Final Project Report

Document information	
Project Title	Trajectory Management Framework in TMA
Project Number	05.05.01
Project Manager	ENAV
Deliverable Name	Final Project Report
Deliverable ID	D26
Edition	00.03.00
Template Version	03.00.04
Task contributors	
ENAV	

Abstract

The project 5.5.1 was launched to address topics related to the Trajectory Management Framework in the TMA. Due to the many synergies and common issues, P5.5.1 worked very closely with P4.5 Trajectory Management Framework in Enroute. Jointly with 4.5, the project captured the flight and trajectory exchange needs from across the Enroute and TMA projects and consolidated them to provide a coherent set of trajectory management requirements. The project has also accommodated under its scope the initial IOP operational requirements.

Validation activities at V2 level were performed within the project by means of Fast Time Simulation (FTS) techniques.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] ENAV	[redacted]	20/09/2016

Reviewed By - *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] INDRA	[redacted]	28/09/2016
[redacted] ENAIRE		28/09/2016
[redacted] EUROCONTROL		03/10/2016
[redacted] AIRBUS		10/10/2016
[redacted] THALES		28/09/2016
[redacted] NATS		28/09/2016

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	Position & Title	Date
[redacted] EUROCONTROL	[redacted]	28/09/2016
[redacted] NATS		06/10/2016

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] ENAV	[redacted]	06/10/2016
[redacted] THALES		06/10/2016
[redacted] ENAIRE		10/10/2016
[redacted] EUROCONTROL		10/10/2016
[redacted] INDRA		10/10/2016
[redacted] NATS		10/10/2016
[redacted] AIRBUS		10/10/2016

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	25/02/2015	Initial Draft	[redacted]	New Document. Draft requested for the Gate 2015
00.00.02	11/12/2015	Second Draft		Updated draft according to SJU guidelines
00.00.03	20/09/2016	Final Draft		Alignment to the new

				template and content consolidation before the members review and approval
00.00.04	29/09/2016	Final Draft	[redacted]	Project members comments included
00.00.05	06/10/2016	Final		Final version ready for project members' approval
00.01.00	10/10/2016	Final		Approved from the project members and submitted to SJU
00.02.00	11/11/2016	Final		Updated version taking into account the SJU assessment report
00.03.00	18/11/2016	Final		Section 1.5 updated after closure gate

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ACC	Area Control Centre
AMAN	Arrival MANager
ATC	Air Traffic Control
ATM	Air Traffic Management
CTA	Controlled Time Of Arrival
EFPL	Extended Flight PLan
ENB	ENaBler
EPP	Extended Projected Profile
FAA	Federal Aviation Administration
FIXM	Flight Information eXchange Model
FMS	Flight Management System
FTS	Fast Time Simulation
IOP	Interoperability (often used as shorthand for Flight Object Interoperability)
KPA	Key Performance Area
TMA	Terminal Manoeuvring Area
TMF	Trajectory Management Framework
TMR	Trajectory Management Requirement
OFA	Operational Focus Area
OI	Operational Improvement
OSED	Operational Service Environment Definition
PCP	Pilot Common Project
RBT	Reference Business Trajectory
RMT	Reference Mission Trajectory
SESAR	Single European Sky ATM Research

TP	Trajectory Prediction
V&V	Validation&Verification

1 Project Overview

The Trajectory Management Framework in TMA, working jointly with the P4.5 (Trajectory Management Framework in Enroute), captured the flight and trajectory exchange needs from across the Enroute and TMA projects and consolidated them to provide a coherent set of trajectory management requirements. The project has also accommodated under its scope the initial IOP operational requirements.

1.1 Project progress and contribution to the Master Plan

P5.5.1 jointly with P4.5 have defined the trajectory management requirements derived from operational TMF use cases, in close coordination with the relevant En Route and TMA primary projects.

Through defining the trajectory exchanges required between stakeholders, the TMF projects contributed directly to the Trajectory Management and System Interoperability with Air/Ground Data Sharing essential operational changes of the European ATM Master Plan [2].

Contribution has been provided through the provision of initial IOP operational requirements defined from SESAR IOP Analysis Team, for the exchange of flight and trajectory information in SESAR step 1. The requirements are to cover the level of IOP that is needed for initial deployment and were developed by the IOP analysis team in 2016.

