of the LPV approach operation.
5	Capability to select from the database into the installed system the whole approach procedure to be flown (SBAS channel number and/or approach name).
6	Indication of the Loss Of Integrity (LOI)~~/Loss of Navigation~~, of the LPV airborne capability, in the primary field of view, by means of an appropriately located warning annunciator and the removal or invalidation of any ~~all~~ guidance ~~clues~~ cues that no longer meet the approach integrity requirements. Note The indicator may be located in the normal field of view subject to Agency agreement.
7	Capability to support ~~provide an appropriate output to an installed Terrain Awareness and Warning System (TAWS) enabling~~ an alert ~~the use of the~~ for excessive downward deviation from the ~~a~~ glide path ~~slope function~~. Note: This is only applicable where operational regulations require the use of a Class A TAWS or a Class A TAWS is installed. Note: If the alert is not provided by the TAWS system, the alert should have equivalent effect to that provided by a TAWS system
8	Capability to immediately provide ~~track deviation~~ indications of deviation from the intended flight path relative to the extended final approach segment. ~~in order to facilitate the interception of the extended final approach segment from a radar vector (e.g. Vector To Final (VTF) function).~~

8. AIRWORTHINESS COMPLIANCE

8.1 General

This section details a means of airworthiness compliance for new or modified installations (Paragraph 8.2) and for existing installations (Paragraph 8.3). It also details specific points that should be considered during these approval processes (Paragraph 8.4 and 8.5).

Relevant documentation demonstrating airworthiness compliance should be available to establish that the aircraft is equipped with an airborne system meeting LPV approach requirements.

8.2 New or Modified Installations

In demonstrating compliance with this AMC, the following specific points should be noted:

The applicant will need to submit, to the Agency, a compliance statement which shows how the criteria of this AMC have been satisfied. The statement should be based on a plan, agreed by the Agency at an early stage of the implementation programme. The plan should identify the certification data to be submitted which should include, as appropriate, a system description together with evidence resulting from the activities defined in the following paragraphs.

Compliance with the airworthiness requirements for intended function and safety may be demonstrated by equipment qualification, system safety analysis, confirmation of appropriate software design and complex electronic hardware assurance level, performance analysis, and a combination of ground and flight tests. To support the approval application, design data will need to be submitted showing that the objectives and criteria of Sections 6 and 7 of this AMC have been satisfied.

8.3 Existing Installations

The applicant will need to submit, to the Agency, a compliance statement which shows how the criteria of this AMC have been complied with for the existing installations. Compliance may be established by inspection of the installed system to confirm the availability of required features and functionality. The performance and integrity criteria of Sections 6 and 7 may be confirmed by reference to statements in the Aircraft Flight Manual or to other applicable approvals and supporting certification data. In the absence of such evidence, supplementary analysis and/or tests may be required.

8.4 Specific Installation criteria

The following points need to be taken into consideration during the airworthiness approval process.

a) Where other conventional navigation/approach systems, apart from the installed system, provide display and/or guidance to a Flight Director/Autopilot, means should be provided for:

- a system source selector as the only means of selection;
- clear annunciation of the selected approach system on or near the guidance display;
- display of guidance information appropriate to the selected approach system; and
- delivery of guidance information to a Flight Director/Autopilot appropriate to the selected approach system.

b) Annunciation for Flight Director, Autopilot and selected approach system should be consistent, and compatible with the original design philosophy of the cockpit.

c) Equipment failure scenarios involving conventional navigation/approach systems and the installed system(s) should be evaluated to demonstrate that:

- adequate alternative means of navigation are available following failure of the installed system, and
- reversionary switching arrangements, e.g. Selection of ILS system 2 or LPV system 2 on HSI#1 in case of ~~dual equipage~~ multiple (or redundant) equipment, does not lead to misleading or unsafe display configurations,
- adequate means to isolate or deactivate the failed system.

