EPISODE 3

Single European Sky Implementation support through Validation

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EXECUTIVE SUMMARY

This document provides the consolidated validation exercise report for the exercises performed in Episode 3 (EP3) Work Package 5 (WP5) “Airport and TMA”. This document is the deliverable D5.4-01 WP5 Final Report and contributes to the elaboration of the Integrated Report of EP3 WP2.5.

The objectives of Work Package 5 (WP5) of Episode 3 (EP3) were to:

- Analyse methods and validation techniques to detail the SESAR concept of operation;
- Assess the operational definition and feasibility of SESAR concept elements for the TMA and Airport;
- Consolidate the results of WP5 (this report) and deliver them to EP3 WP2 for system integration and system assessment;
- Consolidate the detailed operational requirements in accordance with results and proposed associated changes to the concept, and deliver these to EP3 WP2 for an integrated update of the concept elements.

The emphasis was on obtaining a first assessment of the ability of different concept elements to contribute to the defined performance benefits in the 2020 time horizon corresponding to ATM Capability Level 2/3 and Implementation Package IP2.

WP5.1 *Work Package Management and Co-ordination*, managed all aspects of the work. WP5 exercises provided valuable output because of the combined professionalism and teamwork within WP5. The WP5 team are ready and have the required knowledge to support future concept validation within ATM.

WP5.2 *Validation Strategy, Support and Operational Concept Refinement*, provided the initial validation strategy for the airport and TMA studies. The concept refinement sub-work package supported WP2.2 and the WP5 exercises for DOD, operational scenario and all concept-related questions and feedback.

The remaining WP conducted the exercises and produced the WP reports. Results were collected from four exercises for the TMA concept and two exercises for the airport concept.

The TMA exercises used a TMA expert group, to provide two TMA fast-time simulations and the TMA prototyping sessions. The expert group answered operational questions and developed assumptions including refinement of the concept provided by WP5.2. Results from the TMA exercises were reviewed by the TMA expert group and passed via WP5.2 to WP2.

A TMA FTS addressed the use of advanced CDAs in a multi-airport TMA. A second TMA FTS showed an increase in capacity in such TMAs through the use of new separation modes. This exercise also showed how transition from a structured TMA to another TMA can affect the TMA and the local en-route airspace when user-agreed trajectories are allowed.

The four TMA prototyping sessions focused on operability, with initial trends for other KPAs for high-density TMA operations. The sessions progressively addressed 2D, 3D and 4D concept elements, using the output from previous sessions and advice from the TMA expert group.

There were two airport exercises, an expert group to review and refine the ‘airside’ concept elements related to the execution phase of the SESAR flight at the airport and a fast-time modelling exercise providing initial results of SESAR proposed improvements at the runway.

The following paragraphs summarise the results of WP5:

<u>Work Package Management</u>: The success of the WP arose from a flexible approach to managing partners in a distributed environment, with simple, supportive communication.

People management including human behaviour expertise created a team that delivered results. WP5 benefited from the support that members of the team gave to solving problems.

Validation Strategy: The validation strategy provided the link between the concept and the exercises, showing justifications and latest developments in the area to be covered. This ensured that consistent information was used by the exercise leaders when using E-OCVM.

Concept Refinement: The use of a clear process to provide concept information to exercises and feedback to the concept following results reduced incorrect assumptions and widened the use of correct practice, knowledge and clarification. Operational Scenarios were useful in supporting the exercises and should be identified and developed as early as possible.

TMA Expert Group: The TMA expert group identified TMA improvements for arrivals and departures. The expertise of the group reduced the uncertainty of results during fast-time and prototyping exercises by providing clear assumptions and answers to questions.

Multi-Airport TMA Modelling Exercise: The exercise addressed the use of Continuous Descent Approach profiles from Top of Descent and showed that this would provide benefits in terms of flight efficiency and workload, if operated along undisturbed “Dedicated Arrival Flow Corridors”. Demand and Capacity Balancing measures to optimise arrival operations at airports of interest by prioritisation of departure operations benefited services for on-time arrival at congested airports. Airspace improvement and demand and capacity balancing measures set the scene for advanced arrival traffic synchronisation that ensured sequencing at the Initial Approach Fix and enabled flight-efficient and noise-friendly CDAs.

Airport Expert Group: The use of operational experts from different backgrounds and roles was vital in ensuring the realistic refinement of a concept. The expert group results that were presented as storyboards show that uploading and negotiating of the runway exit and taxi route for arrivals and taxiways for departures will improve predictability and efficiency at the airport. The use of speed during taxiing and other airport improvements being implemented worldwide should be reviewed.

Runway Improvements: The runway fast-time modelling exercise provided input to the airport expert group refinement by showing the benefits of runway-specific concept elements. In a busy runway environment, the application of Brake To Vacate technology, Time Based Spacing and reduced Wake Turbulence separations, together with a technical solution to reduce ILS critical and sensitive area restrictions, all based on accurate, coordinated time, can provide the potential to achieve SESAR airport capacity goals. It was noted that improvements provided benefits individually but the sum of the benefits was not increased by combining the improvements.

TMA Trajectory Management: A modelling exercise showed that using the P-RNAV/Point Merge System (PMS) technique to arrivals, whilst maintaining current departure operations can improve operations in busy or high density TMAs. The benefits are reduced workload, fewer conflicts and improved safety. In addition, the application of VNAV together with PMS techniques supports the implementation of advanced continuous-descent approaches.

A second exercise showed that if new controller tools can give a 20% reduction in the executive controller’s task load, the expected 2020 traffic demand could be handled in a complex TMA such as Barcelona. However, precision trajectory clearances (both 2D and 3D) in isolation do not provide any significant capacity gain in a complex TMA. For Precision Trajectory Clearance-2D to be effective in terms of capacity, it should be integrated with tools.

A concept refinement exercise carried out by the TMA expert group showed that a dynamic modification in the TMA structure can improve the efficiency of the TMA if the solutions are negotiated in the long- and medium-term planning phases. It also showed that changes made to the TMA during the day of operation are made in the medium-short term planning phase and revised or updated if necessary as the flights intentions become more visible.

Operability of P-RNAV/A-CDA, CTA and RTA: Prototyping exercises showed that the use of required time of arrival to comply with a controlled time of arrival in a dense TMA could provide a suitably-measured flow into the airspace around an airport It was also shown that the P-RNAV/Advanced-CDA concept that was tested is operationally viable. Subjective feedback suggested that CTA reduces flexibility and controllers' situational awareness and lacks robustness against external factors (e.g. weather). Open issues include the variability of working methods (and their impact on performance) and CTA/RTA maturity.

Operability of P-RNAV/PMS, CDA and ASPA S&M: The exercise showed that the introduction of new concepts such as P-RNAV/PMS, continuous descent approach and airborne spacing - advanced separation and merging is operationally viable. In particular, when all three concepts are introduced simultaneously, controllers, having delegated spacing tasks to the cockpit, are able to better monitor the traffic evolution on the arrival streams.

1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

This document provides the consolidated report for all validation exercises, concept clarification and expert groups performed in Episode 3 WP5 "*Airport and TMA*". This document is the delivery D5.4-01 Work Package Report for EP3 WP5.4 "*TMA and Airports Results' Analysis and Report*" which will contribute to the elaboration of the Integrated Report of EP3 by WP2.5.

1.2 INTENDED AUDIENCE

The intended audience includes:

- EP3 WP0: Project Coordinator;
- EP3 WP2: System Consistency leader;
- EP3 WP2: Coordination Cell;
- EP3 WP2.5: Reporting and Dissemination;
- EP3 WP3: Collaborative Planning;
- EP3 WP4: En-Route and Traffic Management;
- EP3 WP5: TMA and Airports.

This document is also intended for use by the exercise leader in EP3 WP2.5 "*Reporting and Dissemination*" as input for the consolidated project Reporting and Dissemination document.

1.3 DOCUMENT STRUCTURE

The document is structured as follows:

- Section 2 introduces the methodologies, techniques and tools used for validation;
- Section 3 describes the concept detailing carried out;
- Section 4 details results of operability aspects covered;
- Section 5 summarises the results obtained against the performance aspects;
- Sections 6 and 7 provide discussion, recommendations and conclusions from TMA and airport validation;
- Section 8 lists the references and applicable documents.

1.4 BACKGROUND

The SESAR ConOps [22]

- Performance-driven;
- Process-orientated;
- Trajectory-based;
- Founded on SWIM.

The SESAR Concept introduces the notion of ATM capability levels. These levels are defined to describe the on-going deployment of progressively more advanced ATM Systems for aircraft, ground systems and airports.

Figure 1 shows the links between SESAR ATM Capability Levels and the SESAR Implementation Packages (IP) and time.

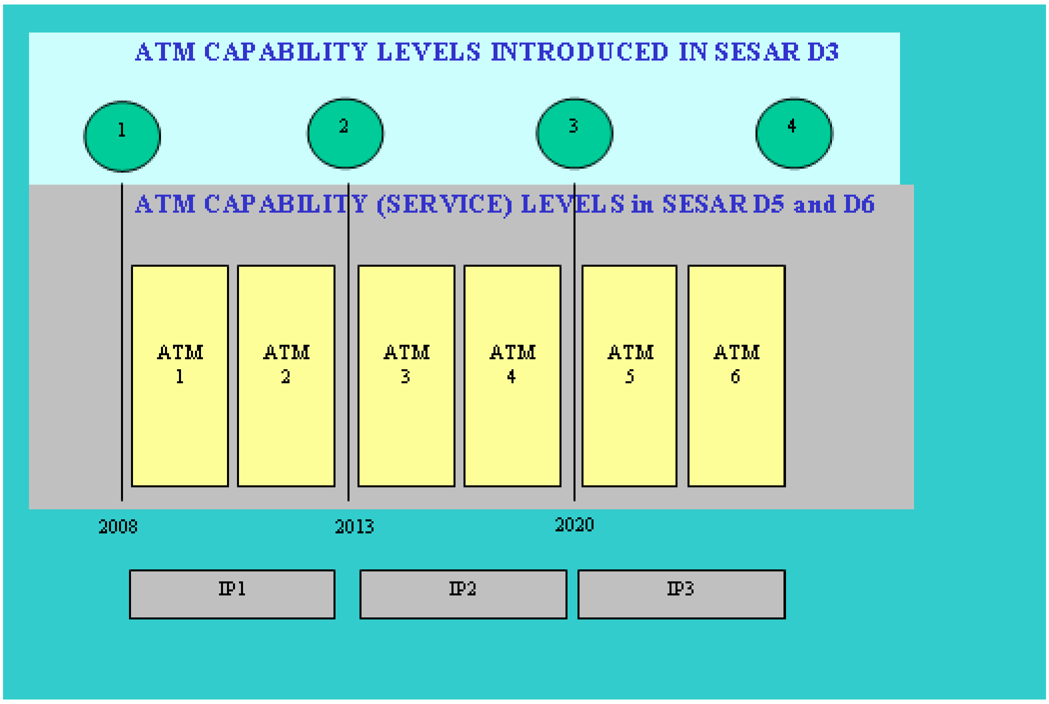

Figure 1: SESAR ATM Capability Levels and Implementation Packages (IP)

The SESAR Concept is described in Operational Improvement Steps (OI Steps). These OI Steps are defined for each of the IP (1, 2 or 3).

The challenge is to evaluate the ATM Concept improvements defined as OIs to ensure that the concept can achieve the required performance targets at the different timescales (IP).

EP3 was tasked with the following key objectives (DOW 3.1 - Ref [17]):

- Clarification of the concept; recognising that the concept is large and that EP3 does not have the resources to address all areas and OIs;
- Expanding the repertoire of cost-effective validation techniques suited to these early stages of concept validation;
- Consolidating our learning on the application of the E-OCVM to SESAR-scale Concept of Operations;
- Provide initial performance results for some SESAR concept elements.

