V3 INTEROP

Document information	
Project Title	Approach Procedure with Vertical Guidance (APV)
Project Number	05.06.03
Project Manager	NATS
Deliverable Name	V3 INTEROP
Deliverable ID	D41
Edition	00.01.01
Template Version	03.00.00
Task contributors	
NORACON; THALES; NATS; EUROCONTROL; ENAV; AIRBUS; AENA.	

Abstract

This document is the INTEROP of the advanced APV concept.

This V3 INTEROP refines the first version of the INTEROP (P05.06.03.D19). This version is based on the OSED V3 (P05.06.03.D40) and considers the results of the advanced LPV validation exercises (VP-225, VP-353, VP-623, VP-482 and VP-483).

This document :

- includes interface requirements ;
- includes INTEROP requirements for the aircraft segment.

There are no INTEROP requirements for the ground segment.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] THALES	[redacted]	29/08/2014

Reviewed By - *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] ENAV	[redacted]	26/09/2014
[redacted] AENA	[redacted]	26/09/2014
[redacted] NORACON	[redacted]	26/09/2014
[redacted] NATS	[redacted]	26/09/2014
[redacted] AIRBUS	[redacted]	26/09/2014
[redacted] EUROCONTROL	[redacted]	26/09/2014

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	Position & Title	Date
[redacted] ENAV	[redacted]	26/09/2014

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] NATS	[redacted]	02/10/2014
[redacted] THALES	[redacted]	02/10/2014
[redacted] AENA	[redacted]	02/10/2014
[redacted] ENAV	[redacted]	02/10/2014
[redacted] AIRBUS	[redacted]	02/10/2014
[redacted] NORACON	[redacted]	02/10/2014
[redacted] EUROCONTROL	[redacted]	02/10/2014

Rejected By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
None.		

Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
00.00.01	29/08/2014	Draft	[redacted]	First D41 version produced by modifying P5.6.3 D19 : - OSED V3 and results of the validation exercises taken into account.
00.01.00	26/09/2014	Final	[redacted]	Final version following internal and external reviews.

00.01.01	03/12/2014	Final	[redacted]	Update following SJU assessment report.

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Table of Contents

List of tables

No table in this document.

List of figures

Executive summary

This document is the INTEROP of the advanced APV concept.

This V3 INTEROP refines the first version of the INTEROP (P05.06.03.D19). This version is based on the OSED V3 (P05.06.03.D40) and considers the results of the advanced LPV validation exercises(VP-225, VP-353, VP-623, VP-482 and VP-483).

This document :

- includes interface requirements ;
- includes INTEROP requirements for the aircraft segment.

There are no INTEROP requirements for the ground segment.

Note : the feasibility of the Advanced APV concept within high density, high complexity TMAs will be assessed in VP-792. The potential impacts of this exercice on the INTEROP requirements are out of the scope of this document.

1 Introduction

1.1 Purpose of the document

This document is the INTEROP of the advanced APV concept, an innovative flight approach procedure where RF legs, CDA technique and LPV FAS are combined.

This V3 INTEROP refines the first version of the INTEROP (P05.06.03.D19). This version is based on the OSED V3 (P05.06.03.D40) and considers the results of the advanced LPV validation exercises.

This document :

- includes interface requirements ;
- includes INTEROP requirements for the aircraft segment.

There are no INTEROP requirements for the ground segment.

1.2 Intended readership

The intended audience inside SESAR is : P9.9, P9.10, SWP5.2, SWP5.6, WP5, and the different partners of Project 05.06.03.

The project P08.01.03 can be interested as they are providing some support for the IERs.

The project P06.08.05 can be interested for the similarity of the RNP to GLS procedure with the advanced APV procedure.

It will be of interest for Air Navigation Service Providers who will in the future intend to implement in their operational environments the advanced procedure selected by 05.06.03. It will also be of interest to data base suppliers, aircraft operators, flight crew, air traffic controllers and aircraft manufacturers intending to work with such type of procedures.

1.3 Inputs from other projects

There are no specific inputs from other projects or past-projects.

1.4 Glossary of terms

There are no specific terms to define.