The evaluation should consider also the probability of failures within the switching arrangements.

d) The coupling arrangements between the installed system and the flight director/autopilot should be evaluated to show compatibility and to demonstrate that operating modes, including installed system failure modes, are clearly and unambiguously indicated to the Flight Crew.

e) The use of the installed system and the manner of presentation of lateral and vertical guidance information to the Flight Crew should be evaluated to show that the risk of Flight Crew error has been minimised. The Flight Crew should be aware, at all times of the system in use for the approach.

f) Controls, displays, operating characteristics and the Flight Crew interface with the installed system should be assessed in relation to Flight Crew workload, particularly in the approach environment. Essential design considerations include:

- Minimising reliance on Flight Crew memory for any system operating procedure or task.
- Developing a clear and unambiguous display of system modes/sub modes and navigational data with emphasis on enhanced situational awareness requirements for any automatic mode changes.
- Use of context sensitive help capability and error messages (e.g. invalid inputs or invalid data entry messages should provide a simple means to determine how to enter "valid" data).
- Placing particular emphasis on the number of steps and minimising the time required to accomplish flight plan modifications to accommodate ATC clearances, holding procedures, runway and instrument approach changes, missed approaches and diversions to alternate destinations.
- Minimising the number of nuisance alerts so the Flight Crew will recognise and react appropriately when required.

8.5 FTE performance evaluation for LPV approach operation

ILS "look alike" presentation is detailed in RTCA DO-229C ~~(or subsequent version)~~ in particular the lateral and vertical Full Scale Deflection (FSD) requirements. The deflection may be fully angular with no limitation or angular but bounded at a certain value (e.g. bounded at ±1 Nm in lateral and ±150 m in vertical).

a) For installations where the autopilot has not been modified and the equipment provides ILS look alike deviations, the applicant should conduct ~~several~~ a sufficient number of approaches while flying raw data, flight director and coupled to the autopilot, as required to ensure that the installed equipment interface is compatible. ~~applicable. The objective of this test is to ensure that the installed equipment interface is compatible with the aircraft; the objective is not to verify approach performance.~~

b) For installation where the autopilot has been modified, where the autopilot lateral/vertical control channel performance has not been assessed, or where non-standard deviations are provided (not ILS look alike), then the approach performance will need to comply with CS xx.1329 or equivalent.

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

~~d) LPV approach tracking performance should be stable as follows:~~

- ~~Lateral guidance from 1000 ft HAT to DA(H) should be stable without large deviations (i.e. within ±50 microamps deviation) from the indicated path.~~

- ~~Vertical guidance from 700 ft HAT to DA(H) should be stable without large deviations (i.e. within ±75 microamps deviation) from the indicated path.~~

~~Note 1: Compatibility with ILS display systems can be achieved by converting the lateral and vertical deviation to microamps based upon a Full Scale Display (FSD) at 150 microamps.~~

8.6 Intermixing of equipment

Simultaneous use of airborne systems with different crew interfaces can be very confusing and can lead to problems when they have conflicting methods of operation and conflicting display formats. For approach operations, simultaneous use of equipment that is not identical or compatible is not permitted.

9. AIRCRAFT FLIGHT MANUAL/PILOT OPERATING HANDBOOK

For new or modified aircraft, the Aircraft Flight Manual (AFM) or the Pilot's Operating Handbook (POH), whichever is applicable, should provide at least the following information:

a) A statement which identifies the equipment and aircraft build or modification standard certificated for RNAV GNSS approach operation to LPV minima using SBAS. This may include a very brief description of the installed system, including the airborne equipment software version, display equipment and a statement that it is suitable for LPV approach operations. A brief introduction to the LPV approach concept may also be included.

b) Appropriate amendments or supplements to cover LPV approach operation in the following sections:

- Limitations - including use of Lateral and Vertical deviations, FD and AP; currency of navigation database; crew verification of navigation data.
- Normal Procedures
- Abnormal Procedures - including actions in response to a Loss of Integrity or~~/~~ Loss of Navigation or in response to a degradation of the GNSS approach mode (e.g. downgrade from LPV to LNAV).

Note ~~1~~ This limited set of information assumes that a detailed description of the installed system and related operating instructions and procedures are available in other operating or training manuals.