The Performance Framework [16] describes which measurements (Key Performance Indicators or KPI) should to be taken when validating the different areas of the SESAR ATM Concept, the relationship between the different areas and the KPI and how these KPI can demonstrate the overall impact on the performance targets (Key Performance Areas, KPA).

However the Performance Framework was not in place at the start of EP3, and exercises, although using KPI to measure improvements, could not provide precise consolidated results. The reason for this is well documented and set out in the EP3 Objectives.

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The EP3 WP5 objectives were as follows:

- Analyse methods and validation techniques to detail the SESAR concept of operation;
- Assess the operational definition and feasibility of SESAR concept elements for the TMA and Airport;
- Consolidate the results of WP5 (this report) and deliver them to EP3 WP2 for a system integration and system assessment;
- Consolidate the detailed operational requirements in accordance with results and proposed associated changes to the concept, and deliver these to EP3 WP2 for an integrated update of the concept elements.

The emphasis is on obtaining a first assessment of the ability of different concept elements to contribute to the defined performance benefits in the 2020 time horizon corresponding to ATM Capability Level 2/3 and the Implementation Package IP2.

The objectives of the WP5 sub-work packages were, in brief:

WP5.1 – Work Package Management & Co-ordination (NATS)

- Coordinate all WP5 activities in line with project and WP5 objectives;
- Report progress and risks of WP5 to the EP3 Project Management Board (PMB) and to EP3 Partners;
- Support EP3 PCO for management related issues;
- Provide technical approval of WP5 deliverables.

WP5.2 – Validation Strategy and Operational Concept Refinement (DFS)

To provide the WP Validation Strategy and concept refinement processes. WP5.2 included technical coordination between EP3 Coordination Cell (WP2) and WP5 Exercises and the technical review of all WP5 exercise plans and reports to be carried out by WP5.2.

WP5.2.1 – Validation Strategy and Support

To provide a WP5 Validation Strategy and manage assumptions in EP3 WP5 for all WP5 validation exercises. To perform technical reviews of WP5 results to ensure consistency of reports and link results to the Lessons Learnt for use by the SESAR Joint Undertaking.

WP5.2.2 – Operational Concept Refinement

To develop operational scenarios according to the Work Package 5 exercise needs. Furthermore, the Work Package reviewed the Detailed Operational Descriptions (DODS) and participated in the update of the DODS related to WP5 exercise results.

WP5.3 – Process prototyping and Simulation

Figure 2 shows where the WP5 exercises focussed according to the SESAR flight profile.

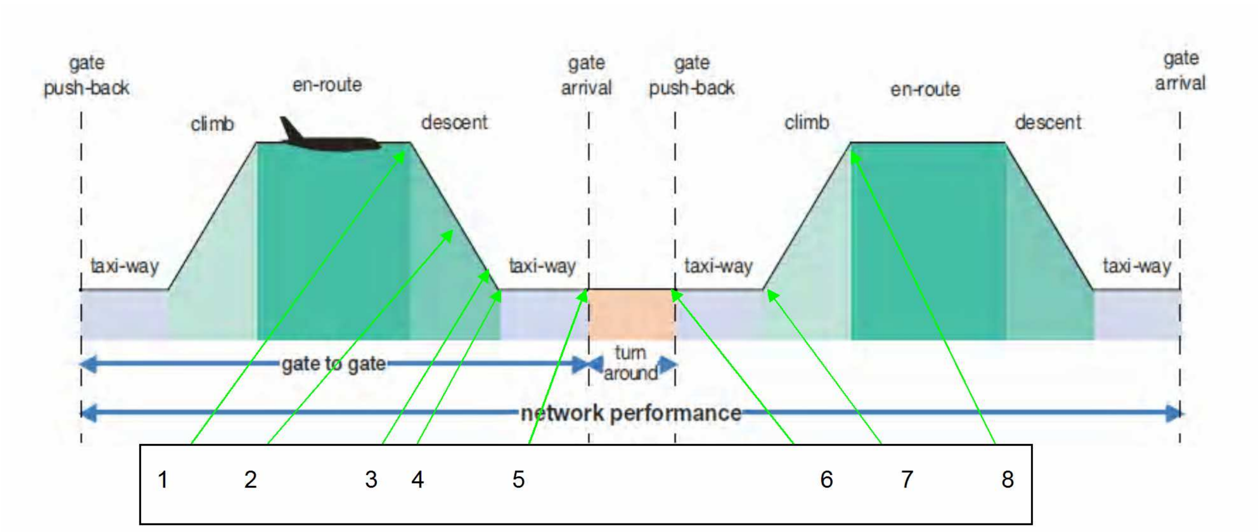

Figure 2: WP5 Exercises covering SESAR Concept

The key to the diagram is as follows:

1. TMA (WP5) interface with en-route phase (WP4);
2. TMA arrival flow and structure;
3. TMA interface to airport (runway);
4. Runway management;
5. Arrival taxiway management to stand;
6. Departure stand and taxiway management;
7. Departure;
8. TMA departure flow and structure.

The objective of WP5.3 was:

- To carry out all the validation exercises in the TMA and Airport areas. The exercises comprised expert groups and workshops, fast-time simulations and prototyping sessions;
- To perform the detailed planning and preparation of all exercises performed by WP5.3.1 to 5.3.6.

WP5.3.1 – TMA Expert Group

To manage a group of experts (Operational, SESAR, R&D, Project) to support the WP5 TMA validation, WP5 TMA Safety study and WP6 technical validation exercises.

The TMA Expert Group covered 1, 2, 3, 7 and 8 in the diagram above.

WP5.3.2 – Airport Expert Group

To manage a group of experts (Operational, SESAR, R&D, and Project) to refine the 'airside' concept elements related to Runway and Taxiway Management at the Airport.

WP5.3.2 was also to provide clarification on the Hot Topic "SBT to RBT agreement".

The Airport Expert Group covered 3, 4, 5, 6 and 7 in the diagram above.

Note that the airport concept work carried out was related to the execution phase of the SESAR business trajectory, the related concept area for the planning is covered in WP3. The links between planning and execution are discussed in the WP5 Airport Expert Group Report [2].

WP5.3.3 – Runway Operations FTS

To identify potential improvements from Brake to Vacate, Time Based Spacing, crosswind, Wake Turbulence and the effects of a reduction in the ILS protection zone on runway operations.

This exercise concerned 3 and 4 in the diagram above.

WP5.3.4 – Multi Airport TMA

To review SESAR improvements related to advanced arrival and departure management in a multi-airport TMA environment.

This exercise concerned 1 and 2 in the diagram above.

WP5.3.5 – TMA Trajectory and Separation Management

To conduct three exercises to review the SESAR improvements related to separation modes and TMA supporting tools for departures and arrivals. The transition to/from different TMA structures was also investigated.

This exercise concerned 1, 2, 3, 7 and 8 in the diagram above.

WP5.3.6 – Prototyping of a Dense TMA

This exercise looked at advanced TMA concepts (CDA, CTA, RTA, P-RNAV/Point Merge System) in a dense TMA environment with controllers (human in the loop) progressively adding complexity in line with findings and agreements with the TMA expert group. The fourth session also examined ASAS-S&M. Three prototyping sessions using an airspace derived and adapted from the Dublin TMA were carried out in EEC/Brétigny. The fourth, using an airspace based on the Rome TMA was held on SICTA premises in Naples.

This exercise concerned 1, 2 and 3 in the diagram above, although it should be noted that for the first three sessions, the departures were not controlled, but scripted, as the focus was not on measuring effects on Departure Controllers. Aircraft were organised to fly in accordance with efficient climb profiles and de-conflicted from arrival streams

Sourced Project Information

The principle projects providing inputs to WP5 were the TMA 2010+ Project (for TMA), Airport CDM, EMMA2 and TAAM for Airports and P-RNAV/PMS.

1.5 Glossary of Terms

Term	Definition
ACC	Area Control Centre
A-CDA	Advanced Continuous Descent Approach
AMAN	Arrival Manager
ASAS	Airborne Separation Assistance Systems

Term	Definition
ASPA	Airborne Spacing
ASPA S&M	ASPA - Enhanced Sequencing and Merging operations
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
BIC	Best in Class
BT	Business Trajectory
BTV	Brake to Vacate
CDA	Continuous Descent Approach
ConOps	Concept of Operations
CTA	Controlled Time of Arrival
DCB	Demand Capacity Balancing
DMAN	Departure Manager
DOD	Detailed Operational Description
DOW	Description of Work
EC	European Commission
ECAC	European Civil Aviation Conference
EEC	EUROCONTROL Experimental Centre
EG	Expert Group
E-OCVM	European Operational Concept Validation Methodology
EP3	Episode 3
ETMA	Extended TMA
FAF	Final Approach Fix
FTS	Fast Time Simulation
GND	Ground
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Implementation Package
KPA	Key Performance Area
KPI	Key Performance Indicator
N/A	Not Available
NOP	Network Operations Plan
OI	Operational Improvement
OS	Operational Scenario
PCO	Project Coordinator
PMB	Project Management Board
PMS	Point Merge System

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Term	Definition
P-RNAV	Precision Area Navigation
PTC	Precision Trajectory Clearance
RAMS	Reorganised ATC Mathematical Simulator
RBT	Reference Business Trajectory
RTA	Required Time of Arrival
RWY	Runway
SESAR	Single European Sky ATM Research
SBT	Shared Business Trajectory
SJU	SESAR Joint Undertaking
SMAN	Surface Manager
SWIM	System Wide Information Management
TAAM	Total Airspace and Airport Modeller
TBS	Time Based Spacing
TMA	Terminal Movement Area
TOD	Top of Descent
TWR	Aerodrome Control Tower
UDPP	User Driven Prioritisation Process
VNAV	Vertical Navigation
WP	Work Package

Table 1: Glossary of terms

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2 TOOLS, TECHNIQUES AND METHODOLOGIES FOR VALIDATION

2.1 INTRODUCTION

This chapter describes how the exercises of WP5 were organised. The methodology carried out followed E-OCVM [18]. Detailed descriptions of the validation techniques and tools are given in the following sections. Lessons learnt about the different validation techniques can be found in chapter 5.4.

2.2 METHODOLOGY

The high level methodology of WP5 was to:

- Produce the WP5 Validation Strategy [14];
- Give guidance on E-OCVM [18] to WP5 exercise leaders as they developed their exercise plans;
- Ensure SESAR concept questions, assumptions and targets were communicated between the WP5 exercises and the EP3 work packages;
- Ensure that individual WP5 exercises were consistent with their objectives, WP5 validation strategy, expert group (TMA specifically) recommendations, assumptions and answers to WP5 exercise questions (review of plans);
- Provide support during exercise running (specifically for iterations of the prototyping sessions) including assumptions and guidance for next sessions;
- Review results to ensure consistency and alignment (technical approval of exercise reports).

2.2.1 TMA Methodology

The TMA Exercise methodology adopted in WP5 was to support the exercises with an expert group (WP5.3.1) to review questions and assumptions in an iterative fashion according to the timescales of the TMA exercises and in particular the TMA prototyping sessions (WP5.3.6).

The TMA exercise plans were then defined with more certainty, the exercises were carried out (following review of plans by WP2 and experts) and the reports written and results reviewed by the TMA experts. Recommendations and conclusions from the exercises were then included in the TMA Expert Group report [1] and this report.

2.2.2 Airport Methodology

There were two airport concept exercises, one fast time modelling exercise looking at the proposed improvements at the runway (WP5.3.3) and an expert group (WP5.3.2) refining the concept for ‘airside’ activities related to runway and taxiway usage.