1.5 Acronyms and Terminology

Term	Definition
ADD	Architecture Definition Document
APCH	Approach
APV	Approach Procedure with Vertical guidance
A-RNP	Advanced RNP
ATC	Air Traffic Control
ATM	Air Traffic Management
CDO	Continuous Descent Operation
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
FAF	Final Approach Fix
FMS	Flight Management System
FPAP	Flight Path Alignment Point
FTE	Flight Technical Error
FSD	Full Scale Deflection
FTP	Fictitious Threshold Point
GARP	Global Navigation Satellite System (GNSS) Azimuth Reference Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HAL	Horizontal Alarm Limit
IER	Information Exchange Requirements
ILS	Instrument Landing System
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
LPV	Localizer Performance with Vertical guidance
LTP	Landing Threshold Point

Term	Definition
OFA	Operational Focus Areas
OSED	Operational Service and Environment Definition
PBN	Performance Based Navigation
RF	Radius to Fix
RNP	Required Navigation Performance
RNP AR	Required Navigation Performance Authorization Required
RWY	Runway
SBAS	Satellite-Based Augmentation System
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Safety and Performance Requirements
TAD	Technical Architecture Description
TS	Technical Specification

2 System Description

The technology supporting the service defined in the OSED is based on the same technology that currently supports LPV and RNP operations.

The aircraft and ground ATM system functions required to support LPV and RNP operations are impacted by the advanced APV concept as detailed in the following sections.

3 Interoperability Requirements

3.1 Requirements for ATS CNS/ATM Applications

3.1.1 Interface requirements

No new IER (Information Exchange Requirements) is identified in the OSED (paragraph 6.2) so there are no interface interoperability requirements for the advanced APV.

Note : the OSED states that: “the concept does not require neither expect that the aircraft informs the ATC of their advanced APV capabilities (RF leg, Advanced RNP if needed because RNP value lower than 1 NM)”

The current exchanges linked with advanced APV are :

1) Procedures

New approach procedures are designed for the advanced APV. The way these procedures are managed from the procedure designers to the aircraft navigation database is the same process as for current RNP and LPV approach procedures.

If this process is changed for a complete digital data chain, there is no identified incompatibility with advanced APV. Advanced APV approach procedures will be managed as will be standard LPV approach procedures.

This compatibility between advance and standard LPV approach procedures is the rationale of the following OSED requirement :

Identifier	REQ-05.06.03-OSED-ALPV.0030
Requirement	The construction of the Advanced APV procedures shall respect the guidance given by PANS OPS 8168 volume II.
Title	Advanced APV concept procedure design criteria
Rationale	To cope with current procedure design and ease the widespread use of the concept, and to prevent loss of separation with obstacles, terrain or other departing or arriving aircraft.

Note : issues have been raised by P06.08.05 concerning the coding of the procedures within FMS NavDB :

- Coding of RF leg directly to FAP would require evolution of the ICAO PANS-OPS and ARINC 424 standards. The subject is already being discussed within ICAO Instrument Flight Procedures Panel (IFPP) Working Group.
- Coding of multiple (more than two) precision approaches on the same runway would require evolution of the ARINC 424 standard. This issue has been addressed to the ARINC Navigation Data Base Subcommittee by AIRBUS FMS team, and A424 next issue (A424-21) will be updated in this sense.

2) Flight plans

The way an airspace user planning to use an advanced APV approach procedure informs the ATM of its flight plan is the same as for standard LPV approaches.

3) Voice (ATC – aircraft)

The voice exchanges between the ATC and the aircraft when performing advanced APV procedures are the same as for standard LPV procedures. These voice exchanges are detailed in the OSED (paragraph 6.2 : Information Exchange Requirements).

3.1.2 Aircraft CNS requirements

The aircraft CNS functionalities required to support the advanced APV are specified in paragraph 6.3 "Requirements for the advanced APV aircraft capabilities" of the OSED. These OSED requirements are refined into some INTEROP requirements.

Note : there is no new information exchanged between ground and A/C systems (as indicated in the paragraph "interfaces") therefore there are no interoperability requirement on the Aircraft System on how to manage any new information.

