Final Project Report

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Abstract

The objective of the project has been to bring together several navigation solutions, analyse the potential combined capabilities of GNSS and non-GNSS Navigation Technologies versus PBN and precision approach requirements in a roadmap perspective and taking into account aspects of performances (accuracy, integrity, continuity and availability), quality of service, interoperability, back-up role, certification issues and institutional concerns and select the most adequate combination for deployment in ECAC. This project has delivered the SESAR Navigation Baseline for 2020 and 2030 timelines integrating contributions from our partners from 15.3.2, 15.3.4 and civil and military Airspace Users. This project has provided inputs to update the Navigation elements of the ATM Master Plan

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] EUROCONTROL	[redacted]	15/06/2016

Reviewed By - *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] INDRA	[redacted]	20/06/2016
[redacted] EUROCONTROL		20/06/2016
[redacted] EUROCONTROL		20/06/2016
[redacted] AIRBUS		20/06/2016
[redacted] SELEX		20/06/2016
[redacted] Finmeccanica		20/06/2016
[redacted] INECO (ENAIRE)		20/06/2016

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	Position & Title	Date
[redacted] THALES	[redacted]	20/06/2016

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] INDRA	[redacted]	20/06/2016
[redacted] /Enaire		20/06/2016
[redacted] AIRBUS		20/06/2016
[redacted] SELEX Consortium		20/06/2016
[redacted] Finmeccanica		20/06/2016
[redacted] EUROCONTROL		20/06/2016

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

Rational for rejection
None.

Document History

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00.01.00	21/06/2016	Final		Updated version that summarises D9 results
00.01.01	15/07/2016	Final		Implements comments discussed during GATE meeting
00.01.02	08/12/2016	Final		Implements final SJU

				comments

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This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ATM	Air Traffic Management
A-PNT	Alternative Positioning Navigation and Time
PBN	Performance Based Navigation
RNP	Required Navigation Performance

1 Project Overview

The 15.03.01 project has developed the SESAR Navigation Baseline defined as the adequate combination of different Navigation systems (i.e. GNSS, Conventional Navaids and A-PNT), to support PBN and Precision approach applications for 2020 and 2030 timelines. The project has also produced roadmaps for the transition and provided the recommendations that have been used to update the navigation system enablers of the ATM Master Plan.

1.1 Project progress and contribution to the Master Plan

The project contributed to the ATM Master Plan through recommendations to update the Navigation system enablers in line with the SESAR Navigation Baseline for 2020 and 2030 timelines. The project has been acting as federating project of all navigation projects in SESAR 1 (15.3), coordinating inputs from projects on specific navigations systems (e.g. 15.3.2 on conventional Navaids and 15.3.4 on GNSS).

The methodology applied in the project is based in on these 3 sequential tasks:

1) Operational needs: Definition of the operational requirements coming from navigation applications and the corresponding performance requirements in terms of availability, continuity, integrity and accuracy (e.g. performance requirements related to the use of RNP 1 in a TMA). This task has taken as main inputs the PBN related regulations (e.g. PCP on PBN), SESAR CONOPS, ICAO Global Air Navigation Plan, European strategies on Navigation, PBN specifications and ICAO SARPS. However, these requirements could change depending on the content of the final version of the EASA regulation on PBN.

2) System analysis: Definition of adequate combination of Navigation systems (e.g. DMEs, VORs, and GNSS including GPS, EGNOS and Galileo) to support the required operational requirements considering safety, capacity, cost efficiency, environment as evaluation criteria. This comprehensive assessment has considered several economic, technical, operational and regulatory aspects considering the perspectives of ANSPs and airspace users. Real time simulations have been carried out to bridge the gap between the operational domain and system technical domains. The simulations allowed to assess the operational impact for pilots and Air Traffic Controllers of a GNSS failure, and to determine the capabilities of the systems to be used as GNSS backup (e.g. conventional navaids like DMEs). This system analysis has been customised to a set of operational scenarios (e.g. complex/busy TMA or airport, low density En route sectors…) that are representative to most of the real operational scenarios of Europe.

3) ATM Master Plan updates: The project provided the inputs to update in the following enablers of the Master Plan through Data Sets from 12 to 16.