The modelling exercise was run with little input required from the expert group. However, feedback was planned from the runway exercise to ensure that the airport expert group used the recommendations when reviewing runway improvements in the concept.

The airport expert group Methodology was to move the experts progressively from today’s situation to the proposed solution. By recognising that there is a problem with today’s operation it was ensured that experts would look for a solution and review the SESAR ConOps with a positive, open mind.

The airport expert group employed brainstorming techniques to analyse airport 'airside' scenarios and the Hot Topic "SBT to RBT agreement".

2.2.3 WP5 Relationships and Information Flow

The following diagram and description show the principal WP5 relationships and information flow after the agreement of strategy and concept coverage outlined in the WP5 Validation Strategy and detailed in the WP5 exercise plans. This shows how the exercises interacted with each other and with the concept refinement and results work in WP5.

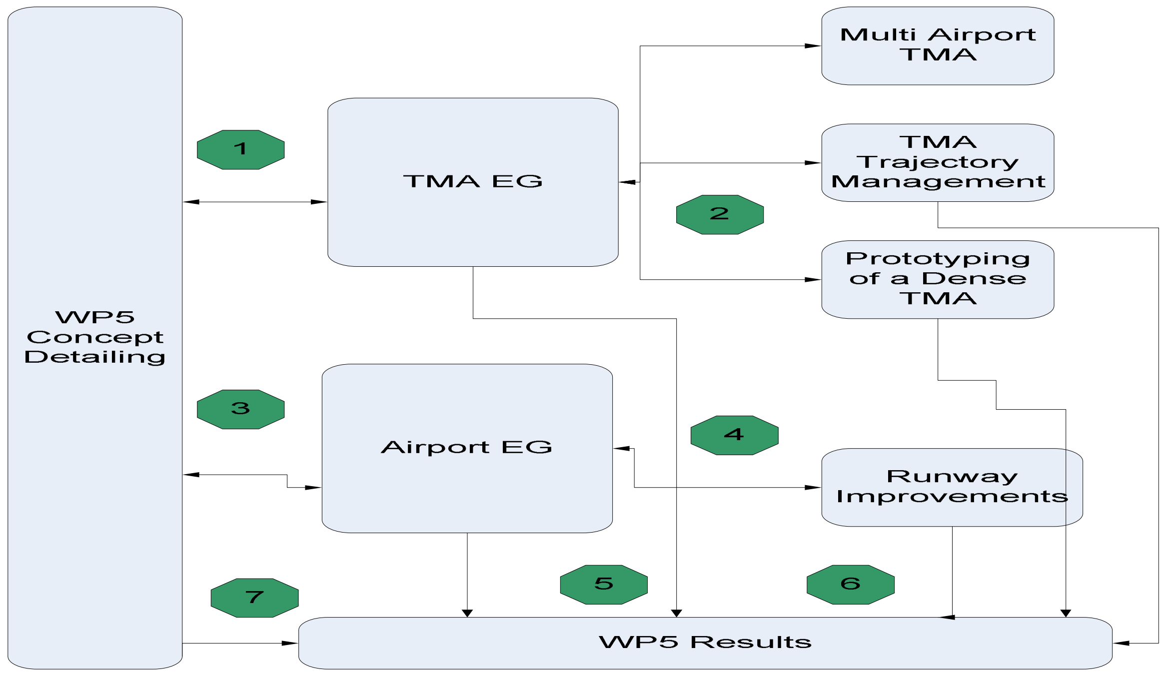

Figure 3: WP5 Relationships and Information Flow

The points in the above diagram describe the relationships and information flow as follows:

1. TMA concept detailing information flow:
    a. Concept documentation (DODS, operational scenarios, storyboard) and support provided to WP5 TMA exercises via the TMA expert group;
    b. Concept detailing results provided by the TMA expert group for TMA exercises.
2. TMA expert group relationship with TMA Exercises:
    a. Concept clarification from experts to exercises (question and answer spreadsheet) from the TMA expert group;
    b. Results from exercises (concept, operability, performance) reviewed by the TMA expert group.
3. Airport concept detailing Information flow:

a. Concept documentation (operational scenarios) for review passed to the airport expert group;

b. Storyboards and scenario comments passed back to WP5 concept detailing.

4. TMA Expert Group Results Flow:

   a. Results from use of TMA expert group on supporting validation passed to WP5 results (this report);

   b. Reviewed recommendations and conclusions from TMA exercises via the TMA expert group.

5. Airport Expert Group Results Flow:

   a. Results of the use of the expert group;

   b. Comments on airport 'airside' scenarios including storyboards for arriving at and departing from an airport.

6. TMA and Airport Exercise Results:

   a. Initial findings of concept validation against performance targets;

   b. Use of validation tools;

   c. Concept refinement conclusions and recommendations.

7. Consolidated Concept Refinement Results

The WP5 results (this report) include the high-level findings of the various exercises carried out in WP5.

2.3 Validation Methodology

The Validation methodology was defined using the tenets of the E-OCVM [18]. The following steps were performed and applied for the exercises:

- Understand the problem (as defined during SESAR Definition Phase);
- Understand the proposed solution – SESAR ConOps;
- Review the latest information within Europe (ongoing projects);
- Describe validation expectations focusing on EP3 objectives;
- Identify which performance areas were to be covered and how the performance framework was used (KPA, KPI) to measure the concept improvements measured (where possible);
- Map the SESAR OI onto the WP5 exercises (where OIs were specifically covered);
- Plan the WP5 exercises to ensure best use of different validation techniques to meet exercise objectives (expert groups, FTS, prototyping sessions);
- Carry out exercises;
- Report results according to E-OCVM and EP3, WP5 and exercise objectives.

2.4 VALIDATION TECHNIQUES AND FINDINGS

2.4.1 Description of Techniques used

WP5 used the following techniques:

- Expert groups, both to support validation exercises (TMA) and to refine the concept as an exercise validation tool (airport);
- Fast Time Simulations – multi-airport TMA (A-CDA), TMA trajectory management and runway improvements were assessed with fast-time modelling tools (RAMS, TAAM);
- Prototyping sessions - SESAR TMA concept elements (CTA, RTA) were addressed, to look at the operability aspects in a human-in-the-loop environment.

See the DOW [17] for a description of the different techniques.

2.5 VALIDATION TOOLS

2.5.1 Description of Tools

2.5.1.1 Expert Groups

Expert groups were used in both the TMA and Airport areas of WP5.

The TMA Expert Group supported the WP5 TMA exercises by using a combination of facilitated meetings and questionnaire techniques applied to a group of selected individuals with specific knowledge within the areas of ATM operations and systems, airborne systems and aircraft related to TMA operations.

Operational Scenarios (OS) were developed and coordinated by WP5.2.2 *Operational Concept Refinement* with support from the TMA expert group to assist TMA exercises and to present the results of the concept refinement[15]

Storyboards show pictorially the actors, sequence of activities and coordination events (as well as outstanding comments and assumptions made). The storyboards provided a simple picture of the airside scenarios and provided a clear method for presenting information to SESAR partners. A storyboard was developed and presented to the TMA expert group to review and approve before finalising the storyboard with the results of the exercises. The TMA EG supported validation exercises with assumptions, guidance for further iterations and supported integration of exercise results and feedback to the concept clarification WPs (via WP5.2 to WP 2.2 for the update of DODs).

The airport EG consisted of experts working in the area of 'airside' activities such as ATC TWR Controllers, ATC GND Controllers and airline representatives (planning, GND Handling) and pilots). The objective was refinement of the SESAR ConOps related to the Execution Phase of the Business Trajectory at the airport. SESAR Experts, ATM R&D Experts and facilitators were combined with operational experts to assist on understanding of the state of the art (current projects), the proposed solution (SESAR) and ensuring results were coordinated and in consistent with other EP3 activities.

The airport EG was presented with the current situation at the airport regarding tolerances for departure and arrival of aircraft. This ensured that the group agreed on the current limitations, and that there is an operational problem to be solved. Ongoing projects and recommendations were then discussed to provide a baseline for reviewing the proposed SESAR ConOps solution. The group were provided with questionnaires and supporting information prior to meetings. The principal output was two storyboards (landing and taxi to stand and stand, taxi out and departure). See the WP5.3.2 Expert Group report [2] for more details.

2.5.1.2 Fast Time Modelling

Fast time modelling allows a quick method of setting up and performing an exercise providing mathematical and statistical information on ATC operations.

Fast-time modelling tools (RAMS plus, TAAM) were used to validate multi-airport TMA, TMA trajectory management and runway operational improvements. A limiting factor in the use of such tools is that the results depend on the environment chosen, and on the traffic levels selected. Careful consideration is required when analysing results to show overall results in Europe for a specific area covered.

2.5.1.3 Prototyping sessions

The concept clarification and operability aspects of fundamental TMA concept elements (P-RNAV/A-CDA, CTA, RTA, ASPA S&M) for 2013/2017 was addressed by a series of four prototyping sessions held between October 2008 and February 2009 using the ESCAPE Real Time Simulator (used for all sessions). Three sessions were carried out at the EUROCONTROL Experimental Centre (EEC). The fourth session was carried out at SICTA premises in Naples, Italy.

A prototyping approach provides an iterative process, introducing the concept elements step by step, facilitating interactions between each step with the Expert Group, and ensuring feedback from the experts is included in subsequent sessions.

Prototyping session advantages are:

- Reduced cost: small scale focusing on specific issues;
- Iterative process, building from one session to the next;
- Flexibility: implementation of changes from one session to the next.

Prototyping session limitations are:

- Limited time to train the controllers (1-1,5 day max per session);
- Limited representation of results, which must be considered as trends rather than strong performance measures;
- Limited time between sessions to conduct acceptance tests on the platform.

The ESCAPE Platform provides a capability based on components from Industry to support the validation activities of the European ATM Program and the EC Single European Sky initiative. ESCAPE supports the rapid introduction of new technologies, and has adopted a functional and technical strategy for simulator development that follows standards (AVENUE) defined and accepted at a European level. These standards are designed to ensure that simulator components are interchangeable, no matter where they are developed.

3 CONCEPT DETAILING

3.1 INTRODUCTION

Within WP5, concept detailing was carried out using information and support provided from WP2, specifically WP2.2 *(Concept Refinement of SESAR ConOps*). WP5.2.2 *Operational Concept Refinement* ensured both that exercises had the necessary concept information and that the concept detailing results were consolidated and passed back to WP2.2.

The SESAR ConOps, the initial DODs [8][9][10][11][12] and the Operational Scenarios [15] were used as concept support documents when refining the exercises described in the DOW [17].

The principal source of concept detail used was from the Operational Scenarios (OS). The OS provided the experts with operational examples (particularly when adapted to storyboard format) to review and understand the area of the concept covered. The storyboard format was a particularly useful way of performing this task.

3.2 METHODOLOGY

In order to further clarify the SESAR ConOps, WP 5.2.2 was tasked with the development of operational scenarios. In order to do this the WP took a combined bottom-up and top-down approach to select the topics for the OS. The first bottom up selection of OS was based on the needs of the WP5.3 validation exercises and aimed to provide support for the conduct of these exercises. In a second step, further scenarios were selected from the top down, focusing on other key elements of the airport and TMA processes.

The first draft OS were developed using information provided in the SESAR ConOps[22] and the relevant DODs ([10], [11] [12]). The Information Navigator [23] was particularly useful in this task. The information from the ConOps and the DODs was combined with recent studies and the results of expert discussions. During the production of the OS, draft versions were made available to WP5.3 exercise leaders to support validation exercises. The early drafts were also used to develop the storyboards in the expert groups, specifically to support exercises in the TMA group and as an output in the airport expert group. The results of the validation exercises together with the scenarios themselves were in turn discussed within the EP3 WP5 airport and TMA expert groups. Experts and exercise leaders provided comments which served to update the Operational Scenarios. Further review and discussion of the OS took place between WP5, WP4 and the WP2 Coordination Cell. However, due to the fact that not all scenarios were used or referenced in the exercises not all Operational Scenarios have been updated.