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0010
Requirement	The aircraft shall provide the necessary navigation, flight plan management, guidance and control, performance monitoring and alerting and display and system functions to conduct RNP APCH operations down to LPV minima with segments with RNP values of 1 NM or 0.3 NM with RF legs ending at the FAP together with the CDA technique
Title	Aircraft Capability
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0010	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Flight path management gate-to-gate	N/A
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0090
Requirement	At any time during the flight, the aircraft shall enable the monitoring of the availability of either RNP 1 or RNP 0.3 with RF legs and APV-SBAS (LPV) aircraft capabilities.
Title	Aircraft status monitoring
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0090	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Displays & Controls	N/A

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0100
Requirement	During the transition from the RNP intermediate segment with or without an RF leg directly linked to the APV-SBAS (LPV) final approach segment, the aircraft shall enable the monitoring of the change from the RNP segment to the LPV segment with its respective raw data and guidance modes.
Title	Transition monitoring
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0100	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Displays & Controls	N/A

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0130
Requirement	The aircraft shall enable a manual or automatic transition from RNP (with or without VNAV) to LPV guidance mode.
Title	Transition activation management
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0130	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0140
Requirement	The aircraft shall avoid unexpected early capture of the LPV Final Approach Segment.
Title	Transition start
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0140	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0151
Requirement	The aircraft shall provide the necessary navigation, flight plan management, guidance and control, performance monitoring and alerting and display and system functions to conduct the RNP coded missed approach, including the RF legs, with a LNAV mode.
Title	Missed Approach aircraft operation
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0151	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Flight path management gate-to-gate	N/A

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0160
Requirement	The aircraft shall meet the current regulations for degraded cases, in accordance with flown operations.
Title	Degraded Cases
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0160	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Flight path management gate-to-gate	N/A
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A
<ALLOCATED_TO>	<Functional block>	Alerts	N/A

[REQ]

Identifier	REQ-05.06.03-INTEROP-ALPV.0170
Requirement	The aircraft shall provide the necessary navigation, flight plan management, guidance and control, performance monitoring and alerting and display and system functions to conduct the ADV LPV with a RF-turn into the FAP ensuring stabilized approaches.
Title	Stabilized approaches
Status	<In Progress>
Rationale	This is an aircraft required functionality to support advanced APV operations.
Category	<Operational>
Validation Method	<Flight Trial><Real Time Simulation>
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0170	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA02.01.01	N/A
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A
<ALLOCATED_TO>	<Functional block>	Displays & Controls	N/A

These requirements can be summed up by the following aircraft CNS functionalities :

- LPV function ;
- RNP function with RF legs and when RNP value lower than 1 is required also the scalability of the RNP value down to 0.3 NM (that should correspond to future advanced RNP navigation specification) ;
- Transition function between the RNP part and the LPV part.

Today, for the airborne side, a standardization and certification baseline exist for the LPV function and RNP function (see P09.10.D19 : Yearly APV-SBAS Standardisation report V3). This baseline includes safety and performance requirements. During advanced APV operations, the aircraft will be either in the RNP part or in the LPV part ; therefore, either the LPV safety and performance requirements (of AMC 20-28) or the RNP safety and performance requirements (of AMC 20-27 if the RNP navigation specification is RNP APCH) will be applicable. No additional safety and performance requirements are expected on the airborne side for the transition function.

3.1.3 Ground ATC requirements

There are no ATC INTEROP requirement for the advanced APV. Current ATC tools are not modified for the advanced APV. The changes are limited to procedures.

There is no new information exchanged between ground and A/C systems (as indicated in the paragraph "interfaces") therefore there are no interoperability requirement on the ground system on how to manage any new information. There is no impact on ground/air systems interoperability.

Note : the advanced APV concept is demonstrated in VP-353, VP-623 and VP-483 as feasible from the ATC side in light traffic, but not in moderate and heavy traffic. The feasibility of the Advanced APV concept within high density, high complexity TMAs will be assessed in VP-792. The potential impacts of this exercice on the INTEROP requirements are out of the scope of this document.

3.2 Dynamic functions / operations

There are no “dynamic functions / operations” interoperability requirements for the advanced APV.

3.3 Unique characteristics

3.3.1 Aircraft lateral transition

3.3.1.1 Standardization

The aircraft transition from RNP to LPV is not planned to be standardized. Advanced APV operations will be covered by RNP standards until the FAP, and LPV standards after the FAP.

The RNP to LPV transition and in particular the LPV capture laws would be difficult to standardize, as capture laws are designed differently on each aircraft to ensure the best performances on the final segment, and is not considered as mandatory for the advanced APV concept.

Note : the standards are AMC 20-27 and FAA AC 20-138D for the RNP part, and AMC 20-28 for the LPV part ; see OSED paragraph 4.1.2.

The consequence is that the point where the guidance laws switch from RNP to LPV will not be the same on all aircraft. While in the RNP corridor, at the end of the RF turn before the FAP, the aircraft may be already in LPV law. The aircraft will still comply with the RNP requirements but may not follow the flight path with the same accuracy as in RNP law.

