Final Project Report

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THALES.	

Abstract

The P10.07.01 project aimed at contributing to the enhanced data link technical requirements for ground systems in all environments.

These requirements were developed and verified by providing the Air-Ground exchanges capability to En-Route, Approach and Airport projects supporting validation in pre-industrial ground platforms. These validations improved the SESAR (Single European Sky ATM Research) data link concepts enablers' maturity level.

The Technical Specification was finalised with continuous validation outcomes that also contributed to the final EUROCAE (European Organisation for Civil Aviation Equipment) / RTCA (Radio Technical Commission for Aeronautics) ATN B2 (Aeronautical Telecommunication Network Baseline 2) published standard.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	**Position & Title**	**Date**
███████ THALES	████████████	16/08/2016

Reviewed By - *Reviewers internal to the project.*		
Name & Company	**Position & Title**	**Date**
████████ ENAV	████████████	26/08/2016
████████ EUROCONTROL		26/08/2016
████████ EUROCONTROL		26/08/2016
████████ INDRA		26/08/2016
████████ (SELEX)		26/08/2016

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	**Position & Title**	**Date**
████████ THALES	████████████	29/08/2016
████████ THALES		02/09/2016
████████ THALES		29/08/2016
████████ THALES		02/09/2016
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████████ AIRBUS		31/08/2016
████████ NORACON		01/09/2016
████████ LEONARDO (SELEX)		02/09/2016

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	**Position & Title**	**Date**
████████ THALES	████████████	07/09/2016
████████ THALES		07/09/2016
████████ ENAV		07/09/2016
████████ EUROCONTROL		07/09/2016
████████ INDRA		07/09/2016
████████ LEONARDO (SELEX)		07/09/2016
████████ NORACON		07/09/2016

Rejected By - *Representatives of the company involved in the project.*		
Name & Company	**Position & Title**	**Date**

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This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
4D	Four Dimensional
4DTRAD	4-Dimensional Trajectory Data Link
ADS-C	Automatic Dependent Surveillance - Contract
AGDL	Air Ground Data Link
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATN B1	ATN Baseline 1
ATN B2	ATN Baseline 2
ATS	Air Traffic Services
CTA	Controlled Time of Arrival
CTO	Controlled Time of Over flight
CP	Coordination Plan
CPDLC	Controller Pilot Data Link Communication
D-TAXI	Data Link Taxi
DCL	Departure Clearance
EPP	Extended Projected Profile
ETA	Estimated Time of Arrival
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
FDP	Flight Data Processor
i4D	Initial Four Dimensional
INTEROP	Interoperability Requirements
IPS	Internet Protocol Suite
LSD	Large Scale Demonstration

PCP	Pilot Common Project
PEGASE	Providing Effective Ground & Air data Sharing via EPP
RTCA	Radio Technical Commission for Aeronautics
RTS	Real Time Simulation
SC	Special Committee
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
SPR	Safety and Performance Requirements
TBO	Trajectory Based Operations
USA	United States of America
VDL	VHF Data Link
VHF	Very High Frequency
WG	Working Group

1 Project Overview

The project was a technical project which focused on the implementation of the Enhanced Datalink Services in the Datalink ground functional blocks and their provision to other En-Route, Approach and Airport projects.

1.1 Project progress and contribution to the Master Plan

P10.07.01 project had a supportive datalink role and provided datalink expertise to various ground stakeholders in the following way:

- Work in close collaboration with airborne prototypes providers
- Provide ground prototypes with enhanced datalink services in consolidated En-Route/Approach and Airport ground systems
- Provide datalink support during validation exercises
- Provide feedback to EUROCAE / RTCA standardisation working groups

The project first developed an initial technical specification, architecture definition and Air-Ground interoperability definition, to implement and verify ground prototypes ready for early validation. This activity used the pre-standard Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP) material from EUROCAE Working Group 78 (WG78) / RTCA Special Committee 214 (SC-214) standardisation groups. This has been done in close cooperation with related technical and operational projects.

The main targeted datalink concepts validated by SESAR operational projects were:

- Initial Four Dimensional (i4D) / Controlled Time of Arrival (CTA) in En-Route/approach domains to synchronise Four Dimensional (4D) trajectory and improve predictability on arrival
- Departure Clearance (DCL) / Data Link Taxi (D-TAXI) in Airport domain to improve the surface movement

The DCL/D-TAXI SESAR concept involved the new DCL and D-TAXI services of the Controller Pilot Data Link Communication (CPDLC) application defined by EUROCAE WG78 / RTCA SC-214 standardisation groups.

