RNP to xLS Functional Requirements - final

Document information	
Project Title	Transition RNP to xLS
Project Number	09.09._
Project Manager	Thales
Deliverable Name	RNP to xLS Functional Requirements - final
Deliverable ID	D25
Edition	00.01.01
Template Version	03.00.00
Task contributors	
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Abstract

This document refines the functional analysis of the "RNP to xLS" operational concept (including the "advanced LPV" operational concept).

This refinement is considering the results of exercises EXE-09.09-VP-800 and VP-801 (RNP to ILS simulations performed by Thales and Eurocontrol) for the RNP to ILS, and the outcomes of P05.06.03 for the RNP to LPV and P06.08.05 for the RNP to GLS.

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Document History

Edition	Date	Status	Author	Justification
00.00.01	10/09/2014	Draft	[redacted]	Version for P09.09 internal review.
00.01.00	19/09/2014	Final		Final version.
00.01.01	20/01/2015	Final		Update following the SJU assessment report.

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Executive summary

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This refinement is considering the results of exercises EXE-09.09-VP-800 and VP-801 (RNP to ILS simulations performed by Thales and Eurocontrol) for the RNP to ILS, and the outcomes of P05.06.03 for the RNP to LPV and P06.08.05 for the RNP to GLS.

This functional analysis includes high level functional requirements. These requirements don’t aim at specifying the design and implementation of the transition RNP to xLS on a specific aircraft, but at specifying the functionality.

The first version of the functional analysis was developed in deliverable P09.09.D02.

1 Introduction

1.1 Purpose of the document

This document refines the functional analysis of the “RNP to xLS” operational concept (including the “advanced LPV” operational concept).

This refinement is considering the results of exercises EXE-09.09-VP-800 and VP-801 (RNP to ILS simulations performed by Thales and Eurocontrol) for the RNP to ILS, and the outcomes of P05.06.03 for the RNP to LPV and P06.08.05 for the RNP to GLS.

The first version of the functional analysis was developed in deliverable P09.09.D02.

This functional analysis includes high level functional requirements. These requirements don’t aim at specifying the design and implementation of the transition RNP to xLS on a specific aircraft, but at specifying the functionality.

This functional analysis is related to the Aircraft Enabler A/C-07 “Curved approach e.g. automatic RNP transition to XLS/LPV”, that contributes to the Operational Improvement AOM-0605 : “Enhanced terminal operations with automatic RNP transition to XLS/LPV”. All xLS/LPV approaches are considered in this functional analysis.

1.2 Intended readership

This document is mainly addressed to :

- Projects P09.10, P05.06.03, P06.08.05, OFA 02.01.01.
- Aircraft manufacturers and avionics suppliers wanting to implement the RNP to ILS, RNP to GLS or RNP to LPV (advanced LPV) transition.

1.3 Inputs from other projects

The project P09.09 is linked with:

- Project P06.08.05 for the RNP to GLS transition.
- Project P05.06.03 and WP9.10 for the RNP to LPV transition.

1.4 Glossary of terms

Definition of different terms used in this document:

- “LNAV mode” : Managed lateral guidance function used to follow the lateral profile of the RNP part of the procedure.
- “VNAV mode” : Selected or Managed vertical guidance function used to follow the vertical profile of the RNP part of the procedure. A “Selected” mode means that the selection of the target is realised by the crew (for example, in “Vertical Speed” guidance mode where the crew selects the vertical speed target). A “managed” mode means that the target is managed by the avionics (and comes from the FMS for example).
- “LOC mode”: Managed lateral guidance function used to follow the lateral profile of the xLS part of the procedure. This function is composed of the capture and track modes.
- “G/S mode”: Managed vertical guidance function used to follow the vertical profile of the xLS part of the procedure. This function is composed of the capture and track modes.
- “xLS modes”: LOC and G/S modes.

1.5 Acronyms and Terminology

Term	Definition
A/C	Aircraft
AGL	Above Ground Level
ANSP	Air Navigation Service Provider
APV	Approach Procedure with Vertical guidance
A-RNP	Advanced RNP
ATC	Air Traffic Control
ATM	Air Traffic Management
Baro-VNAV	Barometric Vertical NAVigation
CAT	CATegory
CDA	Constant Descent Approach
CDFA	Constant Descent Final Approaches
CDO	Constant Descent Operation
DA	Decision Altitude
DH	Decision Height
DME	Distance Measuring Equipment
EBAA	European Business Aviation Association (Airspace User)
FAF	Final Approach Fix
FAP	Final Approach Point
FAS	Final Approach Segment
FASDB	Final Approach Segment Data Block
FMS	Flight Management System
FTE	Flight Technical Error
GBAS	Ground Based Augmentation System
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GS	Glide Slope
HDG	HeaDinG
HMI	Human-Machine Interface
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
IF	Intermediate Fix
IGS	Instrument Guidance System
ILS	Instrument Landing System
ISA	International Standard altitude
LDA	Localiser Type Directional Aid
LH	Lufthansa (Airspace User)
LNAV	Lateral NAVigation
LOC	LOCaliser
LP	Localizer Performance
LPV	Localizer Performance with Vertical guidance
MCDU	Multipurpose Control and Display Unit
NDB	Non Directional Beacon
MDA	Minimum Descent Altitude

Term	Definition
MLS	Microwave Landing System
NM	Nautical Mile (1852 m)
NPA	Non-Precision Approach
NSE	Navigation System Error
NVR	Novair (Airspace User Leader)
PA	Precision Approach
PBN	Performance Based Navigation
PDE	Path Definition Error
PFD	Primary Flight Display
PIR	Project Initiation Report
RF	Radius constant to Fix
RNP	Required Navigation Performance
RNP APCH	RNP APproaCH
RNP AR APCH	RNP Authorisation Required APproaCH
RWY	RunWaY
SBAS	Satellite-Based Augmentation System
SDF	Simplified Directional Facility
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SLS	Satellite Landing System
TF	Track between 2 Fixes
ToD	Top of Descent
TS	Technical Specification
TSE	Total System Error
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
V/S	Vertical Speed
xLS	x Landing System
XTK	Cross TracK

2 Functional Description

2.1 Operational concept

The “RNP to xLS transition” concept is described in P09.09.D24.

It consists in the use of Radius to Fix (RF) legs in the RNP part of an approach that can be directly connected to the Final Approach Point (FAP) of the xLS final segment, combined with a Continuous Descent Approach (CDA) in the RNP part and a short xLS final approach segment.

Note : the “RNP to GLS” concept is also described in P06.08.05-D42 (OSED V3 for the RNP to GLS) and the “RNP to LPV” (advanced LPV) concept in P05.06.03-D40 (OSED V3 for the advanced LPV).

