



Final Project Report

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Abstract

This project had the objective to conduct integrated validations between different SESAR TMA Solutions and cross validations with SESAR Solutions in other domains – en-route, airport and network –. It was not in the nature of this project to develop any new SESAR Solution, but to analyse their feasibility to operate in the same environment.

P05.03 conducted two types of activities. First, in coordination with other transversal projects, an iterative process was performed to identify the needs for integration and cross validations. In second term, P05.03 conducted four exercises to demonstrate the operational viability to implement in the same environment SESAR Solutions that were developed in isolation.

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Rational for rejection

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Acronyms

Acronym	Definition
AF	ATM Functionality
AMAN	Arrival Management
ASAS	Airborne Separation Assurance System
ATC	Air Traffic Control
ATM	Air Traffic Management
CAR	Complexity Assessment & Resolution
CDO	Continuous Descend Operations
CTA	Controlled Time of Arrival
CWP	Controller Working Position
DB	Deployment Baseline
D/L	Datalink
ENB	Enabler
FTS	Fast Time Simulation
IBP	Industrial Based Platform
INTEROP	Interoperability
IP	Implementation Package
OFA	Operational Focus Area
OSD	Operational Service and Environment Definition
PCP	Pilot Common Project
P-RNAV	Precision Area Navigation
R	Release
R&D	Research & Development
RNP	Required Navigation Performance
S&M	Sequencing & Merging
SPR	Safety & Performance Requirements
TMA	Terminal Manoeuvring Area

1 Project Overview

The aim of P05.03 was to validate at V3 maturity phase that SESAR TMA Solutions¹ previously tested in isolation in other SESAR projects can be technically and operationally integrated, and that expected performance benefits quantified in stand-alone are not constrained by the interactions between SESAR Solutions.

This project worked alongside and in very close collaboration with other transversal projects like P04.03, its En-route equivalent, as well as with P04.02 and P05.02. This working group identified in a top-down process the needs to integrate SESAR Solutions not only within the TMA domain but also across different areas (en-route, airport and network). P05.03 executed exercises integrating different SESAR Solutions within the TMA and also with other domains.

In addition, P05.03 supported other validations executed by projects in charge of testing the SESAR Solutions in isolation by providing the necessary resources for the execution of their exercises.

1.1 Project progress and contribution to the Master Plan

P05.03 integration nature prevented it to contribute directly to a single SESAR Solution. However, it provided useful know-how on integration aspects of several of them.

The project was born with some validation activities already in the planning; getting to execute only a Real-Time Simulation led by ENAIRE.

Three more validation exercises were defined in a top-down process managed by P04.02 and P05.02 with the support of P04.03 and P05.03. This process is detailed below:

- Validation Needs defined systematically in line with validation strategies²;
- Workshop with solution-oriented projects as well as with transversal projects in charge of SESAR Concept alignment in order to:
 - Clarify the interaction between the different SESAR Solutions;
 - Assess the maturity status of the SESAR Solutions addressed;
 - Assess available documentation from projects delivering SESAR Solutions.
- Set the scope of integration exercises;
- Detail integration exercises taking into account integration project partners' capabilities (effort, platform availability).

The following table highlights the main Solutions addressed by P05.03 validation exercises. As mentioned before, the nature of the project was not oriented to mature the Solutions in stand-alone so there was no major maturity evolution due to the action of P05.03. Note that the Solutions refer to Operational Improvement steps (OIs) included in Dataset 15.

Code	Name	Project contribution
AOM-0603 ³	Enhanced Terminal Airspace for RNP-based Operations	EXE-05.03-VP-034 (real-time simulation; R2) and EXE-05.03-VP-034-FTS (fast-time simulation; R2) covered the gaps of implementing P-RNAV procedures stand-alone by integrating a pre-sequencing tool.

¹ A SESAR Solution consists of one or several Operational Improvements (OIs) working together.

² A Validation Strategy 'Provided a top-down validation view for each Step of the Concept Story Board as a whole'. It contains a section called 'Needs for integrated and cross validation' where possible integration and cross validation activities were identified [6].

