Final Project Report

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Abstract

The purpose of P10.09.01 was to define system and interface requirements derived from operational requirements and develop verified prototypes for sequencing tools.

The prototypes developed within the project provided support to operational validations focused on the integration of queue management tools such as Arrival Manager (AMAN), Departure Manager (DMAN), Center Manager (CMAN) to provide a safe, ordered and efficient flow of traffic.

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00.00.04	10/06/2016	Draft	Ruth Tapia	Enabler analysis update after coordination with related

			[redacted]	projects contributing to same enablers
00.00.05	13/06/2016	Draft		Updated version with external reviewers comments implemented
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Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ANSP	Air navigation service provider
AMAN	Arrival Manager
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATM	Air Traffic Management
CMAN	Center Manager
CTA	Controlled Time of Arrival
CTO	Controlled Time Over
DCB	Demand and Capacity Balance
DMAN	Departure Manager
IBP	Industrial Based Platform
PCP	Pilot Common Project
OFA	Operational Focus Area
RSFM	Runway Sequence and Flow Manager
PR-NAV	Precision Area Navigation
SESAR	Single European Sky ATM Research
SWIM	System Wide Information Management
TMA	Terminal Manoeuvre Area
TRL	Technology Readiness Level

1 Project Overview

The objective of this project was to define system requirements and interface requirements for queue management tools and later on develop, verify and integrate prototypes into Industrial Based Platforms (IBP) to support operational and integrated validations where queue management tools were evaluated or required.

The project focused on supporting validation activities for:

- Coupled AMAN/DMAN
- Coupled AMAN/DMAN integrated with Advanced Surface Movement Guidance and Control System (A-SMGCS)
- Center Manager (CMAN)
- Extended AMAN in combination with Complexity tools.

The project also worked on the definition of a System Wide Information Management (SWIM) service for different stakeholders to manage the integrated sequence for arrivals and departures in mixed mode or dependent runways: RunwayMixSequence

1.1 Project progress and contribution to the Master Plan

The project worked in two phases using the same pattern for both of them. At the beginning of each phase the project analysed the operational documentation with the aim of translating the operational requirements into system and interface requirements. Based on the technical specification and the requested capabilities to support the validation exercises (from the validation plans), prototypes were developed. After the verification of the prototypes the support to the operational validation started. During this step technical support was essential to integrate the prototype into the IBPs used for the validations. After the validation exercise was finished and conclusions were ready, a support to validation report and an update of the technical requirement were done.

For the first phase, the project has contributed to the definition of technical requirements covering aspects of the Extended Arrival Management horizon, Flow based integration of Arrival and Departure Management , Controlled Time of Arrival in Medium density / medium complexity environment and for Arrival Management into Multiple Airports. Within this project phase one prototype was developed to support a validation exercise focus on the assessment of Arrival Management with Precision Area Navigation (PR-NAV) procedures in complex Terminal Manoeuvre Areas (TMAs) with more than one airport in the vicinity. The prototype also covered requirements for the integration of AMAN and DMAN in a Master/Slave configuration.

For the second phase, the project has contributed to the definition of technical requirements covering aspects of the Sequence Based integration of AMAN and DMAN, Extension of the AMAN Horizon and Cross Border Arrival management. During this phase the project has developed interface requirements between AMAN and RSFM (Runway Sequence and Flow Manager). Three prototypes were developed to support validation activities:

- A first prototype was developed covering Coupled AMAN/DMAN requirements able to be integrated with A-SMGCS for a sequence based solution and covering also Extended AMAN Horizon requirements. This prototype was integrated in two different IBPs for two validation exercises, one of them focused on the measure of the runway throughput for dependent runways when coupling AMAN/DMAN/A-SMGCS. The second exercise was focused on tactical complexity measures in the Extended AMAN Horizon. A first version of this prototype also implemented the SWIM service RunwayMixSequence for the exchange of the integrated arrival and departure sequence between TMA and aerodrome and was run in a demo.

