Final Project Report

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Abstract

This document is the Final Project Report for P09.10.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] Thales	[redacted]	07/10/2014

Reviewed By - *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] Alenia	[redacted]	10/10/2014
[redacted] Airbus		16/10/2014

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	Position & Title	Date
[redacted] Airbus	[redacted]	20/01/2015

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] Thales	[redacted]	27/10/2014
[redacted] Airbus		20/01/2015

Rejected By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date

Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
00.00.01	07/10/2014	Draft	P09.10	Version for internal review.
00.01.00	27/10/2014	Final	P09.10	Final version.
00.01.01	20/01/2015	Final	P09.09	Update following SJU assessment report.

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

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Publishable Summary

Description of the "advanced LPV" concept :

The "advanced LPV" concept studied in P09.10 and P05.06.03 is described in P05.06.03.D40 OSED V3.

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 LPV final segment, combined with a Continuous Descent Approach (CDA) in the RNP part and a short LPV final approach segment.

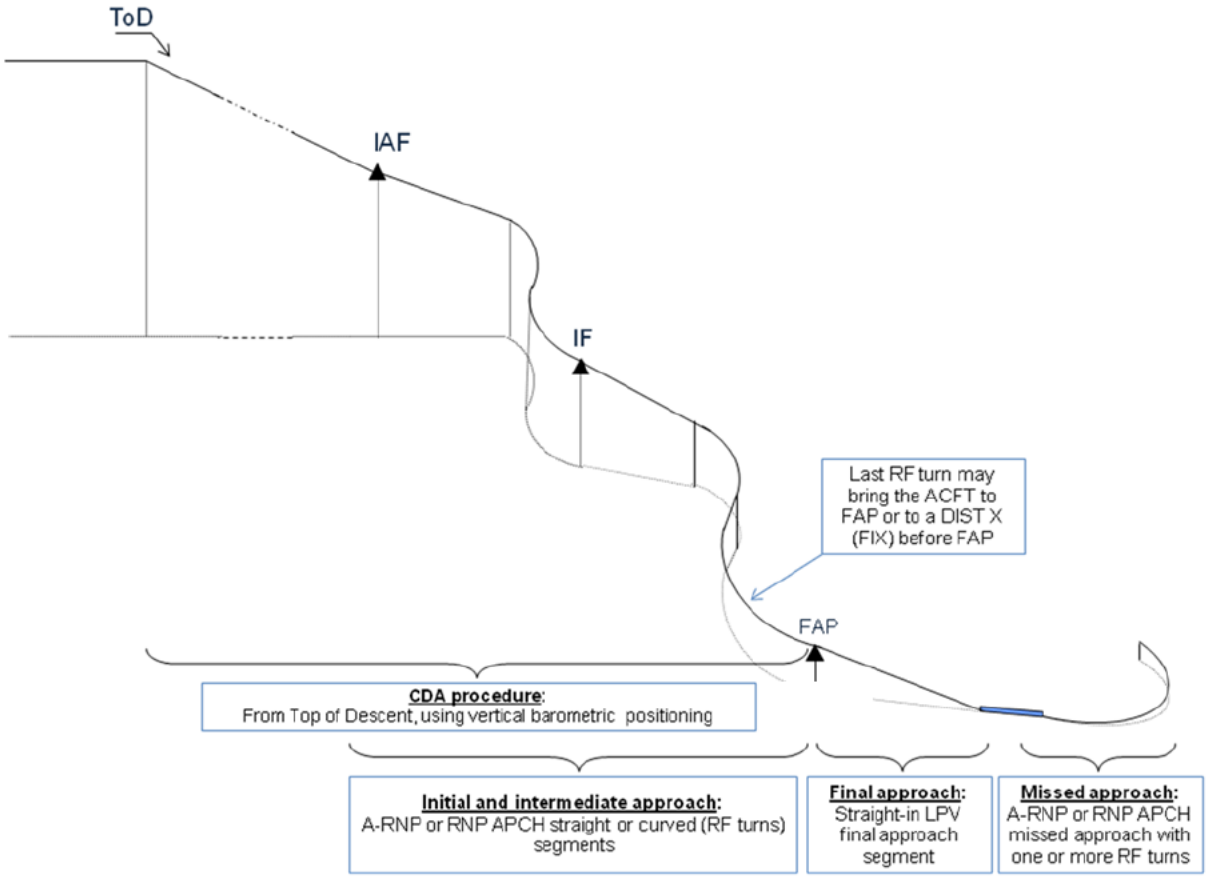

Figure 1: illustration of the "advanced LPV" concept

Expected Benefits of this concept :

The use of RF legs in the approach procedure, the reduction of the length of the last final segment and the use of CDA will lead to lower fuel consumption and optimized noise abatement procedures.

The use of RF legs can also enable to design approach procedures with lower minimas than existing procedures.