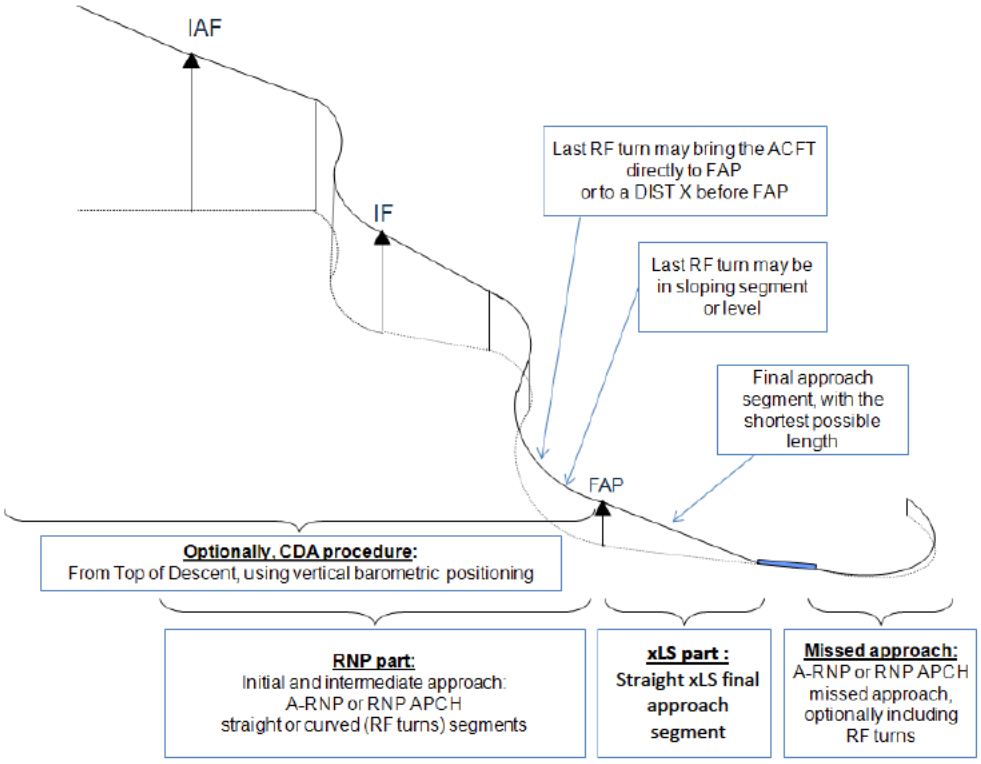


Figure 1: illustration of the “RNP to xLS” concept

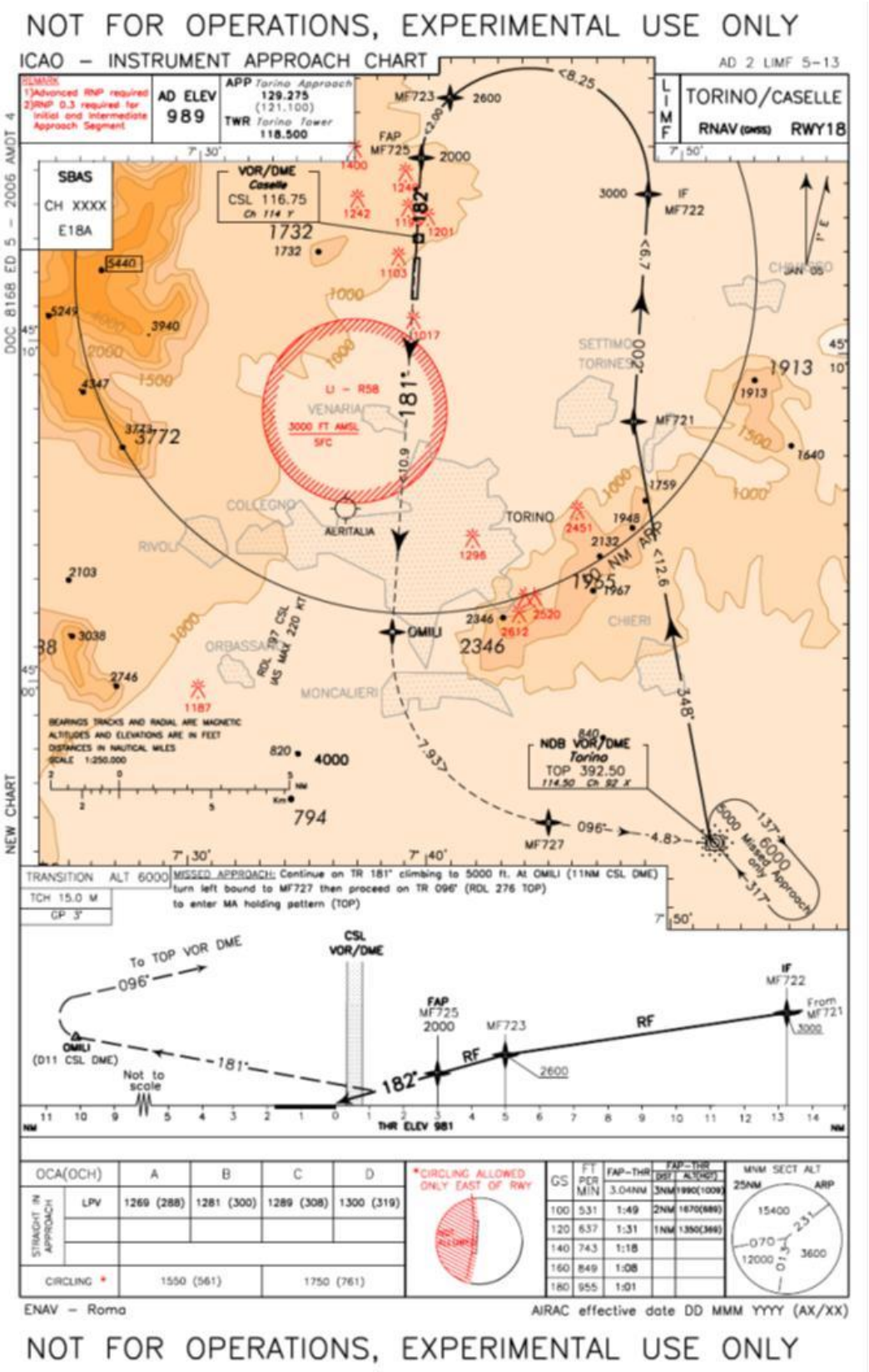


Figure 2: example of a “RNP to LPV” (advanced LPV) procedure

2.2 Operational Scenario

The operational scenario to perform an “RNP to xLS” approach is the following :

- The RNP part of the RNP-xLS approach is performed using LNAV mode in lateral, and VNAV or V/S mode in vertical.
- In the RNP part of the RNP-xLS approach, the crew can set the selected altitude at one the following values, depending of the operating procedures :
    - The altitude constraint attached to the FAP/F
    - The DA/H of the xLS approach.
    - The Go-Around altitude (when the aircraft is below the Go-Around altitude).
- Once authorized by ATC and only before the last turn, the crew arms the xLS modes to capture the xLS axis.
- The final xLS (straight) segment is performed with the xLS modes.