- A second prototype was developed covering cross border arrival management requirements. This prototype was integrated in an IBP to validate the smooth arrival flows into multiple airports in high traffic density E-TMAs when using CMAN linked to individual AMANs.
- A third prototype was developed covering Coupled AMAN/DMAN requirements. The prototype was expected to be used in a validation exercise covering a sequenced based solution of coupled AMAN/DMAN in a mixed mode runway configuration but the validation exercise was cancelled and substituted by an operational verification. The outcome of the operational verification was also considered by the related operational project in the operational documentation latest update.

Due to the complex nature of the concept, and the split within SESAR of the projects among aerodrome, TMA and En-route areas, this project worked in close coordination with all the technical projects dealing with the queue management process to avoid gaps and overlaps on the technical specifications documents. These projects agreed to jointly develop arrival management technical specifications and to put the requirements in the deliverable of one project according to the queue management topic they are related to. That's the reason why not all the requirements implemented by the prototypes developed within the project has been delivered as part of this project deliverables. Based on this agreement this project has been in charge of delivering the interface requirements between AMAN and RSFM.

The table below shows the enablers the project has contributed to, and their initial and final maturity level

The referred enablers are those identified in [5] PB.01, B.01-D83-Integrated_Roadmap_DS15_Release_Note, D83, 00.01.00, 21/12/2015

Due to its collaborative work with other projects, this project has also contributed to the following enablers under the scope of related projects, in charge of providing the maturity level at the end of the project: APP ATC 111, APP ATC 148, APP ATC 158, ER APP ATC 109, APP ATC 110, APP ATC 161 and ER ATC 163.

Note: The maturity assessment of the enablers has been performed in common with related projects dealing with same topics of this enablers.

Next table shows the agreed level of maturity level achieved.

Code	Name	Project contribution	Maturity at project start	Maturity at project end
AERODROME-ATC-09b	Sequence-based Improvement of operational orchestration among arrival / departure management and surface management services	Technical requirements specified with project contribution for sequence based integration of AMAN and DMAN and A-SMGCS. Technical requirements had been deliver by another project but interface requirements between AMAN and RSFM had been delivered by this project. Related requirements had been implemented in a prototype developed within the project and used in V3 validation that conclude that maturity level didn't reached V3 for the whole concept.	TRL4	TRL5

AIRPORT-33	Provision of departure and arrival constraints to the Aerodrome ATC surface management	Technical requirements specified with project contribution for sequence based integration of AMAN and DMAN and A-SMGCS. Technical requirements had been deliver by another project but interface requirements between AMAN and RSFM had been delivered by this project. Related requirements had been implemented in a prototype developed within the project and used in V3 validation that conclude that maturity level didn't reached V3 for the whole concept.	TRL4	TRL5

The project has contributed to the following SESAR solutions:

- SESAR Solution #5: Extended Arrival Management (AMAN) horizon
- SESAR Solution #6: Controlled Time of Arrival (CTA) in Medium density / medium complexity environment
- SESAR Solution #8: Arrival Management into Multiple Airports
- SESAR Solution #15: Integrated and throughput-optimised sequence of arrivals and departures
- SESAR Solution #54: Flow based Integration of Arrival and Departure Management

1.2 Project achievements

The goal of the project was to contribute to the production of technical and interface requirements covering different aspects of the arrival management process. All those requirements needed for validation activities has been implemented in the prototypes delivered within the projects to support validation activities:

- Contributing to SESAR Solution #54: AMAN/DMAN coupled in a master/slave configuration where AMAN is the master, providing Arrival Free Intervals according to the applicable arrival-departure pattern for the runway to sequence departure flights between arrival flights taking into account static taxi times. This solution is flow based
- Contributing to SESAR Solutions #5, #6 and #8: AMAN with extended horizon to assess the integration of SESAR Arrival Management with P-RNAV procedures in complex TMAs with more than one airport in the vicinity
    - Sequencing and merging to the runway or the merging point(s), taking into account the constraints as well as additional information enabling to refine the sequence optimisation (such as wake turbulence categories).
    - Computation and display of advisories: the main considered advisory will be a time advisory.
    - Computation and display of time-based constraints, Controlled Time Over (CTO) and Controlled Time of Arrival (CTA)

