Final Project Report

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Abstract

The objective of the project was to describe how the Air Traffic Control (ATC) system will support the Trajectory Management (TM) services by tackling issues like ensuring a consistent view of the trajectory, collecting TM related requirements, coming up with ways to propose changes to the Reference Business/Mission Trajectories (RBT/RMT), documenting assumptions about the capabilities of the overall Ait Traffic Management (ATM) system and developing a TM roadmap. To achieve these objectives, the project developed an advanced TM design together with an implementation roadmap. It collected and consolidated TM design requirements from WP10 projects and developed TM prototypes which were used in validation exercises which helped to demonstrate the feasibility of the TM design as well as validation of operational concepts and requirements. It also provided support for the integration of these prototypes into a validation environment.

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Rational for rejection
None.

Document History

1 Caveat: ENAIRE did not reply to the approval request for this final version of the document, the provided date concern the approval of the previous version of the document. We consider silent approval of ENAIRE for this final version.

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00.00.02	06/05/2015	Draft	INDRA	Modifications in section 1.4.1
00.00.03	06/05/2015	Draft	THALES	Minor modifications in Publishable Summary, Sections 1.2, 1.4.2, 1.4.3 and 1.5
00.00.04	08/05/2015	Draft	LEONARDO / ECTL	Changes in in Section 1.3 & Addition of Table of Contents
00.01.00	18/05/2015	Revised Draft	EUROCONTROL	Final draft version to be submitted including minor editorial changes
00.01.01	11/04/2016	Revised Draft	EUROCONTROL	Modifications with lesson learned from P10.2.2 FPR and new template
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Acronyms

Acronym	Definition
ADD	Aircraft Derived Data
ADS-C	Automatic Dependent Surveillance - Contract
AGDL	Air Ground Data Link
AIRM	ATM Information Reference Model
AMAN	Arrival Manager/Management
APP	Approach
ASAS	Airborne Separation Assistance
ASPA	Airborne Spacing Application
ATFCM	Air traffic Flow and Capacity Management
CTA	Controlled Time of Arrival
EPP	Extended Projected Profile
ETA	Estimated Time of Arival
EUROCAE	European Organisation for Civil Aviation Equipment
FDP	Flight Data Processing
FDPS	Flight Data Processing System
i4D	Initial 4D
IOP	Interoperability
OI	Operational Improvement
PCP	Pilot Common Project
RBT	Reference Business Trajectory
RMT	Reference Mission Trajectory
RNAV	Area Navigation
RNP	Required Navigation Precision
SBT	Shared Business Trajectory
TBO	Trajectory Based Operations

TM	Trajectory Management
TOD	Top Of Descent
TP	Trajectory Prediction/Predictor
TRL	Technology Readiness Level

1 Project Overview

Trajectory Based Operations (TBO) is the foundation of the SESAR TM concept. It requires a significant shift in the focus for ATM from airspace to trajectory. The essence of the TBO concept is an agreement in which aircraft fly their preferred trajectories (SBT & RBT) which are facilitated by airport and air navigation service providers.

In SESAR, Step 1 “Time-based operations” provided initial TBO through the use on the ground of airborne trajectories and a controlled time of arrival.

The project contributed by developing a high level design together with a roadmap to describe how the ATC system is supposed to support the Trajectory Management (TM) services in a Time Based Operation environment. The following issues were considered:

- How to ensure a consistent view of the trajectory among the Air Traffic Management (ATM) system components
- How to define TM and Trajectory Prediction (TP) requirements derived from both operational and technical needs
- How to establish an amendment process for changes in the Reference Business Trajectory (RBT) and Reference Mission Trajectory (RMT)
- How to document assumptions about the capabilities of parts of the overall ATM system
- How to identify steps from where we currently are and where we would like to be in terms of SESAR objectives

The main objectives of project were:

- to define an advanced TM design together with an implementation roadmap to achieve Time Based Operation
- to collect, support and consolidate TM design requirements from other projects on En-Route/APP ATC Systems
- to develop research/pre-industrial TM prototypes
- to demonstrate feasibility of the TM design by the implementation and verification of TM prototypes
- to provide support for the integration of the prototypes into a validation environment
- to provide support for the validation exercises of TM related operational concepts and requirements

1.1 Project progress and contribution to the Master Plan

Besides the delivery of a roadmap and a high-level design, the project main contributions encompassed the technical specification of the requirements concerning Trajectory Management in the ATC systems and the delivery of verified prototypes used validation exercises.

