Final Project Report

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Abstract

The aim of this project was to specify, develop and verify an Advanced Tower Controller Working Position (A-CWP) able to provide a homogeneous human-machine interface by integrating the different concepts from the airport domain defined in SESAR.

This project, in its iterative phases, has successfully contributed and supported integrated validations by delivering the front-end with controllers to interact with the functionalities developed by other technical projects. This project has also gathered all HMI requirements produced in SESAR1 into a complete document that leads the implementation of a complete A-CWP.

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Acronyms

Acronym	Definition
A-CWP	Advanced Tower Controller Working Position
AMAN	Arrival Manager
AOP	Airport Operation Plan
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Controller
ATM	Air Traffic Management
CPDLC	Controller Pilot Data Link Communications
CWP	Controller Working Position
DCB	Demand and Capacity Balancing
DMAN	Departure Manager
EFS	Electronic Flight Strips
EMMA2	European Airport Movement Management by A-SMGCS
EN	Enabler
GBAS	Ground Based Augmentation System
HMI	Human Machine Interface
ITWP	Integrated Tower Working Position
MET	Meteorological
NOP	Network Operation Plan
OFA	Operational Focus Area
OSED	Operational Service and Environment Definition
PCP	Pilot Common Project
SESAR	Single European Sky ATM Research programme
SJU	SESAR Joint Undertaking
SPR	Safety and Performance Requirements
SWIM	System Wide Information Management

TRL	Technology Readiness Level
TS	Technical Specification

1 Project Overview

This project has been focussed on the definition, development and verification of an Advanced Tower Controller Working Position (A-CWP) that continuously provides an airport situation display to the tower controllers.

1.1 Project progress and contribution to the Master Plan

The technical project "Integrated Tower Working Position (A-CWP) Design, Specification Prototyping and Test/Validation" was the main technical project in the Airport domain for the definition, development, verification and support to integrated validations of a homogeneous human-machine interface (HMI) of the different concepts defined in SESAR1.

Since the beginning of the project a stepwise approach in three phases was agreed and evolutionary prototypes were developed in accordance to the maturity of the operational concepts. The stakeholders involved in the project were allocated to project tasks according to their expertise.

At the beginning of each phase a coordination meeting with the Operational Project 06.09.02 was held to identify the possible HMI inputs that other projects were addressing and the validation exercises to be supported.

Each phase was composed of a Technical Requirements definition which were implemented of an evolutionary prototype developed by the Ground Industries participating in the project (Leonardo, Frequentis/DFS, Indra and Thales), and the necessary verification activities to support the different validation exercises identified to evaluate the Controller Working Position according to new functionalities. Each validation exercise could address all or part of the functionalities included in the Technical Specification.

- Phase 1 Technical Specification included the following functionalities:
    - Basic HMI Requirements from EUROCONTROL Integrated Tower Working Position (ITWP) project [54].
    - Surveillance requirements from 'Improved surveillance for surface management' SESAR1 project.
    - Departure Manager Requirements from 'Enhanced Sequencing Tools' SESAR1 project.
    - Surface Routing Requirements from European Airport Movement Management by A-SMGCS (EMMA2) project [55] and 'Enhanced Surface Routing' SESAR1 project.
    - Surface Guidance Requirements from 'Enhanced Surface Guidance' SESAR1 project.

  Six validation exercises were supported in Phase 1 by this project.
- Phase 2 was split in two incremental parts including the functionalities:
    - Part 1
        - Basic HMI requirements (update of requirements initially obtained from ITWP)
        - A-SMGCS Routing and planning functions (update of requirements initially obtained from EMMA2)
        - Safety Nets for Controllers
        - A-SMGCS Guidance function
        - Enhanced Runway Management Through Optimised Braking Systems
    - Part 2

- Flexible and Dynamic Use of Wake Vortex Separations.

Two validation exercises were supported by this project, addressing part of the functionalities described.

- Phase 3 was split in two incremental parts including the functionalities:
  - Part 1
    - A-SMGCS Routing and planning functions
    - Airport safety support tools for controllers
    - A-SMGCS Guidance function (D-TAXI and Virtual Block Control using Virtual Stop Bars)
    - Flexible and Dynamic Use of Wake Vortex Separations.
  - Part 2
    - Coupled AMAN-DMAN
    - Airport capacity and flow management

Six Validations were performed using all or part of functionalities from Part 1 and/or Part 2.

This approach has allowed different technical solutions with different implementation principles to be validated in different platforms and scenarios and with various air traffic controllers.