On the stabilization criteria :

There is an operational consensus stating that being stabilized and aligned on the final approach at 3NM /1000 ft AGL makes sense. Indeed, EASA rules identifies that aircraft should be stabilised on final approach by 1000ft AGL. In VP-483 (RNP to LPV transition flight test exercice on ATR-600) and VP-166 (RNP to GLS simulation exercice on Airbus), pilots stated that it can be considered that the aircraft is correctly stabilized as long as it is : "Stabilized along the desired flight path", or “Stabilized on guidance trajectory, even if curved”.

On the CDA :

The CDA operational requirements do not request that the CDA terminates at the FAF. A level-off (or slope limitation or other) can be done before the FAF to perform the transition. It depends on procedure and avionics characteristics. Also, the benefits from the CDA will depend on the aircraft equipment ; in particular of the availability of the VNAV mode. Indeed, as shown in the exercice VP-483 (the advanced LPV flight tests performed in P05.06.03 / P09.10 with an ATR-600 aircraft without the VNAV mode), following the vertical profile in the RF legs to avoid any level off without a VNAV function (the auto-pilot coupled to the FMS vertical profile) requires to continuously adjust the Vertical Speed target, increasing pilot workload significantly.

On the selected altitude :

The management of the selected altitude will depend on the aircraft and operating procedure. If the aircraft behaviour is correct with current procedures, then these procedures should be kept (see appendix A). If not, these procedures should be modified : for example, in VP-483, when the selected altitude was set at the altitude of the FAP (which is generally the current procedure), the LPV GS was not always automatically captured ; the selected altitude had to be set at the DA/H of the LPV approach to ensure a correct capture of the LPV GS.

On the xLS arming :

RNP trajectory may cross the final segment axis several times. Depending on the avionics, the crew may have to arm the xLS modes only when reaching the last turn before alignment on final xLS straight segment.

2.3 RNP phase

The RNP phase will be flown with different accuracy levels.

NAVIGATION SPECIFICATION	APPROACH			
	INITIAL	INTERMEDIATE	FINAL	MISSED
RNP APCH	1.0 NM	1.0 NM	0.3 NM	1.0 NM
A-RNP	1.0 - 0.3 NM	1.0 - 0.3 NM	0.3 NM	1.0 - 0.3 NM

Table 1 : RNP accuracy

A lateral deviation indicator should display cross-track deviations with full-scale deflection equal to the RNP value during initial/intermediate/missed approach segments.

Pilots are expected to maintain procedure centrelines (unless authorized by ATC or under emergency conditions). For normal operations, cross-track deviation should be limited to ±½ RNP accuracy associated with the procedure.

When flying with autopilot coupled, the observed cross-track deviation is typically small for both straight and turning segment and pilot intervention is normally not required (excessive lateral deviation is most likely to occur in case of loss of autopilot, bank angle limitation or excessive wind during turns).

2.4 Transition phase

The transition from the RNP mode to the xLS mode will have impacts on the navigation function, guidance function, on the HMI, and on the monitoring alerting. The following aspects will be considered in the transition :

- RNP type (accuracy of the preceding RNP phase) ;
- Autoland (for stabilization issues) ;
- xLS beams characteristics (e.g. course width) ;
- Decision height and distance to runway ;
- Autopilot coupling ;
- Aircraft performances ;
- Procedure constraints…

2.4.1 Lateral transition

The crew action of arming the approach is still requested (it is not searched to have a fully automatic LPV mode engagement).

- LOC and G/S beams are tuned automatically (in case an auto-tuning is provided) or manually;
- Once the xLS signal is received and the xLS deviations are valid, the system either automatically displays them or the pilot can manually request their display. During this phase the crew should be able to monitor both RNP and LOC-G/S deviations (depending on the aircraft concept of cockpit) according to Flight plan and xLS beam respectively, and the pilot should distinguish between the active guidance mode (RNP LNAV/VNAV guidance) and non active guidance mode (xLS not engaged);
- When the xLS LOC capture conditions are fulfilled and the keeping of the RNP corridor is ensured, the LOC capture mode engages (either automatically or manually).
- Then, the crew may continue the approach with the same interface as a standard xLS approach.

The following diagram illustrates the possible aircraft trajectory, with different guidance laws :

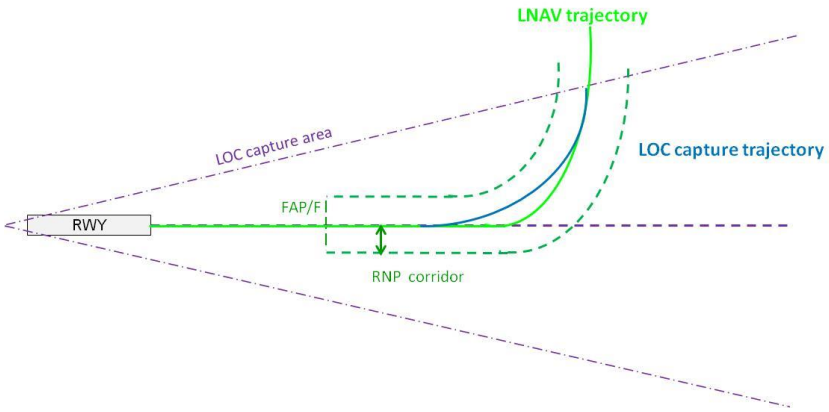


Figure 3 : The RNP corridor is not infringed

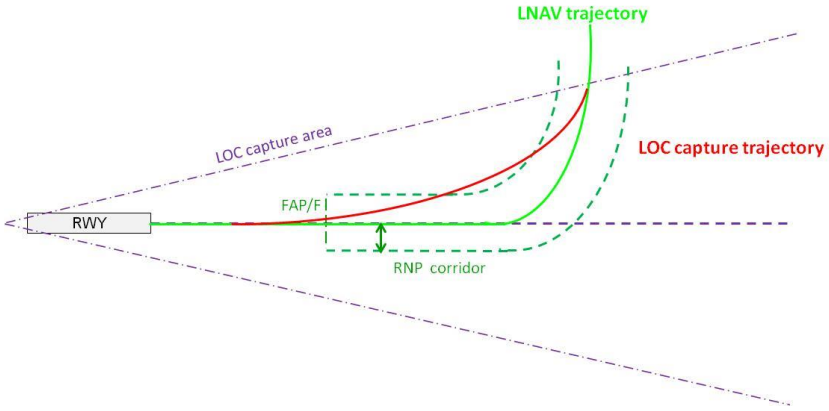


Figure 4 : The RNP corridor is infringed

Different solutions are foreseen to ensure the keeping of the RNP corridor : modification of the guidance laws, of the capture conditions (that can be a restriction of the LOC capture area in the above diagrams, or the addition of a condition on the aircraft position versus the FAP/F…), of the operating procedure (armament of the xLS mode only at the middle or end of the RF turn), ... These solutions will be different depending on the aircraft architecture.

Refer also to the P09.09.D24 paragraph 2.2 for a detailled analysis of this lateral transition and its impacts on the minimal length of the final approach segment.

