



Final Project Report

Document information

Project Title	Global Interoperability - Airborne Architecture and Avionics Interoperability Roadmap
Project Number	09.49
Project Manager	Airbus
Deliverable Name	Final Project Report
Deliverable ID	D20
Edition	00.01.02
Template Version	03.00.04

Task contributors

Airbus

Abstract

Project P09.49 is the federating project for the aircraft systems domain and, as such, responsible for producing the aircraft level architecture, the avionics roadmap, the retrofit and the Interoperability analysis, facilitating the coordination between aircraft system primary projects, managing the definition and planning of aircraft enablers, and for managing the contribution of the airborne domain to the integrated roadmap / master plan. Project P09.49 also contributed to system engineering tasks such as reviewing deliverables and participation in release reviews, developing the system-of-systems architecture and associated ATM modelling, all in coordination with the A/C system primary projects and other federating/transverse projects as necessary.

Authoring & Approval

Prepared By - <i>Authors of the document.</i>		
Name & Company	Position & Title	Date
████████ Airbus	████████████████████	14/03/2016
████████ Airbus	████████████████████	16/03/2016

Reviewed By - <i>Reviewers internal to the project.</i>		
Name & Company	Position & Title	Date
████████ Airbus	████████████████████	23/05/2016>
████████ Honeywell		23/05/2016
████████ Boeing		25/05/2016
████████ Finmeccanica Aircraft Division		23/05/2016
████████ Thalès		-
████████ Eurocontrol		2405/2016

Reviewed By - <i>Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.</i>		
Name & Company	Position & Title	Date
████████ Airbus	████████	26/05/2016

Approved for submission to the SJU By - <i>Representatives of the company involved in the project.</i>		
Name & Company	Position & Title	Date
████████ Airbus	████████████████████	23/05/2016
████████ Honeywell		23/05/2016
████████ Boeing		26/05/2016
████████ Finmeccanica Aircraft Division		23/05/2016
████████ Thalès		-
████████ Eurocontrol		2405/2016

Rejected By - <i>Representatives of the company involved in the project.</i>		
Name & Company	Position & Title	Date

Rational for rejection	
None.	

Document History

Edition	Date	Status	Author	Justification
00.00.01	16/03/2016			First draft for SJU comment
00.00.02	31/03/2016			Second draft c
00.01.00	07/04/2016	Issue 1.0		Issue 1.0 for SJU submission
00.01.01	26/05/2016	Issue 1.1		SJU comments taken into account
00.01.02	02/06/2016	Issue 1.2		Final update prior to Closure Gate

founding members



Avenue de Cortenbergh 100 | B -1000 Bruxelles
www.sesarju.eu

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.



Acronyms

Acronym	Definition
A/C	Aircraft
ADD	Architecture Design Document
ATM	Air Traffic Management
CNS	Communication Navigation Surveillance
EASA	European Aviation Safety Agency
EATMA	European Air Traffic Management Architecture
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Authority
I4D	Initial 4D
ICNS	Integrated Communications Navigation and Surveillance
IOC	Initial Operating Capability
OEM	Original Equipment Manufacturer
PCP	Pilot Common Project
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking (Agency of the European Commission)
TAD	Technical Architecture Description
WP	Work Package

1 Project Overview

Project P09.49 is the federating project for the aircraft systems domain and, as such, responsible for producing the aircraft level architecture, the avionics roadmap, the retrofit and the Interoperability analysis, facilitating the coordination between aircraft system primary projects, managing the definition and planning of aircraft enablers, and for managing the contribution of the airborne domain to the integrated roadmap / master plan. Project P09.49 also contributed to system engineering tasks such as reviewing deliverables and participation in release reviews, developing the system-of-systems architecture and associated ATM modelling, all in coordination with the A/C system primary projects and other federating/transverse projects as necessary..