During the lifecycle of the project, the prototypes contributed to the following Enablers (ENs) included in Dataset 16 [4] that are transversal to several Operational improvements:

Code	Name	Project contribution	Maturity at project start	Maturity at project end
AERODROME-ATC-50	Advanced Controller Working Position (A-CWP) supporting A-SMGCS functionalities	Advanced Airport CWP integrating updates on current HMI functionalities (Configuration, Track Management, Airport Information, Range and Bearing, Movement Plan, EFS…) and support to new functionalities such as: enhanced situational awareness, improved safety nets, routing function, D-TAXI, pre-departure sequence and departure management integrated with surface constraints, coupled arrival and departure sequence.	TRL3	TRL6
AERODROME-ATC-49	Advanced CWP (A-CWP) to support Airport DCB and integration of DMAN system component/tool.	Specification and implementation in the Controller HMI of new tools defined in SESAR1 such as Coupled AMAN-DMAN to help controller on following a traffic queue to/from the runway using accurate flight information to reduce the waiting time at the holding points.	TRL3	TRL5
AERODROME-ATC-57	Advanced CWP to support improved runway management concept	HMI requirements definition for new wake vortex separation indicators, Virtual Block Control or Airfield Ground Lighting to be integrated in the Controller Working Position and Runway Management information such as mode of operation, runway	TRL3	TRL5

		capacities, availability... to enhance runway capacity throughout the day of operations.		

At the end of the programme it was identified the need to clarify the scope, description and allocation of the ENs addressed by this project and an action to rework these ENs was initiated.

After coordination two enablers were kept as transversal to several Operational Improvements, AERODROME-ATC-50 and AERODROME-ATC-57, while AERODROME-ATC-49 was removed from Dataset 16 as the previous ENs were enough to cover all the needs on A-CWP for current and future initiatives.

AERODROME-ATC-50 was considered mature enough (TRL6) covering HMI basic functionalities and functionalities linked to the following SESAR Solutions:

- #02 Airport Safety Nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances
- #14 Departure Management integrating Surface Management constraints
- #15 Integrated and throughput-optimised sequence of arrivals and departures
- #22 Automated Assistance to Controller for Surface Movement Planning and Routing
- #23 D-TAXI service for CPDLC application
- #53 Pre-departure sequencing supported by route planning
- #54 Flow-based integration of arrival and departure management

AERODROME-ATC-57 which covered HMI functionalities linked to the SESAR solutions:

- #01 Runway Status Lights (partial)
- #21 Airport Operations Plan and AOP-NOP Seamless Integration
- #35 MET Information Exchange
- #47 Guidance Assistance through Airfield Ground Lighting
- #48 Virtual Block Control in LVPs
- #55 Precision approaches using GBAS Category II/III

concluded on TRL5 because the functionalities were not fully integrated in the Advanced Controller Working Position.

This project has contributed to the above mentioned SESAR solutions gathering HMI requirements in the Final Technical Specification, providing the necessary documentation and supporting their related validation exercises from an HMI perspective.

1.2 Project achievements

Since its kick-off, the objectives of this project were to:

- Define the technical requirements to guide the development of an Advanced Controller Working Position (A-CWP) based on SESAR1 concept for the Tower environment.
- Develop a feasible technical solution based on the new concepts.
- Improve the efficiency of the Tower Controllers by providing appropriate information.
- Integrate old and new system components into a harmonized HMI.

- Minimize the amount of displays that currently compound a CWP.
- Specify and develop relevant HMI parts when not covered by primary operational prototypes.
- Verify developed prototypes and identify anomalies during verification and validation to be implemented in the next phase prototype.
- Support integrated operational validations of new concepts regarding HMI with the target of harmonizing the CWPs.

All these objectives have been achieved along the SESAR Execution Phase.

During its lifecycle, this project translated into technical requirements those HMI user requirements generated by the operational projects, and collected through P06.09.02, with the objective of implementing them into a homogeneous Controller Working Position to support all validations planned in SESAR, from Release 1 to Release 5.

This iterative approach and the fact that several Ground Industries were participating in the project allowed different technical solutions with different implementation principles to be validated in different platforms, and with a variety of front-end users that enriched not only the evolution of the functionalities such as routing or safety nets, but in general the look-and-feel of the CWP.