3.3.1.2 Capture conditions

3.3.1.2.1 Problem

LPV can be designed as “ILS look alike”. The same or similar capture laws are used for LPV and ILS approaches. A LPV “pseudo-localizer” cone is considered, similar to the localizer cone of an ILS approach.

The RNP to LPV transition is then similar to the RNP (AR) to ILS transition that has already been studied, in particular in [5] and [6].

The analysis done in [5] show that with RNP values of 1 NM or 0.3 NM and short final segments, it is not ensured that the LPV capture conditions are fulfilled when reaching the FAP.

The following figure shows the LPV pseudo-localizer full scale and the RNP corridor, for a final approach segment of 7 NM and a RNP of 1 NM :

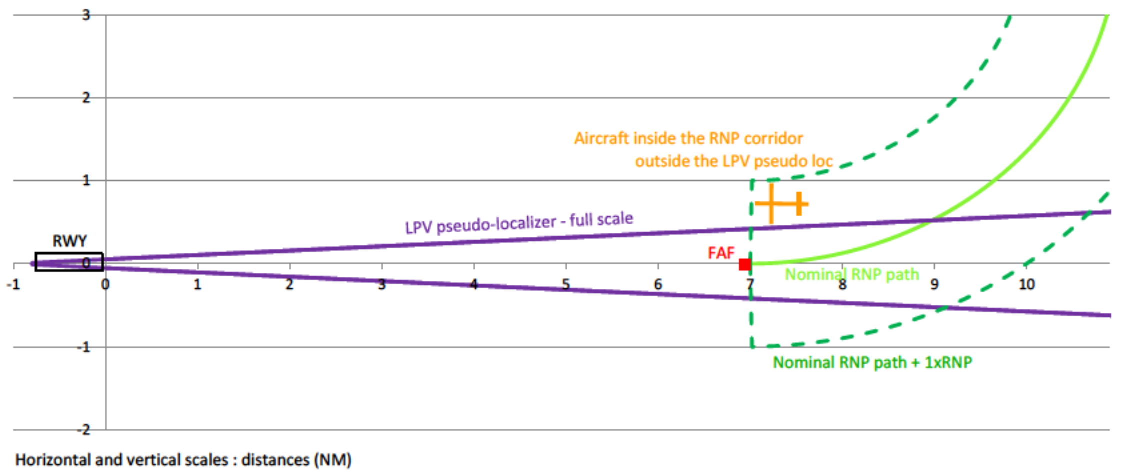


Figure 1 : RNP 1 corridor and LPV pseudo-localizer

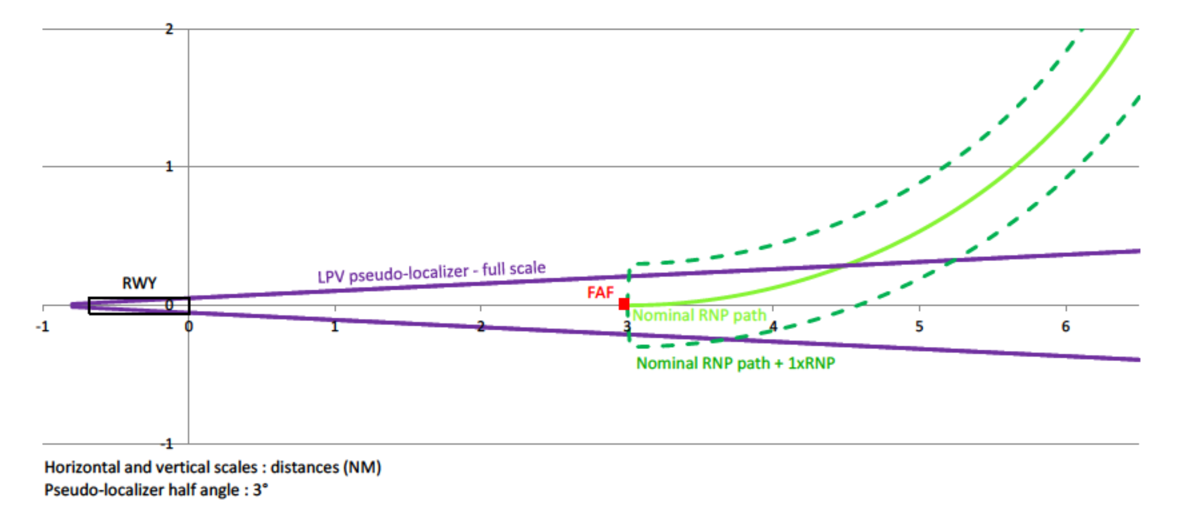


Figure 2 : RNP 0.3 corridor and LPV pseudo-localizer

The aircraft can be inside the RNP corridor (it is compliant with the RNP navigation specification) but outside the LPV pseudo-localizer : at the FAF, the aircraft will not be able to perform the LPV approach and will probably initiate a missed approach.