2.4.2 Vertical transition

Baro-referenced altitude is used in the initial and intermediate segments of the RNP part. The use of the GPS-SBAS altitude in the initial and intermediate approach segments is not considered in the scope of the project.

The main concern about using baro-referenced altitude is that the actual vertical flight path varies depending on the surrounding air mass conditions. For temperatures above ISA the actual flight path will be steeper (and above) the reference path. Moreover, the altimeter error linearly increases with the height above threshold. Therefore, when the FAP/F is far from the runway, this error can be important and the vertical transition to the xLS G/S may not be performed. Furthermore, in case of a CDA flown till the FAP/F, the aircraft may follow a vertical path parallel to the xLS G/S beam, without being able to capture the xLS G/S.

Note : on some aircraft, with the current guidance laws design, a slope in the intermediate segment converging with the xLS G/S beam is needed for the G/S capture mode engagement. If the aircraft vertical trajectory is quite parallel to the xLS G/S beam but with a vertical gap, the aircraft may remain in VNAV mode and not engage the xLS G/S mode.

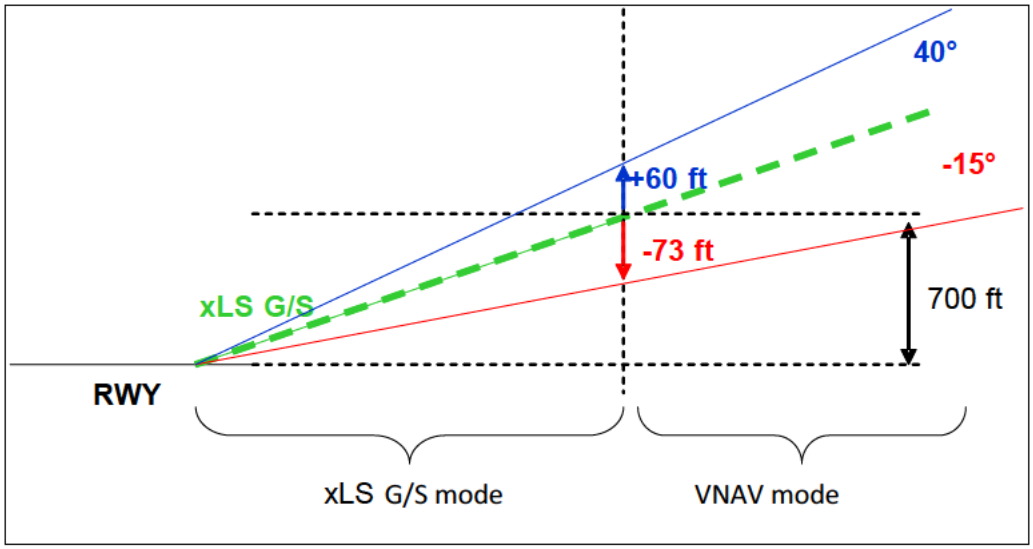


Figure 5 : Vertical path with baro-referenced altitude in delta-ISA conditions

In order to ensure the xLS G/S mode engagement on most aircraft without heavy avionics modifications, it is considered that the procedure will be designed such as the slope of the RNP segment is converging with the xLS G/S beam. The delta ISA conditions and CDA considerations will have to be taken into account. The procedure may have the following characteristics :

- A limitation of the ΔISA conditions on the chart (for uncompensated baro-VNAV systems);
- A limitation of the slope of the last RNP segment vertical path;
- A level-off before the G/S capture.

In the refinement of the concept in P09.09.D24, it is noted that publishing altitude constraints to force a continuous descent is not possible, because it would not work for any type of aircraft, or even for one aircraft type depending on the day conditions (wind, temperature, aircraft weight, use of anti-ice, etc...).

3 Functional Requirements

Note : the content of the functional requirements is globally unchanged from the first version of P09.09.D02. The changes are mainly related to clarifications and corrections.

3.1 Navigation – path definition and flight planning

[REQ]

Identifier	REQ-09.09-TS-FUNC.0022
Requirement	The RNP-xLS approach procedures shall be coded within the FMS Navigation Data Base.
Title	**Navigation Database**
Status	<Validated>
Rationale	Issues have been raised in the RNP-GLS exercice VP-166 on the coding of the procedures in the FMS Navigation Data Base.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0001	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0010	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Flight path management gate-to-gate	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0001
Requirement	RNP part of the procedure (initial and intermediate approaches) shall be selectable by the crew for inclusion inside the flight plan.
Title	**Approach procedure selection - RNP part**
Status	<Validated>
Rationale	RNP and xLS procedures are published procedures. The crew thus needs to select the procedure to be inserted in their flight plan that corresponds to their chart.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0001	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0010	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Flight path management gate-to-gate	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0002
Requirement	xLS approach procedure shall be selectable by the crew for inclusion inside the flight plan.
Title	**Approach procedure selection - xLS part**
Status	<Validated>
Rationale	RNP and xLS procedures are published procedures. The crew thus needs to select the procedure to be inserted in their flight plan that corresponds to their chart.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0001	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0010	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight path management gate-to-gate	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0003
Requirement	In case of an RNP-xLS approach, the system shall enable the crew to perform a shortcut from the RNP part to the xLS straight segment.
Title	**Shortcut from RNP to xLS**
Status	<Validated>
Rationale	The crew may want to capture earlier the xLS axis due to ATC/traffic reasons and a straightforward action is requested.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	For example, the crew should be able to leave RNP trajectory by reverting to selected lateral guidance (heading or track mode).

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0016	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0160	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0160	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight path management gate-to-gate	N/A

3.2 Guidance

[REQ]

Identifier	REQ-09.09-TS-FUNC.0004
Requirement	The system shall enable the crew to use an appropriate lateral managed guidance mode to fly the lateral RNP flight path.
Title	**RNP lateral guidance**
Status	<Validated>
Rationale	RNP part of the RNP-xLS approach is a linear trajectory.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0001	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0010	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0005
Requirement	The system shall enable the crew to use an appropriate vertical guidance mode (managed or selected) to fly the vertical part of the RNP flight path.
Title	**RNP vertical guidance**
Status	<Validated>
Rationale	RNP part of the RNP-xLS approach is a linear and baro-referenced trajectory.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	In case of use of a managed vertical guidance mode, this vertical guidance mode should be disengaged in case of exit of the lateral managed guidance (for example in case of shortcut towards xLS beam).