1.1 Project progress and contribution to the Master Plan

The project 9.49 partners included Alenia (now Finmeccanica Aircraft Division), Airbus, Boeing (as associated partner to Airbus), Eurocontrol, Honeywell, Thales, Selex (now Finmeccanica Airborne & Space Systems) and Indra.

As per the P9.49 Project Initiation Report (ref [4]) amended by various Change Requests, the technical deliverables were organised in 6 different activities.

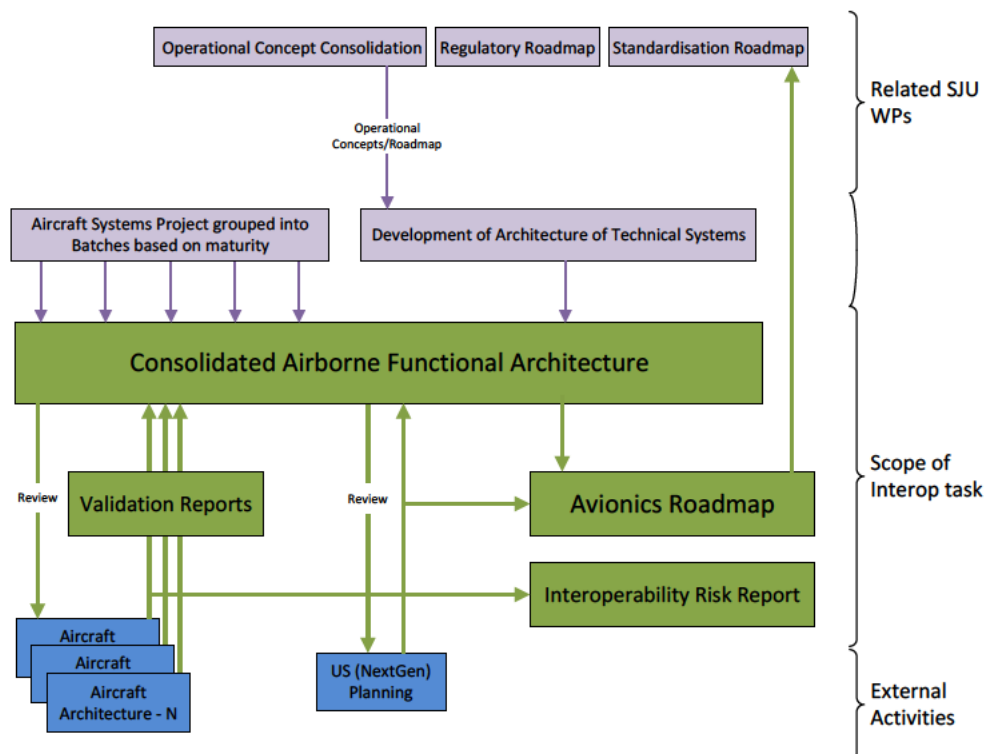
- The "airborne functional architecture" featuring the airborne TAD (Technical Architecture Description) and providing a functional description of the SESAR aircraft functions bridging the ADD (ATM high level architecture) to the primary projects Technical specifications, an abstract of the WP 9.x primary project Technical Specification and Functional Requirement thus validating them as part of an overall coherent approach and a reference and common understanding among P9.49 partners of P9.x new SESAR functions in support to other analysis (e.g. retrofit ability, ...)
- The aircraft capability evolution report providing a proposed clustering of the European fleet with typical Avionics configurations accounting for the various aircraft manufacturers, Avionics architectures and generation and a qualitative analysis of the retrofit effort and challenges for the Airlines to equip with SESAR Solutions. The evolution assessment provided insight into the overall impact to airspace users for each new aircraft capability.
- The "Interoperability risk report" providing an assessment of the air / ground interoperability of the SESAR Solution in Europe based on an analysis of the Integrated Roadmap, and a combined air and ground roadmap with the relevant Enablers and Operation Improvements and a status on the SESAR and NextGen harmonisation, taking benefit of the synergies with the Coordination Plan 4.2 under the SJU/FAA Memorandum of cooperation
- The "Avionics interoperability roadmap" providing "not earlier than" deployment dates of the SESAR Solutions, mapped with the supporting aircraft Enablers, and need dates for the standardisation and regulatory Enablers,
- The global harmonisation complementary trials providing an analysis of the differences in SESAR and NextGen operating environment and proposals for complementary trials in the NextGen environment in order to complete SESAR Solutions Validation
- Cross projects consolidation providing an analysis of the combination of aircraft functions with possible interactions or competition with respect to aircraft resources, and providing test program and results to mitigate risks