The TMF projects also assessed validation needs resulting from analysis of the TMF use cases. These validation needs were mapped to the objectives defined by the various validations within the programme. As a consequence, this work also led to the identification of gaps where validation needs were not being addressed.

For some of the gaps identified during the V&V needs analysis, internal validation activities within the TMF projects were initiated. Those remaining V&V needs identified as not addressed in the final delivery form a set of V&V objectives to be addressed under the SESAR2020 programme.

In the context of its internal validation activities, P05.05.01 started investigating the provision of quantitative evidence of potential benefits related to the use of information sharing between air and ground.

The internal validation activities were performed by means of Fast Time Simulations (FTS), using the AirTOp Soft platform. For the purpose of the investigations, innovative changes were made to the FTS platform, to allow simulation of different simultaneous views of the trajectory (e.g. the predicted air trajectory is different from the ground trajectory) and their synchronisation.

Code	Name	Project contribution	Maturity at project start	Maturity at project end
IS-0303-A	Downlink of onboard 4D trajectory data to enhance ATM ground system performance: initial and time based implementation	Investigation related to the use of the EPP data: • for improvement of ground trajectory prediction accuracy in time and altitude • for enabling higher ground TP accuracy operational benefits for ATC applications.	V1	V2 partly covered

AUO-0226	Agreed iRBT: Exchange of EFPL with ATC	Investigation related to the use of the EFPL data: • for improving ground trajectory prediction accuracy in time and altitude • for enabling higher ground TP accuracy operational benefits for ATC applications.	V1	V2 partly covered
CM-0201-A	Automated Assistance to Controller for Seamless Coordination, Transfer and Dialogue through improved trajectory data sharing	TMF contribution through the definition of operational information exchanges between ATS units to maintain a common view of the ground planned trajectory in order to conduct further operations, starting initially with standard coordination and transfer and the associated information exchanges. Contribution to the Solution #28	V2	V3 partly covered
TS-0305-A	Extended Arrival Management (AMAN) horizon	TMF provided an up-to-date common view of the planned trajectory at the extended horizon which may be within the operational area of responsibility of a different ATS unit to the AMAN. Contribution to the Solution #05	V2	V3
TS-0103	Controlled Time of Arrival (CTA) in medium density/complexity environment	TMF consolidated the requirements on how ATC manage the downlink of trajectory information from the aircraft (through ADS-C) and the management of a time constraint on the trajectory (the CTA) between different ATS units. Contribution to the Solution #06	V2	V3

1.2 Project achievements

P5.5.1 has contributed to the requirements work undertaken by the project 4.5 and jointly with it has captured, at the operational level, a definition of what trajectory information needs to be exchanged, when and by which stakeholders. These operational requirements have been consolidated into a framework that supports multiple SESAR Solutions and importantly allows stakeholders to maintain a common view of the trajectory.

In addition, P5.5.1 was considered to accommodate the Stream2 IOP operational activities. Over the last year of the project execution, the requirements work was mainly dedicated to the capturing and integrating the IOP operational requirements defined by SESAR IOP Analysis Team under the scope of the project operational specification task, in order to have an initial IOP view in SESAR1 and to secure compatibility towards the final solution to be developed in SESAR2020 (full IOP PCP coverage).

In the following paragraphs main achievements are also reported deriving from the internal validation activities (three iterations of FTS) performed over the P5.5.1 execution phase.

First two validation iterations focused on the 4D EPP usage and results suggested that the use of the 4D trajectory downlinks allowed an improvement of the ground trajectory prediction accuracy with respect to a reference scenario (no 4D trajectory sharing), coming closer to typical airborne FMS predictions. In addition, this led to better conflict detection management (an earlier detection with less false alerts and missed conflicts). Both methods to trigger the 4D trajectory downlinks, on-event or regular, were showing similar performance results. However, the use of the TMR thresholds was found to be more complex (technical specification and operational parameter settings) but more efficient: they reduced by half the number of downlinks compared with the periodic rates.