- Contributing to SESAR Solution #8: CMAN (Center Manager) to generate a combined planning for several arrival streams into different airports
    - Calculating the sequence of aircraft flying towards an area where their routes intersect.
    - Imposing an adequate spacing of the aircraft in that area, a Time To Lose (TTL) for the appropriate E-TMA sector is calculated to meet this constraint.
- Contributing to SESAR Solution #15: Coupled AMAN/DMAN to be integrated with A-SMGCS to generate an optimised arrival and departure flow in mixed mode or dependent runways with the aim of increasing runway throughput. This solution is sequence based.

1.3 Project Deliverables

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

Reference	Title	Description
D22	Consolidated Final Step 2 TS	Technical Specification for Step 2 addressing interface requirements between AMAN and RFSM functional blocks

The project has also contributed to other project deliverables:

- [24] P10.09.02, Step 1 Technical Specification, D64, 00.08.00, 05/09/2016. This document includes requirements implemented by this project's prototypes contributing to SESAR Solutions #5, #6, #8 and #54.
- [26] P12.04.04, System requirements Final S2V3, D38, 00.01.00, 26/04/2016. This document includes requirements implemented by this project's prototypes contributing to SESAR Solution #15.

1.4 Contribution to Standardisation

No specific standardisation or regulation activities were performed within this project.

1.5 Project Conclusion and Recommendations

This project, as a technical project, developed system requirements and prototypes taking into account operational needs to support the delivery of the ATM Master Plan.

The project concluded that:

- Queue management process is very complex, considering that:
    - Many actors are involved in the process: clearance, ground, local, TMA and en-route controllers
    - Exists a lot of uncertainty in the information used by the tools to provide stable sequences in advance
    - Sequencing tools are providing sequences in different time horizons and in planning and execution phase at the same time. For example when arrival

flights in the en-route phase are mixed with departure flights, still on the stand with no start-up clearance

- Another conclusion was that accuracy information coming from external systems to queue management tools has a significant impact on sequence stability, for example, no matter how good the algorithm is if the trajectory predictor is not accurate enough
- On the other hand, the integrated sequence for mixed mode or dependent runways provides to the controllers with a precise sequence that optimizes the runway throughput avoiding congestion at the holding point
- The integrated sequence facilitates silent coordination between Tower and Approach controllers, mainly for light traffics and departures from no preferential runway
- When the integrated sequence is shared also with TMA or even en-route controllers using the SWIM service RunwayMixSequence all controllers involved on queue management process collaborate to provide a safe, ordered and efficient flow of traffic
- AMAN advisories in the en-route phase are considered useful by the controllers, but taking care of AMAN advisories on TTL/TTG and sequence order in case of overload is not feasible

The project recommends to further investigate:

- Stability criteria for the coupled AMAN/DMAN sequence, with clear operational procedure to be developed and parameterization of the different frozen horizons for departure and arrival flights in the sequence since arrivals and departures are working on different time horizons, moreover when AMAN works in an extended horizon
- Delay absorption strategies in the upstream sectors when extending AMAN Horizon
- Management of interacting traffic flows within complex TMA
- Integration of the prototypes with additional tools with the aim of improving predictability and efficiency of the information provided by the queue management tools, for example, integration with Demand and Capacity Balance (DCB) tools
- Exchange of more accurate information via SWIM services to be used as input for queue management algorithms
- Definition of a different role for management of AMAN advisories in en-route sectors

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] Release 5 Plan v1.0, 00.01.00, 19/12/2014

[5] PB.01, B.01-D83-Integrated_Roadmap_DS15_Release_Note, D83, 00.01.00, 21/12/2015