The prototypes developed in the project participated to the validation of elements of the following SESAR solutions:

- Solution #06, Airborne Technology Aids Arrival Sequence, Controlled time of arrival (CTA) in medium-density/medium-complexity environments
- Solution #08, Streamlining Traffic Flow into multiple airports, Arrival management into multiple airports

- Solution #16, Aircraft spacing tools to stabilise arrival management, ASAS spacing applications ‘remain behind’ and ‘merge behind’.
- Solution #27, Keeping ahead of traffic with advanced controller tools, Medium-term conflict detection (MTCD) and conformance monitoring tools.

In addition the project coordinated and consolidated, at work package level, the technical requirements regarding trajectory management and trajectory prediction. This included its contribution to the definition of the Trajectory Management/Trajectory Prediction functional block in the Technical Architecture Document (TAD) and its participation to the task forces working on Trajectory Management and Trajectory Prediction issues.

The following table lists the Enablers the project has contributed to:

ENABLER CODE	ENABLER NAME	Project Contribution	Initial TRL	Final TRL
ER APP ATC 104	Controller Tools to Use Aircraft-Derived 4d Data	The project contributed to the definition and improvement of the data exchange required as a basis for this enabler for the exchange of aircraft data between air and ground. In this respect the project works in co-ordination with other SESAR projects working on airborne related matters, with EUROCAE WG78 for air/ground TM related exchanges standardisation. The participation of the project to the Extended Projected Profile (EPP) task forces also contributes to these enablers. From Flight Data Processing System (FDPS) point of view, the trajectory will be calculated using Aircraft Derived Data (ADD) when available.	2	6
ER APP ATC 82	FDP to Use SBT/SMT, RBT/RMT	The project contributed to the modelling of the trajectory data required by the FDP for trajectory prediction purpose. This activity was co-ordinated with other SESAR projects ensuring alignment with AIRM. From FDPS point of view, FDP: System shall accept creation and revision of the RBT/RMT. However, implementation not foreseen for Step 1. It was recommended that a new Ground-Ground interoperability is created (for Flight Object).	2	6
ER APP ATC 100a/b/c	4D Trajectory in Step 1 - FDP/HMI/MONA	From FDPS point of view, the trajectory is refined using the EPP obtained through ADS-C when available. (TOD position and descent vertical profile used to improve ground TP accuracy). Via i4D + CTA exercise(s), the project contributes to this by means of using EPP in the ground ATM system. For Step 1, the ground FDPS system uses information from the EPP to update the ground prediction. However, it is not foreseen that EPP will replace FDPS trajectory.	2	6
APP ATC 148	AMAN Support CTA	From FDPS point of view, the system manages the dialogue to agree a CTA with	4	6

		the aircraft and the consequent RBT/RMT amendment. AMAN tool uses Estimated Time of Arrival (ETA) and ETA min/max to provide the CTA to be up linked. It also provides tolerance and Time to lose/Time To Gain (TTL/TTG) to support Air Traffic Control officer (ATCO) decision on CTA implementation. Via i4D + CTA exercise(s), the project supports CTA operations from step 1.		
ER APP ATC 149	AGDL for i4D Including CTA Between ATSUs	Cf. Contribution for APP ATC 148	4	6
APP ATC 94a	ATC Tools in Support of RNP.1 in App	From FDPS point of view, the trajectory will be calculated using ADD when available. Some use of ADD is foreseen for step 1 (aircraft weight and vertical profile) for the project's prototype(s). Step 2 objective was to extend the use of ADD to speed schedule and other data available through EPP. In step 1, prototype(s) will already use some ADD data derived from EPP (e.g. Top of descent) and times to update ground trajectory prediction.	2	6

1.2 Project achievements

The project has defined a TM design together with an implementation Roadmap (High Level Design and TM Roadmap deliverables).

The project has collected, supported and consolidated TM requirements (ATC TM Requirements deliverables). Based on these requirements, TM prototypes have been developed to be used in verification/validation exercises (three prototypes built by partners INDRA, LEONARDO & THALES). The project has demonstrated the feasibility of the TM design by the implementation and verification of the prototypes (Verification Plans & Verification Reports deliverables).

The project also provided support for the integration of the prototypes into a validation environment (Support to Validation deliverables) and for the validation exercises of TM related operational concepts and requirements (participation in the validation exercises).

The contribution of the project to EN's as described in 1.1 is aligned with what is required for PCP ATM Functionalities:

- AF#6: The project participated to the EPP task force and contributed to the definition and improvement of the data exchange required for the exchange of aircraft data between air and ground. The provision by the project of the technical specification for the FDP trajectory prediction using Aircraft Derived Data (ADD).
- AF#5: The project contributed to the modelling of the trajectory data required by the FDP for trajectory prediction purpose. The co-ordination of this activity with WP8 & WP14 has been done ensuring alignment with AIRM.