10. OPERATIONAL CRITERIA

This section describes acceptable operational criteria for an LPV approach, subject to the limitations given below. The operational criteria assume that the corresponding airworthiness approval has been granted by the Agency.

Operational criteria apply to the use of the approach system on any aircraft operated under IFR in accordance with EU legislation or the applicable operational regulations in the fields for which the EU legislation has not yet been established.

Operations of the installed equipment should be in accordance with the AFM or POH ~~AFM supplement~~. The operational procedures to be addressed by the operator are detailed in APPENDIX 3. The ~~(Master)~~ Minimum Equipment List (~~MMEL/~~MEL) should be amended if required to identify the minimum equipment necessary to satisfy LPV approach operations using the installed system.

The operator should determine the operational characteristics of the procedure to be flown. It is recommended that the process described in paragraph 10.3 and APPENDIX 2 of this AMC should be followed, to validate its operational use by the crew.

Depending on the aircraft capability, an LPV approach may be conducted with either a flight director or autopilot mode engaged. In this case the "approach" flight guidance mode should be used.

Prior to LPV approach operation, the operator needs to be authorised or approved by their competent authority for such operations.

10.1. Flight Operations Documentation

The relevant parts and sections of the Operations Manual (e.g. Aircraft Operations Manual, check lists, training of crew) should be revised to take account of the operating procedures detailed in APPENDIX 3. The operator should make timely amendments to the Operations Manual to reflect relevant procedure and data base checking strategies. Manuals and check lists may need to be submitted for review by the competent authority as part of the authorisation process.

10.2. Flight Crew Training

The Flight Crew should receive appropriate training, briefings and guidance material in order to safely conduct an LPV approach. This material and training should cover both normal and abnormal procedures. Standard training and checking, ~~such as recurrent aeroplane/STD training and proficiency checks,~~ should include LPV approach procedures. Based on this, the operator should determine what constitutes a qualified crew.

The operator should ensure that during line operations Flight Crew can perform assigned duties reliably and expeditiously for each procedure to be flown in:

a) normal operations: and

b) abnormal operations.

A training program should be structured to provide sufficient theoretical and practical training. An example ~~of~~ training syllabus is described in APPENDIX 4.

10.3. Aerodrome competence and Operator verification

Before planning a flight to an aerodrome (destination or alternate) with the intent to use a LPV approach procedure contained in the Navigation Database, the operator should determine the operational characteristics of the procedure in accordance with EU-OPS 1.975 or the applicable operational regulations. Further details are provided in APPENDIX 2.

Based on this assessment, the appropriate information should be given to the crew. If the aerodrome access requires a specific competence, the designated crew shall have a validated competence.

10.4. Navigation Database Management

10.4.1. Operator involved in the operation of ~~aeroplanes~~ aircraft for commercial air transportation

The operator shall comply with the requirements of EU-OPS 1.873 for the management of navigation databases.

10.4.2. Operator not involved in the operation of ~~aeroplanes~~ aircraft for commercial air transportation

The operator shall not use a navigation database for LPV approach operations unless the navigation database supplier holds a Type 2 Letter of Acceptance (LoA) or equivalent.

An EASA Type 2 LoA is issued by EASA in accordance with EASA OPINION Nr. 01/2005 on "The Acceptance of Navigation Database Suppliers" dated 14 January 2005. The FAA issues a Type 2 LoA in accordance with AC 20-153, while Transport Canada (TCCA) ~~is~~ issues an Acknowledgement Letter of an Aeronautical Data Process using the same basis. Both the FAA LoA and the TCCA Acknowledgement Letter are seen to be equivalent to the EASA LoA.

EUROCAE/RTCA document ED-76/DO-200A Standards for Processing Aeronautical Data contains guidance relating to the processes that the supplier may follow. The LoA demonstrates compliance with this standard.

Note 1: The LPV approach is characterised in the navigation database by the FAS Data Block protected by a CRC. The FAS Data Block contains the lateral and vertical parameters, which define the approach to be flown. Those parameters have been calculated, validated and promulgated by the Air Navigation Service Provider. In addition, each FAS Data Block ends with a CRC, which wraps around the approach data. Consequently, the integrity is ensured when the airborne equipment making use of the data successfully passes the CRC on the data block.

