



Final Project Report

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Abstract

This document reports on the work performed by project Airport Surface Taxi Clearance - D-TAXI which was in charge of defining, validating and implementing the on-board taxi routing function, on both mainline and regional aircraft.

The taxi routing function encompasses both the on-board implementation of the D-TAXI service and the manual taxi routing function, as defined in OFA (Operational Focus Area) 04.02.01 OSED (Operational Services and Environment Definitions : ref [7]).

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Acronyms

Acronym	Definition
ADA	Architecture Definition Assumptions
ADB	Aeronautical DataBase
AMDB	Airport Mapping Data Base
AMM	Airport Moving Map
ARINC	Aeronautical Radio Incorporated
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASRN	Aerodrome Surface Routing Networks
ATCo	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Services
CPDLC	Controller–pilot data link communications
D-TAXI	Datalink TAXI
ED	EUROCAE Document
OFA	Operational Focus Area
OI	Operational Improvement
OSD	Operational Services and Environment Definitions
RTCA	Radio Technical Commission for Aeronautics
RTS	Real Time Simulation
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
SPR	Safety Performance Requirements
TVP	Technical Validation Plan
TVR	Technical Validation Report
VALP	VALidation Plan
VALR	VALidation Report

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4 of 14

WG	Working Group
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1 Project Overview

The project Airport Surface Taxi Clearance (D-TAXI) was in charge of defining, implementing, and validating the on-board taxi routing function, for both mainline and regional aircraft.

The taxi routing function encompasses both the on-board implementation of the D-TAXI service and the manual taxi routing function, as defined in OFA (Operational Focus Area) 04.02.01 OSED (Operational Services and Environment Definitions - ref[7])

1.1 Project progress and contribution to the Master Plan

The project started its execution phase in January 2010 and is expected to be closed on 27/06/2016. The project addressed the following aspects:

Technical aspects:

- On-board datalink communications enabling the exchange of Surface Operations data-link requests/info/instructions between the flight crew and ATCo (e.g. Start-up approval, provision of taxi clearances), through the use of CPDLC (Controller–pilot data link communications) application.
- Graphical display of taxi routing information (“Expect Taxi”) and taxi clearances on airport surface, for taxi-out & taxi-in phases,
- Manual taxi routing function (onboard standalone function added during the lead-time of the project via a specific change request, allowing the flight crew to manually enter the taxi routes elements and obtain a graphical display),

Development aspect:

- Provision of airborne mock-ups and prototypes (D-TAXI + manual taxi) to operational projects, to be used within validation exercises

Standardisation aspect:

- Participation to EUROCAE WG-78 (Working Group) activities to challenge the set of Datalink messages for D-Taxi operations.

The project addressed mainline and regional aircraft. It was led by Airbus Operations SAS and involved Thales group and Leonardo.

The project was structure into two phases:

- The initial package
- The advanced package

These 2 phases correspond to 2 different maturity steps and the main difference deals with the type of airports databases used (AMDB). Different types of aircraft were addressed: mainline and regional; the specificities of aircraft mainly rely on the basic architecture depending on the type of aircraft. Then different maturity levels were assessed depending on performed test and validation.

The project addressed the following OI step:

Code	Name	Project contribution	Maturity at	Maturity at
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			project start	project end
OI/EN code		Summarize in one paragraph (~100 words)	V-level / TRL	V-level / TRL
AUO-308 - A	Datalink Services used for Provision of Ground-related Clearances and Information for Step 1	The project was contributing to this OI (Operational Improvement) step, with the definition, validation and implementation of D-TAXI (on-board) datalink for start-up/pushback/taxi (finalised in exe #719 for mainline aircraft).	V1	V3 for mainline aircraft V2 for regional aircraft
AUO-603 - A	Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing in Step 1	The project was contributing to this OI step, with the definition, validation & implementation of display of the airport layout, the aircraft's own position, the route and the taxi clearances. (finalised in exe #719 for mainline aircraft).	V1	V3 for mainline aircraft V2 for regional aircraft
A/C-31a	A/C-31a — Data link communication exchange for ATN baseline 2 (FANS 3/C)	Definition of Aircraft requirements for mainline and regional aircraft	V1 (TRL1)	V3 (TRL6) for mainline
A/C 24	Airport moving map and own aircraft position display in cockpit	Definition of Aircraft requirements for mainline and regional aircraft	V1 (TRL1)	V3 (TRL6) for mainline V2 (TRL4) for regional
A/C 42a	Onboard graphical display of taxi clearance using common air/ground airport database	Definition of Aircraft requirements for mainline and regional aircraft	V1 (TRL1)	V3 (TRL6) for mainline

Besides, the project contributed to the following SESAR Solutions:

#23 – D-TAXI service for CPDLC application (partly):

This on-board solution, as developed in the project, deals with the on-board implementation of the D-TAXI service, through the exchange of D-TAXI messages with the ATCo, the textual display of these messages and the graphical display of taxi routes (expected and cleared taxi routes)

#26 – Manual taxi route:

The manual taxi, specifically developed within the project, is a function provided to pilots to allow them to enter the taxi route given by voice by the controller in an aircraft system. The system displays graphically the route on an airport moving map.