Main achievements of project P09.10 :

The main achievements of the project P09.10 are the followings :

- The contribution to the definition of the "advanced LPV" operational concept, with project P05.06.03.
- The functional analysis of this concept for the airborne side.
- The description of the aircraft architectures that enable to perform such "advanced LPV" procedures.

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- The development of an avionics solution for the “advanced LPV” on a regional aircraft (ATR-600).
- Validation exercises, in coordination with P05.06.03, with this prototyped solution and the advanced LPV procedure designed by ENAV in P05.06.03 :
    - Simulations on the Alenia Regional Aircraft Research Simulator (VP-482) :
    - Flight tests on an ATR-600 aircraft (VP-483).

  These exercises assessed the aircraft behaviour and the crew perspective (workload, situation awareness, operational procedures, ...), to ensure that the avionics solution enables to perform advanced LPV approches.

  Note : the VALR of VP-482 is P05.06.03.D27 and the VALR of VP-483 is P05.06.03.D28.

Airborne Technical Specification :

The project P09.10 contributed to the airborne Technical Specification (functional analysis) of the “RNP transition to xLS / LPV”, for the “RNP to LPV” (advanced LPV) part.

This functional analysis is related to the Aircraft Enabler A/C-07 “Curved approach e.g. automatic RNP transition to XLS/LPV”. The project P09.10 adressed the “RNP transition to LPV” part ; this enabler is completely covered by the functional analysis of P09.09 (P09.09.D25).

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 LPV final approach segment remain to be published.

Note : this way forward is also presented in the final project report of P09.09.

Project team :

The SESAR P09.10 project team was composed of EUROCONTROL, AIRBUS, ALENIA and THALES.

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Acronyms

Term	Definition
ACFT	Aircraft
A-RNP	Advanced RNP
CDA	Continuous Descent Approach
FAP	Final approach Point
GBAS	Ground Based Augmentation System
GLS	GBAS Landing System
IAF	Initial Approach Fix
IF	Intermediate Fix
ILS	Instrument Landing System
LPV	Localizer Performance with Vertical guidance
MLS	Microwave Landing System
RF	Radius to Fix
RNP	Required Navigation Performance
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking
ToD	Top of Descent
xLS	x Landing System (ILS/GLS/MLS)

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1 Final Project Report

1.1 Project progress and contribution

The activities addressed by P09.10 contributed to the following system Enabler :

EN Code	EN Title	P09.10 activities /contributions	Maturity before project	Maturity after project
A/C-07	Curved approach e.g. automatic RNP transition to XLS/LPV	Contribution to the definition of the concept. Airborne functional and architecture analysis. Advanced LPV simulations and flight tests.	-	V3

Table 1 - List of enablers and project contribution

Level of maturity :

Project P09.10 contributed to the maturity of the airborne solution for the advanced LPV, validated by the simulation exercise VP-482 and flight test exercise VP-483.

Operational Improvement :

The project P09.10 contributes to the Operational Improvement AOM-0605 : “Enhanced terminal operations with automatic RNP transition to XLS/LPV”.

OFA :

The project P09.10 is involved in the OFA02.01.01 : “optimised 2D 3D routes”. Refer to [5] for a description of this OFA. Refer to [6] for the maturity assessment of AOM-605 done by OFA02.01.01.

Note that the Operational Improvement AOM-605 and the enabler A/C-07 are also studied in the following projects (involved in the OFA02.01.01) :

- P09.09 for the “RNP transition to ILS”.
- P06.08.05 for the “RNP transition to GLS”.

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1.2 Project achievements

The main achievements of the project P09.10 are the followings :

On the “standard LPV” capability :

- The functional analysis, the description of the possible aircraft architectures, and the follow-up of the standardization and regulation activities and documents for “standard LPV”.

On the “advanced LPV” concept :

- The analysis of different innovative concepts (based on a “standard LPV” final segment) and the definition of the “advanced LPV” concept, in coordination with P05.06.03.
- The functional analysis of this “advanced LPV” concept.
- The description of the aircraft architectures that enable to perform such “advanced LPV” procedures.
- The development of an avionics solution for the “advanced LPV” on a regional aircraft (ATR-600).
- Validation exercises, in coordination with P05.06.03, with this prototyped solution and the advanced LPV procedure designed by ENAV in P05.06.03 :
    - Simulations on the Alenia Regional Aircraft Research Simulator (VP-482) :
    - Flight tests on an ATR-600 aircraft (VP-483).

  These exercises assessed the aircraft behaviour and the crew perspective (workload, situation awareness, operational procedures, ...), to ensure that the avionics solution enables to perform advanced LPV approches.

  Note : the VALR of VP-482 is P05.06.03.D27 and the VALR of VP-483 is P05.06.03.D28.