Code	Name	Project contribution	Maturity at project start	Maturity at project end
CTE-N01	GPS L1/L5	Enabler defined and introduced in the ATM MP following the project request, in coordination with project 15.3.4	TRL4	TRL6

CTE-N02	GALILEO E1/E5	Enabler defined and introduced in the ATM MP following the project request, in coordination with project 15.3.4	TRL4	TRL6
CTE-N03	GLONASS-K	Enabler defined and introduced in the ATM MP following the project request, in coordination with project 15.3.4	TRL4	TRL6
CTE-N04	BEIDOU B1/B5	Enabler defined and introduced in the ATM MP following the project request, in coordination with project 15.3.4	TRL4	TRL6
CTE-N05	GNSS performance assessment system	Enabler defined and introduced in the ATM MP following the project request, in coordination with project 15.3.4	TRL2	TRL4
CTE-N06	Space Based Augmentation System (SBAS)	NA - The enabler refers to a mature system which was in the deployment phase at start of the project	TRL8	TRL9
CTE-N06a	EGNOS V2.4.X	Enabler defined and introduced in the ATM MP following the project request, in coordination with project 15.3.4	TRL4	TRL8
CTE-N06b	EGNOS V3	Enabler defined and introduced in the ATM MP following the project request, in coordination with project 15.3.4	TRL2	TRL4
CTE-N07	Ground Based Augmentation System (GBAS)	The enabler covers the various technological solutions for GBAS implementation. The project introduced the change request for the introduction of the specific technology enablers (CTE-N07a/b/c)	TRL8	TRL9
CTE-N07a	GBAS Cat I based on Single-Constellation / Single-Frequency GNSS (GPS L1)	NA - The enabler refers to a mature system which was in the deployment phase at start of the project	TRL8	TRL9
CTE-N07b	GBAS Cat II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1)	Enabler defined and introduced in the ATM MP following the project request, through coordination with projects 15.3.4 and 15.3.7	TRL4	TRL6
CTE-N07c	GBAS Cat II/III based on Multi-Constellation / Multi-Frequency (MCMF) GNSS (GPS + GALILEO / L1 + L5)	Enabler defined and introduced in the ATM MP following the project request, through coordination with projects 15.3.4 and 15.3.7	TRL2	TRL4
CTE-N07d	GBAS service volume extension	Enabler defined and introduced in the ATM MP following the project request, through coordination with project 15.3.7	TRL2	TRL2
CTE-N08	DME Ground Infrastructure optimisation	Enabler defined and introduced in the ATM MP following the project request, through coordination with project 15.3.2	TRL7	TRL8

CTE-N09	ILS (Instrument Landing System)	NA - the enabler refers to a fully mature system which needs to be maintained in operation in parallel with the new navigation enablers	TRL9	TRL9
CTE-N10	Microwawe Landing System (MLS)	NA - the enabler refers to a fully mature system which needs to be maintained in operation in parallel with the new navigation enablers	TRL9	TRL9
CTE-N11	NDB Decommissioning	Enabler defined and introduced in the ATM MP following the project request, through coordination with project 15.3.2	TRL7	TRL8
CTE-N12	VOR/DME MON (Minimum Operational Network)	Enabler defined and introduced in the ATM MP following the project request, through coordination with project 15.3.2	TRL7	TRL8
CTE-N13a	A-PNT (Alternative Positioning Navigation and Timing)	Enabler defined and introduced in the ATM MP following the project request, through coordination with project 15.3.2	TRL1	TRL2
CTE-N14	Rationalisation of approach and landing systems	Enabler defined and introduced in the ATM MP following the project request, through coordination with project 15.3.2	TRL7	TRL8
CTE-NGOV01	Ground Navaids Optimisation/Rationalisation Plans	Enabler defined and introduced in the ATM MP following the project request, through coordination with project 15.3.2	TRL7	TRL8

In addition the project has recommended further updates of navigation related enablers to be implemented through SESAR 2020 programme.

Deliverables of the project have been reviewed by civil and military AUs that have participated to the project. Intermediate results of the project have been presented to aviation stakeholders not participating in SESAR (e.g. through EUROCONTROL Navigation Steering Group and ICAO PBN Task Force).

1.2 Project achievements

1) The project has developed the SESAR Navigation Baseline and roadmap that gives the strategy on the evolution of navigation systems (e.g. GPS, Galileo, EGNOS, DMEs, VORs, ILS, A-PNT,..) in Europe considering the perspectives of different stakeholders (e.g. civil and military users, ANSPs and industry) involved in the project. The results of the project are a good basis to continue consultation with European stakeholders to reach a wider consensus on the final results.