For each of these 6 activities, the technical deliverables were instantiated per the "Step1", then "Batch 2" and "Batch 3" accounting for SESAR story board and the lead time for the SESAR primary projects to reach a sufficient level of maturity i.e. a batch refers to a grouping of SESAR Avionics Projects, each addressing an aircraft or operational capability, which has reached sufficient maturity for integration into the airborne functional architecture (e.g. D-Taxi, Advanced datalink capabilities...).

founding members



Avenue de Cortenbergh 100 | B -1000 Bruxelles
www.sesarju.eu



Beside the activities required by the Project Initiation Report, the P09.49 also supported the SESAR program with activities required from federating projects.

- Participation to the System thread activities with a support to the development of the "System Thread Guidance" document under "Development of Architecture of Technical systems (Project B.04.03)" leadership, and the networking with other systems federating project (e.g. CNS System of System definition and roadmap, ...) for the consolidation of the federating projects Deliverables (TAD, ...)
- Participation to the ATM Master Plan level 2 (Integrated Roadmap) set-up to ensure the completeness of the airborne and ground Enablers, their consistency verses the dependent Operational Improvements, the correctness of IOC dates, and participation to its maintenance with the ownership of changes to the aircraft Enablers
- Participation to the European ATM Architecture (EATMA) development, where P9.49 provided the aircraft "Functional Blocks" decomposition and supported a number of sessions aimed at linking the various elements in this architecture
- Participation to the Pilot Common Project definition, with ad-hoc support to the airborne manufacturing industry member in the PCP steering Group
- Participation to the Release process with a focus on the System Engineering review 2 and 3, and P9.49 maturity assessment on the translation of the Operational requirements into System requirements, the Validation platform readiness and stability, and the documentation of the technological requirements and supporting aircraft Enablers
- Contribution to the update of the ATM Master Plan level 1, through P9.49 members' participation in the Master Planning Group and the Master Plan Campaign Steering Group.

1.2 Project achievements

founding members



Avenue de Cortenbergh 100 | B -1000 Bruxelles
www.sesarju.eu

6 of 12

P09.49, as the federating project for the aircraft systems, has developed an aggregated and consolidated description of the airborne systems contribution to SESAR, in term of content (TAD), planning (Avionics roadmap), retrofit effort, and technical interoperability with ground systems. These consolidated descriptions have enabled to link the "Development of Architecture of Technical systems (Project B.04.03)" and primary projects P9.x activities, as well as to develop an overall system of systems description within the EATMA. They have also contributed to a global understanding of SESAR by the airborne industry, through the publication in the SESAR Master Plan of the aircraft Enablers, the supported Operational Improvement and associated roadmaps

The P09.49 project has also contributed to some specific achievements:

- The cross projects consolidation activities have validated the I4D, Spacing and Datalink functions integration into the aircraft, focusing on the possible competition on aircraft resources, and the operational aspects with the cohabitation of these functions from the Human Factors perspective..
- In the frame of the analysis of the SESAR/NextGen interoperability risks, some synergies have been identified with the activities of the Collaboration Plan 4.2 under the FAA/SJU Memorandum of Cooperation. The expertise within P09.49 (including Boeing as associated partner to Airbus) has therefore been used to develop the CP4.2 SESAR/NextGen avionics roadmap, providing a global and synthetic vision on the harmonisation of the CNS airborne functions within SESAR and NextGen..
- The P09.49 has also supported the SJU for the promotion of the SESAR work on the external scene, inside and outside Europe, at the opportunity of the EUROCAE Symposium, EASA Safety conference, ICNS conference, Avionics conference, ... with presentations based on P9.49 outcomes (e.g. Avionics roadmap,...).
- The P09.49 Avionics interoperability roadmap" (ref [30]) Batch 3 preliminary edition, whose development was advanced to Dec 2015 in order to be used as the reference for the update of the airspace user roadmap of the Master Plan (ref Figure 16).

