Final Project Report

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Abstract

As part of the Operational Focus Area (OFA) 04.02.01 - Integrated Surface Management - P06.07.03 focused on the definition and validation of operational concept and associated requirements related to the Guidance function of the Advanced-Surface Movement Guidance and Control System (A-SMGCS) intended to support controllers and flight crews in the ground operations especially in adverse weather conditions. To this end, the project followed the European-Operational Concept Validation Methodology (E-OCVM) focusing on V2 and V3 phases based on the starting maturity level of the addressed operational concepts. The related validation activities were performed mainly via Real Time Simulations (RTS) and live trials / shadow mode validations involving both ground and airborne partners.

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Acronyms

Acronym	Definition
AGL	Airfield Ground Lighting
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATCO	Air Traffic Controller
ATM	Air Traffic Management
CPDLC	Controller Pilot Data Link Communications
D-TAXI	Data Link Taxi service
DOD	Detailed Operational Description
E-OCVM	European - Operational Concept Validation Methodology
FIB	Functional Integration Bench
FtG	Follow-the-Greens
IBP	Industry Based Platform
ICAO	International Civil Aviation Organization
INTEROP	Interoperability Requirements
ITWP	Integrated Tower Working Position
KPA	Key Performance Area
LVC	Low Visibility Conditions
LVP	Low Visibility Procedure
OFA	Operational Focus Area
OI	Operational Improvement
OSED	Operational Services and Environmental Description
PANS-ATM	Procedures for Air Navigation Services - Air Traffic Management
R/T	Radio/Telephony
RTCA	Radio Technical Commission for Aeronautics
RTS	Real Time Simulation
SPR	Safety and Performance Requirements

VBC	Virtual Block Control
VCD	Visual Cockpit Display
VSB	Virtual Stop Bars
WG	Working Group

1 Project Overview

As part of the OFA04.02.01 - Integrated Surface Management - P06.07.03 focused on the definition and validation of operational concepts, requirements and procedures related to the A-SMGCS Guidance function with the objective to support controllers and flight crew in the ground operations also in adverse weather conditions.

1.1 Project progress and contribution to the Master Plan

The project was split into two Phases detailing respectively basic and advanced surface guidance functions according to the available capabilities. During both phases, the elaboration of operational documents as well as validation plans / reports followed a top down approach by taking as input the high level Airport Detailed Operational Description (DOD) and Airport Validation strategy defined by a dedicated project within SESAR. Any validation outcomes and resulting operational concept update was considered to update those high level documents. Furthermore, reference materials concerning Transversal Areas (as Safety, Human Performance) and guidelines about performance framework have been taken as input throughout project life cycle. In this context, P06.07.03 contributed to the production of OFA04.02.01 documents in collaboration mainly with P06.07.02 "A-SMGCS Routing and Planning functions" as the Routing function is considered as an enabler for the guidance of mobiles on the assigned routes. However, the contribution to the OFA04.02.01 activities envisaged also the execution of validation activities integrating several functionalities related to the Airport environment.

The project partners, based on the outcomes of previous European projects (such as European Airport Movement Management by A-SMGCS (EMMA), European Airport Movement Management by A-SMGCS part 2 (EMMA 2), Integrated Tower Working Position (ITWP)), decided to start Phase 1 from v2 (as defined in the E-OCVM). An overview of the validation lifecycle in the context of P06.07.03 (or somehow related to P06.07.03 operational concept) is provided here below for both phases.

Phase 1 - Basic surface guidance

Phase 1 focused on initial validation of Operational Improvements concerning Data Link Taxi (D-TAXI) service, guidance assistance for vehicle drivers as well as the use of Airfield Ground Lighting (AGL) service. The execution of RTS allowed confirming the operational usability and utility to exchange "basic" instructions (as start-up, push back) between tower controllers and pilots via data link (through Controller Pilot Data Link Communications (CPDLC) application). At the same time, those exercises provided first indications about what vehicles related instructions (e.g. TOW and PROCEED) could be exchanged via data link. The definition of a "basic surface guidance" considered also the use of AGL as supporting navigation means with no combination with other guidance means.

Phase 2 - Advanced surface guidance

In addition to the concepts analysed during Phase 1 timeframe, Phase 2 focused also on the definition of Virtual Block Control (VBC) by means of Virtual Stop Bars (VSBs) and on the Manual Taxi Routing for pilots. The set of data link instructions investigated during Phase 1 has been consolidated and integrated with further messages (such as CONTACT) to assess their operational usability. The definition of an advanced surface guidance included also the on-board aircraft display of the taxi route issued by Air Traffic Controller (ATCO). Furthermore, the use of AGL for providing longitudinal spacing between mobiles in low visibility operations was investigated as well.