1.2 Project achievements

The project has defined, implemented and validated the on-board part of the taxi routing function for mainline and regional aircraft.

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The taxi routing function encompasses both the on-board implementation of the D-TAXI service and the manual taxi routing function, as defined in OFA 04.02.01 OSED.

The initial package (maturity level 1) used the AMDB in ARINC 816-1 (ED99B) format (the only format available at the beginning of the project). This ARINC standard version, currently used in service on existing airport moving map (AMM), does not include the connectivity information called Aerodrome Surface Routing Networks (ASRN).

This information is necessary to build a graphical taxi route on an AMM, as it clearly mentions which taxi elements are connected to a given taxi element, and has been added by standardization group EUROCAE WG-44 in the next ARINC 816-2 (ED99C) standard.

Consequently, for the initial package and in coordination with Aeronautical databases project, it has been decided not to wait for the publication of ARINC 816-2 standard and to develop an additional algorithm (done by Thales) so as to generate the connectivity information on top of existing ARINC 816-1 databases. The assessment of this algorithm has allowed the project to provide the EUROCAE WG-44 (in charge of AMDB and ASRN definition) with results that were found useful by the standardisation group when it defined the ARINC 816-2 standard.

Initial package activities led to:

- Definition of common functional requirements (for both mainline & regional aircraft)
- Mock-up (V2) development and verification for mainline & regional aircraft, on research simulator,
- Real systems prototypes (V3) development and verification on integration simulator (no flight tests) for mainline aircraft
- Operational evaluations using mainline mock-up (V2), led by 06.07.02 and performed with Eurocontrol (coupling between Airbus research simulator and Eurocontrol ITWP test platform).

The advanced package (maturity level 2) used the AMDB in ARINC 816-3 (ED99D) format that include the apron areas (stands and gates) as well as the de-icing areas. A modification of databases format was manually introduced to extend the ASRN network up to apron & de-icing areas. The modifications of this database format were shared with the EUROCAE WG-44 and taken into account by this standardization group into the next standard to come (ED99D, ARINC 816-3, publication planned end 2016).

Advanced package activities led to:

- Update of common functional requirements (for both mainline & regional aircraft)
- Improvement of design from initial package, for both manual taxi & D-TAXI functionalities (bugs corrections, HMIs updates),
- Mock-up (V2) development and verification for mainline & regional aircraft, on research simulator,
- Real systems prototypes (V3) development and verification on integration simulator (including qualification for flight tests) for mainline aircraft,
- Operational evaluations using mainline mock-up (V2), led by 06.07.02 and performed with Eurocontrol (coupling between Airbus research simulator and Eurocontrol ITWP test platform),
- Operational evaluations using mainline systems prototypes (V3), performed with ENAV (RTS -Real Time Simulation- on Airbus integration simulator, coupled with ENAV & Leonardo ground platforms, then flight trial on Milan Malpensa airport using A320 aircraft and real Datalink network).

It has to be noted that both packages (initial and advanced):

- Used textual datalink exchanges between pilots & ATCo,

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- Used datalink messages from EUROCAE WG-78, updated with operational projects inputs when relevant,
- Included Manual taxi route functionality
- Were synchronized with operational projects phase 1 (at least) due to lead-time of onboard prototyping.

For regional aircraft, a specific systems and software architecture was defined. Specific mock-ups were developed and tested so as to assess the compliance with the project common functional requirements (high level FRD).

For mainline aircraft, a specific real systems architecture was defined. Specific mock-ups and prototypes were developed and tested so as to verify the compliance with the project common function requirements (high level FRD).

These mock-ups and prototypes were also provided to operational projects 06.07.02 and 06.07.03 and were involved in validation exercises.

Mock-ups and prototypes involved in validation exercises have shown a good level of maturity allowing to pass the validation objectives identified by operational projects and collecting relevant results for operational deliverables updates (OSD, SPR & INTEROP).

The project also participated to D-TAXI concept definition through a close coordination with SESAR operational projects.