1.3 Project Deliverables

The following table presents the relevant deliverables that have been produced by the project.

Reference	Title	Description
D04	Batch 1, 2 & 3 - Consolidated functional airborne architecture	Consolidated functional airborne architecture for Batch 1, 2 & 3, resulting from the analysis of WP9.X and "Development of Architecture of Technical systems (Project B.04.03)" results and considering the level of details of individual airframe manufacturer's physical architectures.
D06-002	Step 1 - Aircraft capabilities evolution report - V2	The report presents for Step 1 the retrofit ability difficulties that each aviation segment faces to have legacy aircraft capable of the new functions as introduced by the ATM Concept Storyboard Steps.
D07	Batch 2 - Aircraft capabilities evolution report	The report presents for Batch 2 the retrofit ability difficulties that each aviation segment faces to have legacy aircraft capable of the new functions as introduced by the ATM Concept Storyboard Steps
D08	Batch 3 - Aircraft capabilities evolution assessment report	The report presents for Batch 3 the retrofit ability difficulties that each aviation segment faces to have legacy aircraft capable of the new functions as introduced by the ATM Concept Storyboard Steps

founding members



Avenue de Cortenbergh 100 | B -1000 Bruxelles
www.sesarju.eu

D10-002	Step 1 - Interoperability risk report V2	The report presents for Step 1 the regional interoperability risks, and the global harmonization risks identified from the review of external activities (e.g. US NextGen).
D11-002	Batch 2 - Interoperability risk Report – Version 2	The report presents for Batch 2 the regional interoperability risks, and the global harmonization risks identified from the review of external activities (e.g. US NextGen).
D12	Batch 3 - Interoperability risk report	The report presents for Batch 3 the regional interoperability risks, and the global harmonization risks identified from the review of external activities (e.g. US NextGen).
D16-002	Batch 1, 2 & 3 - Avionics interoperability roadmap	The document presents the Avionics Interoperability Roadmap enabling the evolution of the existing physical architectures towards the consolidated functional airborne architecture, taking into account implementation constraints
D18	Batch 2 - Complementary trials	<p>This document presents for the complementary trials that have been identified on 9.x primary projects related to Batch 2</p> <p>The objective of this document is to identify the need for flight trials as a final step in the validation of target architecture interoperability and global harmonization</p>
D19	Batch 3 - Complementary trials	<p>This document presents the complementary trials that have been identified on 9.x primary projects related to Batch 3.</p> <p>The objective of this document is to identify the need for flight trials as a final step in the validation of target architecture interoperability and global harmonization</p>
D21-002	Multi-function evaluations - Cockpit integration - Lot 1 - Validation Report	This report provides the results of the Human factors and operational validation of the cockpit integration and co-existence of the "Initial 4D", "Spacing" and Datalink functions.
D22-002	Multi-function evaluations - Cockpit integration - Lot 2 - Validation Report	This report provides the results of the Human factors and operational validation of the cockpit integration and co-existence of the "Initial 4D" and Datalink over SATCOM.
D30	D30 : Synthesis to support SESAR1 SESAR 2020 transition	Detailed final report that summarizes all the outputs of the project and opening the overview towards SESAR 2020

1.4 Contribution to Standardisation

founding members



Avenue de Cortenbergh 100 | B -1000 Bruxelles
www.sesarju.eu

8 of 12

It was not P9.49 purpose to directly contribute to the development of technical standards. Instead P9.49 has collected the need dates for standards and certification from the P9.x, for inclusion in the P9.49 Avionics interoperability roadmap. The need dates for standards and certification were consolidated taking into account the industrial roadmaps of the aircraft manufacturers and avionics suppliers partnering in the project P09.49.