Quality Monitoring

The operator should continue to monitor both the process and the products in accordance with the quality system required by the applicable operational regulations.

Data Distribution

The operator should implement procedures that ensure timely distribution and insertion of current and unaltered electronic navigation data to all aircraft that require it.

10.4.3. Reportable Events

A reportable event is one that adversely affects the safety of the operation and may be caused by actions/events external to the operation of the aircraft navigation system. The operator should have in place a system for investigating such an event to determine if it is due to an improperly coded procedure, or a navigation data base error. Responsibility for initiating corrective action rests with the operator.

For those operators for whom approval is granted under EU-OPS 1, Technical defects and the exceeding of technical limitations, including the following events, should be the subject of Occurrence Reports (see EU-OPS 1.420):

a) Significant navigation errors attributed to incorrect data or a database coding error.

b) Unexpected deviations in lateral/vertical flight path not caused by pilot input or erroneous operation of equipment.

c) Significant misleading information without a failure warning.

d) Total loss or multiple navigation equipment failure.

e) Loss of Integrity (LOI) ~~function~~ annunciation where~~as~~ SBAS for LPV approach operations had not been notified as unavailable or unreliable during pre-flight planning.

11. AVAILABILITY OF DOCUMENTS

JAA documents are available from the JAA publisher Information Handling Services (IHS). Information on prices, where and how to order is available on the JAA website: www.jaa.nl

EASA documents may be obtained from EASA (European Aviation Safety Agency), PO Box 101253, D-50452 Koln, Germany. Website: www.easa.europa.eu

EUROCAE documents may be purchased from EUROCAE, 102 rue Etienne Dolet, 92240 MALAKOFF, France, (Fax: 33 1 46 55 62 65). Website: www.eurocae.eu

FAA documents may be obtained from Superintendent of Documents, Government Printing Office, Washington, DC 20402-9325, USA. Website: www.faa.gov/aviation.htm

RTCA documents may be obtained from RTCA Inc, 1828 L Street, NW, Suite 805, Washington, DC 20036, USA, (Tel: +1 202 833 9339; Fax: +1 202 833 9434). Website: www.rtca.org.

ICAO documents may be purchased from Document Sales Unit, International Civil Aviation Organisation, 999 University Street, Montreal, Quebec, Canada H3C 5H7, (Fax: +1 514 954 6769, e-mail: sales_unit@icao.org) or through national agencies.

APPENDIX 1: GLOSSARY

The following are definitions of key terms used throughout this AMC.

Abnormal procedure: Crew procedure defined in the AFM or POH to address Warnings and Cautions issued by aircraft systems

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

Area navigation (RNAV): A method of navigation which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Accuracy: 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. Navigation performance accuracy is usually presented as a statistical measure of system error and is specified as predictable, repeatable and relative.

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

Availability: An indication of the ability of the system to provide usable service within the specified coverage area and is defined as the portion of time during which the system is to be used for navigation during which reliable navigation information is presented to the crew, autopilot, or other system managing the flight of the aircraft.

~~**Basic GNSS operation**: Operation that are based on GNSS Aircraft Based Augmentation System (ABAS). An ABAS system is typically a GNSS receiver with fault detection compliant to E/TSO-C129a, E/TSO-C145( ) or E/TSO-C146( )~~

Contingency Procedures: A procedure developed by the operator to address a situation where the intended procedure could not be performed.

Continuity of Function: The capability of the total system (comprising all elements necessary to maintain aircraft position within the defined airspace) to perform its function without non-scheduled interruptions during the intended operation.

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

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

~~**Fault Detection and Exclusion (FDE):** FDE is a receiver processing scheme that autonomously provides integrity monitoring for the position solution, using redundant range measurements. The FDE consist of two distinct parts: fault detection and fault exclusion. The fault detection part detects the presence of an unacceptably large position error for a given mode of flight. Upon the detection, fault exclusion follows and excludes the source of the unacceptably large position error, thereby allowing navigation to return to normal performance without an interruption in service.~~

FAP: Final Approach Point.