These achievements answered the following R&D questions :

- Are these “advanced LPV” procedures feasible from the airborne side ?
- What are the airborne requirements to fly such “advanced LPV” procedures ?
- Are there constraints from the airborne side on the design of these procedures ?
- Are there any operational requirements for flight crew to fly these procedures ?

Note : the project P09.10 did not quantify the benefits of the “advanced LPV” concept. This is done in project P05.06.03.

Changes from the initial scope :

No major activities has been introduced or removed from the initial scope.

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1.3 Project deliverables

A summary of the project deliverables is presented in the table below :

Del. code	Del.Name	Description
D01	High Level APV Functional Requirements - V0	This deliverable is the functional analysis of the "standard LPV" (from the airborne side), and the first analysis of different "advanced LPV" concepts (later analysed in project P05.06.03).
D02	High Level APV Functional Requirements - V1	This deliverables presents the future technology enablers (GBAS, SBAS, multi-constellations) that could be used for "advanced LPV" concepts.
D03	High Level APV Functional Requirements - V2	This deliverable is the architecture analysis of the "standard LPV" and the initial version of the functional and architecture analysis "advanced LPV" (from the airborne side).
D04	Standardisation report - V0	This deliverable is the presentation of the certification and standardisation basis for "APV-baro" (RNP APCH down to LNAV/VNAV minima operation).
D05-001	Yearly APV-SBAS Standardisation report - V0	This deliverable is the first version of the presentation of the certification and standardisation basis for "standard LPV" and "advanced LPV".
D06	High Level Aircraft architecture definition - V0	This deliverable defines the equipment technical specifications for the advanced LPV on a regional aircraft (ATR-600).
D07	High Level Aircraft architecture definition - V1	This deliverable defines the best suitable architecture for advanced LPV on a regional aircraft (ATR-600).
D08	Selected Aircraft configuration - V0	This deliverable defines the avionics architecture configuration for the advanced LPV on a regional aircraft (ATR-600).
D09	White Paper for GNSS & FMS APV-SBAS Prototype Readiness	This deliverable is the availability note of the initial versions of the avionics prototypes developed for the advanced LPV on a regional aircraft (ATR-600).
D10	Equipments Test Report - V0	This deliverable is the availability note of the matured versions of the avionics prototypes (FMS SW and GNSS receiver) developed for the advanced LPV on a regional aircraft (ATR-600) for Alenia simulator, for the simulation exercice VP-482.
D11	Equipments Test Report - V1	This deliverable is the availability note of the "safety of flight" versions of the avionics prototypes developed for the advanced LPV on a regional aircraft (ATR-600), for the flight test exercice VP-483.

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D12	Validation scenario definition - V0	This deliverable presents the activities to be performed during the simulation exercice VP-482.
D13	Validation Report - V0	This deliverable is the availability note of Alenia simulator (for the simulation exercice VP-482).
D14	Validation Report - V1	This deliverable is the report of the simulation exercice VP-482.
D16	Report for EXE-05.06.03-VP-483 Flight tests	This deliverable is the report of the flight test exercice VP-483.
D17	Yearly APV-SBAS Standardisation report - V1	This deliverable is the 2011 update of the presentation of the certification and standardisation basis for “standard LPV” and “advanced LPV”.
D18	Yearly APV-SBAS Standardisation report - V2	This deliverable is the 2012 update of the presentation of the certification and standardisation basis for “standard LPV” and “advanced LPV”.
D19	Yearly APV-SBAS Standardisation report - V3	This deliverable is the 2013 & 2014 update of the presentation of the certification and standardisation basis for “standard LPV” and “advanced LPV”.
D24	Final Project Report	The deliverable (this document) is P09.10 final project report.
D25	Flight order for EXE-05.06.03-VP-483 Flight tests	This deliverable presents the activities to be performed during the flight test exercice VP-483. This deliverable also include the availability note of the ATR-600 flight test aircraft.
D26	Advanced LPV Functional Requirements - final	This deliverable is the final version of the functional analysis of the “advanced LPV” (from the airborne side).
D27	Advanced LPV Architecture - final	This deliverable is the final version of the architecture analysis of the “advanced LPV” (from the airborne side).

Table 2 - List of Project Deliverables

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1.4 Contribution to standardization

P09.10 did not contribute to standardization activities.

The “RNP to LPV” concept (as for other “RNP to xLS” concepts) 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.

1.5 Project Conclusions and Recommendations

The project P09.10 contributed to the airborne Technical Specification (functional analysis) of the “RNP transition to xLS / LPV”, for the “RNP to LPV” (advanced LPV) part.

This functional analysis is related to the Aircraft Enabler A/C-07 “Curved approach e.g. automatic RNP transition to XLS/LPV”. The project P09.10 adressed the “RNP transition to LPV” part ; this enabler is completely covered in by the functional analysis of P09.09 (P09.09.D25).