[6] P10.09.01, D10.9.1 - Phase 1 - System requirement - V3 - Step 1, D02, 00.02.00, 31/05/2011

[7] P10.09.01, D10.9.1 - Phase 1 - INDRA Prototype - V3 - Step 1, D03, 00.01.00, 15/11/2011

[8] P10.09.01, D10.9.1 - Phase 1 - INDRA Support to OPS validation report - V3 - Step 1, D04, 00.01.00, 09/07/2012

[9] P10.09.01, D10.9.1 - Phase 1 - INDRA Test plan - V3 - Step 1, D05, 00.01.00, 08/11/2011

[10] P10.09.01, D10.9.1 - Phase 1 - Test cases - V3 - Step 1, D06, 00.01.00, 28/10/2011

[11] P10.09.01, D10.9.1 - Phase 1 - INDRA Test execution report - V3 -Step 1, D07, 00.01.00, 15/12/2011

[12] P10.09.01, Consolidated Step 2 TS, D09, 00.01.00, 21/12/2015

[13] P10.09.01, D10.9.1 - Phase 2 - INDRA Prototype - V2 - Step 2, D12, 00.01.00, 25/11/2013

[14] P10.09.01, THALES Step 2 Prototype availability note, D14, 00.03.00, 04/02/2016

[15] P10.09.01, Consolidated Final Step 2 TS, D22, 00.01.00, 6/06/2016

[16] P10.09.01, INDRA Step 2 Coupled AMAN-DMAN prototype Availability Note, D25, 00.02.00, 19/10/2015

[17] P10.09.01, D10.9.1 - Phase 1 - Architecture assessment - V3 - Step 1, D31, 00.01.00, 13/10/2011

[18] P10.09.01, INDRA:Step 2 Support to validation report, D42, 00.01.00, 25/05/2016

[19] P10.09.01, Thales Step 2 Support to validation report, D43, 00.01.00, 26/04/2016

[20] P10.09.01, DFS CMAN prototype availability note, D44, 00.02.00, 19/05/2015

[21] P10.09.01, DFS support to validation report, D45, 00.01.00, 20/07/2015

[22] P10.09.01, INDRA Step 2 Integrated Coupled AMAN-DMAN and Complexity prototypes Availability Note, D51, 00.02.00, 02/02/2016

[23] P10.09.01, INDRA Step 2 Coupled AMAN-DMAN - V&V Platform Availability Note, D52, 00.02.00, 21/01/2016

[24] P10.09.02, Step 1 Technical Specification, D64, 00.08.00, 05/09/2016

[25] P12.04.04, System requirements definition STEP 1 (Phase 1), D01, 00.01.00, 28/06/2011

[26] P12.04.04, System requirements Final S2V3, D38, 00.01.00, 26/04/2016

[27] P12.03.05, D12.3.5.D02 - Phase 1 - System Requirements Specification, 00.01.00, 1/07/2011

[28] P05.06.07, Update of 5.6.4 OSED – Step 1, D15, 00.01.01, 30/09/2015

[29] P05.06.07, Update of 5.6.4 SPR-INTEROP - Step 1 - Edition 2, D53, 00.01.00, 28/01/2016

[30] P06.08.04, S01V3 Final OSED, D17, 00.01.01, 21/07/2015

[31] P06.08.04, S01V3 Final SPR, D18, 00.01.11, 28/09/2015

[32] P06.08.04, S01V3 Final INTEROP, D82, 00.01.01, 21/07/2015

[33] P06.08.04, S02V3 Final OSED, D29, 00.01.00, 30/05/2016

[34] P06.08.04, S02V3 Final SPR, D30, 00.02.00, 30/05/2016

[35] P06.08.04, S02V3 Final INTEROP, D91, 00.01.00, 30/05/2016

[36] P05.04.02, Step 1 Final OSED, D04, 00.01.00, 22.03.2016

[37] P05.04.02, Step 1 Final SPR, D05, 00.01.00, 22.03.2016

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