~~**FPAP:** Flight Path Alignment Point. FPAP coordinates are stored in the FAS Data Block (see also RTCA DO-229( )).~~

FSD: Full Scale Deflection

FTP: Fictitious Threshold Point. The threshold location is referred to as the FTP when it is displaced from the runway. FTP coordinates are stored in the FAS Data Block (see also RTCA DO-229( )).

GNSS stand-alone receiver: A GNSS system incorporating the GNSS sensor, the navigation capability and the navigation data base.

GNSS sensor: A GNSS system incorporating only the GNSS receiving and positioning part. It doesn't incorporate the navigation capability and the navigation data base.

GPA: Glidepath Angle. It represents the angle of the approach path (glide path) with respect to the horizontal plane defined according to WGS-84 at the LTP/FTP. GPA is stored in the FAS data block (see also RTCA DO-229( )).

HAL: Horizontal Alert Limit.

ILS Look alike: "ILS Look alike" is defined as the ability of a non-ILS based navigation receiver function to provide operational characteristics and interface functionality to the rest of the aircraft equivalent to that provided by an ILS based receiver function. ~~The output should be in DDM/micro amps, with a sensitivity equivalent to an ILS receiver.~~

Integrity: The ability of a system to provide timely warnings to users when the system should not be used for navigation.

LPV: Localiser ~~Precision~~ Performance with Vertical guidance.

LPV approach operation: RNAV GNSS approach operation conducted down to LPV minima.

LPV approach procedure: RNAV GNSS approach procedure containing LPV minima.

LPV approach capability: Airborne capability to fly LPV approach procedure.

LPV OCA(H). Obstacle clearance altitude (OCA) or obstacle clearance height (OCH). The lowest altitude or the lowest height above the elevation of the relevant runway threshold or the aerodrome elevation as applicable, used in establishing compliance with appropriate obstacle clearance criteria.

LTP: Landing Threshold Point. The threshold location is referred to as the LTP when it is collocated with the runway. LTP coordinates are stored in the FAS Data Block.

~~**Receiver Autonomous Integrity Monitoring (RAIM**): A technique whereby a GNSS receiver/processor determines the integrity of the GNSS navigation signals using only GPS signals or GPS signals augmented with altitude. This determination is achieved by a consistency check among redundant pseudo range measurements. At least one satellite in addition to those required for navigation should be in view for the receiver to perform the RAIM function.~~

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

RNAV(GNSS) approach: A GNSS RNAV approach promulgated by a state and designed in accordance with PANS-OPS Criteria ICAO Doc 8168.

SBAS: Satellite Based Augmentation System. SBAS augments core satellite constellation by providing ranging, integrity and correction information via geostationary satellites. This system comprises a network of ground reference stations that observe satellites signals, and master stations that process observed data and generate SBAS messages for uplink to the geostationary satellites, which broadcast the SBAS message to the users.

RNP APCH: RNP AProaCH. A RNP approach defined in the ICAO Performance Based Manual (PBN) manual. ~~An approach equivalent to the RNAV (GNSS) one~~.

ETSO: European Technical Standard Order.

~~**TSO-C129( )/ETSO-C129( ) GPS Class A equipment:** Equipment incorporating both the GNSS sensor and navigation capability. This equipment incorporates RAIM as defined by TSO/ETSO-C129( ).~~

~~**TSO-C129( )/ETSO-C129( ) GPS Class B and C equipment**: GNSS sensor providing GNSS data (position, integrity,..) to an integrated navigation system (e.g. FMS).~~

~~**TSO-C146( ) Class GAMMA:** This functional class corresponds to equipment consisting of both the GNSS/SBAS position sensor and a navigation function, so that the equipment provides path deviations relative to a selected path. The equipment provides the navigation function required of a stand-alone navigation system. This equipment also provides integrity in the absence of SBAS signal through the use of FDE. In addition, this class of equipment requires a data base, display outputs and pilot controls.~~