3.3 CONCEPT RESULTS

Eleven Operational Scenarios were developed as part of the concept support and refinement activities. They describe nominal and non-nominal situations during arrival, taxi-in/out and departure of an aircraft. Assumptions, roles and responsibilities of the different actors as well as processes and interactions are explained. The scenarios are named and coded as follows:

- OS-12 Landing and Taxi to Stand;
- OS-13 Taxi-out and Take-off;
- OS-17 Solve Hazardous Situations during Taxiing;
- OS-21 Departure from Non-Standard Runway;
- OS-27 Allocation of the Departure Profile;
- OS-28 Allocation of the Departure Route;

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- OS-29 Closely Spaced Parallel Operations in IMC;
- OS-31 Handle Unexpected Closure of an Airport Airside Resource;
- OS-32 Management of Vehicles on Manoeuvring Area;
- OS-35 High Density TMA Arrival- Flying a CDA Merging;
- OS-39 Aborted Take-off.

Figure 4 gives a graphical overview of the relationships between the different operational scenarios. Arrival scenarios are shown in blue, departure scenarios in orange, and the transverse scenario is shown in green.

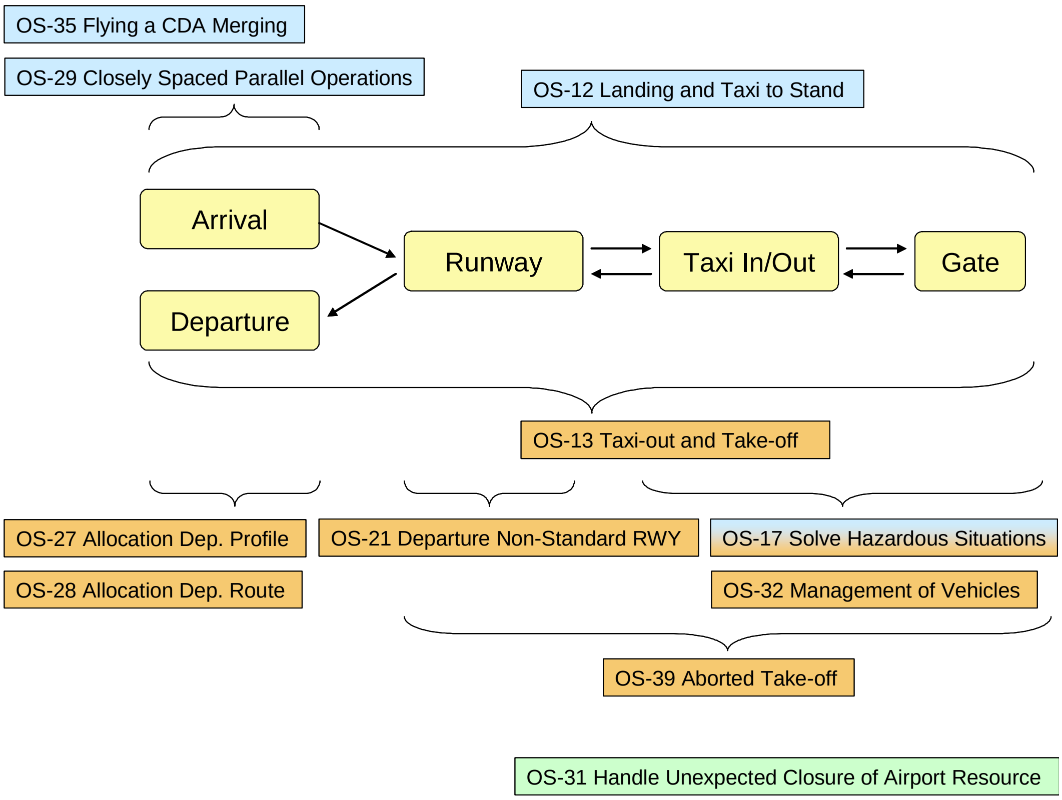


Figure 4: Overview of WP5 Operational Scenarios

Detailed information on WP5 Operational Scenarios can be found in [15]; information on all EP3 Operational Scenarios can be obtained from the General DOD [8].

3.3.1 TMA Concept Results

The TMA concept results were provided in the following:

- Storyboard and Operational Scenario for ‘Flying CDA Merging’ – OS-35 [1] [15]. The scenario describes the processes and interactions when flying an (Advanced) Continuous Descent Approach in a medium/low complexity airspace with high traffic density. It explains 6 different cases:
    1. Nominal CDA before IAF;
    2. CDA with holding before IAF;

3. Tactical intervention during CDA before IAF;
4. Nominal CDA after IAF;
5. CDA with wind impact after IAF;
6. Tactical intervention during CDA after IAF.

- Operational Scenario for 'Closely Spaced Parallel Operations in IMC' OS-29 [15]. The scenario describes the processes and interactions when managing closely spaced parallel runway operations in Instrument Meteorological Conditions (IMC). In the scenario two different aircraft are routed to the start of two separated RNP procedures, each leading to one of the parallel runways. In this nominal case the aircraft are able to land without detecting risks from wind, vortices or trajectory deviations;
- Concept Recommendations included in TMA Expert Group [1] report and this report.

More TMA concept element conclusions can be found in section 6.7.

3.3.2 Airport Concept Results

OS-12, OS-13, OS-17 and OS- 21 have been amended with comments from the WP5.3.2 *Airport Expert Group*. OS-12 and OS-13 which are the main scenarios related to landing an aircraft and departure of an aircraft from an airport ('airside' activities during Execution Phase of the SESAR Trajectory) were translated into storyboards. These storyboards were then progressively reviewed and provided as results in the WP5.3.2 report [2].

In summary, OS-12 describes the processes and interactions to control the landing and the Taxi-in of an aircraft. It contains 5 different cases describing nominal and non-nominal procedures for landing and Taxi-in to stand:

- An aircraft lands with BTV;
- An aircraft lands without BTV, misses the exit runway and is issued with a new taxi plan to get to its original stand;
- An aircraft suffers a change of stand after landing and is re-directed to another stand;
- An aircraft lands with an exceeding Runway Occupancy Time (ROT);
- Forcing a subsequent aircraft to perform a go-around.

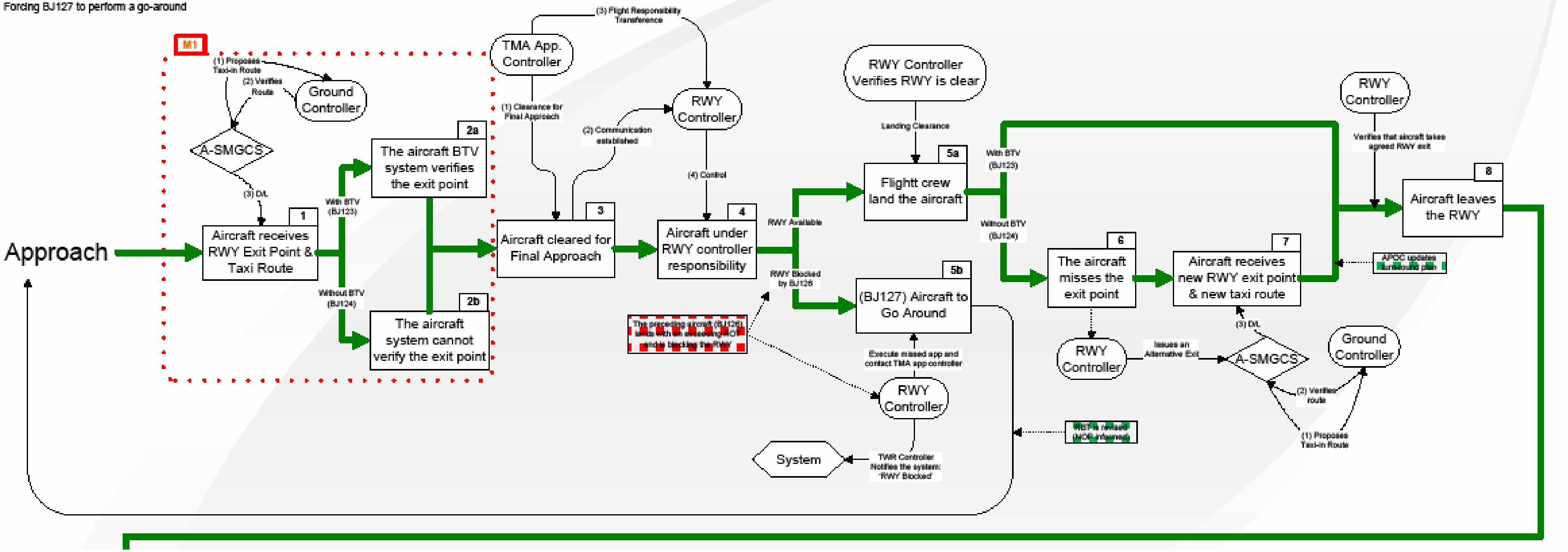
Scenario OS-13 describes the processes and interactions to control the Taxi-out and Take-off of an aircraft. It outlines 5 different cases:

- Nominal case for Taxi-out and Take-off;
- Deviation from planned RBT Taxi-out route;
- Abortion of Take-off and inability to vacate the runway;
- Forcing the subsequent aircraft to return to stand;
- Taxi out with abortion of taxi and return to stand.

More detail can be seen on the storyboards shown below. The storyboards are displayed on two pages for clarity.

<u>Flights sequence</u>

- BJ123 operation corresponds to the nominal case landing with BTV;
- BJ124 lands without BTV, misses the exit runway and is issued with a new taxi plan to get to its original stand;
- BJ125 suffers a change of stand after landing and is re-directed to another stand;
- BJ126 lands with an exceeding Runway Occupancy Time (ROT);
- Forcing BJ127 to perform a go-around