³ Given that P-RNAV procedures were considered DB (Deployment Baseline), and so more mature than E-AMAN, the conclusions and recommendations were oriented to the scenario of integrating the E-AMAN into a P-RNAV environment.

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TS-0305-A ⁴	Arrival Management Extended to En-Route Airspace	<p>EXE-05.03-VP-034 and EXE-05.03-VP-034-FTS addressed the integration of this OIs with P-RNAV procedures providing not only the operational perspective but also the quantification of expected performances results. This quantification of performances had not been done before for TS-0305-A.</p> <p>EXE-05.03-VP-708 (real-time simulation; R4) and EXE-05.03-VP-805 (RTS and Flight Trial) validated the integration of CTA and ASAS procedures in an E-AMAN environment.</p> <p>EXE-05.03-VP-804 (real-time simulation; R5) integrated a complexity assessment and resolution tool into an extended AMAN environment. In addition, this exercise quantified for the first time the increase of workload experienced by en-route controllers derived from the use of the E-AMAN.</p>
TS-0103	Controlled Time of Arrival (CTA) in medium density/complexity	<p>EXE-05.03-VP-708 integrated for the first time the execution of these procedures followed by ASAS manoeuvres.</p> <p>EXE-05.03-VP-805 (RTS and Flight Trial) validated the integration of CTA and ASAS procedures in an E-AMAN environment in a more complex environment than EXE-708 and also addressed performance quantification in CTA-dedicated scenarios to support its transition to V3.</p>
TS-0105-A	ASAS Spacing – target direct to merge point (speed/simple geometry)	<p>EXE-05.03-VP-708 integrated for the first time the execution of these procedures in combination with CTA.</p> <p>EXE-05.03-VP-805 (RTS and Flight Trial) validated the integration of CTA and ASAS procedures in a more complex environment than EXE-708 and also measured performance indicators in dedicated scenarios to confirm that the implementation proposed wouldn't bring the expected benefits for this concept.</p>
CM-0103-A	Automated Support for Traffic Complexity Assessment	<p>EXE-05.03-VP-804 analysed the operational feasibility of using a complexity resolution tool in the same environment where a pre-sequencing was being performed.</p>
CM-0104-A	Automated Controller Support for Trajectory Management	<p>EXE-05.03-VP-804 assessed the impact that complexity resolution measures based on trajectory changes had on different Performance Indicators like fuel consumption or block-to-block variability and identified the trade-offs when implementing such measures in an E-AMAN environment.</p>

⁴ Given that TS-0305-A was considered mature enough –end of V3 maturity phase – one year before the execution of VP-804 and VP-805, these exercises were oriented to validate how the other SESAR Solutions under test were integrated in an E-AMAN environment – without providing relevant inputs to the E-AMAN in isolation –.

The Project validation results were provided to the relevant projects delivering each SESAR Solution. An annex was included in each validation report with the updates to be done in the relevant SESAR Solution documents, mainly operational requirements, to take into consideration the P05.03 results.

Here below are listed the main SESAR Solutions which were addressed by P05.03 validations:

- SESAR Solution #62 - P-RNAV in a complex TMA - that is formed by AOM-0603;
- SESAR Solution #16 - ASAS Spacing applications 'Remain behind and Merge behind' - that includes OIs TS-0105-A;
- SESAR Solution #06 - Controlled Time of Arrival (CTA) in Medium density / medium complexity environment - that includes OIs TS-0103;
- SESAR Solution #05 - Extended Arrival Management (AMAN) horizon - that includes the OIs TS-0305-A;
- SESAR Solution #19 - Automated support for Traffic Complexity Detection and Resolution - that includes OIs CM-0103-A and CM-0104-A.

Additionally, P05.03 partners supported the execution of the following exercises executed by projects delivering SESAR Solutions:

- EXE-05.06.01-VP-203 - I4D flight trials with mainline ac flying in MUAC and NORACON airspace - Iteration 1;
- EXE-05.06.01-VP-204 - i4D Real Time Simulation with NORACON IBP, incl. coupled sessions with Airbus cockpit simulator - Iteration 1;
- EXE-04.03-VP-711 - Seamless Cross-border Operations;
- EXE-05.06.01-VP-477 - i4D Real Time Simulations supporting Step C;
- EXE-05.06.02-VP-763 - CDO at Orly Live Trials Validation.