~~**TSO-C145( )/ETSO-C145( ) class BETA**: Equipment consisting of a GNSS/SBAS sensor that determines position (with integrity) and provides position and integrity to an integrated navigation system (e.g. flight management system, multi sensor navigation system). This equipment also provides integrity in the absence of the SBAS signal through the use of fault detection and exclusion (FDE).~~

~~**TSO-C146( )/ETSO-C146( ) or TSO-C145( )( )/ETSO-C145( ) Operational Class 1:** This operational class supports oceanic and domestic enroute, terminal, LNAV and departure operation.~~

~~**TSO-C146( )/ETSO-C146( ) or TSO-C145( )/ETSO-C145( ) Operational Class 2:** This operational class supports oceanic and domestic enroute, terminal, LNAV, LNAV/VNAV and departure operation.~~

~~**TSO-C146( )/ETSO-C146( ) or TSO-C145( )/ETSO-C145( ) Operational Class 3:** This operational class supports oceanic and domestic enroute, terminal, LNAV, LNAV/VNAV, LPV and departure operation.~~

~~**VAL:** Vertical Alert Limit.~~

Vertical Navigation: A method of navigation which permits aircraft operation on a vertical flight profile using altimetry sources, external flight path references, or a combination of these.

~~**VTF:** Vector To Final.~~

APPENDIX 2: OPERATIONAL CHARACTERISTICS OF THE PROCEDURE AND ITS OPERATIONAL USE

Depending upon the type of operation being undertaken the operator should consider the following:

a) The operator should show evidence that consideration has been given to the evaluation of any new or modified LPV approach procedures. Particular attention should be paid to procedures:

- in mountainous environment;
- within the proximity of well-known obstacles; and
- that may require adequate knowledge for the aerodrome access or aerodrome competence qualification, as specified in EU-OPS 1.975 or the applicable operational requirements.

b) Competence may be required specifically for an LPV approach procedure or the procedure may be published for an aerodrome already listed as requiring an aerodrome competence. The required competence may be aircraft type related and subject to periodic revalidation. Particular attention should be paid to procedures that:

- are not in radar coverage;
- have ~~a~~ missed approach trajectories involving turns, especially at low altitudes;
- are subject to a declared exemption to the procedure design rules specified by the ICAO PANS OPS; and
- every other case considered necessary to be evaluated by the operator.

c) The operator may develop an internal process (e.g. filtering methods or tools covering the AIP review) to detect LPV approach procedure(s) showing one or more of the above-listed characteristics.

d) The operational evaluation of a LPV approach procedure showing evidence of the above mentioned operational characteristics may include, at operator discretion, an approach conducted with the aircraft in VMC or the use of a full flight simulator (FFS) in order to evaluate if the procedure is correctly executed by the navigation system and fly-able with the aircraft type.

APPENDIX 3: LPV APPROACH OPERATIONAL PROCEDURES

This appendix should be used by the operator to amend operational manual(s) to support LPV approach operation.

1. Normal Procedures

1.1 Pre-flight Planning

The on board navigation data must be current and must include the appropriate procedures.

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

a) The instrument approach chart should clearly identify the LPV approach operation as RNAV(GNSS) to LPV minima ~~or equivalent (e.g. RNAV(GNSS) RWY 27,…)~~. The operator should determine in accordance with the promulgated OCA(H) and the operational requirement (e.g. EU-OPS 1.430) the Decision Altitude/Height (DA(H)).

b) The Flight Crew must ensure that LPV approach procedures which may be used for the intended flight (including alternate aerodromes) are selectable from a valid navigation data base (current AIRAC cycle) and are not prohibited by a company instruction or NOTAM.

The Flight Crew could check approach procedures (including alternate aerodromes) as extracted by the system (e.g. CDU flight plan page) or presented graphically on the NAV display, in order to confirm the correct loading and the reasonableness of the procedure content. The vertical path of the LPV approach procedure could be checked as extracted from the navigation database on the system Man Machine Interface (e.g. CDU).