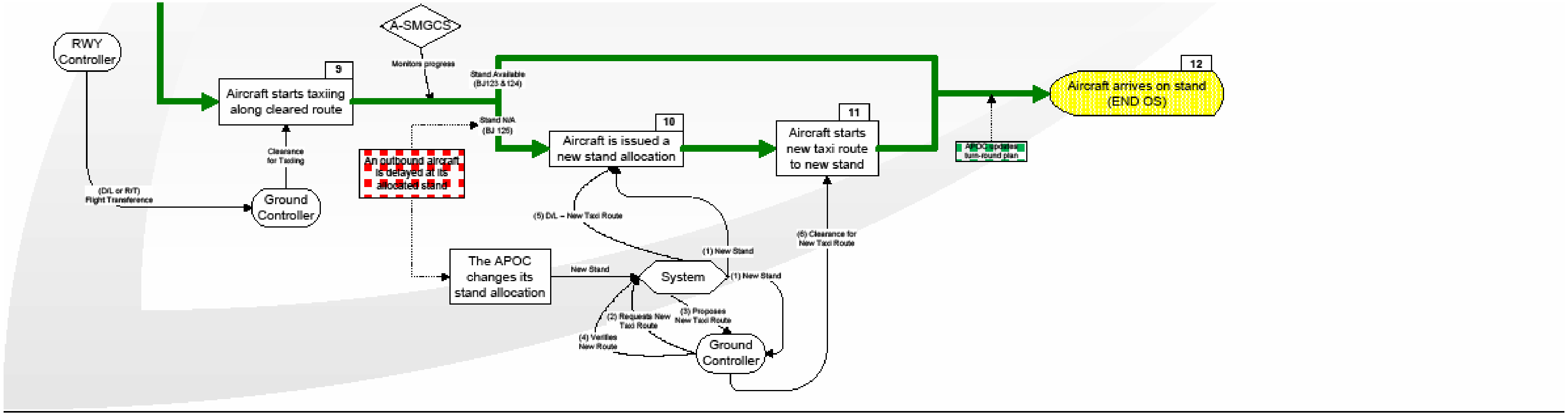
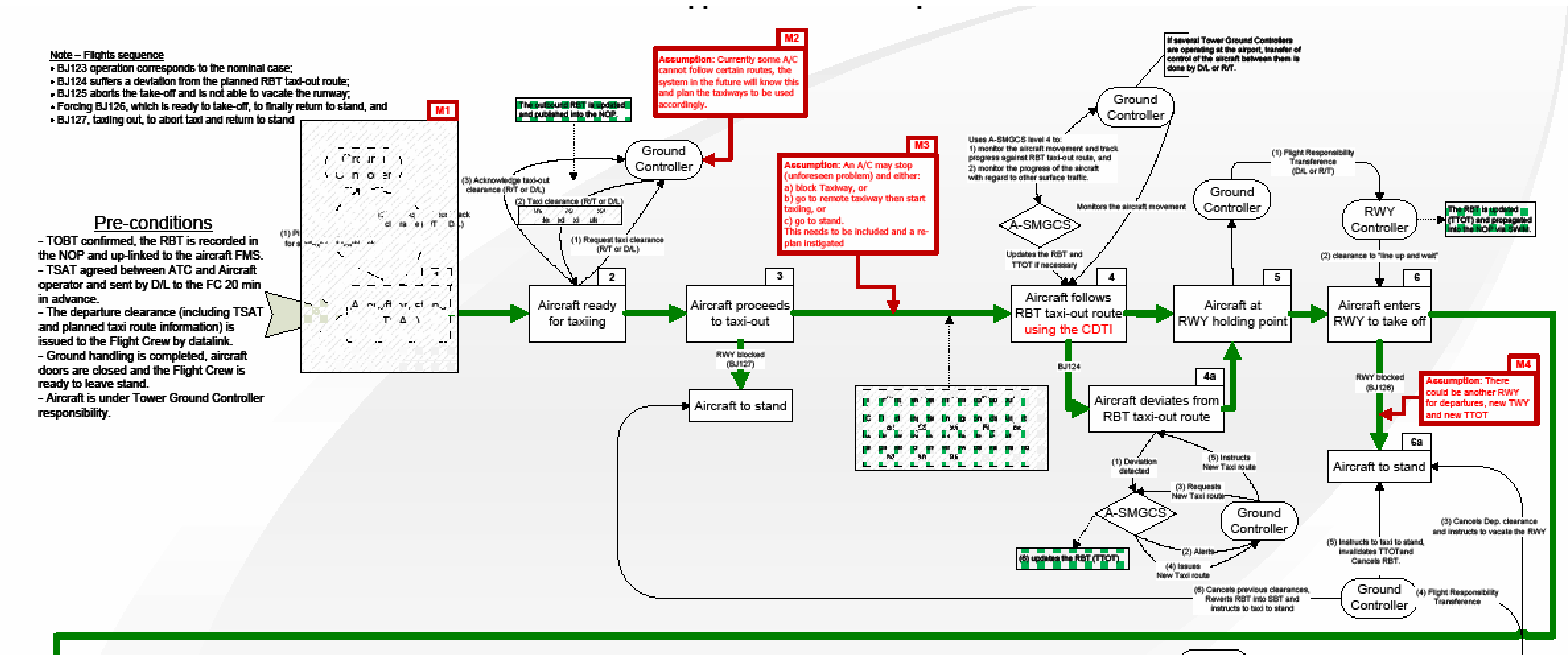


Figure 5: Storyboard for OS-12 – Landing and Taxi to Stand



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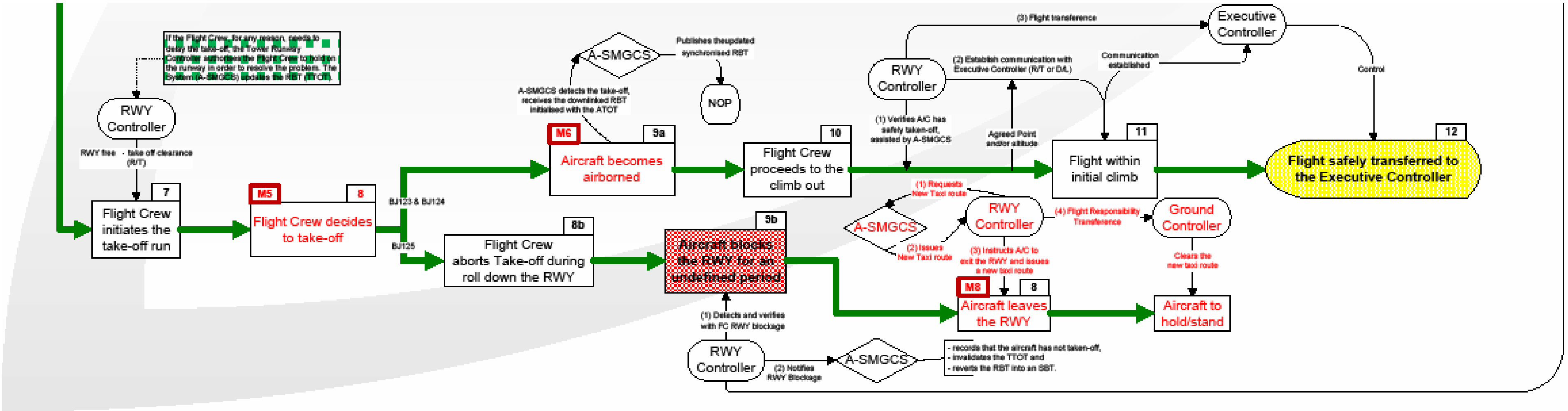

Figure 6: OS-13 – Stand, Taxi out and Departure

3.4 LESSONS LEARNT

Many lessons were learned during the concept detailing work:

1. The links between the concept (DODS), the operational scenarios and any use cases should be well defined to allow update of the concept following review and update of the OS during the exercises.
2. The storyboard format was a particularly useful way of saving time and effort when ensuring that experts could understand and review the concept.
3. For concept detailing a concept authority needs to be established which has the mandate to challenge or change the concept in order to mediate discussions and find approved solutions.
4. Expert groups proved to be very valuable for refining the concept and scenarios.
5. A transparent process for feedback of exercise results/expert discussions to the scenarios and DODs should be established.

4 OPERABILITY ASPECTS

4.1 INTRODUCTION

Operability studies provide results on how the concept being validated would be integrated into the day to day work of the Air Traffic Control Officer (ATCO).

WP 5.3.6 *Prototyping of a Dense TMA* investigated the Operability aspects of the TMA Concept elements addressed using ATCOs.

4.2 METHODOLOGY

A prototyping session methodology was adopted in order to investigate the feasibility and operability of P-RNAV, A-CDA and CTA (and Airborne Spacing S&M as far as session 4 was concerned), Prototyping sessions allowed a progressive approach for controllers to assess the concept. The prototyping sessions gradually increased in complexity and included lessons learnt from previous sessions and recommendations from interactions with the TMA expert group. The series of prototyping sessions focused on the intermediate timeframe (Implementation Package 2).

Feedback from controllers to the expert group showed how well aligned the experts were with the concept assumptions made and the potential benefits.

4.3 OPERABILITY RESULTS

Task 1 (P-RNAV, A-CDA and CTA assessment)

The main aim of the operability assessment was to clarify the predicted SESAR-IP2 improvements of the route structures in a dense TMA, combined with the optimisation of descent procedures (A-CDA)and controlled time of arrival (CTA) constraints. The main focus was upon operability, with assessment of initial trends on SESAR KPAs (e.g. efficiency, predictability, capacity and safety) as a secondary objective. The iterative approach allowed the scope of the prototyping sessions to be successively adjusted. This was communicated and agreed through TMA expert group meetings scheduled in between the prototyping sessions.

The first session aimed at refining the controllers' roles, working methods and ATC procedures, and assessed the operability and acceptability of A-CDA in a P-RNAV route structure.

The second session assessed the impact of variability in traffic presentation at the TMA boundary (through different levels of clustering of arrival traffic) on the operability and acceptability of A-CDA in an improved new P-RNAV route structure.

The third session confirmed the acceptability and operational feasibility of A-CDA down to the FAF in the improved P-RNAV environment, and assessed the impact of mixed aircraft RTA equipage on this acceptability and operational feasibility.

The fourth session (Task 2) evaluated, in a different environment similar to the high density Rome TMA, the use of Airborne Spacing S&M application combined with the use of the Point Merge System (PMS) and A-CDA.

Results from Task 1 showed that the P-RNAV/Advanced CDA concept that was tested is operationally viable. With P-RNAV and A-CDA, the overall feedback was positive, controllers found it easy to work with the procedures, and provided a suitable and safe routes design. P-RNAV and A-CDA enable a large reduction in R/T, leaving free cognitive resource. Teamwork and coordination, especially between approach and final were deemed essential for efficiency and throughput. The controllers found that the CTA concept has potential for optimal delivery at a metering point (i.e. the IAF in the design considered for the Task 1 sessions), increase in regularity, punctuality, predictability, reduction in stack usage, but might reduce flexibility and controllers' situation awareness and lack robustness against external factors (e.g. meteorological conditions). Open issues include the variability of working methods (and their impact on performance) and the CTA/RTA maturity. Despite these issues, initial trends on performance showed that even under high traffic load, the concept provided benefits, allowing aircraft to remain on lateral navigation (2D), carry out Advanced Continuous Descent Approaches (3D) and achieve consistent inter-aircraft spacing on final (4D).

In summary, the exercises in task 1 showed that the following operability – related hypotheses were confirmed or partly confirmed:

- HO1. In a dense terminal area, the P-RNAV/A-CDA concept is achievable.
- HO3. Compared to today, P-RNAV/A-CDA allows for better task allocation between controllers in TMA airspace.
- HO4. The phraseology, HMI and tools used are appropriate and easy to work with.
- HO5. The P-RNAV/A-CDA allows segregation between arriving and departing flows.
- HO6. Compared to today, with P-RNAV/ACDA and aircraft arriving on CTA, a reduction in instructions leads to a reduction in workload.
- HO7. Aircraft adjusting their speed (RTA function) induces a monitoring load increase and reduced RTA equipage induces a workload increase.

Task 2 (Airborne Spacing S&M, P-RNAV/PMS, A-CDA)

Results from the Task 2 (session 4, ENAV/SICTA) showed that P-RNAV/A-CDA and Airborne Spacing S&M concepts in a today environment (same sectorisation and coexistence of traditional handled flows) are operationally viable. Controllers found P-RNAV/A-CDA a valuable technique allowing a reduction of workload through the avoiding of vectoring, leaving more time to monitoring. In the simulated environment, A-CDA concept application did not have a negative impact on the traffic management as the traffic flows were sequenced by a scripted AMAN. The controllers suggested to further investigate this aspect in a realistic environment considering all the possible different descend profiles of inbound traffic.

The controllers found it easy to manage the traffic using P-RNAV and A-CDA together. The new route structure and associated new working methods allow the controllers to manage high traffic loads with an acceptable workload thanks to a reduction of tasks associated with this new operational environment. P-RNAV and A-CDA allow the controllers to have a better situation awareness of the traffic evolution due to a standardised working methods based on an arrival structured route layout. Accordingly, in the nominal situation, controllers perceived an increased safety level.

The combined use of Airborne Spacing S&M, P-RNAV and CDA allow ATCO to focus more on sequence leg management. A controller having delegated spacing tasks to the cockpit can improve monitoring of the arrival stream traffic evolution. The availability of Airborne Spacing S&M infringement tool was appreciated by controllers enabling them to have a timely warning in case of infringement.