During both Phase 1 and Phase 2, RTS and Live Trial validations were executed by means of Tower ATC simulators interfaced with cockpit simulators, Industry Based Platforms integrating ground prototypes interfaced with cockpit simulators and Flight Test Aircraft.

The progress the project has made in increasing the level of maturity is summarized in the following table1 reporting all the Operational Improvements (OIs) the project has contributed to. The applicable version of the Integrated Road Map data base for those OIs is the latest DS16 [4]

Code	Name	Project contribution	Maturity at project start	Maturity at project end
AUO-0308-A	Datalink services used for provision of ground related clearances and information for Step 1	Confirm the usability and utility of data link service from both ATC and airborne side. In addition, the project contributed to the identification of the ground instructions which could be exchanged via data link (i.e. the non-time critical ones)	V2	Partial V3
AUO-0603-A	Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing in Step 1	Identification of information (including airport layout, aircraft's own position, route and taxi clearances issued by ATCO) to be displayed on-board to support flight crew during surface ground operations.	V2	Partial V3
AO-0222-A	Enhanced Guidance Assistance to Mobiles based on the Automated Switching of Taxiway Lights and Stop Bars according to the Airfield Ground Lighting (AGL) Operational Service	Identification of the main elements guidance information via AGL is constituted of. In addition, project focused also on the definition of the related operational procedures (including the need to standardise the concerned phraseology)	V2	V3
AO-0223	Enhanced safety in LVP through use of virtual block control	Definition of ad hoc procedures for the provision of Virtual Block Control service by means of Virtual Stop Bars when low visibility procedures are in place.	V2	V3
AO-0206	Enhanced Guidance Assistance to Airport Vehicle Driver Combined with Routing	Initial identification of the guidance information (including the status of runways and taxiways) to be provided to vehicle drivers.	V1	V2
AO-0215	Airport ATC provision of ground-related clearances and information to vehicle drivers via datalink	Initial definition of data link message which could be sent to the vehicle drivers via data link.	V1	V2

Based on the list of the covered OIs, P06.07.03 contributed to the following SESAR solutions:

- Solution #23 D-TAXI service for CPDLC application;
- Solution #26 Manual Taxi Routing function;
- Solution #47 Guidance assistance through airfield ground lighting
- Solution #48 Virtual Block Control in Low Visibility Procedures (LVPs).

In addition to the above mentioned SESAR Solutions, P06.07.03 contributed also to the definition of an improved vehicle guidance which has achieved the V2 maturity level. Therefore, it is recommended to be further investigated during SESAR 2020 horizon.

1 The table refers only to the OIs and the associated services which will be part of the final operational documents.

1.2 Project achievements

The main achievements per Key Performance Area (KPA) of P06.07.03 are split for the two Phases of the project.

Phase 1 - Basic surface guidance

Human Performance

The exchange of "basic" data link messages (such as expect taxi routing information, departure clearance, start-up, pushback) investigated during Phase 1 resulted in decrease of both controllers' and pilots' workload due to the reduction of R/T communications.

From vehicle drivers' perspective, the availability of an Airport Moving Map didn't result in a significant reduction of workload as they had to monitor two situations at the same time: the one outside the van and the one presented. Vehicle drivers' related aspects were not analysed during Phase 2 of the project, so they are recommended to be further investigated during SESAR 2020 time frame.

Safety

The exchange of data link messages between Controllers and Flight Crew leads to a reduction of potential misunderstandings which should have a consequent positive impact on Safety.

Furthermore, the definition of Follow-the-Greens procedures provided pilots with an illuminated taxi route indication on the taxiway centreline leading to an increase of their situational awareness and, therefore, to a significant improvement of safety especially in low visibility conditions.

Environment / Fuel Efficiency

The observed reduction of taxi time and start & stop cycles resulting from the use of AGL and associated Follow-the-Greens (FtG) procedures led to a reduction of average fuel consumption. About a 40% reduction in pollutants emitted by aircraft engines were calculated when using FtG.

Predictability

The use of AGL ensured more smoothness of the traffic flow related to reduction of speed changes and taxi route deviations. The resulting reduction of taxi time variability had a positive impact on predictability especially in Low Visibility Conditions (LVC).

Phase 2 - Advanced surface guidance

Human Performance

The consolidation of the set of instructions / clearances to be exchanged via data link (mainly for static operations) resulted in a further decrease of controllers' and pilots' workload mainly for static operations. Anyway, generally speaking, D-TAXI service has been shown to keep the level of workload at a reasonable level. However, the provision of TAXI clearance on complex airports via data link is recommended to be further investigated during SESAR 2020 horizon to assess the level of workload in a mixed mode environment and for the dynamic operations.