1.3 Project Deliverables

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

Reference	Title	Description
D72	High Level Trajectory Management Design step1 for release 2	This document aims at providing a decomposition of the TM function through NATO Architecture Framework (NAF) V3 EA sub-views. The objective is to explain for SESAR step 1 how the functional baseline linked to Trajectory Management for ATC systems gets allocated to ER/APP ATC system functions by the means of Enterprise Architecture (EA) sub-views (mainly NSV-4) and how operational requirements are traced by this design. The current document is the continuation of the deliverable D02-001 which has been produced in analogy with the Arrival Management functional breakdown. It has been adapted to the full step1 context (Time Based Operations) according to the TM roadmap that is defined for Step1.
D73	Trajectory Management Step1 Roadmap	This roadmap describes the path to follow for the ATM technical systems in order to evolve from the present baseline systems to the system required for Step1. As it has been identified in the different OSEDs and other documents that have served as input to this document, we can list the following areas as to be part of Step1: • i4D • CTA operations • Precision RNAV (PRNAV)/ADD • Air Traffic Flow and Capacity Management (ATFCM) / Flexible Use of Airspace (FUA) • Efficient and Green Terminal Airspace Operations – Continuous Descent Approach (CDA) • Airborne Spacing and Separation: Airborne Spacing Application (ASPA) Sequencing & Merging (S&M). It explains the improvement steps required for the ground ATM system, the ground communications, the air/ground communications and the air systems, in respective sections.
D88	Updated Step 1 ATC TM System Requirements - Cycle 3	This document contains the Step 1 ATC technical requirements for TM (Cycle 3). The document is developed in the form of a technical specification (TS / Interface Requirements Specification (IRS)), to be used as one of the primary inputs to the prototype development and verification phases. The document is an update of the Step 1 Requirements already produced by the project in previous years according to the latest step 1 inputs.

1.4 Contribution to Standardisation

EUROCAE WG78:

The project participated to the EUROCAE WG78 in order to present SESAR / WP10 expectations in terms of evolutions to the ADS-C standard (proposed changes to the ADS-C standard). Even though not all the items proposed were expected by EUROCAE WG78, most of the proposals have been accepted by the group. The accepted evolutions encompass the inclusion of the procedure name, the resolution of ambiguous point identification and the addition of ETA/ETO and fix name to the ETA Min/Max report.

1.5 Project Conclusion and Recommendations

This project derived technical Trajectory Management and Trajectory Prediction requirements from the operational requirements developed by the SESAR operational projects. It also consolidated at the Trajectory Management work package level the technical TM and TP requirements originating from other technical projects.

These requirements were the base for the development, by the project, of verified prototypes that, being integrated in Industry-based platforms, contributed to the validation of important elements of SESAR Solutions (with a major emphasis on the validation of i4D).

The project so contributed at increasing the Technical Readiness Level of several enablers (see section 1.1).

However during the course of the project, it appeared that the definition and scope of some of these enablers was very high level and led to several (sometimes diverging) interpretations. The project would them recommend that the definition of these enablers are reviewed in order to refine their definition and scope taking into account the results achieved and the experience gained during the execution of the programme and of this project in particular.

Moreover, as technical project, it played an intermediary role between the operational projects and the validations and had only a remote view (at the project level) of the way the different prototypes it developed contributed to the validations. Attempts were made to allow project members to participate to the preparation of the validations. This was however organized in an ad hoc manner. It is recommended that in future programmes, the ability for project to keep an end-to-end view is better supported by the organisation.

In step 1, Time-based operations validated initial Trajectory Based Operations elements and the project contributed to these validations of SESAR solutions and concept elements by providing ATC system requirements in the form of Technical Specifications and verified prototypes integrated in Industry Based Platforms.

Despite the limited view on the results of the validations, the work carried during the project made clear that in a TBO environment, flight and trajectory management components will be using many different automation facilities. Technical Interoperability among these facilities will be paramount if a fully efficient TBO is to be achieved.

Similarly, the project's involvement in initial trajectory sharing brought out the fact that the TP performance requirements will be significantly different from those required for legacy systems.

Based on the promising results to which the project contributed, it is recommended that further research and validations are conducted regarding the integration and interoperability of the different functions supporting trajectory management in the ATC systems and this to achieve the level of automation required in the future. Moreover the TP function will have to be enhanced to fulfil the new TP performance requirements induced by a transition to Trajectory Based Operations.

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