In summary, the exercise in task 2 showed that the following operability – related hypotheses were confirmed or partly confirmed:

- H1.2.1 The defined P-RNAV/A-CDA and ASPA S&M working method is feasible and acceptable to the controller.
- H.1.3.1 In a dense terminal area, the P-RNAV/A-CDA and ASPA S&M concepts ew achievable.
- H1.4.1 The defined phraseology is appropriate and easy to understand.
- H2.1.1 Compared to today, with P-RNAV/ACDA and ASPA S&NM a reduction in instructions leads to a reduction in workload.

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All hypotheses are related to the WP5.3.6 exercises and more details on how these results were determined including the context and assumptions can be found in the WP5.3.6 report [6].

5 PERFORMANCE ASPECTS

5.1 INTRODUCTION

The WP5 exercises identified the Key Performance Areas (KPA) to be addressed [14], and the Key Performance Indicators (KPI) from the Performance Framework [16] that would be measured. An overview of the assessment of performance indicators is given in section 5.2 and in section 5.3 some trends to performance indicators are given. Finally, section 5.4 summarises the lessons learnt.

5.2 METHODOLOGY

The EP3 Performance Framework deliverable [16] is one of the key outputs of EP3. The Influence diagrams show how measurements (KPI) in the different areas of an ATM concept can be consolidated to show the overall impact on the KPA.

Within EP3, due to the timescales involved, it was not possible to populate the Performance Framework [16] with data from the experiments in a coherent and useful way. Nor was it possible to modify the platforms used to provide measurements against the KPI for all required measurements. In addition, the different exercises although using the same KPI, require a method of ensuring the KPI are measured in a consistent way to provide viable results.

However, the KPIs were measured where possible and the exercise reports [1][2][3][4][5][6] indicate which KPI were measured and the results gained against those KPI in each exercise.

The results are initial findings and should be seen as such; the WP5 exercise reports provide a more detailed analysis of the results obtained.

5.3 KEY PERFORMANCE AREA RESULTS

The results set out below cover runway capacity for the airport, but the TMA was more extensively assessed.

5.3.1 Capacity

Airport Capacity

Validated runway improvements [3] showed the following:

- Brake to Vacate (BTV) will reduce runway occupancy time (of the order of 2 to 3 minutes in a 60 minute period was recorded);
- Time Based Spacing (TBS) will prevent the loss of landing slots during periods of strong headwind;
- Crosswind reduced separations for departures and arrivals will increase runway throughput when favourable wind conditions prevail;
- Fixed reduced separations (based on Wake Turbulence prediction) will increase runway throughput under CAT I conditions;
- The reduction of ILS critical and sensitive areas will result in a reduction in the loss of runway throughput due to low visibility conditions;
- Improvements proposed in the SESAR concept related to the execution phase of the business trajectory at the airport 'airside' improve efficiency and predictability [2].

TMA Capacity

TMA Trajectory Management [5] validation showed the following:

- 2D P-RNAV, 3D P-RNAV, TMA ATC Support Tools and Allocation of TMA Route/Profile Routes (using Precision Trajectory Clearance -2D and Precision Trajectory Clearance -3D) will increase Airspace Capacity;
- Modifying the TMA Structure (increasing flexibility) through definition of procedures and modification of TMA boundaries previously defined and included in the NOP taking into account real-time traffic conditions could increase capacity;
- In a Multi Airport TMA Environment [4] the improvements related to DCB and airspace development as well as CDAs can provide the required capacity under nominal conditions.

It should be noted that although SESAR 2020 traffic level was used, these results are from local studies. A limited assessment of how well the results extrapolate elsewhere is needed.

5.3.2 Efficiency

TMA

In the TMA, the following can be concluded from the exercise results:

- 2D P-RNAV, 3D P-RNAV and allocation of TMA route/profile routes (Precision Trajectory Clearance-2D, Precision Trajectory Clearance-3D) will increase flight efficiency in terms of reducing flight duration [5];
- Additionally P-RNAV, 3D P-RNAV, ATC support tools and the allocation of TMA route/profile routes (Precision Trajectory Clearance-2D, Precision Trajectory Clearance-3D) will reduce potential conflicts and the number of ATC overloads/underloads;
- P-RNAV/A-CDA provides efficient management of high traffic in a TMA [5];
- Improved performance of CDA operations is possible in extended TMA airspace by the creation of “dedicated arrival flow corridors” and advanced (CDA, A-CDA, DCB) arrival concept elements [4];
- Noise emissions are reduced with CDA in a multi-airport TMA environment [4].

5.4 Lessons Learnt

The following list summarises the lessons learnt by WP5. Many lessons seem to be quite general, but have been confirmed as valuable on a project such as EP3, where a large, geographically-dispersed team of experts had to cooperate on a variety of tasks. Others are more specific to WP5, but still illustrate valuable practices.

- The exercises in WP5 provided valuable results showing indications and in some cases measurements against SESAR improvement steps (see runway improvements above);
- To allow consistent and useable results it is necessary to measure KPI consistently in different areas of Europe. The performance framework, although providing a method of bringing together results (KPI) that can be used to measure the impact in the different areas against the KPA, does not include guidance on how to ensure consistency or how to extrapolate results to a wider context (for example, to ECAC from a local area).This shortcoming will require attention in SESAR before measurements can be used in a realistic fashion to show the impact on the SESAR Performance Targets;

- The context of an exercise (geographical area, traffic levels, type of traffic) needs to be evaluated as soon as possible to ensure steps can be taken to provide worthwhile results. This was done in WP5 but issues still remain;
- The limited availability of some experts meant that some questions remained unanswered and it was necessary at some stages to give priority to the exercises to ensure that they could continue;
- The relationships (dependencies) between operational improvement steps were not addressed. Had they been, this would have simplified the work package overall view of the exercises and areas covered;
- Assumptions need to be managed, and the effect of assumptions on performance results must be clarified;
- Clear links between exercises and the concept areas covered by the exercises, as developed in the WP5 Validation Strategy [14], are necessary;
- It is difficult to coordinate both concept refinement and validation techniques within the timeframe of an exercise, although the use of assumptions partially mitigated this;
- A clear decision-making process for setting up exercises and preparing questions/assumptions/issues to be resolved is essential.

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6 DISCUSSION AND CONCLUSIONS

6.1 INTRODUCTION

This chapter contains discussions and conclusions gained from the WP5 exercises, related to project management, validation and concept clarification, and validation tools and techniques. Finally, a list of Hot Topics is given.

6.2 PROJECT MANAGEMENT

The location of the distributed project team is a key element in reducing the risk of poor performance. It is essential to build teams carefully to ensure that key resources are motivated and to provide support to the exercises.

It is essential to listen to the key resources within the project and ensure their issues are resolved in a fair and consistent manner.

Issues management involving all exercise leaders reduces the overhead of repeating the same mistakes and allows exercise leaders to get on with their job (e.g. problems with traffic and environment are general issues to ensure the baselines are consistent).

Leadership requires flexibility to support partners and allow them to concentrate on their exercises with the necessary support (concept expertise, EOCVM, Management Structure) in place.

6.3 VALIDATION STRATEGY

A validation strategy showing the justification of concept elements to be addressed and how they are to be addressed supports exercises and projects in providing an overall view of the work to be carried out in line with E-OCVM.

In WP5, the validation strategy did not completely fulfil its purpose of providing a top down approach and selecting the ideal validation activities. However, it did provide guidance to the project (in particular related to E-OCVM), and provided a means of checking that the exercises as conducted matched the original intent.

The DOW contained both top-down and bottom-up objectives. The validation strategy should be in line with E-OCVM and ensure the exercises (bottom) are aware of and aligned to both the concept (identifying what area is to be covered) and the validation performance framework or a separate study of the concept (to say why the area is to be covered). In addition the use of the performance framework and indicators to be measured could be included here for a consistent approach across the work package.

A key question to be addressed early in a validation project is “How will the different exercises show results at the larger scale (ECAC wide)?”

6.4 CONCEPT CLARIFICATION

The refinement of the concept requires expertise (concept and methodology) with clear definitions. The DODs and scenarios provided were a stable baseline to commence work from; the scenarios proved most worthwhile when presenting the concept to groups of operational experts.

Hot Topics can be discussed within expert groups and the results used to refine the concept.

Training on the concept is required for consistent use of assumptions and terminology from the start of the project.

A process including clear roles and responsibilities is necessary to review the changes and update concept documents.

The use of common scenarios and cross scenario-validation between different operational areas would assist in reducing errors in assumptions and results.

Coordination between exercises and work packages for concept questions and assumptions must be in place before commencing detailed exercise plans.

6.5 VALIDATION TOOLS

The use of tools to validate the SESAR ConOps was constrained:

- Firstly, due to the initial limited understanding and detail of the concept. In order to be able to make suitable requirements for the update, the ATM concept under analysis should be clearly defined;
- Secondly, due to planning. The writing of requirements, the updating of the tool and testing of the introduced updates should be done before the beginning of the modelling. However with the limited detail of the concept and knowledge this can be seen as a recommendation to use other more suitable tools first.

The use of tools to refine and validate concept elements requires planning, knowledge of the concept and a consistent approach. The tools require validation themselves by concept experts to check they represent the concept correctly. In addition, discussions should be held with the providers of validation tools to determine how the different areas that have been validated can be linked to provide ECAC-wide measurements.

The use of storyboards to represent the concept is a way of ensuring groups of people can understand the problem or solution in a simple manner.

It is not clear that current tools provide results (KPI) in a consistent fashion. This did not affect WP5 greatly, since only trends were measured.

The combination of expert groups with fast time modelling and prototyping sessions is an efficient means of providing "quick look" results as well as providing input to the maturing of the concept. Further more detailed iterations could provide more detailed results.

6.6 VALIDATION TECHNIQUES

Expert Groups

The use of expert groups is a valuable tool when refining concepts. Facilitation and selection of the correct experts (including their area of expertise and their openness to change) is critical for a realistic and viable solution. Experts are also valuable in supporting assumptions and key questions when planning and carrying out exercises (FTS, Prototyping sessions).

FTS

EP3 WP5 has provided evidence, of possible improvements from the introduction of new concepts in a high density TMA. This is aligned with the SESAR JU's expectation from the EP3 Project to refine the concept whilst limiting the use of Fast Time techniques through an assessment of trends and not absolute values. This approach is valid for TMA concept elements at the current level of maturity in the SESAR concept.

FTS can be used to show initial trends and identify areas requiring further investigation. Measurements are taken and although the concept may not be at a required level of detail for modelling, there is still real benefit in identifying the potential improvements and areas of concern.

Prototyping sessions

Prototyping sessions showed the benefit of using ATCOs as validation subjects in a flexible environment using a consistent set of experts and progressive investigation on the Concept.

Issues include ensuring a consistent set of ATCOs participate due to the shortened training timescales and knowledge required from ongoing sessions.

Prototyping sessions provided a "quick" look on the concept to see if it was suitable with ATCOs and which areas would need to be addressed for further progress (procedures, concept refinement).

The concept documentation is not suitable for training ATCOs directly. The training required must be focused and provided at the correct level to move ATCOs from today's operation progressively to the SESAR concept.

Prototyping sessions are a useful tool for starting the human in the loop aspects required. Areas for further investigation related to working methods and areas of clear benefit can be identified. Additionally ATCOs participating can relay the ideas to their companies for further investigation and pave the way for further involvement and "buy in" as the concept validation progresses.

Concept Refinement Exercise

The Concept Refinement Exercise (CRE) was successful in providing a problem in a way that was suitable for experts to review. The results, in the form of a storyboard, simplified both the results and the presentation of the results (see [2] [5]).