Note that the LPV pseudo-localizer half angle is the full-scale deflection angle defined in the DO229D [12] :

112

2.2.4.4.2 Non-Numeric Lateral Cross-Track Deviation

2.2.4.4.2.1 Definition of Final Approach Segment Lateral deviations

Final approach segment lateral deviations (see Figure 2-15) are defined from the following:

a) lateral deviation reference plane: the plane that contains the LTP/FTP vertical direction vector and the flight path alignment point (FPAP).

b) vertical direction vector: the vector that passes through the LTP/FTP and is normal to the WGS-84 ellipsoid at the LTP/FTP.

c) GNSS Azimuth Reference Point (GARP): the point that lies in the horizontal plane containing the LTP/FTP and is 305 m beyond the point where the vertical projection of the FPAP intersects this plane.

Positive lateral deviations shall correspond to aircraft positions to the left of the lateral deviation reference plane, as observed from the LTP/FTP facing toward the FPAP.

The *final approach segment lateral deviation* is referenced to the lateral deviation reference plane and is defined to be proportional to the angle (α_{lat}) measured at the GARP between the aircraft and the lateral deviation reference plane, with full-scale deflection (FSD) at a lateral cross-track error of:

$$\alpha_{lat\_FS} = \pm\tan^{-1}\left(\frac{\text{FAS Course Width at LTP/FTP (m)}}{\text{Distance from LTP/FTP to GARP (m)}}\right)$$

Note: Compatibility with ILS display systems can be achieved by converting the lateral deviation to μA (DDM) based upon a FSD at 150 μA (0.155 DDM).

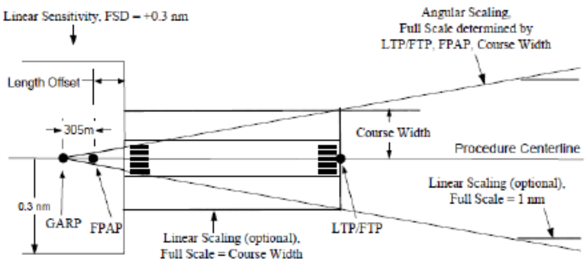


FIGURE 2-15 VTF FINAL APPROACH SEGMENT LATERAL DEVIATIONS WITH FAS DATA BLOCK

Figure 3 : extract of DO229D on the LPV full-scale deflection

For the localizer full-scale to match with the RNP corridor (nominal RNP path +/- 1 RNP), the minimal length of the final segment should be :

Minimal length = RNP / tan θ – (distance from LTP/FTP to GARP) where θ = localizer half angle

With the following characteristics of the LPV approach :

distance from LTP/FTP to GARP = 2000 m

FAS course width = 105 m

θ localizer half angle = 3.0° (=arctan 105/2000)

The minimum length of the final segment is :

- With RNP of 1 NM : 18 NM.
- With RNP of 0.3 NM : 4.6 NM.

Note that the RNP navigation specification is that the aircraft shall be inside the RNP corridor (nominal RNP path +/- 1 RNP) 95% of the time. This means that the minimum length given above ensures that 95% of the time the aircraft will be inside of the pseudo-localizer full-scale if the RNP requirements are satisfied ; this also means that there can be 5% of missed approaches even if the RNP requirements are satisfied.