Safety

The availability of Virtual Block Control service provides controllers with a notification of VSB infringement allowing them to timely recognize hazardous situations. A further increase of situational awareness has been ensured through the introduction of new instructions (such as "CONTACT") via data link. From pilots' perspective, their situational awareness is supported by the taxi clearance display and data link communications especially for those clearances concerning the static phase of the flight and the pilots have time to check the message and the route display.

Environment / Fuel Efficiency

Implementing FtG results in reduced longitudinal spacing in low visibility conditions as well as a reduction in speed changes and smoother traffic flow with a positive impact on fuel burn and corresponding emissions.

Predictability

The availability of AGL service resulted in mobiles operating at steadier speeds with a positive impact on predictability of surface movements.

1.3 Project Deliverables

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

Reference	Title	Description
D09	Preliminary Validation exercises report Step 1	This document describes the first validation activities carried out in the context of P06.07.03. It is intended to confirm the initial maturity level of the Operational Improvements Steps addressed by project 06.07.03
D10	Final OSED and Final Operational Procedures Step 1	This document details the outcomes, in terms of operational concept and associated operational requirements, resulting from Phase 1 validation lifecycle. Therefore, it confirms the target maturity level as indicated in the first iteration of the Operational Services and Environmental Description (OSED). Furthermore, it has been considered as starting point for Phase 2 activities.
D11	Final SPR and Operational Requirements Step 1	In addition to the description of the failure approach, the document integrates the success approach as recommended by project 16.06.01 (Safety support and coordination function) guidelines. It has been considered as one of the inputs for the elaboration of the following OFA04.02.01 Safety and Performance Requirements (SPR) and Safety Assessment Report documents in collaboration with project 16.06.01
D27	Preliminary Validation exercises Phase 2 (VSB - ENAV)	This document reports the first assessment to confirm the level of maturity associated to the definition of Virtual Block Control concept investigated during phase 2. Furthermore, the outcomes are considered as useful inputs for preparing R5 activities.
D64	Preliminary Validation exercises Phase 2 (D-TAXI - ECTL-NATMIG)	As validation report of the Integration of D-TAXI and AGL exercise, the document contains useful information for preparing R5 activities. The document reports operational recommendations on the use of data link service also in a mixed mode environment (i.e. data link and voice communications) as well as the use of AGL taxiway centreline lighting and stop bars for guidance
D28	OFA04.02.01 (Integrated Surface Management) Final INTEROP	This document is the final iteration of the Interoperability Requirements (INTEROP) document at OFA04.02.01 level with the contribution of project 06.07.02. The document reports the OFA04.02.01 architecture diagram showing the interactions and the data flow among the concerned functional blocks. It is important to

		highlight that the architecture diagram has been consolidated in collaboration with project 12.01.07 "Airport Systems Specification drafting and maintenance".

In addition to the deliverables reported in the table above, P06.07.03 contributed to the production of consolidated deliverables in collaboration with P06.03.01 (i.e. D148 "Release 5 VALP and D149 "Consolidated DEL Release 5 Validation Report) and P06.07.02 (i.e. D46 "OFA04.02.01 Final OSED" and D45 "OFA04.02.01 Final SPR")

1.4 Contribution to Standardisation

Main contribution P06.07.03 has made to standardisation activities concerns the definition and validation of the D-TAXI service. The operational concept associated to the provision of ground instructions via data link corresponds to the D-TAXI service of the CPDLC application according to the standard format defined by the joint standardisation groups RTCA and EUROCAE (respectively through SC214 and WG-78). SESAR had set up coordination with SC-214/WG-78 during the development of these documents to provide the standardisation group with early validation results and guide the definition and, potentially in the future, the implementation of the D-TAXI service.

In addition, the projects discussed also about the need of standardising data link messages concerning vehicles movements (e.g. TOW and PROCEED). Nowadays, there is no specific standard defining data link messages for vehicles as D-TAXI for aircraft. Therefore, keeping in mind the different level of maturity, it is recommended to establish collaboration with relevant standardization bodies to deal with that topic during SESAR 2020 horizon.

Standardisation issues were also identified regarding the definition of the AGL as guidance means. No standardised wording exists for the guidance via AGL and, therefore, appropriate standardization bodies are required to address the issue and provide a solution (e.g. it should be defined in the ICAO PANS-ATM, Doc. 4444). Furthermore, the AGL "Follow-the-Greens" service is being incorporated in the new A-SMGCS Specification Document being elaborated by EUROCONTROL in collaboration with EUROCAE WG 41 as result of the revision of the A-SMGCS Implementation Package.

1.5 Project Conclusion and Recommendations

This section is intended to provide the reader with the main conclusions and recommendations to be taken into account for the further development / deployment of the addressed solutions.