Storyboards

Storyboards provide an excellent method of presenting and reviewing a concept to a group of experts and non-experts. It is critical to use simple terminology and standard definitions to ensure agreement. When presenting to experts from different operational and or cultural backgrounds the storyboards provide an efficient and well understood method for review.

Storyboards are good for high level concept work but unsuitable for detailed concept work.

Combination of exercise types

The combination of expert group (including operational scenario and storyboard provision), fast-time simulation and prototyping sessions is an efficient means of refining and detailing a concept using an iterative approach. Time is needed (and should be planned) to update the tools to meet the (re)defined objectives following expert review.

6.7 TMA Concept Element Conclusions

The fast-time experiment, conducted with TAAM© and simulating 24 hours of traffic demand in the core area of Europe for a current flow, 2008, and a future flow, 2020 scenario, was able to validate successfully:

- CDA profiles from TOD provide significant benefits in terms of flight efficiency and workload, if operated undisturbed along dedicated arrival flow corridors.
- "Dedicated Arrival Flow Corridors" are offering more efficient use of airspace than today's, i.e. 2009, airspace organisation, but these corridors are to be compromised yet with the needs of other airspace users. These corridors have to be considered therefore as airspace requirements for future arrival operations of hub airports of interest in this experiment.
- DCB measures are contributing to optimise arrival operations at airports of interest by prioritising departure operations, benefiting services for on-time arrivals of congested arrival flows, and contributing therefore to minimising the variability of traffic demand of these flows. These measures contribute by reducing flight duration of flights involved and by limiting the airspace needed to create the "Dedicated Arrival Flow Corridors".

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- Arrival traffic synchronisation by an advanced AMAN operating with 4D trajectory planning can provide additional benefits, depending on deviations of arrivals from earlier planning. In addition, advanced AMAN provides opportunities to optimise wake vortex sequences and to keep control on realisation of high accuracy sequencing over the IAFs.
- Together, airspace improvement, layered planning and arrival traffic synchronisation with high accuracy sequencing over the IAF are enabling the noise friendly final CDAs in lower TMA airspace.

Full details of the environment in which the concepts were validated, and the detailed results can be found in the work package report [4].

The fast-time simulations conducted by WP5.3.5 covered:

- An adapted Rome TMA, using a 2020 traffic sample to assess the introduction of 2D P-RNAV with CDAs and PRNAV+VNAV capability.
- The Barcelona TMA, using 2020, new procedures, new ATC Supporting Tools, with and without PTC-2D and PTC-3D, and equipage levels of 50% and 100% of aircraft are 3D equipped.

The key findings from the two FTS are summarised below. Full details of the environment in which the concepts were validated, and the detailed results can be found in the work package report [5].

- P-RNAV/PMS allows the management of an increased arrival flow.
- Safety is improved with the introduction of P-RNAV.
- Results confirmed the expectation that A-CDA concept would produce benefits in terms of Flight Efficiency but not of Capacity.
- Safety is improved with the introduction of P-RNAV.
- A tool that allocates flights to a conflict-free procedure needs to be introduced together with PTC-3D separation mode in order to manage potential conflicts generated due to removing the pre-defined FL restrictions linked to this new separation mode.
- The introduction of the Allocation Route Tool (linked to the PTC-2D separation mode) reduced the number of Separation losses.
- The introduction of ATC supporting tools (assuming a task load reduction of 20%), in comparison with baseline scenario, would improve the safety in terms of number of overloaded hours (around 45%).
- If new supporting tools save 40% of workload in some of the controller tasks, it would be unnecessary to implement the PTC-2D separation mode.
- If new supporting tools save 30% of workload in some of the controller tasks, it would be required to implement the PTC-2D separation mode.
- If new supporting tools save 20% of workload in some of the controller tasks, it would be strongly recommended to implement the PTC-2D (and even the PTC-3D).
- The introduction of supporting tools considerably reduces the time the TMA sectors are overloaded. However, the number of conflicts does not change.
- The introduction of PTC-2D by itself provides a very slight capacity increase, as it was already foreseen by different experts.

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- The introduction of PTC-2D together with an Allocation Tool (CM-0405) provides different gains in capacity depending on the kind of sector under analysis (up to 10% for Arrival Sector, around 3% for mixed Arrival and Departure Sectors).
- The introduction of ATC supporting tools (CM-0406 assuming a task load reduction of 20%) together with PTC-2D and an Allocation Tool, results in a significant Capacity Improvement (up to 26% for Arrival Sector, around 19% for mixed Arrival and Departure Sectors).
- Safety is improved, as long as there is a tool that correctly allocates a conflict-free procedure to solve potential conflicts on the same SID or on the same STAR.
- The introduction of ATC supporting tools (assuming a task load reduction of 20%), in comparison with the baseline scenario, would improve the safety in terms of number of overloaded hours.
- Efficiency is not considerably improved with the introduction of PTC-2D. However, due to the FTS Platform limitations, this KPA needs further investigation.
- The introduction of PTC-3D, together with an Allocation Tool (CM-0405), provides different gains in capacity depending on the kind of sector under analysis (up to 11% for sectors with a low number of arrival integrations and arrival vs. departure crosses; around 25% for sectors with a high number of arrival merging or arrival vs. departure crosses).
- The introduction of ATC supporting tools (CM-0406 assuming a task load reduction of 20%) together with PTC-3D and an Allocation Tool, result in a significant Capacity Improvement (up to 30% for sectors with a low number of arrival integrations and arrival vs. departure crosses; around 50% for sectors with a high number of arrival merging or arrival vs. departure crosses).
- The introduction of PTC-3D without the Allocation Tool would worsen safety due to a large increase in the number of potential conflicts. This is because the introduction of PTC-3D is linked to the introduction of user-preferred profile (i.e. climb and descent rate) operation in the procedures (Experts opinion).
- Efficiency is considerably improved with the introduction of PTC-3D (around 17%) because flights can fly using their optimum climb or descent rate. The introduction of PTC-3D together with an Allocation Tool reduce tactical level-offs and therefore the flight profile can be similar to the user-preferred one.

WP5.3.6, conducted a series of four prototyping sessions clarify the SESAR-IP2 improvements of the route structures in a dense TMA, combined with the optimisation of descent procedures (A-CDA), CTA constraints, and with the ASPA S&M application. The focus was upon operability with initial trends on SESAR KPAs. Full information (including simulation environment and results is given in the WP report [6]. The four sessions focussed on:

- Refining the controllers' roles, working methods and ATC procedures, to assess the operability and acceptability of A-CDA in a P-RNAV route structure.
- Assessing the impact of variability in traffic presentation at the TMA boundary on the operability and acceptability of A-CDA in an improved new P-RNAV route structure.
- Confirming the acceptability and operational feasibility of A-CDA down to the FAF in the improved P-RNAV environment and assessed the impact of mixed aircraft RTA equipage on this acceptability and operational feasibility.
- Evaluating, in a different environment like the high density Rome TMA, the use of ASPA S&M application combined with the use of Point Merge System (PMS) and A-CDA.

The results are summarised below:

- The PRNAV/Advanced CDA concept tested is operationally viable. With P-RNAV and A-CDA, the overall feedback was positive, controllers found it easy to work with the procedures, given a suitable and safe routes design. P-RNAV and A-CDA enable a large reduction in R/T, leaving free cognitive resource.
- Teamwork and coordination, especially between approach and final were deemed essential for efficiency and throughput.
- The controllers found that the CTA concept has potential for optimal delivery at metering point (i.e. the IAF in the considered design for the Task 1 sessions), increase in regularity, punctuality, predictability, reduction in stack usage, but might reduce flexibility and controllers' situation awareness and lack robustness against external factors (e.g. meteorological conditions).
- Open issues include the variability of working methods (and their impact on performance) and the CTA/RTA maturity.
- Despite these issues, initial trends on performance showed that even under high traffic load, the concept provided benefits, allowing aircraft to remain on lateral navigation (2D), carry out Advanced Continuous Descent Approaches (3D) and achieve consistent inter-aircraft spacing on final (4D).
- The P-RNAV/A-CDA and ASPA S&M concepts in a today environment (same sectorisation and coexistence of traditional handled flows) are operationally viable.
- Controllers found P-RNAV/A-CDA a valuable technique allowing a reduction of workload through the avoiding of vectoring, leaving more time for monitoring.
- In the simulated environment, A-CDA concept application did not have a negative impact on the traffic management as the traffic flows were sequenced by a scripted AMAN. The controllers suggested further investigation of this aspect in a realistic environment considering all the possible different descend profiles of inbound traffic.
- The controllers found it easy to manage the traffic using P-RNAV and A-CDA together. The new route structure and associated new working methods allow the controllers to manage high traffic loads with an acceptable workload thanks to a reduction of tasks associated with this new operational environment.
- P-RNAV and A-CDA allow the controllers to have a better situation awareness of the traffic evolution due to a standardised working methods based on an arrival structured route layout. Accordingly, in the nominal situation, controllers perceived an increased safety level.
- The combined use of ASPA S&M, P-RNAV and CDA allowed ATCOs to focus more on sequence leg management. A controller, having delegated spacing tasks to the cockpit, can improve monitoring of the arrival stream traffic evolution. The availability of ASPA S&M infringement tool was appreciated by controllers enabling them to have a timely warning in case of infringement. The controllers generally accepted the new working methods that allow a partial delegation of their tasks to the cockpit.

More general conclusions, based on all the exercises, showed that:

- There was variability in working methods (due to maturity, training, subjects' continuity issues) with an impact on measured KPAs (CTA/RTA), giving subjective results.
- The impact of individual differences and a large number of experimental conditions resulted in difficulties in comparing the runs in prototyping sessions.

6.8 AIRPORT CONCEPT ELEMENTS

The Airport Expert group results show that uploading and negotiating the runway exit and taxi route for arrivals, and taxiways for departures, using SESAR improvements will improve predictability and efficiency at the airport.

In a busy runway environment, the application of brake to vacate technology, time-based spacing and reduced Wake Turbulence separations, together with a technical solution to reduce ILS CSA restrictions, and all based on accurate, coordinated time, can play a positive role in achieving the SESAR airport capacity goals.