The third iteration refined and complemented the content of the preceding iterations by:

- Providing a more realistic current operations ground prediction accuracy assessment
- Assessing the ground prediction accuracy improvement enabled by the use of EFPL. This was enabled via a large collection (3500) of real EFPLs along with relevant ground TP information.
- Improving the metrics and statistical reliability by simulating an higher traffic volume, subject to more unplanned tactical actions (e.g. direct routes)

and the results, considering the specificities of the simulated traffic and airspace, suggested that:

- The use of EFPL performance data could allow a significant improvement of the ground trajectory prediction accuracy, especially during the climb phase: the error in predicted vertical rate is pretty decreased.

As a consequence, some ATC applications, using these predictions showed the following metrics estimates improvement:

- Conflict detection metrics for all simulated traffic: it was noted a reduction in both missed conflicts and nuisance alerts rates. The main improvement was for conflicts involving traffic in evolution.
- A better prediction of sector entry times (and therefore a better estimation of the sector flight duration), in particular for flights entering the sectors in descent.

The obtained results need to be considered as indicative and should not be taken in isolation.

1.3 Project Deliverables

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

Reference	Title	Description
D13	Phase1 Closure	This document provides a summary of the TMF Phase 1 conclusion. The Phase 1 was focussed on the baseline construction relying on previous projects in the field of trajectory management.
D841	TMF-IOP V&V Needs for 2015	It identifies the V&V needs for trajectory management and the mapping of where those needs are validated within the programme or where there are gaps to be addressed.
D843	Internal Validation Exercise Reports	Last deliverable of a series of three FTS iterations

	VP832 (5.5.1 Deliverable - 4.5 Contribution)	to provide TMF/IOP with some quantitative results/evidence (V2 level) on potential benefits of sharing information between air and ground. Final iteration includes a refinement of the previous FTS iterations (VP721/D81 and VP777/D842), especially to take into account the flight intent changes, collecting more available real data and assessing more operational applications where air – ground data sharing may have benefits.
D846	TMF INTEROP for Step 1 Final Release (5.5.1 Deliverable – 4.5. Contribution)	It defines operational interoperability requirements for the exchange of flight and trajectory information between stakeholders in support of step 1 En Route and TMA concepts.

According to the guidelines, the repetitive deliverables of the same nature are not reported, the table only refers to the final versions. Also, documents definitively assessed with reservations have not been reported.

1.4 Contribution to Standardisation

The project 05.05.01 have contributed to standardisation activities via P4.5. During 2013, the P04.05 Project Manager led the European input to CP3.1.

CP3.1 is a coordination plan between SESAR and the FAA, looking at common concepts for the exchange of trajectory information. The aim of the coordination with the FAA is to ensure that the semantic meaning of trajectory information defined for FIXM (the Flight Information eXchange Model) is common to both regions through an agreed and understood concept of use for that information. This will promote wider acceptance of the proposed data information exchange standard among the global community.

1.5 Project Conclusion and Recommendations

Main conclusions and recommendations, mainly deriving from V2 validation activities, can be summarised as follows:

- First step of deployment may include at least the use of EFPL performance data, to improve ground TP predictions and conflict detection. In addition, recorded improvements are expected to be possible at a low cost, since the EFPL transmission to ATC is not supposed to induce significant costs.
- Use of the airborne 4D trajectory might allow as well an improvement of the ground trajectory prediction accuracy and consequently may improve conflict detection. However, more EPP real data are needed for the validation (P5.5.1 fast time simulations were based on a very limited set of available EPP data).
- The FTS iterations findings confirm some of trends highlighted by parallel exercises performed within SESAR 1 projects related to the usage of additional data and provide inputs to SESAR2020 concerned projects.
- Validation work performed for nominal conditions and under specific/theoretical assumptions should not be considered in isolation. For a global picture it may need to take into account all relevant outcomes (benefits, issues, limitations) for all relevant exercises (combining fast time, real time with human in the loop) and to cover the remaining validation gaps.

- The project's activities suggest that TP improvement during the descent phase based on EPP data will be limited compared to what can be achieved in the climb phase. The reason for this is that the descent is flown in managed mode less frequently than the climb, due to the increased ATM-induced uncertainty during this flight phase. The project could recommend that research is undertaken to increase dynamic information sharing during the execution phase from ground to air to enable better FMS descent planning and increased use of managed mode during the descent phase.
- The project worked on improving the TP with no specific TP requirements having been provided by the operational projects working on TP applications. The project could recommend that a sensitivity analysis is conducted to investigate the TP accuracy improvement that is needed for the each of the target ATM applications.