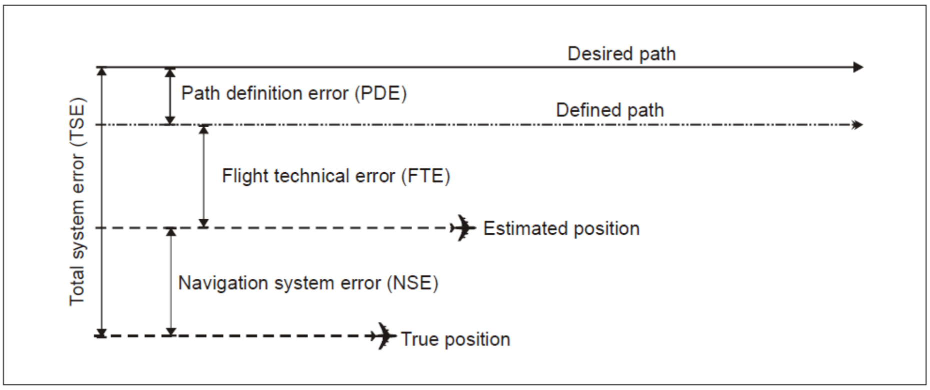
For the advanced APV procedures designed in task T012, the length of the final segment and the RNP value in the intermediate segment are the following :

- AENA procedure : final segment of 4.8 NM ; RNP value of 1 NM.
- NORACON procedure : final segment of 3.1 NM ; RNP value of 0.3 NM.
- ENAV procedure : final segment of 3 NM ; RNP value of 0.3 NM.
- NATS procedure (RWY 27) : final segment of 5.8 NM ; RNP value of 1 NM.

These values are inferior to the minimum lengths given above.

3.3.1.2.2 Mitigation

The following figure, extracted from the PBN manual [8], reminds the lateral navigation errors :



Note: NSE is sometimes referred to as positioning estimation error (PEE).

Figure II-A-2-1. Lateral navigation errors (95 per cent)

Figure 4 : extract of PBN manual on the lateral navigation errors

Note that the “Path definition error (PDE) is constrained through database integrity and functional requirements on the defined path, and is considered negligible.” ([8] volume II part A paragraph 2.3).

Navigation system error

SBAS signal in space performance requirement for horizontal accuracy 95% is 16 m (cf [9]), that includes the nominal performance of the receiver :

Annex 10 — Aeronautical Communications *Volume I*

Table 3.7.2.4-1 Signal-in-space performance requirements

Typical operation	Accuracy horizontal 95% (Notes 1 and 3)	Accuracy vertical 95% (Notes 1 and 3)	Integrity (Note 2)	Time-to-alert (Note 3)	Continuity (Note 4)	Availability (Note 5)
En-route	3.7 km (2.0 NM)	N/A	$1 - 1 \times 10^{-7}$/h	5 min	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
En-route, Terminal	0.74 km (0.4 NM)	N/A	$1 - 1 \times 10^{-7}$/h	15 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Initial approach, Intermediate approach, Non-precision approach (NPA), Departure	220 m (720 ft)	N/A	$1 - 1 \times 10^{-7}$/h	10 s	$1 - 1 \times 10^{-4}$/h to $1 - 1 \times 10^{-8}$/h	0.99 to 0.99999
Approach operations with vertical guidance (APV-I)	16.0 m (52 ft)	20 m (66 ft)	$1 - 2 \times 10^{-7}$ in any approach	10 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Approach operations with vertical guidance (APV-II)	16.0 m (52 ft)	8.0 m (26 ft)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999
Category I precision approach (Note 7)	16.0 m (52 ft)	6.0 m to 4.0 m (20 ft to 13 ft) (Note 6)	$1 - 2 \times 10^{-7}$ in any approach	6 s	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999

NOTES.—

1. The 95th percentile values for GNSS position errors are those required for the intended operation at the lowest height above threshold (HAT), if applicable. Detailed requirements are specified in Appendix B and guidance material is given in Attachment D, 3.2.
2. The definition of the integrity requirement includes an alert limit against which the requirement can be assessed. For Category I precision approach, a vertical alert limit (VAL) greater than 10 m for a specific system design may only be used if a system-specific safety analysis has been completed. Further guidance on the alert limits is provided in Attachment D, 3.3.6 to 3.3.10. These alert limits are:

Typical operation	Horizontal alert limit	Vertical alert limit
En-route (oceanic/continental low density)	7.4 km (4 NM)	N/A
En-route (continental)	3.7 km (2 NM)	N/A
En-route, Terminal	1.85 km (1 NM)	N/A
NPA	556 m (0.3 NM)	N/A
APV-I	40 m (130 ft)	50 m (164 ft)
APV- II	40 m (130 ft)	20.0 m (66 ft)
Category I precision approach	40 m (130 ft)	35.0 m to 10.0 m (115 ft to 33 ft)

3. The accuracy and time-to-alert requirements include the nominal performance of a fault-free receiver.
4. Ranges of values are given for the continuity requirement for en-route, terminal, initial approach, NPA and departure operations, as this requirement is dependent upon several factors including the intended operation, traffic density, complexity of airspace and availability of alternative navigation aids. The lower value given is the minimum requirement for areas with low traffic density and airspace complexity. The higher value given is appropriate for areas with high traffic density and airspace complexity (see Attachment D, 3.4.2). Continuity requirements for APV and Category I operations apply to the average risk (over time) of loss of service, normalized to a 15-second exposure time (see Attachment D, 3.4.3).