2) Recognising the fact that "one size does not fit all", the SESAR Navigation Baseline has been customised to a set of operational scenarios that are representative of most of specific real scenarios of European airspace.

3) The project has provided recommendations on future evolutions of the navigation system enablers of the ATM Master Plan and provided European inputs to evolution of ICAO Global Air Navigation Plan.

4) The project has developed a 18 pages executive summary of a comprehensive navigation systems study (15.3.1 D9) that provides a succinct description of the Navigation system part of the ATM Master Plan.

5) The project has provided the navigation elements of the CNS roadmap developed in 15.1.7 in SESAR I and that will be further developed in SESAR 2020 (PJ 14).

6) The project has provided the European inputs to the joint SESAR/Next Gen Navigation systems roadmap that is being developed through Coordination Plan 4.8.

7) The project has made recommendations of the decisions to be taken on regulatory, standardisation and deployment support to enable the implementation of the prosed strategy.

8) Results from this project have contributed to the Pilot Common Project on PBN for 24 airports and to comment PBN rulemaking.

9) The Real Time Simulations carried out within this project have provided very valuable information about the operational impact (for ATC and pilots) of a GPS outage in a RNP environment and associated considerations regarding the performance and robustness needed for Navigation systems.

The contribution from 15.3.2 and 15.3.4 and the engagement from AUs has been instrumental to the project achievements.

1.3 Project Deliverables

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

Reference	Title	Description
15.3.1 D8	SESAR Navigation performance requirements	This document updates and consolidates the requirements collected by 15.3.1 D03 specifying the navigation operational requirements for 2020 and 2030
15.3.1 D9	SESAR Navigation Baseline and roadmap (steps 1&2)	This document develops the adequate combination of different Navigation systems (i.e. GNSS, Conventional Navaids and A-PNT), to support PBN and Precision approach applications for 2020 and 2030 timelines. This deliverable is building upon the results of 15.3.1 D4 and D5. The document includes a short executive summary and recommendations on the updates of the ATM Master Plan.
15.3.1 D12	Final report on RTS on RNP reversion (GPS outage)	This deliverable presents the main results of Real Time Simulations that were conducted to assess the operational impact in case of a RNP reversion following a GPS loss in the context of the PBN introduction in Europe. This work has contributed to define the Navigation operational requirements and subsequently the adequate combination of GNSS and alternative navigation capabilities (e.g. DME/DME or DME/DME/INS).

1.4 Contribution to Standardisation

The project results did not have a direct impact on standards. However some results of the project (e.g. Results of Real time simulations on RNP reversion) have been presented to ICAO PBN Study Group, Navigation Systems Panel and are being considered to develop amendments to SARPS Annex 10 and to update the PBN manual.

1.5 Project Conclusion and Recommendations

The project has:

- Developed the SESAR Navigation Baseline and roadmap that provides the short and long term strategy on the evolution of navigation system in Europe (Deliverable 09);

- Provided the key navigation artefacts to enable the update the "Navigation System Enablers" of the "ATM Master Plan";

- Provided the navigation elements of the CNS roadmap developed in "CNS System of System" Project (15.1.7) in SESAR 1 and that will be continued in SESAR 2020 (PJ 14);

- Provided recommendations of the decisions to be taken on regulatory, standardisation and deployment support to enable the implementation of the prosed strategy;

In order to maximise the impact of the project output, the project recommends that the "SESAR Navigation Baseline and roadmap (15.03.01 D9)" be:

- Distributed to the European stakeholders (e.g. ICAO PBN Task Force and EUROCONTROL NSG) for consultation aiming at reaching consensus and buy-in from the community.

- That the document with the feedback received from stakeholders, is handed over to SESAR 2020 (PJ 14) to consolidate the CNS roadmap that was initiated in SESAR I (15.3.7).

- That the document with the feedback received from stakeholders is taken as a key contribution to further develop the NAV systems roadmap with Next Gen through the Coordination Plan 4.8.

- Be used to propose updates to the ATM Master Plan and to develop further research work in particular on Multi Constellation GNSS and A-PNT within the SESAR 2020 Programme.

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

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