The implementation of the above objectives entailed additional challenges to solve in the case of integrating components from different manufacturers. DFS and Frequentis, jointly developing an A-CWP prototype from their individual components, developed an open architecture providing a software design concept to overcome the difficulties of a multi-vendor A-CWP solution (see [53])

Although this project is not itself a PCP objective, it contributes as an enabler to all Airport Integration and Throughput ATM sub-functionalities, being more visible in the "Automated Assistance to Controller for Surface Movement Planning and Routing" and "Airport Safety Nets" by providing an integrated interface to allow the management of surface routes, hosting warnings and alerts; and allowing the "Departure Management Synchronised with Pre-departure sequencing" and "Departure Management integrating Surface Management Constraints" sub-functionalities to be fully integrated in the Electronic Flight Strips.

1.3 Project Deliverables

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

Reference	Title	Description
D93	Final system requirements	This document gathered the Final Technical Requirements for Basic Human Machine Interaction, Departure Manager, Arrival Manager, Surface Routing and Guidance, Airfield Ground Lighting, Virtual Block Control, Safety Nets for controllers, Wake Vortex Information, Enhanced Braking System, Coupled Arrival & Departure Manager and Runway Management, divided in two groups; Functional Requirements, used for the implementation of the A-CWP prototypes, and Non-functional Requirements identified and collected along the SESAR Programme This document has been the final version of the Technical Specification that evolved from Phase 1 to 3, and it is based on the analysis of the operational requirements from SESAR project 06.09.02

Due to the tight schedule at the end of the Programme it was not possible to include the feedback from Release 5 validations in the Final Technical Specification. This analysis should be performed in future tasks addressing A-CWP

1.4 Contribution to Standardisation

Although this project has contributed to System Wide Information Management (SWIM) enabled validation exercises, they had a limited impact on the HMI being the applications (Routing, Guidance…) the ones connected through information services.

Due to the fact that airport controller operations vary depending on the country, the type of airport or even the controller role, no standardisation activity related to the A-CWP concept has been carried out in SESAR1

1.5 Project Conclusion and Recommendations

The harmonization of different individual systems showing its own information, sometimes in isolation, without any commonalty with the main HMI was one of the initial difficulties in the project, being one of the statements from the operational side that the integration of the new functions into the A-CWP should not have a negative impact on the controller operations.

Initial validations assessing the feasibility and usability indicated that, although the controllers were able to efficiently manage high traffic complexity by using the A-CWP, some information was missing or not correctly displayed when A-SMGCS elements, flight plan information, meteorological data and airport equipment data were integrated and adapted to different roles in the Tower environment. The feedback obtained through the different validation exercises was reflected in an incremental technical specification which led the implementation of evolutionary prototypes.

Latest validations concluded that the HMI objects implemented to interact with were considered practical and intuitive for the controllers' tasks and the number and sequence of inputs required was adequate in general terms. Controllers rated positively how textual information was provided, the graphical objects and other symbols, together with the flexibility of the HMI, allowing the different controllers to perform their tasks in an efficient and safely way according to their roles and preferences. In conclusion the integration of the new functions improved situational awareness and safety whilst maintaining workload at an acceptable level without losing sight on the fact that the out of the window view is crucial for Tower operations.

Along the project lifecycle the Technical Specification deliverable has been incrementally improved with new requirements in each phase. However the fact that, results from latest validation exercises were not available when closing the project, some requirements coming from Remote Tower projects were not included and other requirements were not part of any validation exercise in SESAR1, leads to the recommendation of continue working on the validation of HMI requirements including the cross-check with the latest updates generated by operational projects.

It is also recommended to organise requirements (both operational and technical) not only per functionality but per role and position (Runway Controller, Tower Supervisor…), allowing an accurate HMI definition and requirements allocation. This would enable the validation of specific roles, such as Tower Supervisor Position which was not properly assessed in SESAR1

The fact that controller operations could vary depending on the country, the airport or even the role derived that no standardisation activity related to the A-CWP concept was promoted in SESAR1. Although the use of SWIM was a good start, its impact on the A-CWP should be further investigated since currently it had a limited impact on the A-CWP but on underneath applications.

The work of an open architecture to overcome the difficulties of a multi-vendor A-CWP solution concluded that the integration layer was the key enabler to a flexible and scalable A-CWP cluster. It is recommended that this work should be attended by a standardization body in next activities.

Obviously the work to adapt the Controller Working Position to the new functionalities is a never-ending story. The new concept of Virtual Centres, where the CWP is decoupled from the ATM Data Service Providers, and the incorporation of new interaction modes such as speech recognition, multi-

touch, and gaze detection are waiting around the corner and to be further analysed in SESAR2020 and beyond to help controllers on performing their daily work while being technologically up-to-date

2 References

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