The P9.49 then coordinated with the project C3 to derive the standardisation/regulation needs lists, the standardisation/regulation roadmaps, and contribute to the maintenance and monitoring processes.

1.5 Project Conclusion and Recommendations

The aircraft consolidated functional architecture developed in P09.49 TAD is instrumental in connecting the EATMA high level architectures with the primary P9.x projects architectures, and remains the reference for the assessment of the SESAR solutions retrofit ability, for figuring out a deployment planning, and performing the interoperability analysis. The project P09.49 choice on the TAD granularity, featuring 30 functional blocks, has proven to be effective for mapping onto the various aircraft physical implementations, while providing to the ground partners a good level of understanding of the SESAR solutions impact on the aircraft.

Project P09.49 has developed detailed recommendations in Project 9.49, D30 : Synthesis to support SESAR1 SESAR 2020 transition, D30, Edition 00.01.00, 05/04/2016 with the lessons learned to best prepare airborne transverse activities in SESAR 2020. The recommendations below are the most salient points extracted from D30.

- As illustrated in the P9.49 aircraft capability evolution report, the retrofit challenge of the SESAR solutions can be very different from one Solution to another. The project developed a qualitative rating with 6 levels of effort ranging from "none" to "very high". While these qualitative ratings cannot be correlated to quantitative retrofit efforts (in Euros), they suggest that the quantitative efforts can however be quite different from one Solution to another. One recommendation could be to refine the future business cases to be undertaken for the scoping of future ATM Master Plan Essential changes. Indeed, past Master Plan business cases have been performed with raw hypothesis on the cost of aircraft equipage, associating systematically a "high cost" to Solution requiring an aircraft Enabler.
- The P9.49 work on SESAR federating activities has highlighted the need for Avionics suppliers and aircraft manufacturer's participation for their comprehensive knowledge of the aircraft systems and industrial constraints. While this participation was satisfactory for the Mainline segment with Airbus and Boeing, it was insufficient for the Regional segment. One recommendation could be to secure the availability of OEM experts from Boeing, Embraer, and Bombardier in SESAR 2020 PJ20.
- The analysis on the worldwide interoperability was focused on the US, and can be used as the reference for the "remain to do" on SESAR and NextGen harmonisation. One recommendation would be that worldwide interoperability analysis also considers other ATM modernisation programs in China, Middle East, Australia... and other regions.