The i4D/CTA concepts involved the new 4-Dimensional Trajectory Data Link (4DTRAD) service of both CPDLC and ADS-C (Automatic Dependent Surveillance - Contract) applications defined by EUROCAE WG78 / RTCA SC-214 standardisation groups. The 4DTRAD service allows the aircraft trajectory sharing thanks to reception of Extended Projected Profile (EPP).

In the second phase, the project implemented modifications required by operational projects after feedback from their validation exercises. Finally this phase was depicted in four yearly iterations to refresh the ground prototypes with modifications improving maturity step by step.

The outcomes from those operational validations were taken into account to improve the technical requirements with intermediate releases for prototype implementation and provide feedback to EUROCAE WG78 / RTCA SC-214 groups. Those technical requirements were finalized in the last edition of the Technical Specification.

P10.07.01 project contributed to the maturity evolution of several SESAR Enablers but the project was only responsible of the datalink ground functional blocks.

The following table lists the SESAR Enablers that the project contributed to with the maturity at the P10.07.01 project level:

Code	Name	Project contribution	Maturity at project start	Maturity at project end
AERODROME-ATC-02a	Surface movement management tools updated to provide the D-TAXI information to the pilot in Step 1	Definition and verification of ground prototypes that provide DCL and D-TAXI capabilities. Prototypes have been integrated in Airport pre-industrial platforms and validated in two different airport environments.	TRL3	TRL6
ER APP ATC 100	4D Trajectory Management in Step 1 - Synchronization of Air and Ground Trajectories	ER APP ATC 100 is concerned with the ground Flight Data Processor (FDP) capability to use information in the downlinked EPP trajectory to update the planned (ground) trajectory of the flight. The contribution of 10.07.01 lay in the provision of the airborne trajectory and hence fulfilled an ancillary role in the validation of ER APP ATC 100. Definition and verification of ground prototypes that provide the 4D trajectories received form aircraft to enhanced FDP. Prototypes have been integrated in En-Route pre-industrial platforms and validated in two different En-Route environments. (*) Maturity is TRL5 at the P10.07.01 level even if TRL4 was identified by the responsible of the enabler	TRL3	TRL5*
ER APP ATC 119	Enhance Air/Ground Data Communication for Step 1	Definition and verification of ground prototypes that provide enhanced Air Ground communication capability. Prototypes have been integrated in En-Route and Approach pre-industrial platforms and validated in three different En-Route and Approach environments, including two flight trials.	TRL3	TRL6
ER APP ATC 149a	Air-Ground Datalink Exchange to Support i4D - Extended Projected Profile (EPP)	Definition and verification of ground prototypes that provide EPP capability Prototypes have been integrated in En-Route and Approach pre-industrial platforms and validated in three different En-Route and Approach environments, including two flight trials.	TRL3	TRL6
ER APP ATC 149b	Air-Ground Datalink Exchange to Support i4D - Controlled Time	Definition and verification of ground prototypes that provide Estimated Time of Arrival (ETA) Min/Max	TRL3	TRL6

	of Arrival/Overflight (ETA Min/Max)	capability Prototypes have been integrated in En-Route and Approach pre-industrial platforms and validated in three different En-Route and Approach environments, including two flight trials.		
ER APP ATC 149c	Air-Ground Datalink Exchange to Support i4D - Controlled Time of Arrival/Overflight (CTA/CTO)	Definition and verification of ground prototypes that provide Control Time of Arrival (CTA) / Control Time of Over flight (CTO) capability Prototypes have been integrated in En-Route and Approach pre-industrial platforms and validated in three different En-Route and Approach environments, including two flight trials.	TRL3	TRL6

The project contributed to the following SESAR Solutions:

- #06: Controlled Time of Arrival (CTA) in medium-density / medium-complexity environments
- #23: D-TAXI service for Controller Pilot Data Link Communication (CPDLC) application

The project has actively contributed to the maturity of the ATN B2 standard by bringing verification and validation feedback to the EUROCAE WG78 / RTCA SC-214 groups.

This work performed during the project will be the basis for the implementation and deployment of the new ATN B2 standard necessary for the Pilot Common Project (PCP) AF#6 and the SESAR2020 projects related to trajectory synchronisation.

1.2 Project achievements

P10.07.01 project main achievement was the datalink technical requirements that were refined to take into account the outcomes of the validation activities. These technical requirements were finally consolidated in the last edition of the Technical Specification by also including a gap analysis with the published ATN B2 standard.

P10.07.01 project contributed to the development and verification of datalink aspects of several technical enablers related to i4D/CTA and DCL/D-TAXI concepts that were integrated and validated with other prototypes in both En-Route/Approach and Airport domains. It has been achieved by the delivery of 13 prototypes versions and 5 testing tools versions addressing operational needs.

Those prototypes version took part of the SESAR validation plan that demonstrated the maturity of several SESAR solutions as presented above in the previous section.