P05.03 partners contributed to the preparation of EXE-04.03-VP-799 - Full ATC/ATC Iteration 2 - Initial What-If which was finally cancelled.

1.2 Project achievements

One of the main achievements of the project was the top-down identification of integration validation needs and the exercises designed to cover some of them. However, only some exercises were finally executed to address these needs. Apart from the initially conceived VP-034⁵, the following exercises were performed under P05.03 responsibility: VP-708, VP-805 and VP-804.

SESAR projects in charge of developing the validation strategies i.e. PX.2s, with the support of those responsible to conduct integration exercises, like P05.03, defined at high level the integration needs between SESAR Solutions and the prioritization criteria – high, medium or low - based on the level of interaction between Solutions. This information was used as the starting point for the definition of the integration validation needs between SESAR Solutions in the transition validation strategy for SESAR 2020.

The added value of this process in comparison with how integration needs were identified at the beginning of the program was to interact directly with the projects in charge of delivering the SESAR Solutions. Such interactions were reflected in the validation strategies of the different operating environments.

Moreover, some of these integration needs were deeper described up to concept interaction level in order to define exercises to address them.

The following graph shows the integration validation needs identified in the validation strategies of the different operating environments (**grey**), those deeply described by integration projects, i.e. X.3s, (**blue**) and it also highlights the exercises executed (**green**) and cancelled (**red**).

Bearing in mind that these needs were identified well advanced the Program, only those integration needs that were of more interest for project partners were deeply analysed. Based on the resources available, each organisation defined potential exercises to cover such integration needs. Finally,

⁵ This exercise was executed before the integration needs were identified.

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taking into account the maturity of the concepts and the different company strategies, some partners decided to go ahead and perform validation activities to cover the integration needs while some others finally cancelled theirs.

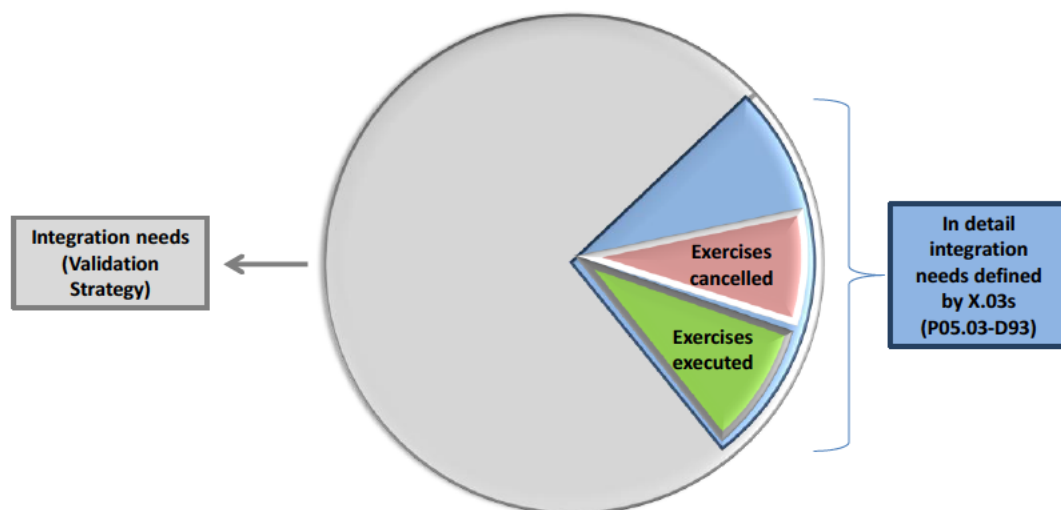


Figure 1 - SESAR Integration needs identified and integration exercises executed

As it can be appreciated from the number of integration exercises executed over the number of needs identified, the execution of integration exercises is a difficult task.