Solution #23 (D-TAXI service for CPDLC application)

- P06.07.03 contributed to the definition of the integrated surface management data link by identifying the set of the main data link messages / instructions which could be exchanged between pilots and controllers. The collected operational feedback confirmed the operational utility only for the use of data link to "static" requests/clearances for every movement, such as Expected Taxi Routing information, Departure Clearance, Start-up, Push-back, and Contact.
- The provision of TAXI clearance has been shown to be useful especially at simple airports where the traffic is usually managed through standard taxi routes. The provision of TAXI clearance at complex airports is recommended to be further investigated during SESAR 2020 activities.
- Further study on the procedures to manage mixed-mode environment (i.e. voice and data link) could be part of SESAR 2020 activities.

Solution #26 (Manual taxi routing function)

- The operational feedback collected during the project lifecycle has confirmed the potential benefits in terms of workload and situational awareness;
- As the concept is associated with an appropriate means to enter the route manually in a timely manner, easily and so that it reflects exactly the initial voice clearance, it is recommended to study a more user friendly interaction means during SESAR 2020 horizon. It means that the Solution #26 has not achieved the V3 maturity level.

Solution #47 (Guidance Assistance through Airfield Ground Lighting)

- Validation activities confirmed that AGL could reduce workload and at the same time increase situational awareness of both controllers and pilots;
- Reduction of speed changes and smoother traffic flow resulting from the availability of the guidance assistance through AGL confirmed a positive impact on environment / fuel efficiency as well as on predictability of surface ground operations. Based on those considerations, the solution #47 is confirmed to have achieved the expected V3 maturity level;
- The evolution of the operational concept associated to the AGL including specific points such as the length of the lights segment and priority lights switching is recommended to be further analysed during SESAR 2020 timeframe.
- About phraseology, no standardised wording exists for the guidance via AGL and, therefore, appropriate standardization bodies are required to address the issue and provide a solution.

Solution #48 (Virtual Block Control in Low Visibility Procedures (LVPs)

- The provision of VBC service by means of VSB confirmed mainly the improvement in terms of situation awareness thanks to display of VSB and to the notification in case of VSB infringement. Therefore, the Solution #48 is confirmed to have achieved the expected V3 maturity level;
- With the objective to bring benefits also in terms of capacity and predictability, it is recommended to investigate the definition of Dynamic VBC by means of VSBs also not linked to already existing intermediate holding positions.

Improved vehicle guidance

- First conclusions confirmed the potential utility of issuing both TOW and PROCEED instructions via data link. However, the potential benefits were not considered significant comparable to the ones associated to the aircraft operations which were, therefore, considered the focus of P06.07.03 activities. Therefore, the operational concept associated to ground vehicles operations is expected to be further investigated during SESAR 2020 timeframe;
- There is a need to define an ad hoc standard related to the data link service for vehicle drivers (as for the CPDLC application concerning aircraft operations). It is suggested to address all the vehicles related open points during SESAR 2020.

2 References

[1] SESAR Programme Management Plan, Edition 03.00.01

[2] European ATM Master Plan

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[16] P06.07.03, Preliminary Validation Plan Phase 2 (VSB - ENAV), D19, Edition 00.01.00, 27 April 2015

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[18] P06.07.03, Preliminary technical feasibility and interoperability Phase 2, D26, Edition 00.01.00, 31 October 2014

[19] P06.07.03, Preliminary Validation exercises Phase 2 (VSB - ENAV), D27, Edition 00.01.00, 23 November 2015

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[21] P06.07.03, Validation Plan development Phase 1 exe 649 (AGL-SEAC), D61, Edition 00.01.00, 18 June 2013

[22] P06.07.03, Validation exercise Phase 1 exe 649 (AGL -SEAC), D62, Edition 00.01.00, 15 April 2014

[23] P06.07.03, Preliminary Validation Plan Phase 2 (D-TAXI-ECTL-NATMIG), D63, Edition 00.01.00, 8 April 2015

[24] P06.07.03, Preliminary Validation exercises Phase 2 (D-TAXI - ECTL-NATMIG), D64, Edition 00.01.00, 28 September 2015

[25] P06.07.03, Update of Preliminary INTEROP for advanced surface guidance, D65, Edition 00.01.00, 6 August 2015

[26] P06.07.02, OFA04.02.01 (Integrated Surface Management) Final SPR, D45, Edition 00.01.00, 16 September 2016

[27] P06.07.02, OFA04.02.01 (Integrated Surface Management) Final OSED, D46, Edition 00.01.00, 8 September 2016

[28] P06.07.02, Second OFA04.02.01 (Integrated Surface Management) Interim OSED, D76, Edition 00.01.01, 30 November 2015

[29] P06.07.02, OFA04.02.01 (Integrated Surface Management) Interim SPR, D77, Edition 00.01.00, 5 August 2015

[30] P06.02, Step 1 Airport DOD 2014 Update, D122, Edition 00.01.01, 31 March 2015

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