6.9 Hot Topics for further discussion:

This section includes two tables containing, respectively Hot Topics that were answered satisfactorily by the expert groups, and Hot Topics that need further discussion

Hot Topic	Expert answer	Reference
The lateral route is fixed, and the longitudinal and vertical elements of the trajectory are not constrained and can be computed by the FMS. This implies that the flight level of the aircraft at the transition to the High Density Area is not determined. Could a vertical level band also be applied at the IAF or at the SL Entry Point?	WP5 TMA Expert Group discussion: This depends on the density of inbound traffic, on how the en-route sectors can deliver that traffic and the design of the Point Merge System. In this example of the Point Merge System a level restriction at SL entry level is suggested.	OS-35 - High Density TMA Arrival - Flying a CDA Merging
It is to be determined how the revised CTA will be translated into a revised RTA and how the aircraft manages the holding pattern in order to meet the new CTA at the IAF.	WP5 TMA Expert Group discussion: if holding pattern is known to FMS it can be operated in automatic mode during these procedures. RTA and CTA might not remain. Instead expected time to leave hold can be applied. The FMS has to be developed in order to do this. Generally: if the CTA is to stay in the SESAR timeframe 2015/2020 the holding procedures have to be updated.	OS-35 - High Density TMA Arrival - Flying a CDA Merging
This task is more complex if the wind profile varies with different flight level or altitude (in particular in boundary layer wind, variability can be high). Update of the AMAN with actual wind profiles is essential, otherwise sequence building and metering may become inaccurate.	WP5 TMA Expert group discussion: This might add to complexity but is still judged by controllers to be no more demanding than vectoring.	OS-35 - High Density TMA Arrival - Flying a CDA Merging

Table 2: WP5 Hot Topics answered by the expert groups

Hot Topic	Expert answer	Reference
It is not clear whether the uplinking of the ground portion (exit point and taxiway routing) of the trajectory is feasible operationally during approach. There is a balance of availability of the routing plan versus the workload. Receipt of this instruction would impose on the flight crew during this busy phase of flight. Furthermore, the roles and responsibilities for issuing a combined runway exit/taxiway route clearance need to be clarified.	The WP5.3.2 Storyboards provide a way of supporting the uploading of runway exit and taxiway via the OI step "Brake to Vacate with datalink". However the workload impact on the flight crew will require further investigation. The Airport Expert Group report [2] includes the storyboards for OS-12 "Landing and taxi to Stand" and OS-13 "Stand, Taxi out and Departure".	OS 12 - Landing and Taxi to Stand OS13 - Taxi Out and Take- Off
The actor (human or system) that updates or revises the RBT during this process needs to be clearly stated and agreed with User and Airport experts in order to respect the principle of User ownership of the trajectory versus pragmatic operational considerations.	The Paper on "SBT to RBT agreement" (annex to [2]) highlights some of the issues related to the RBT agreement and management at the airport during departure covered in the 5.3.2 "SBT to RBT Workshops. The Airport Expert Group report [2] contains more details.	OS13 - Taxi Out and Take- Off
How can the CTA and RTA of the aircraft be revised? With a tactical intervention at controller discretion it is not clear when own navigation will be resumed.	WP5 TMA Expert group discussion: next generation of AMAN tools should dynamically and continuously compute revised CTA and a place in the sequence until the aircraft resumes own navigation.[1]	OS-35 - High Density TMA Arrival - Flying a CDA Merging
To what extent should speed restrictions be applied? To establish and maintain a sequence in high traffic situations is more efficient for ATC with common speed profiles. On the other hand, this means additional constraints for aircraft and may imply fewer economic and environmental benefits.	WP5 TMA Expert group discussion: Speed restrictions above Minimum Clean speed do not deteriorate CDA. Speed reductions should be achieved early during descent before IAF.	OS-35 - High Density TMA Arrival - Flying a CDA Merging
Design for optimum CDA should allow flying in "Minimum Clean" configuration as long as possible.	WP5 TMA Expert group discussion: Setting of flaps depends on the kind of approach procedure (ILS/GPS.).Generally first flaps will be set at the last deceleration level. This is	OS-35 - High Density TMA Arrival - Flying a CDA Merging

[1] Note that current AMANs already continuously/periodically maintain a sequenced time for each aircraft in the arrival sequence, based on ground Trajectory Predictor's calculations including in some cases (imperfect) heuristics to "guesstimate" how an aircraft that is being vectored will resume navigation.

Hot Topic	Expert answer	Reference
	around 1500 feet depending on airspace design. In this scenario (refer to Figure 5 in [15]) first flaps will be set at the last waypoint before FAF, the second and third flaps at FAF.	

Table 3: Hot Topics requiring further discussion and resolution

7 RECOMMENDATIONS

7.1 General Recommendations

The recommendations in this section are all positive, in the sense that they were found to be helpful for WP5, and they should be considered for use on the SESAR programme.

A review of teams and locations should be carried out when creating work packages. Team building, communication and people management skills are essential in leading a multi-disciplinary team located in many countries.

It is recommended that work packages should have a validation strategy, linking the exercises to the concept and highlighting the reason for validating the areas chosen.

During initiation of a project, there should be an analysis of how to provide a coordinated process between exercises and a way of refining a concept to provide consistent answers (Scenarios, Storyboards, Assumptions).

New approaches to the use of tools or combinations of tools should be used to support concept validation.

Concept and E-OCVM Training should be provided.

The identification and assessment of lessons learned should be iterative to allow improvements in future phases of validation.

Exercises should use a consistent approach to traffic, environment and indicators measured.

Storyboards should be used to support concept refinement. Role playing should be considered as a possible next step for storyboards.

More work should be conducted on how to extrapolate or combine exercise results to obtain ECAC-wide performance results.

Safety should be addressed as early as possible as an ongoing activity when validating a concept.

The KPAs being measured should be given a priority. For example, Efficiency could be seen as more important than Capacity in the current operational and economic climate.

The links between the DODS, Scenarios, Storyboards, Questionnaires and ATM Process Model should be developed and coordinated before validating the concept.

7.2 E-OCVM Recommendations

These recommendations suggest improvements to E-OCVM and the way that it is applied.

E-OCVM should include gates to ensure that the concept is of sufficient maturity to be passed to the next level of validation. Document reviews ensured that some criteria were covered before carrying out an exercise, but it would be better to have official steps to ensure consistent, measured criteria were satisfied before moving into the next phase of validation.

E-OCVM use should be measured. This would be beneficial in order to asses the applicability of E-OCVM. The main use of E-OCVM in WP5 was in specifying the structure of documents. In addition, there were some difficulties in combining the pure top-down approach of E-OCVM with some bottom-up aspects. Examining its use would allow project participants to use E-OCVM and think in E-OCVM terms rather than simply completing sections of a document.

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7.3 Concept Recommendations

General

As required by the E-OCVM, WP5 confirmed that the development of operational scenarios should be started as soon as possible in order to provide timely support to validation exercises. The required OS should be identified according to exercise needs. They should be updated and reviewed with the involvement of project partners in order to get the agreement and buy-in of the consortium. The OS are an important step towards a more mature concept and should be used by SESAR JU to further develop the concept of operations and as an input to SESAR JU validation activities.

TMA Recommendations

Some of the validated benefits of early arrival management in a multi-airport TMA environment were derived from DCB measures to arrive on-time at TOD. These measures were beneficial by ensuring low variability of demand at TOD and benefits were achievable by imposing highly accurate departure constraints. It is recommended that this concept element be further developed as part of DCB. It should be noted, however, that departure constraints are not compliant with the ConOps. It may be possible to achieve the same results by tuning arrival times after departure to achieve the same effect, It is recommended that this be part of any future work on this topic.

Regarding the adapted use of airspace and airspace management in the relevant area assessed, it is recommended that appropriate solutions be examined for all airspace users in the context of creating Functional Airspace Blocks (FABs).

The need to extend en-route service provision with a new service to support on-time arrival over a significant waypoint in support of arrival traffic synchronisation of hub airports was underlined. This recommendation is supported by the WP4 expert group (in agreement with the expert group from WP5) that short term DCB will smooth the traffic to congested destinations to achieve a low variability of planned arrivals, preventing heavy bunching at airports. This smoothing goes beyond what the NOP alone can achieve. In addition, extended AMAN will give controllers more time to facilitate the aircrafts' achievement of the TTA issued by AMAN. It is recommended that this aspect of En-route service provision be further developed.

It is recommended that a role-playing exercise should be carried out to further refine the transition from a structured TMA environment to another TMA environment.

Further exercises should be carried out to refine the concept in the following areas:

- The exact positioning of the RTA/CTA points would be location, airspace and complexity-specific and would need to be placed at a sufficient distance from final approach to allow controllers to provide the necessary safe separation as well as to construct an efficient sequence and optimal landing spacing. Instead of the IAF, which was also a merging point, a point further out such as a TMA entry point could for instance be considered as CTA point. Then, between that point and the IAF, subject to a sufficient level of strategic de-confliction and to inbound traffic delivery conditions, "standard" speed control could be used to ensure separation;
- As a contributing factor to the previous issue, the reduction in the controller's situation awareness regarding the aircraft's speed schedule when flying an RTA to adhere to a CTA should also be addressed. To increase the situational awareness of controllers, information on aircraft intent should be available to the ground system, in particular speed. Note that the same recommendation was reported in the EP3 En Route (WP4) prototyping sessions;
- In a similar manner as for speed adjustments, the interdependency between RTA and A-CDA, their relative priority and the interaction with separation assurance should be clarified;
- The concept introduces time constraints dynamically issued by an arrival manager (AMAN) for metering purposes. As a known limitation in prototyping session 3, these constraints (CTAs) were actually scripted and the displayed arrival sequence, presented on the AMAN timeline,

was static. Consequently it was not possible – nor intended – to explore dynamic aspects of the sequence optimisation in the session. After sufficient maturation is achieved in TMA airspace through further small scale human in the loop experiments, a larger scale real time simulation should be conducted involving more sectors, thus enabling dynamic aspects of the arrival sequence management through e.g. an AMAN to be assessed;

- Compatibility with departures should be confirmed in the frame of a real time simulation that provides a more realistic environment.

7.4 Airport Concept Recommendations

Brake to Vacate, Time Based Spacing and reduced Wake Turbulence separations all provide benefits, but need accurate, coordinated time should be made available in order to generate individual benefits.

The use of speed during taxiing, and airport improvements currently being implemented worldwide should be investigated.

Further work is needed to investigate concept analysis from storyboards and scenario comments provided on the 'airside' activities with the use of role play techniques to identify the optimum use of runway and taxiway allocation between GND and AIR.

Close collaboration between the Planning and Execution phases of the trajectory is crucial and should be investigated further (some triggers are provided in Airport Storyboards, see [2]).

The impact of changes during execution of the plan and how they are managed requires further investigation.

Links between SMAN, DMAN and AMAN should be investigated further.

Links to the AOP/NOP and use of shared information (SWIM) between parties should be investigated.

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8 REFERENCES

[1] **Episode 3** WP5.3.1 TMA Expert Group Report - D5.3.1-02

[2] **Episode 3** WP5.3.2 Airport Expert Group Report - D5.3.1-02

[3] **Episode 3** WP5.3.3 Runway FTS Report - D5.3.3-02

[4] **Episode 3** WP5.3.4 Multi Airport TMA FTS Report - D5.3.4-02

[5] **Episode 3** WP5.3.5 TMA Trajectory Management Report - D5.3.5-02

[6] **Episode 3** WP5.3.6 Prototyping of a Dense TMA Report - D5.3.6-02

[7] **Episode 3** WP2 EP3 Final Report - D2.5-01

[8] **Episode 3** SESAR DOD G - General Detailed Operational Description - D2.2-040

[9] **Episode 3** SESAR DOD M1 - Collaborative Airport Planning Detailed Operational Description - D2.2-042

[10] **Episode 3** SESAR DOD E1 - Runway Management Detailed Operational Description - D2.2-044

[11] **Episode 3** SESAR DOD E2/3 - Apron and Taxiways Management Detailed Operational Description - D2.2-045

[12] **Episode 3** SESAR DOD E5 - Conflict Management in Arrival and Departure High & Medium/Low Density Operations Detailed Operational Description - D2.2-047

[13] **Episode 3** SESAR DOD Lexicon - Glossary of Terms and Definitions - D2.2-049

[14] **Episode 3** WP5 Validation Strategy - D5.2.1-01, v1.01, April 2009

[15] **Episode 3** WP5 Operational Scenarios - D5.2.2-01, v1.00, September 2009

[16] **Episode 3** Performance Framework Document - D2.4.1-04, v3.03, March 2009

[17] **Episode 3** DOW Revision 3.1, July 2009

[18] E-OCVM - European Operational Concept Validation Methodology, Version 2, March 2007

[19] Understanding Trajectory Management; EUROCONTROL - OATA-MCS-32-02, Version 1.3, May 2009

[20] **SESAR** D2 - The Performance Target - DLM-0607-001-02-00a, December 2006

[21] **SESAR** D3 - The ATM Target Concept - DLM-0612-001-02-00a, September 2007

[22] **SESAR** SESAR Concept of Operations WP2.2.2/D3 Task deliverable, DLT-0612-222-01-000, Version 2, October 2007

[23] **Episode 3** Information Navigator http://www.episode3.aero/project/navigator/sesar-navigator

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