P05.03 succeeded to assess the integration of mature concepts to understand the trade-offs they provide when implemented in the same environment. The results of these integration exercises are very useful to define operational requirements and working methods to deploy different SESAR Solutions in the same environment. P05.03 validation reports fed operational documents to include integration requirements.

It must be highlighted that the work done by P05.03 has contributed to fully define the operational method of several PCP concepts; in fact all P05.03 exercises covered PCP Solutions. The so covered ATM Functionalities of the PCP [10] are:

- AF#1: Extended AMAN and PBN in high density TMAs;
- AF#4: Network Collaborative Management;
- AF#6: Initial Trajectory Information Sharing (towards i4D).

The SESAR2020 transition validation strategy [11] has already identified a number of integration needs with different priorities. However, based on the experience of integration-oriented projects and the large effort dedicated to run proper integration exercises, a more specific prioritisation might be developed at the beginning of the SESAR2020 Program to determine where the validation focus should be on.

1.3 Project Deliverables

The following table presents the relevant deliverables that were produced by the project. The deliverables are organized chronologically:

Reference	Title	Description
05.03.D82 [4]	Validation report VA1 EXE-05.03-VP-034 including FTS complementary results	This document combines the results obtained from EXE-05.03-VP-034 and the dedicated FTS defined to quantify performances. These exercises addressed the integration of the operational improvements AOM-0603 and TS-0305-A providing not only the operational perspective but also the quantification of expected performance results. This quantification was not done before for TS-0305-A, and it was

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		<p>only partially done for AOM-0603.</p> <p>Quantitative benefits, potential constraints and trade-offs of the integration were assessed. In particular, P05.03 exercises deeply analysed metrics related to flight efficiency which were not initially covered by P05.07.04. This allowed identifying the constraints in the use of trombone paths which are nominally longer than the STARTs currently in use.</p>
05.03.D93 [6]	Integration Validation Needs beyond 2014 (Consolidated deliverable 04.03 - T004)	<p>This is an update of the document produced for 2014 early 2015, 05.03.D03 'Integration Validation Plan'. The content was refined thanks to a better knowledge of the needs identified in the update of Step 1 Validation Strategies from P04.02 and P05.02 and the close coordination with working teams in charge of the SESAR Solutions. The OIs that were expected to reach V3 maturity in 2015/2016 had been specially considered, enlarging the 2014/2015 ones that were the main focus of the previous version.</p>
05.03.D101 [7]	Validation Report EXE-05.03-VP-805 (RTS)	<p>This document provides the results and conclusions of the Real-Time Simulation defined to address the integration of CTA/i4D and ASAS –Sequencing & Merging - concepts into an Extended AMAN horizon. This is an advance iteration of EXE-05.03-VP-708 which results were presented in P05.03-D92.</p> <p>This exercise not only covered the integrated scenarios but also supported the assessment of ASAS and CTA/i4D concepts in isolation by means of separated scenarios used as reference for the integrated one. Airborne and ground perspectives were considered in this exercise.</p>
05.03.D102 [8]	Validation Report EXE-05.03-VP-805 (Flight Trial)	<p>This validation report gathered the results of the final exercise defined to address the operational feasibility of the integration of ASAS and CTA/i4D concepts into an extended arrival management horizon. This was done through a flight trial flew with an Airbus test aircraft and using the same type of prototypes employed in the Real-Time Simulation EXE-05-03-VP-805.</p>
05.03.D99 [9]	Validation Report EXE-05.03-VP-804	<p>This deliverable provided the results of the integration of a Complexity Assessment and Resolution tool into an Extended Arrival Management horizon.</p> <p>This exercise quantified the trade-offs between both concepts in the same environment. For this purpose, AMAN and CAR stand-alone and integration scenarios were defined so that it was ensured that the results were fully comparable.</p> <p>This report also provided a list of operational requirements that might be adapted in order to accommodate the operation of CAR tools in Extended AMAN environments. Furthermore, it also included conclusions and recommendations for the process to identify and define integration validation exercises.</p>

1.4 Contribution to Standardisation

No direct contribution to the standardisation from the project, having as main deliverables validation plans (VALPs) and reports (VALRs). Nevertheless validation results of P05.03 exercises were used by SESAR Solutions to mature relevant operational documents and requirements taken as input for standardisation activities.