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0001	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0010	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0006
Requirement	xLS angular guidance mode shall be used to fly the xLS final segment.
Title	**xLS guidance**
Status	<Validated>
Rationale	xLS part of the RNP-xLS approach is an angular and geometric trajectory. Appropriate angular guidance laws need to be used to fly the xLS part of the procedure.
Category	<Functional>
Validation Method	<Flight Trial>

Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0001	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0010	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0007
Requirement	The system shall enable the crew to engage manually LNAV guidance mode.
Title	**LNAV mode arming**
Status	<Validated>
Rationale	The engaging of LNAV function has to be initiated on a crew decision, possibly following an ATC clearance.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0001	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0010	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0008
Requirement	The system shall enable the crew to disengage manually LNAV guidance mode.
Title	**LNAV mode disengagement**
Status	<Validated>
Rationale	The aim is to be able to perform a shortcut from the RNP part to the xLS straight segment, in selected guidance.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	For example, the manual selection of the Heading mode (the crew selects the heading to be flown) may disengage the LNAV guidance.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0016	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0160	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0160	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0009
Requirement	The system shall enable the crew to manually request the xLS guidance modes.
Title	**xLS modes arming**
Status	<Validated>
Rationale	For consistency with current operational procedures, no automatic selection of the xLS guidance mode is considered. This action remains to be done by the crew.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	This manual request of the xLS guidance mode may correspond to the manual arming of the mode. It may also be linked with the selection of the xLS navigation source.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0008	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0080	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0010
Requirement	When “VNAV function” managed mode is engaged and LOC mode is requested, “VNAV function” should not be disengaged when LOC capture mode and then LOC track mode engage.
Title	**VNAV behaviour during lateral transition**
Status	<Validated>
Rationale	If the lining up on the LOC axis occurs much earlier than the capture of the G/S axis during the approach, the crew has to be able to perform the transition to xLS modes without impairing the vertical navigation.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	The “VNAV function” managed mode is not mandatory to perform “RNP-xLS” operations. If available, this requirement is an improvement for Continuous Descent Operations but is not mandatory.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0013	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0130	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0130	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0011
Requirement	When “VNAV function” managed mode is engaged, if the crew sets the selected altitude above A/C altitude, VNAV mode should remain engaged.
Title	**VNAV mode and selected altitude setting**
Status	<Validated>
Rationale	Currently the selected altitude can be set to go-around altitude once G/S track mode is engaged, otherwise there is a reversion towards selected vertical guidance mode. In case of RNP-xLS approach, G/S track mode engagement can occur with a short time frame at the end of the approach. Setting go-around altitude on FCU at a target altitude too low can be a constraint. By enabling the crew to set the selected altitude above A/C altitude before G/S track mode engagement, the selected altitude can be set to the go-around altitude at a more appropriate moment.
Category	<Functional>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	<Review of Design>
Additional information	See paragraph 2.2 and appendix A. Note that this requirement enables the crew to remove a safety barrier (by enabling a managed mode to guide the aircraft below the acceptable minimum with current navigation performance).This statement is counter-balanced by : - The fact that a manual crew action is needed to remove this barrier - Some additional monitoring – alerting (see REQ-09.09-TS-FUNC.0021 : Selected Altitude above A/C reminder). This requirement is an improvement to keep the benefits of the “VNAV” managed mode (low workload) but is not mandatory.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0013	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0130	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0130	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0012
Requirement	When “VNAV function” managed mode is engaged and selected altitude is below A/C altitude, A/C shall level-off at selected altitude.
Title	**VNAV mode and selected altitude reaching**
Status	<Validated>
Rationale	VNAV mode is not a final approach guidance mode; as such it does not cross the selected altitude.
Category	<Functional>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	<Review of Design>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0016	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0160	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0160	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>

<ALLOCATED TO>	<Functional block>	Flight Control	N/A

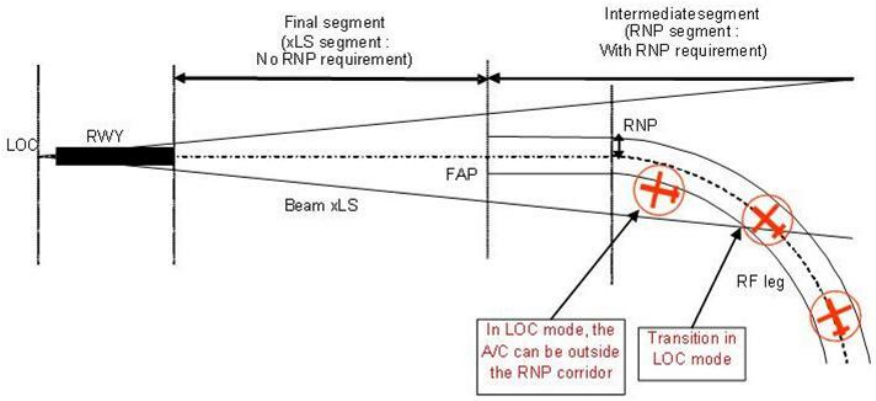
[REQ]

Identifier	REQ-09.09-TS-FUNC.0013
Requirement	After xLS modes are manually requested by the crew, the transition towards xLS guidance modes shall be performed automatically by the guidance systems.
Title	**RNP-xLS guidance transition**
Status	<Validated>
Rationale	Automatic transition to ensure the best trajectory and the less crew workload.
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	When capture conditions are met, the xLS guidance laws automatically engage. No full automatic transition (automatic xLS modes arming and engagement) is foreseen for the moment due to heavy impacts on systems design: either a coded RNP-xLS transition waypoint, or complex automatic arming conditions, would need to be defined. Note 1 : guidance laws modifications may be needed to ensure the LOC capture mode engagement. Note 2 : depending on the way to request the xLS mode, the transition may be considered as automatic (if the request can be done far before the FAP/F) or manual (if some crew action is needed around the FAP/F).

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0013	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0014	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0130	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0140	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0170	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0130	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0140	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Flight Control	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0014
Requirement	During RNP-xLS transition, when xLS modes engage, the RNP corridor requirements shall still be respected.
Title	**Respect of the RNP corridor during RNP-xLS transition**
Status	<Validated>
Rationale	The RNP requirements have to be respected until the end of the RNP corridor (the FAP/F).
Category	<Functional>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	Either current xLS capture laws are compliant, or if not they may have to be modified (for example by delaying the engagement of the xLS capture modes, in order to keep the RNP guidance as long as possible during the last turn before xLS beam). The following scheme illustrates what can be the A/C behaviour with current guidance laws :  The end of the RNP part corresponds to the FAP/F. See also paragraph 2.4.1 : lateral transition.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0014	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0140	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0140	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Flight Control	N/A

3.3 HMI – user's interface

[REQ]