In total, the project supported:

- 10 validations exercises in En-Route/Approach domain supporting i4D/CTA
- 3 validations exercises in Airport domain supporting DCL/D-TAXI

These validation exercises were mainly Real Time Simulation (RTS) but included also two flight trials that validated the real communication between an aircraft flying over two ground systems, the transition between two ground i4D systems and the concept of a shared trajectory thanks to reception of EPP.

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The RTS supported by the project, assessed different scenarios difficult to put in place in flight trials like mixed fleet aircrafts; ATN B2, ATN Baseline 1 (ATN B1) and non-equipped aircraft.

The project also developed a Test Tool allowing End-to-End Interoperability testing for Ground or Air implementation supporting Advanced Datalink Applications as defined by EUROCAE WG78 / RTCA SC-214 standardisation groups.

Several ground prototypes developed in the project were used during the Large Scale Demonstration (LSD) PEGASE (Providing Effective Ground & Air data Sharing via EPP) that involved several ferry flights to collect realistic EPP data and during the Iris Precursor technical exercises to demonstrate the feasibility of using satellite link.

1.3 Project Deliverables

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

Reference	Title	Description
D28	Standardisation Study - Phase 2	This document contains the final report concerning the coordination activities with EUROCAE WG78 / RTCA SC-214.
D46	D10.7.1-9 - Testing Platform - Tools Requirements for ATC System - Phase 1	This document defines the technical requirements for Test Tools to perform End-to-End Interoperability testing for Ground or Air implementation supporting Advanced Datalink Applications as defined by EUROCAE WG78 / RTCA SC-214 standardisation groups.
D76	D10.7.1 - AGDL System Requirements - Final TS 2016	Final AGDL technical specification taking into account the last validation feedback. It includes the Air-Ground interoperability definition and a gap analysis between SESAR prototypes implementation and the published ATN B2 standard. It is the final version of the technical specification that was periodically updated during the project life.

1.4 Contribution to Standardisation

The project contributed to the maturity of the ATN B2 standard by providing prototype implementation and validation feedback to the EUROCAE WG78 / RTCA SC-214 Validation Sub-Group (VSG) especially for 4DTRAD (i4D concept in SESAR) and D-TAXI services.

The project contributed to the maturity of the ATN Baseline 2 Standard which is now published by EUROCAE and RTCA in revision A:

- ED-228A / DO-350A: Safety and Performance Standard for Baseline 2 Air Traffic Services (ATS) Data Communications (BASELINE 2 SPR STANDARD)

- ED-229A / DO-351A: Interoperability Requirements Standard for Baseline 2 ATS Data Communications (BASELINE 2 INTEROP STANDARD)

- ED-230A / DO-352A: Interoperability Requirements Standard for Baseline 2 ATS Data Communications, FANS 1/A Accommodation (FANS 1/A – BASELINE 2 INTEROP STANDARD)

- ED-231A / DO-353A: Interoperability Requirements Standard for Baseline 2 ATS Data Communications, ATN BASELINE 1 Accommodation (ATN BASELINE 1 – BASELINE 2 INTEROP STANDARD)

This standard is the baseline for the next steps of SESAR and the deployment.

In the context of United States of America (USA) / European Union (EU) Memorandum of Cooperation, the project contributed to the Coordination Plan (CP) CP4.5 - Data-link services (applications) by reviewing the plan and assessing the actions taken to monitor the coordination.

1.5 Project Conclusion and Recommendations

The Datalink is a key technical enabler of SESAR deployment especially for Trajectory Based Operations (TBO).

It has been demonstrated during this project that with a close coordination with the standardisation group (i.e. WG78/SC-214), prototype implementations and operational validation, new concepts become mature enough for next steps. It is easier to change the standard before its publication based on verification and validation feedback.

It has been demonstrated that implementation of Enhanced Datalink Services (e.g. ATN B2) to support Air-Ground exchanges will be feasible but further validation activities are needed to secure convergence between latest version of the standard and the prototypes implementations.

It is recommended to continue Air-Ground Interoperability testing with various airborne implementations when the last ATN B2 published standard will be implemented. This kind of validation activity is a good candidate for SESAR2020 and the LSD i4D/EPP.

It is recommended to extend the validation activities by defining the use of EPP in ATC and Airport automation ground systems to secure the PCP - AF#6 deployment. This kind of validation activities are good candidates for SESAR2020.

It is recommended to extend the R&D activities to other new ATN B2 datalink services than the 4DTRAD, DCL and D-TAXI.

It is recommended to continue the USA-EU Global Harmonization on Datalink by avoiding unaligned implementations. The only way is to have a clear deployment plan with agreed EUROCAE / RTCA ATN B2 release to implement and deploy.

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