If above verification is not satisfactory, the Flight Crew should not use the procedure, and not consider this approach(es) during the selection of aerodromes for the intended flight.

Note1: For LPV approach operations, the Flight Crew selects the desired approach procedure using its name or the SBAS channel number and the on board system automatically extracts the high-integrity procedure and associated alert limits (VAL, HAL). This information is protected from data corruption by a cyclic redundancy check (CRC) determined during the procedure design.

c) The Flight Crew should ensure sufficient means are available to navigate and land at the destination or at an alternate aerodrome in the case of loss of LPV airborne capability. In particular, the Flight Crew should check that:

- at least one non RNAV GNSS based procedure is available at the destination aerodrome;
- a non RNAV GNSS based procedure is available at the alternate (where a destination alternate is required) ~~unless the airspace authority does not require such requirement (e.g. FAA within WAAS coverage)~~;
- ~~at least one non RNAV GNSS based procedure is available at the destination aerodrome (where a destination alternate is not required) unless the airspace authority does not require such requirement (e.g. FAA within WAAS coverage).~~

d) Operators and Flight-Crews must take account of any NOTAMs (including SBAS NOTAMs) or operator briefing material that could adversely affect the aircraft system operation, or the availability or suitability of the procedures at the airport of landing, or any alternate airport.

e) If the missed approach procedure is based on conventional means (e.g. VOR, DME) the appropriate airborne equipment required to fly this procedure must be available and serviceable on board the aircraft. The associated ground-based navigation aids must also be operational.

If the missed approach procedure is based on RNAV (no conventional or dead reckoning missed approach available) the appropriate airborne equipment required to fly this procedure must be available and serviceable on board the aircraft (e.g. RNP APCH capable system).

f) Any MEL restriction must be observed.

1.2 Prior to Commencing the Procedure

The Final approach segment (FAS) of an LPV approach procedure may be intercepted by an approach transition (e.g. P-RNAV or initial/intermediate segments of an RNP APCH approach) or through vectoring (interception of the extended Final approach segment following ATC instruction).

In addition to normal procedure prior to commencing the approach (before the IAF and in compatibility with crew workload), the Flight Crew must verify the correctness of the loaded procedure by comparison with the appropriate approach charts. This check must include:

- The waypoint sequence;
- Reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and mileage of the final approach segment.

Note: As a minimum, this check could be a simple inspection of a suitable map display.

- The vertical path angle where the system permits.

ATC tactical interventions in the terminal area may include radar headings, 'direct to' clearances which by-pass the initial legs of an approach, interception of an initial or intermediate segment of an approach or the insertion of waypoints loaded from the database. In complying with ATC instructions, the Flight Crew should be aware of the implications for the navigation system in particular:

- The manual entry of coordinates into the navigation system by the Flight Crew for operation within the terminal area is not permitted;
- 'Direct to' clearances may be accepted to the Intermediate Fix (IF) provided that the resulting track change at the IF does not exceed 45°.

Note: Direct to clearance to FAP is not acceptable.

The approach system provides the capability for the Flight Crew to intercept the Final Approach track well before the FAP (Vector To Final (VTF) function or equivalent). This function should be used to respect a given ATC clearance.

1.3 During the Procedure

The system provides lateral and vertical guidance relative to the LPV Final Approach Segment or to the extended final approach segment (for the direct transition).

The crew must check that the GNSS approach mode indicates LPV (or an equivalent annunciation) 2 NM before the FAP.

The final approach segment should be intercepted ~~no later~~ before ~~than~~ the FAP in order for the aircraft to be correctly established on the final approach course before starting the descent (to

ensure terrain and obstacle clearance). The appropriate displays should be selected so that the following information can be monitored:

- Aircraft position relative to the lateral path;
- Aircraft position relative to the vertical path;
- Absence of LOI (Loss Of Integrity) alert.

The crew should respect all published altitude and speed constraints.

The Flight Crew shall maintain the aircraft within ⅓ the full scale deflection for the lateral deviation and within ½ the full scale deflection for the vertical deviation when manual flying the procedure

Prior to sequencing the FAP, the procedure must be discontinued or may be continued to LNAV minima when supported by the system if there is:

- Loss of integrity~~/Loss of Navigation~~ is indicated by a warning annunciator (e.g. absence of power, equipment failure).