Identifier	REQ-09.09-TS-FUNC.0015
Requirement	The system shall enable the crew to perform all existing published approach types and also RNP-xLS approaches using a unique HMI and procedure.
Title	**HMI and procedure**
Status	<Validated>
Rationale	This is one of the major hypotheses of the design. This requirement, leading to harmonized mechanizations and procedures, enables improved operational efficiency.
Category	<HMI>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	<Review of Design>
Additional information	"Unique HMI and procedure" refers to the fact that the crew performs the approaches with each time the same procedure, the same displays and the same interactions with the systems. The requirement covers: • All published classic non-precision approaches based on radio navigation systems: VOR, VOR/DME, NDB, NDB/DME, GPS, LOC only, LOC back-course, IGS, LDA, SDF, Circle-to-land • RNAV and RNAV(RNP) approaches • All published precision approaches: ILS, MLS and GLS • RNAV-xLS and RNP-xLS approaches.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0008	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0080	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Displays & Controls	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0016
Requirement	The system shall enable the crew to fly the final straight segment of the approach (xLS part) with the "ILS look-alike" concept.
Title	**"ILS look-alike" concept**
Status	<Validated>
Rationale	The aim is to fly the final straight segment in the same way the pilots currently do with ILS approaches. It would enable harmonization of the mechanizations and procedures.
Category	<HMI>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0008	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0080	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Displays & Controls	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0017
Requirement	The navigation system shall display to the crew, in the forward field of view, all the necessary cues to monitor the current operation (flight path, aircraft 3D position, deviations, terrain, weather, RNP value for RNP AR legs).
Title	**Cues to monitor the operation**
Status	<Validated>
Rationale	Regulation.
Category	<HMI>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0009	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0090	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0090	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Displays & Controls	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0018
Requirement	The RNP monitoring and display cues shall be displayed with a resolution adapted with the flown RNP value.
Title	**RNP cues resolution**
Status	<Validated>
Rationale	Regulation
Category	<HMI>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0009	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0090	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0090	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Displays & Controls	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0019
Requirement	During RNP-xLS approach, the system shall enable the crew to monitor both lateral and vertical deviations, in its forward field of view, with regard to: - both the flight plan and the xLS beam when xLS modes are not engaged (depending on the aircraft concept of cockpit) ; - the xLS beam only once established on xLS.
Title	**RNP and xLS monitoring**
Status	<Validated>
Rationale	RNP-xLS approach uses two different signal inputs and two guidance laws/modes within a same approach operation. Therefore, the crew may monitor the deviations according to both references, flight plan and xLS beam. Once established on xLS axis, the deviations with regard to the flight plan are no longer relevant from a pilot point of view since the aircraft is tracking xLS axis. Furthermore, the display of deviations with regard to the flight plan during landing phase with xLS modes can be disturbing for the crew.
Category	<HMI>
Validation Method	<Flight Trial>
Verification Method	<Test>
Additional information	To comply with this requirement, it may be needed to have a unique symbology for the display of the scales associated to the deviations (same scale for linear and angular deviations ; but the deviation pointer will still be different).

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0010	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-OSED-ALPV.0100	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0100	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED_TO>	<Functional block>	Displays & Controls	N/A

3.4 Monitoring – alerting

[REQ]

Identifier	REQ-09.09-TS-FUNC.0020
Requirement	The crew should be warned when a Go-Around is triggered with the selected altitude set below the current A/C altitude.
Title	**Go Around with selected altitude set below A/C**
Status	<Validated>
Rationale	Selected altitude setting to the Go Around altitude can occur with a short time frame at the end of the approach. If a missed approach is triggered before G/S capture engages, the selected altitude may be set below A/C altitude. The pilot shall thus be warned that the A/C will climb indefinitely and will not level off at any altitude.
Category	<Functional>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	<Review of Design>
Additional information	This requirement is an improvement depending on the aircraft architecture and the selected altitude management but is not mandatory.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0016	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0160	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0160	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Alerts	N/A

[REQ]

Identifier	REQ-09.09-TS-FUNC.0021
Requirement	When “VNAV function” managed mode is engaged, the crew should be warned that they are no more protected by the ”selected altitude” if they set the selected altitude above A/C altitude.
Title	**Selected Altitude above A/C reminder**
Status	<Validated>
Rationale	When Selected Altitude is below A/C altitude and VNAV mode is engaged, the A/C will level off at Selected Altitude. Therefore the crew may want to be informed that they will not level-off at Selected Altitude when they have set it above A/C altitude.
Category	<Functional>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	<Review of Design>
Additional information	This requirement is linked to REQ-09.09-TS-FUNC.0011 which is not mandatory.

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-09.09-OSED-OPER.0016	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.03-INTEROP-ALPV.0160	<Partial>
<SATISFIES>	<ATMS Requirement>	REQ-06.08.05-OSED-RNPG.0160	<Partial>
<SATISFIES>	<Enabler>	A/C-07	<Partial>
<ALLOCATED TO>	<Functional block>	Alerts	N/A

4 Safety and performance requirements

For the airborne side, it is considered that the applicable safety and performance requirements are :

- The RNP APCH or Advanced RNP requirements until the FAP : refer to AMC 20-27 for RNP APCH requirements (in particular the paragraphs 6.3 : accuracy, 6.4 : integrity and 6.5 : continuity of function) and to AC 20-138 for advanced RNP requirements (Appendix 3 : Advanced RNP Functions).
- The xLS requirements after the FAP. For exemple, refer to AMC 20-28 (in particular the paragraphs 6.3 : accuracy, 6.4 : integrity and 6.5 : continuity of function) for LPV requirements.

Compliance of the functional analysis to these safety and performance requirements :

After the FAP, the aircraft is in xLS mode (see REQ-09.10-TS-FUNC.0006, REQ-09.10-TS-FUNC.0009, REQ-09.10-TS-FUNC.0013, REQ-09.10-TS-FUNC.0019) therefore the safety and performance requirements are covered by the xLS requirements (which are not in the scope of this document).

Before the FAP, the requirement REQ-09.10-TS-FUNC.0014 specifies that the aircraft has to comply with the RNP requirement.

5 Conclusions and recommendations

Functional analysis :

This functional analysis is related to the Aircraft Enabler A/C-07 “Curved approach e.g. automatic RNP transition to XLS/LPV”. This functional analysis covers completely this enabler.

It takes into account the validation exercices executed by P05.06.03 (VP-482 and VP-483 on RNP to LPV), P06.08.05 (VP-166 on RNP to GLS), and P09.09 (VP-800 and VP-801 on RNP to ILS).

This capability is included in the overall airborne architecture in P09.49.D03 “Consolidated functional airborne architecture”. The functional blocks involved in this capability are :

- Navigation (LNAV logical function) : Construction of ownship trajectory based on RF legs and with a transition to the xLS final segment.
- Guidance (Flight Control Lat, Vert logical function) : Management of the transition from the RNP part to the xLS final segment.
- Displays (Display / Controls logical function) : Visualize the RNP part and the xLS part, monitor the RNP to xLS transition.
- Alerting (Alerts logical function) : Alerting linked to the RNP to xLS transition.

Retrofit challenge :

The retrofit challenge of implementing this capability is presented in P09.49.D06 “step 1 aircraft capability evolution assessment report”. The assessment results are :

- Mainline Aircraft :
  - About two thirds of the mainline traffic could be retrofitted with RNP transition to xLS capability with a medium or lower effort.
  - Not more than one third of the mainline traffic could be retrofitted with LPV capability with a medium or lower effort.
- Regional Aircraft :
  - The assessed sample is too limited to draw general conclusions (see the figures in appendix B).
  - If RNP transition to GBAS is assessed, most of the impact is due to GBAS. Implementing transition from RNP to ILS and SBAS only would have a lower impact (SBAS implementation, if not already present, is assessed for APV).
- Business Jets :
  - For the aircraft fitted with recent IMA : this aircraft configuration could be retrofitted with RNP transition to xLS with Low effort. It is assumed that the aircraft is equipped with LPV.
  - For the legacy aircraft : Legacy aircraft could not be retrofitted with a medium or lower effort.