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.

Note : this way forward is also presented in the final project report of P09.09.

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2 References

[1] SESAR Programme Management Plan, Edition 03.00.01

[2] European ATM Master Plan, Edition 2

[3] Multilateral Framework Agreement ("MFA") signed between the SJU, EUROCONTROL and its 15 selected members on August 11, 2009, amended on 14 June 2010, 19 October 2010 and 2 July 2012

[4] Latest Project baseline : date : 10/07/2014, following CR 1573 approval

[5] OFA02.01.01 Optimised 2D 3D Routes Description, edition : 00.01.00, date : 20/08/2014

https://extranet.sesarju.eu/releasehome/OFA02.01.01/Working%20Library/OFA%2002.01.01%20Working%20Area/OFA_02%2001%2001_Optimised%202D%203D%20Routes_Description_00%2001%2000.docx

[6] AOM-0605 - Maturity Assessment, edition : 00.01.00, date : 03/08/2014

https://extranet.sesarju.eu/releasehome/OFA02.01.01/Working%20Library/OFA%2002.01.01%20Working%20Area/AOM-0605%20-%20Maturity%20Assessment.xls

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

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

[9] P05.06.03-D41 : INTEROP V3 for the advanced LPV, edition : 00.01.00, date : 03/10/2014

[10]P05.06.03-D27 : VALR - EXE-05.06.03-VP-482, edition : 00.01.00, date : 30/07/2014

[11]P05.06.03-D28 : VALR - EXE-05.06.03-VP-483, edition : 00.01.00, date : 25/09/2014

[12]P09.10-D01 : High Level APV Functional Requirements - V0, edition : 00.01.01, date : 03/10/2012

[13]P09.10-D02 : High Level APV Functional Requirements - V1, edition : 00.01.01, date : 06/01/2012

[14]P09.10-D03 : High Level APV Functional Requirements - V2, edition : 00.01.00, date : 15/06/2012

[15]P09.10-D04 : Standardisation report - V0, edition : 00.01.01, date : 31/08/2011

[16]P09.10-D05-001 : Yearly APV-SBAS Standardisation report - V0, edition : 00.01.00, date : 09/12/2010

[17]P09.10-D06 : High Level Aircraft architecture definition - V0, edition : 00.01.00, date : 27/07/2012

[18]P09.10-D07 : High Level Aircraft architecture definition - V1, edition : 00.01.00, date : 31/08/2012

[19]P09.10-D08 : Selected Aircraft configuration - V0, edition : 00.01.01, date : 08/02/2013

[20]P09.10-D09 : White Paper for GNSS & FMS APV-SBAS Prototype Readiness, edition : 00.01.00, date : 28/02/2013

[21]P09.10-D10 : Equipments Test Report - V0, edition : 00.01.00, date : 29/03/2013

[22]P09.10-D11 : Equipments Test Report - V1, edition : 00.01.01, date : 02/05/2014

[23]P09.10-D12 : Validation scenario definition - V0, edition : 00.01.00, date : 02/08/2013

[24]P09.10-D13 : Validation Report - V0, edition : 00.01.00, date : 18/07/2014

[25]P09.10-D14 : Validation Report - V1, edition : 00.01.01, date : 19/09/2014

[26]P09.10-D16 : Report for EXE-05.06.03-VP-483 Flight tests, edition : 00.01.00, date : 09/12/2011

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[27]P09.10-D17 (D05-002) : Yearly APV-SBAS Standardisation report - V1, edition : 00.01.00, date : 09/12/2011

[28]P09.10-D18 (D05-003) : Yearly APV-SBAS Standardisation report - V2, edition : 00.01.00, date : 10/12/2012

[29]P09.10-D19 (D05-004) : Yearly APV-SBAS Standardisation report - V3, edition : 00.01.00, date : 11/07/2014

[30]P09.10-D24 : Final Project Report, edition : 00.01.00, date : 27/10/2014

[31]P09.10-D25 : Flight order for EXE-05.06.03-VP-483 Flight tests, edition : 00.01.00, date : 11/07/2014

[32]P09.10-D26 : Advanced LPV Functional Requirements – final, issue 01, edition : 00.01.01, date : 12/12/2014

[33]P09.10-D27 : Advanced LPV Architecture – final, issue 01, edition : 00.01.01, date : 15/12/2014

[34]P09.09-D25 : RNP to xLS Functional Requirements – final, issue 01, edition : 00.01.01, date : 12/12/2014

[35]P09.09-D20 : Final Project Report, issue 01, edition : 00.01.01, date : 15/12/2014

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

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Appendix A Presentation of the airborne side of the exercices VP-482 and VP-483

The following slides present the airborne side of the exercices VP-482 and VP-483 :

VP-482 & VP-483 presentation

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