Remaining V&V needs identified in the project as not addressed in SESAR1 can be considered V&V objectives to be addressed under the SESAR2020 programme.

In addition, the requirements work related to initial IOP operational activities accommodated by the project will secure compatibility towards the final solution to be developed in SESAR2020 (full IOP PCP coverage).

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] P05.05.01 TMF in TMA, Phase1 Closure, D13, 00.01.00, 31/10/2014

[5] P05.05.01 TMF in TMA, Phase 1 - Initial Modelling Result, D04, 00.01.00, 16/02/2011

[6] P05.05.01 TMF in TMA, Phase 1 - Interim Contribution to AIRM, D07, 00.01.00, 25/08/2011

[7] P05.05.01 TMF in TMA, Phase 1 - Preliminary Modelling Result - thread1, D12, 00.01.00, 25/08/2011

[8] P05.05.01 TMF in TMA, Initial STEP2 Technical Note (5.5.1 Deliverable-4.5 Contribution), D201, 00.01.00, 10/12/2012

[9] P05.05.01 TMF in TMA, Phase 1 - TMA TMF Initial OSED, D01, 00.01.00, 12/02/2011

[10] P05.05.01 TMF in TMA, Phase 1 - Initial SPR, D02, 00.01.00, 12/02/2011

[11] P05.05.01 TMF in TMA, Phase 1 - Initial INTEROP, D03, 00.01.00, 16/02/2011

[12] P05.05.01 TMF in TMA, Phase 1 - V2 Validation Plan, D05, 00.01.00, 02/08/2011

[13] P05.05.01 TMF in TMA, Phase 1 - TMA TMF Advanced OSED, D09, 00.01.00, 19/08/2011

[14] P05.05.01 TMF in TMA, Phase 1 - Advanced SPR, D10, 00.01.00, 25/08/2011

[15] P05.05.01 TMF in TMA, Phase 1 - Advanced INTEROP, D11, 00.01.00, 22/08/2011

[16] P05.05.01 TMF in TMA, STEP1 Validation Needs (5.5.1 Deliverable-4.5 Contribution), D501, 00.01.00, 01/06/2012

[17] P05.05.01 TMF in TMA, Updated STEP1 Validation Needs (5.5.1 Deliverable-4.5 Contribution), D502, 00.01.00, 15/03/2013

[18] P05.05.01 TMF in TMA, Dxx TMF-IOP Co-ordination with OFA Report 2014, D838, 00.01.00, 16/03/2015

[19] P05.05.01 TMF in TMA, TMF-IOP Co-ordination with OFA Report 2015, D839, 00.01.00, 09/12/2015

[20] P05.05.01 TMF in TMA, Dxx TMF IOP V&V Needs for 2014 (5.5.1 Deliverable-4.5 Contribution), D840, 00.01.00, 11/07/2014

[21] P05.05.01 TMF in TMA, Coordination Report 1 (5.5.1 Deliverable - 4.5 Contribution), D401, 00.01.00, 06/08/2014

[22] P05.05.01 TMF in TMA, TMF INTEROP for Step 1 Final Release (5.5.1 Deliverable - 4.5 Contribution), D846, 00.01.00, 28/10/2016

[23] P05.05.01 TMF in TMA, TMF-IOP V&V Needs for 2015, D841, 00.01.01, September 2015

[24] P05.05.01 TMF in TMA, Internal Validation Exercise Reports VP721, D81, 00.01.00, May 2014

[25] P05.05.01 TMF in TMA, Dxx Internal Validation Exercise VP777, D842, 00.01.00, June 2015

[26] P05.05.01 TMF in TMA, Internal Validation Exercise Reports VP832 (5.5.1 Deliverable - 4.5 Contribution), D843, 00.01.00, September 2016

[27] P4.5 TMF in Enroute, TMF INTEROP Initial Release, D823, 00.01.01, December 2015

[28] P04.05 TMF in Enroute, TMF Technical Note for 2014, D822, 00.01.00, December 2014

[29] B.01 Integrated Roadmap DS16 Release Note, D84, 00.01.00, May 2016

-END OF DOCUMENT-