Standardisation and regulation :

The “RNP to xLS” concept is based on the use of RF (Radius to Fix) legs in RNP APCH or Advanced RNP specifications. It is therefore needed that the related standardisation and regulation documents are available. In particular, today there is no European regulation baseline for the airborne RF leg capability in RNP APCH or advanced RNP specifications (whereas the RF capability is already specified in FAA AC 20-138 or AC90-105).

From the ground side, the rules to connect a RF leg to a xLS final approach segment will have to be defined in the ICAO PANS OPS.

The use of RF legs in RNP APCH or advanced RNP specifications is included in the fourth edition of the PBN manual. The use of RF legs in procedure design is included in the latest revision of the PANS OPS. There is a need to standardize the “RNP to xLS” transition for Procedure design (PANS OPS doc8168) and ATC procedure (PANS ATM doc4444) knowing that the ATC procedure will be addressed by SESAR project 6.8.8

Remaining open points and recommendations towards deployment :

The regulations to enable the use of RF legs in RNP APCH or advanced RNP specifications and to define the criteria for the procedure designers to connect a RF leg to a xLS final approach segment remain to be published.

6 References

[1] P09.09-D24 : RNP to xLS Operational Concept Document - final, edition : 00.01.00, date : 26/09/2014

[2] P05.06.03-D40 : OSED V3 for the advanced LPV, edition : 00.01.00, date : 23/09/2014

[3] P06.08.05-D42 : OSED V3 for the RNP to GLS, edition : 00.01.00, date : 08/05/2014

[4] P09.09-D22 : Report for the RNP to ILS simulations on Thales bench (VP-800), edition : 00.01.00, date : 25/07/2014

[5] P09.09-D23 : Report for the RNP to precision approach transition flight simulations (VP-801), edition : 00.01.00, date : 09/09/2014

[6] P05.06.03-D27 : VALR of VP-482 for advanced LPV, edition : 00.01.00, date : 28/07/2014

[7] P05.06.03-D28 : VALR of VP-483 for advanced LPV, edition : 00.01.00, date : 23/09/2014

[8] P06.08.05-D46 : VALR for RNP to GLS for V3, edition : 00.01.00, date : 31/03/2014

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

[10] AMC 20-27 (EASA) : Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations, date : 23/12/2009

[11] AMC 20-28 (EASA) : 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, date : 24/09/2012

[12] AC 20-138 (FAA) : Airworthiness Approval of Positioning and Navigation Systems, edition : D, date : 28/03/2014

[13] ICAO PBN Manual (doc 9613), third edition : 2008 ; fourth edition : 2013.

[14] ICAO PANS OPS (doc 8168), fifth edition : 2006.

[15] B.01-D80 : Integrated Roadmap - DS12 Release Note, edition 00.01.00, date : 30/04/2014

[16] P09.49-D03 : Step 2 Consolidated functional Airborne Architecture, edition :00 02 00, date : 29/09/2014

[17] P09.49.D06 : Step 1 Aircraft Capability Evolution Assessment Report, edition : 00.02.00, date : 19/02/2013

Appendix A Discussion on Selected Altitude management

Note : below is an input from Novair (Airspace Users leader) on the opportunity, during the RNP part of the RNP to xLS approach, to set the Selected Altitude at a low altitude, or at the Go-Around altitude.

The procedure of setting a low altitude (e.g. DA, landing elevation etc.) to enable VNAV flight guidance mode engagement is not fully supported by NVR and requires some additional reasoning:

The general concept adopted by the airlines when conducting a precision (i.e. xLS) approach is to have the “go-around” altitude set when established on the final approach path (e.g. GS captured). When conducting non-precision approaches the procedure of altitude pre-selections during the final approach is by NVR interpreted as varying between the operators. Some operator’s uses intermediate altitudes or the MDA as altitude pre-selections (e.g. “Step-down” approaches) and some operator’s utilises the CDFA-concept when conducting non-precision approaches hence the altitude pre-selection could be the “go-around” altitude as soon as established on the final approach path, i.e. “ILS-look-alike” concept. The concept of “RNP to xLS Transition” is – in a way – a combination of a non-precision approach procedure and a precision approach procedure and the question is what the most suitable, from an operational perspective, option with the altitude pre-selection would be?

With a low altitude pre-selection (e.g. DA) NVR foresees two scenarios, which could be categorized on the “downside”:

1. If the xLS-segment cannot be captured, or the flight crew fails to arm and/or engage the xLS-segment, the aircraft will have prerequisites for the vertical flight guidance mode to continue “un-restricted” to this altitude. Depending on whether the RNP-segment terminates or continues at the FAP and on aircraft guidance mode functions, if the xLS fails to engage, the aircraft will either revert to “basic modes” (“HDG”, “V/S”) or continue in LNAV/VNAV (“NAV”,”DES”). Either way the pre-selected altitude is below the current altitude and the aircraft will continue to descend. In addition to that the aircraft will continue descend to a very low altitude, terrain clearance compared to the xLS could be substantial impacted.

2. A pre-selected, low altitude could, theoretically, force an inadvertent level-off close to the runway. This scenario is a bit “far-fetched” and if the xLS flight guidance modes are captured this will not happen, but when considering all possible scenarios this could be the case.

The other side, as indicated by the comments from EBAA and LH, of this reasoning is of course that a low altitude pre-selection would serve as a “final gate” or the “final safeguard” for the approach. In addition, several other aircraft systems (e.g. EPGWS) and flight crew training also serve as “safeguards” for possible failure scenarios. Nevertheless, NVR would like to suggest the following:

The experience from the “RNP to ILS”-trails in the VINGA-project shows that the most optimum solution from an operational perspective (including flight crew training) is in short to “keep it simple”. When comparing the procedure in the VINGA-trails (RF-leg transitioned to an ILS) with a more advanced procedure (i.e. closer to the runway) - as in the scope of 9.09 - the overall concept is more or less the same. As the RNP-segment and the xLS-segment from procedure design, most likely, will have a distinction via a FAP (see figure 1), the FAP will (again – most likely) be attached with an altitude constraint, i.e. final approach altitude (as for any ILS for example). This is from an operational point of view very similar to any closed inbound route transitioning into an xLS (e.g. P-RNAV STAR + ILS). Therefore, NVR suggest to treat the procedure/concept defined in 9.09 as close as possible to the operational procedures used by most operators today. This will be illustrated with an example:

With reference to figure 1, the aircraft is approaching the IAF in LNAV/VNAV (Airbus: “NAV”/”DES”). Normally the flight crew will get a clearance to descend to the final approach altitude and also be cleared for the approach (when the approach clearance can be issued is of course dependent upon the traffic situation). In this example, the flight crew pre-selects the cleared final approach altitude and

the aircraft can continue to descend in LNAV/VNAV after passing the IAF to the final approach altitude, but not lower. When the approach clearance is issued the flight crew arms the xlS flight guidance mode (or waits until the final turn depending on decided functionality). Once the xLS flight guidance modes are engaged (i.e. established on the final approach path) the flight crew reverts to the precision approach procedure and the “Go-Around” altitude is pre-selected.