2 References

- [1] SESAR Programme Management Plan, Edition 03.00.01
- [2] [European ATM Master Plan](#)
- [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] Project 9.49 Project Initiation Report (Part 1 – Word doc), Edition 00.02.00, 10/03/2011
- [5] Project 9.49, Working together memo, D01, Edition 00.02.00, 03/02/2012
- [6] Project 9.49, Step 1 - Consolidated functional airborne architecture, D02, Edition 00.01.00, 02/12/2011
- [7] Project 9.49, Step 1 - Consolidation of functional airborne architecture - V02, Edition 00.02.00, D02-002, 10/05/2012
- [8] Project 9.49, Step 1 - Consolidated functional airborne architecture- V03, D02-003, Edition 00.03.00, 21/12/2012
- [9] Project 9.49, Step 2 - Consolidated functional airborne architecture, D03, Edition 00.01.00, 09/10/2013
- [10] Project 9.49, Batch 1 & 2 - Consolidated Functional Airborne Architecture - Version 2, D03-002, Edition 00.02.01, 15/12/2014
- [11] Project 9.49, Batch 1, 2 & 3 - Consolidated functional airborne architecture, D04, Edition 00.01.00, 04/11/2015
- [12] Project 9.49, Aircraft capabilities evolution report template, D05, Edition 00.01.00, 23/03/2012
- [13] Project 9.49, Aircraft capabilities evolution report template - V2, D05-002, Edition 00.01.01, 11/07/2012
- [14] Project 9.49, Step 1 - Aircraft capabilities evolution report, D06-001, Edition 00.01.01, 24/05/2012
- [15] Project 9.49, Step 1 - Aircraft capabilities evolution report - V2, D06-002, Edition 00.02.00, 25/02/2013
- [16] Project 9.49, Step 2 - Aircraft capabilities evolution report, D07, Edition 00.01.00, 18/12/2013
- [17] Project 9.49, Batch 2 - Aircraft Capability Evolution Assessment Report - Version 2, D07-002, Edition 00.02.01, 20/08/2015
- [18] Project 9.49, Batch 3 - Aircraft capabilities evolution assessment report, D08, Edition 00.01.00, 18/02/2016
- [19] Project 9.49, Interoperability risk assessment Methodology, D09, Edition 00.01.00, 19/10/2012
- [20] Project 9.49, Step 1 - Interoperability risk report, D10-001, Edition 00.01.00, 14/11/2012
- [21] Project 9.49, Step 1 - Interoperability risk report V2, D10-002, Edition 00.02.00, 19/02/2013
- [22] Project 9.49, Step 2 - Interoperability risk report, D11, Edition 00.01.00, 18/02/2014
- [23] Project 9.49, Batch 2 - Interoperability Risks Report - Version 2, D11-002, Edition 00.02.00, 18/12/2014
- [24] Project 9.49, Batch 3 - Interoperability risk report, D12, Edition 00.01.00, 11/03/2016
- [25] Project 9.49, Avionics interoperability roadmap definition Methodology, D13, Edition 00.00.01, 16/04/2012
- [26] Project 9.49, Step 1 - Avionics interoperability roadmap, D14-001, Edition 00.01.00, 29/05/2012
- [27] Project 9.49, Step 1 - Avionics interoperability roadmap V2, D14-002, Edition 00.02.00, 21/01/2013

- [28] Project 9.49, Step 2 - Avionics interoperability roadmap, D15, Edition 00.01.00, 07/11/2013
- [29] Project 9.49, Batch 1 & 2 Avionics Interoperability Roadmap - Version 2, D15-002, Edition 00.02.01, 29/09/2014
- [30] Project 9.49, Batch 1, 2 & 3 - Avionics interoperability roadmap, D16, Edition 00.01.00, 08/07/2015
- [31] Project 9.49, Batch 1, 2 & 3 - Avionics interoperability roadmap- Final, D16-002, Edition 00.02.00, 15/12/2015
- [32] Project 9.49, Batch 2 - Complementary trials, D18, Edition 00.01.00, 31/08/2015
- [33] Project 9.49, Batch 3 - Complementary trials, D19, Edition 00.01.00, 30/03/2016
- [34] Project 9.49, Step 1: Consolidation with primary projects, D21-001, Edition 00.01.00, 01/04/2014
- [35] Project 9.49, Multi-function evaluations - Cockpit integration (EXE 09.49-VP-767) - Lot 1 - Validation Report, D21-002, Edition 00.01.00, 26/02/2015
- [36] Project 9.49, Multi-function evaluations - Cockpit integration (EXE 09.49-VP-xxx) - Lot 2 - Validation Plan, D22-001, Edition 00.01.00, 22/03/2016
- [37] Project 9.49, Multi-function evaluations - Cockpit integration (EXE 09.49-VP-xxx) - Lot 2 - Validation Report, D22-002, Edition 00.01.00, 22/03/2016
- [38] Project 9.49, D30 : Synthesis to support SESAR1 SESAR 2020 transition, D30, Edition 00.01.00, 05/04/2016
- [39] Integrated Roadmap Dataset 14, SESAR WP B.01, 01 JUL 2015.

-END OF DOCUMENT-

founding members



Avenue de Cortenbergh 100 | B -1000 Bruxelles
www.sesarju.eu