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1.5 Project Conclusion and Recommendations

P05.03 exercises allowed identifying additional operational requirements to guarantee that the addressed concepts and pre-operational prototypes can be integrated. These exercises allowed also identifying how the expected performance benefits of the concepts in isolation are impacted by the integration of them working in the same environment. Some examples of exercises' findings are:

- The support of the Extended AMAN was beneficial to reduce the increase of workload at high complex / density traffic situations that implies the management of non-P-RNAV equipped aircraft in a P-RNAV environment. VP-034 also identified a potential degradation of the time flown and fuel burn along the day when integrating the AMAN with P-RNAV procedures. This needs to be taken into account to analyse the transition steps, not only in terms of implementation timeframe but also in terms of daily use depending on the traffic demand.
- The integration of CTA/i4D and ASAS into an Extended AMAN horizon reduces flexibility with respect to current operations, as prescribed working methods must be followed precisely to get all expected benefits from these concepts. Thus, although remarkable benefits were observed in terms of ATCO and pilots' situational awareness thanks to the information sharing, results didn't show the expected benefits of ASAS Sequencing & Merging in terms of reduction of ATCO's workload or fuel consumption.

With respect to the use of datalink to instruct arrivals to the airport, VP-805 demonstrated pilot and controller's confidence on the use of this enabler, combined with i4D and ASAS. Transmission time for uplink messages was aligned with the expectations and also confirmed by the flight trials.

- The use of a Complexity Assessment and Resolution tool in an Extended AMAN environment allowed implementing more effective trajectory management measures to minimize executive controller's overloads thanks to a better view of the expected traffic to the airports in the vicinity. On the contrary, the complexity algorithm as a mechanism to predict the executive controllers' workload decreased the accuracy of its predictions in an Extended AMAN environment which makes necessary to refine the algorithm to include AMAN-related tasks.

The main conclusions obtained by the project on the execution of integrated validations as such are summarised in the following bullets:

- Results proved the need of performing integration exercises to better quantify the impact of the integration on ATM system performances, especially on the official Focus Areas: Human Performance, Safety, Fuel Efficiency, Predictability, Capacity and Cost-efficiency. On the other hand, these exercises also showed the large effort required to plan, execute and analyse an exercise integrating different SESAR Solutions, mainly due to the proven need of running stand-alone scenarios to really understand and quantify the trade-offs between the concepts, and the complexity of the technical set-up when integrating several prototypes in the same IBP;
- Integration exercises can be executed in coordination with the evaluation of one of the concepts in stand-alone. Using the same platform, simulation environment and time window demonstrated to be beneficial to maximize the resources available and to achieve a double goal: assessing a mature concept at the same time that it is validated the effect of its integration with other concepts that have a potential performance trade-offs.

P05.03 can also provide some recommendations that might be useful for the future program SESAR2020:

- Bearing in mind the relevance of executing integration exercises but also the huge effort spent to analyse and quantify the benefits of integrating two promising SESAR Solutions, the integration needs definition process must be revisited. Prioritisation must be established about the integration exercises to be conducted in the future program since it is not feasible to

analyse all the potential combinations of SESAR Solutions⁶. From the integration needs identified in the SESAR2020 transition validation strategy [11] it must be conducted a prioritisation process at the beginning of the SESAR2020 Program to establish the focus with enough time;

- It is recommended to define a common methodology to validate the integration of different concepts to avoid introducing external factors. For instance, it was proved to be very useful to run four scenarios: reference with no SESAR Solutions, Solution 1 stand-alone, Solution 2 stand-alone and integrated scenarios. This allows the comparison of the two concepts working separately with the results obtained from their integration in the same environment;
- To optimise the R&D resources, integration exercises could be planned to be run in coordination with a stand-alone concept validation. So that, the reference and solution scenarios could be already compared to an integrated scenario using the same environment.

⁶ So far, the SESAR2020 transition validation strategy has identified 65 potential integration needs between SESAR Solutions.

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2 References

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- [2] [European ATM Master Plan](#)
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