In short, final approach altitude (pre-selected by the flight crew) will be the lowest possible altitude the aircraft can descend to (SELECTED or MANAGED) before the xLS guidance modes are engaged. Then, after xLS guidance mode engagements, precision approach procedures will be utilised.

Appendix B Retrofit assessment

The retrofit challenge of implementing this capability is presented in P09.49.D06 “step 1 aircraft capability evolution assessment report”. The following figures are extracted from P09.49.D06 :

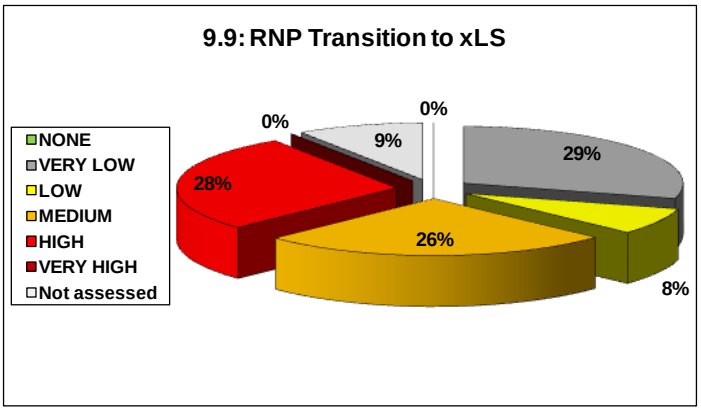


Figure 6: Mainline aircraft – Retrofit challenge assessment (RNP Transition to xls)

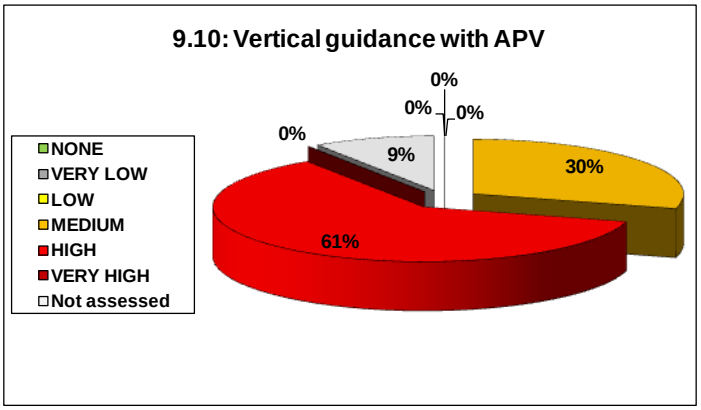


Figure 7: Mainline aircraft – Retrofit challenge assessment (APV)

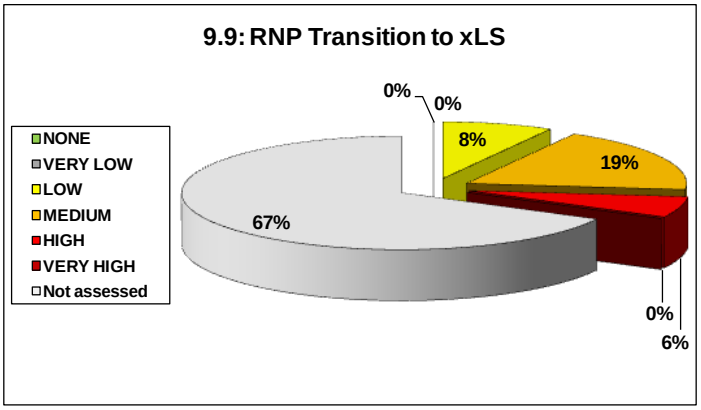


Figure 8: Regional aircraft – Retrofit challenge assessment (RNP Transition to xls)

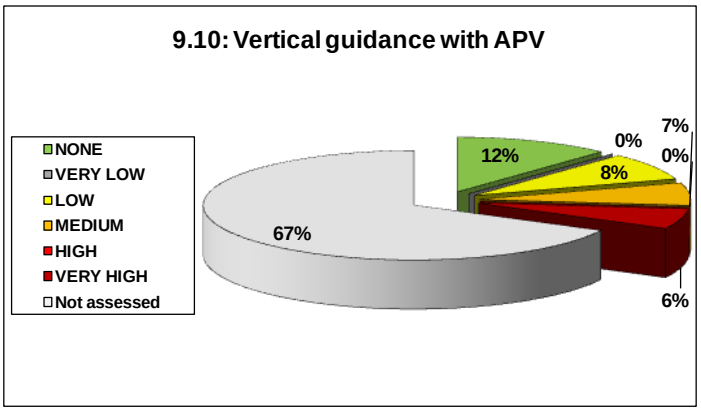


Figure 9: Regional aircraft – Retrofit challenge assessment (APV)

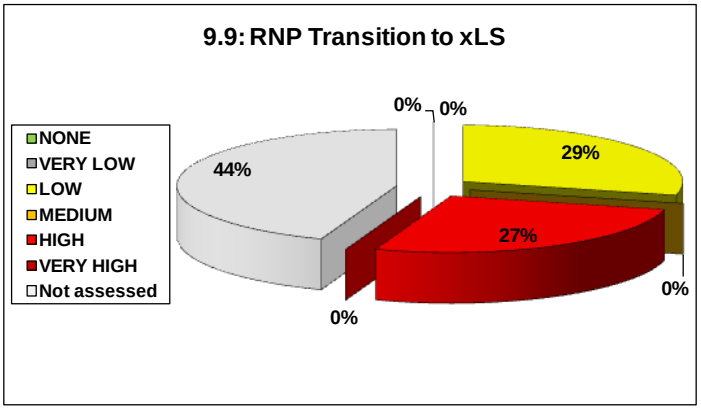


Figure 10: Business aircraft – Retrofit challenge assessment (RNP Transition to xls)

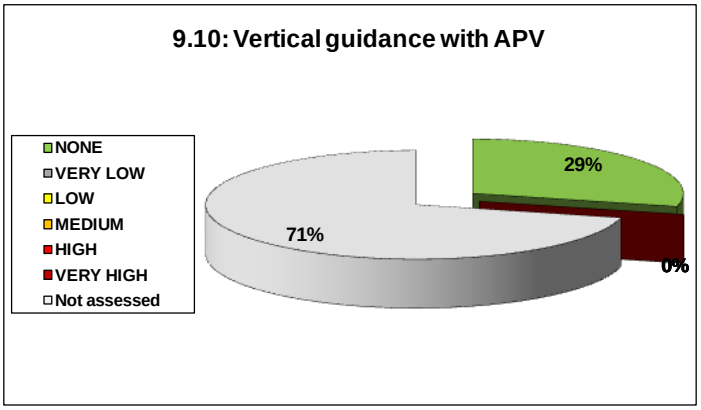


Figure 11: Business aircraft – Retrofit challenge assessment (APV)

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