The alert limit is of 40 m.

Note : the definition of the Horizontal Alert Limit is reminded (extract of DO229D) :

The Horizontal Alert Limit (HAL) is the radius of a circle in the horizontal plane (…), with its center being at the true position, that describes the region that is required to contain the indicated horizontal position with the required probability for a particular navigation mode (e.g. 10^{-7} per flight hour for en route), assuming the probability of a GPS satellite integrity failure being included in the position solution is less than or equal to 10^{-4} per hour.

Conclusion on the navigation system error :

The navigation system error with GNSS SBAS is much lower than a RNP value of 0.3 or 1 NM :

- Accuracy 95% : 16m = 0.009 NM
- Alert limit : 40 m = 0.022 NM

Conclusion and mitigation :

The only remaining error is the flight technical error, that is the path steering error of the FMS, Flight Director and Auto-Pilot systems : only this flight technical error can be responsible of the aircraft being inside the RNP corridor but too far from the nominal RNP path (outside the LPV pseudo-localizer).

Therefore, the crew has to monitor the flight technical error (the aircraft cross-track) during the transition ; and manually correct the trajectory to ensure the capture of the LPV pseudo-localizer in case the aircraft is outside the capture cone.

Note : in most designs the Alert Limit is continuously monitored by the avionics for the LPV approach and an alarm is raised in case the Alert Limit is exceeded. Also, the GNSS Receiver EPE (Estimated Position Error) and other position accuracy data are usually available through the FMS.

3.3.2 Aircraft vertical transition

The Continuous Descent Operation is not standardized. There are no aircraft avionics requirements. The crew will apply the CDA technique and manage the aircraft vertical path and modes to ensure a proper capture of the LPV vertical mode (as done today for Continuous Descent Operations before ILS approaches) ; and the ATC will take into account that the crew is applying the CDA technique (see [7] and [11]).

4 References

4.1 Applicable Documents

This INTEROP complies with the requirements set out in the following documents:

[1] Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[2] Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[3] Templates and Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

[4] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

4.2 Reference Documents

The following documents were used to provide input/guidance/further information/other:

[5] FAA 100328 RNP to ILS Recs

http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/parc/parc_reco/media/2010/100328_RNPtoILSRecs.pdf

[6] AIRE The Vinga project final report
http://www.sesarju.eu/sites/default/files/documents/reports/AIRE_-_Vinga.pdf?issuusl=ignore

[7] ICAO doc 9931 : Continuous Descent Operations (CDO)

[8] ICAO doc 9613 : PBN manual

[9] ICAO Annex 10 Volume 1 : Standards and Recommended Practices – Radio Navigation Aids

[10]ICAO doc 8168 : PAN OPS

[11]EUROCONTROL Guide to implementing Continuous Descent

[12]RTCA DO229D : Minimum operational performance standards for global positioning system / wide area augmentation system airborne equipment

[13]P05.06.03.D36 : advanced APV V2 OSED (date : 31/05/2014)

[14]P05.06.03.D40 : advanced APV V3 OSED (date : 25/09/2014)

[15]P05.06.03.D12 : advanced APV procedures

[16]P05.06.03.D24 : VALR of exe VP-225

[17]P05.06.03.D25 : VALR of exe VP-353

[18]P05.06.03.D26 : VALR of exe VP-623

[19]P05.06.03.D27 : VALR of exe VP-482

[20]P05.06.03.D28 : VALR of exe VP-483

[21]P06.08.05.D46 : VALR for RNP to GLS for V3

[22]P09.10.D19 : Yearly APV-SBAS Standardisation report V3

[23]EASA AMC 20-27 : Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BAROVNAV Operations

[24]EASA AMC 20-28 : Airworthiness Approval and Operational Criteria related to Area Navigation for Global Navigation Satellite System approach operation to Localiser Performance with Vertical guidance minima using Satellite Based Augmentation System

-END OF DOCUMENT-