1.3 Project Deliverables

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

Reference	Title	Description
D08	WA2.1 Technical Validation Plan (TVP) for D-Taxi - Advanced Package validation	Technical validation plan for Advanced package validation for mainline aircraft. The objective was to assess the compliance of the mainline prototypes with advanced package FRD (D03)
D12	WA2.3 TVR Deliverable Taxiway Clearances (initial package)	Technical validation report for Initial package validation for regional aircraft.
D13	WA2.1 High level Architecture Definition Assumptions (ADA) for D-Taxi - Advanced Package	High level Architecture Definition Assumptions for Advanced package for mainline aircraft
D23	WA2.2 Preliminary Technical Verification report (Integration simulator trials) - Initial Package	Technical validation report for Initial package validation for mainline aircraft
D37	WA2.3 TVR Deliverable Taxiway Clearances - final version	Technical validation report for Advanced package validation for regional aircraft
D38	WA2.3 High Level Architecture Definition Assumptions (ADA) (advanced package) - issue 2	High level Architecture Definition Assumptions for Advanced package for regional aircraft
D47	WA1 High level Functional Requirement Definition (FRD) for D-Taxi - Advanced Package - Final version	Final version of FRD taking into account last mainline & regional verification/validation results as well as last operational outcomes from P6.7.2 and P6.7.3

1.4 Contribution to Standardisation

The project has been involved in two different EUROCAE working groups (WG), joint with RTCA (Radio Technical Commission for Aeronautics) special committees (SC):

- WG-78 / SC-214 – Standards for Air Traffic Data Communication Services
- WG-44 / SC-217 – Aeronautical Databases

With WG-78, coordination was initiated early in the project, in coordination with project 06.07.02. It consisted first in analysing WG-78's draft SPR & OSED and deriving recommendations on changes to the set of D-TAXI messages (thus ensuring compatibility with 06.07.02 and 06.07.03 operational concepts).

In parallel, one of the verification objectives addressed with our initial package mock-ups (both regional & mainline) was to assess the initial set of WG-78 D-TAXI messages and produce additional recommendations.

These recommendations were communicated to WG-78 through a position paper in May 2011.

This coordination effort was maintained in the following years, with the project participating to meetings with WG-78 and SC-214 to progress on the definition of a set of D-TAXI messages that suits SESAR needs.

It culminated with the publication in May 2014 of ED-228 (Safety and Performance Standard for Baseline 2 ATS Data Communications (Baseline 2 SPR Standard)) ([5]) and ED-229 (Interoperability Requirements Standard for Baseline 2 ATS Data Communications (Baseline 2 Interop Standard)) ([6]), respectively DO-350 and DO-351 for RTCA, which define, among others, the D-TAXI application for the CPDLC service.

By coordinating with the standardisation body in charge of ATS (Air Traffic Services) data communications (EUROCAE WG-78), the project was able to provide early validation results regarding D-TAXI messages, that were included in the documents published by this group (ED-228 [5] and ED-229 [6]).

Finally, Verifications activities allow the assessment of WG-44 new databases format (ED99C, ARINC 816-2). Limitations were found and communicated to SESAR aeronautical database project and promoted by aeronautical database project to EUROCAE WG-44 / AEEC ADB committee. These limitations are taken into account in new AMDB standards (ED99D, ARINC 816-3).

Cooperation with WG-44 was ensured through the use of airport databases conforming to ED-99 standard during project's mock-ups and prototypes developments & validation activities.

These databases were generated and provided by aeronautical database project, based on corresponding ARINC 816 standards and for project's tests purpose.

Moreover, the project was involved in the review of WG-44s Guidelines for the Verification and Validation of AMDB ASRN for routing applications, ED-220 ([4]), prior to its publication.

Following a joint validation exercise with operational projects in 2012, 06.07.02 and the project submitted an information paper to WG-44 to provide them with relevant results regarding the use of data bases for route generation by A-SMGCS and its display on board the aircraft's moving map. This information paper notably identified some discrepancies between WG-44 and WG-78 documents, regarding the definition of some data elements common to routing and D-TAXI. This resulted in a creation of a coordination team between the two groups to resolve these inconsistencies.

Additional comments come directly from the project's validation activities, like the lack of connectivity information (ASRN) for apron & de-icing areas on the airport. These comments were taken into account by the working group WG-44 and are going to be included in a forthcoming standard release (ED99D, ARINC 816-3).

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10 of 14

1.5 Project Conclusion and Recommendations

By defining and developing the airborne segment, the project has contributed to solution #23 (D-TAXI service for CPDLC application) and solution #26 (Manual taxi route) of ATM (Air Traffic Management) Master Plan.

Data link messages dialog between ATCo and host aircraft (for taxi routing, start up, pushback etc.) has been proved and works as expected, verifications have been performed at V2 level.

The technical documents produced and validation results contribution provided by the project will pave the way for airport SESAR 2020 activities.

Validation exercises performed on D-TAXI identified a limitation of use: D-TAXI seems not adequate for time critical applications. As a consequence, the project recommends to focus on strategic use of D-TAXI concept in SESAR 2020.

As described in section 1.4, coordination between WG-78 and WG-44 is needed to ensure the interoperability of AMDB and D-TAXI messages. This interoperability is not fully completed. Thus, the project recommends to complete this interoperability.

2 References

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- [12] 9.13 D05 WA2.1 High level Architecture Definition Assumptions (ADA) for D-Taxi - Initial Package
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- [35]9.13 D47 WA1 High level Functional Requirement Definition (FRD) for D-Taxi - Advanced Package - Final version
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