After sequencing the FAP, the procedure must be discontinued, unless the Flight Crew have in sight the visual references required to continue the approach if there is:

- Loss of integrity~~/Loss of Navigation~~ is indicated by a warning annunciator;
- Loss of vertical guidance is indicated (even if lateral guidance is displayed);
- lateral or vertical deviation are excessive and cannot be timely corrected.

The missed approach must be flown in accordance with the published procedure (e.g. conventional or RNAV).

Note: Alternatively, when the aircraft is still above 1 000 ft. AGL, the pilot may decide to continue the approach to LNAV minima when supported by the system.

2. Abnormal Procedures

Abnormal procedures to address Cautions and Warnings resulting from the following conditions should be developed:

- Failure of the navigation system components, including those affecting flight technical errors (e.g. failures of the flight director or autopilot).
- ~~Fault Detection and Exclusion (FDE) alert or~~ loss of integrity annunciation ~~function~~.
- Warning flag or equivalent indicator on the lateral and/or vertical navigation display.
- Degradation of the GNSS approach mode during a LPV approach procedure (e.g. downgrade from LPV to LNAV).

In case of a complete RNAV guidance loss during the approach, the crew must follow the operator defined contingency procedure.

In the event of communications failure, the Flight Crew should continue with the procedure in accordance with published lost communication procedures.

The Flight Crew should notify ATC of any problem with the navigation system that results in the loss of the approach capability.

APPENDIX 4: FLIGHT CREW TRAINING SYLLABUS

The Flight Crew training program should be structured to provide sufficient theoretical and practical training, using a simulator, training device, or line training in an aircraft, in the concept of RNAV GNSS approach operations to LPV minima and the use of the aircraft's approach system in such operations to ensure that Flight Crew are not just task oriented. The following syllabus should be considered as a minimum amendment to the training programme to support these operations:

1. RNAV APPROACH CONCEPT CONTAINING LPV MINIMA:

a) Theory of approach operations

b) Approach charting

c) Use of the approach system including:

   i. Selection of the LPV approach procedure

   ii. ILS look alike principle

d) Use of lateral navigation mode(s) and associated lateral control techniques

e) Use of vertical navigation mode(s) and associated vertical control techniques

f) R/T phraseology for LPV approach operations

g) The implication for LPV approach operations of systems malfunctions which are not related to the approach system (e.g. hydraulic or engine failure)

2. RNAV APPROACH OPERATION CONTAINING LPV MINIMA:

a) Definition of LPV approach operations and its direct relationship with RNAV(GNSS) procedures.

b) Regulatory requirements for LPV approach operations

c) Required navigation equipment for LPV approach operations:

   i. GPS concepts and characteristics

   ii. SBAS augmentation and characteristics

   iii. MEL

d) Procedure characteristics

   i. Chart depiction

   ii. Aircraft display depiction

   iii. Minima

e) Retrieving a LPV approach procedure from the database (e.g. using its name or the SBAS channel number)

f) Procedure change at destination airport, change arrival airport and alternate airport

g) Flying the procedure:

   i. Use of autopilot, autothrottle and flight director

   ii. Flight Guidance(FG) mode behaviour

iii. Lateral and vertical path management

iv. Adherence to speed and/or altitude constraints

v. Fly interception of an initial or intermediate segment of an approach following ATC notification

vi. Fly interception of the extended final approach segment (e.g. using the VTF function)

vii. Consideration of the GNSS approach mode indication (LPV, LNAV/VNAV, LNAV,…)

viii. Reversion to LNAV minima

ix. The use of other aircraft equipment to support track monitoring, weather and obstacle avoidance

h) ATC procedures

i) Abnormal procedures

j) Contingency procedures

Appendix B - Attachments

A&C-09-276 NPA 2009-04 Comments Airworthiness Approval RNAV GNSS Approach Op.pdf

Attachment #1 to comment #152