EPISODE 3

Single European Sky Implementation support through Validation

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EXECUTIVE SUMMARY

Episode 3 is a European Commission 6th Framework Programme project, whose aim was to build on the output of the SESAR definition phase work programme (2006-2008) and undertake initial validation activities of its 2020 concept (SESAR D3). The project achieved these objectives over two and a half years with a team of 23 partners from a range of R&D organisations and an overall budget of 20 M€.

This document is the final report of this substantial project, and as such, consolidates outputs from a range of deliverable documents produced during the course of the work programme.

Episode 3 is divided into three operational validation work packages, one technical validation work package, and one system work package whose aim was both to promote consistent approaches to validation across the project and to consolidate the various results according to a number of transversal themes.

This report provides an entry point into all project results, and the reader requiring additional detail is referred to more project documents:

- Concept detail documents (e.g. the Detailed Operational Documents (DODs) and Operational Scenarios);
- Performance Framework and safety and environment assessment documents, describing the approach for assessing performance and providing a framework to consolidate existing and future validation results and the transversal results of the safety and environmental assessments;
- Consolidated reports from the operational validation Work Packages and their consolidated strategies;
- Consolidated report from the technical validation work package;
- Individual validation exercises experimental plans and reports.

All Episode 3 documents can be found on the EP3 website, www.episode3.aero, until end 2011, and in the VDR (www.eurocontrol.int/vdr). The Episode 3 Navigator (http://atm-navigator.eurocontrol.fr), also gives access to these reports and provides a useful database mapping the project results to the SESAR work programme through that can be found through easy-to-use queries.

In line with the project objectives, this report, as well as giving an overview of the project, develops the following areas:

- *Description of the validation approach and of the innovative validation tools used in the project*: how we have applied E-OCVM and adapted it to the validation of a system wide concept, some of which was still at a low level of maturity; the application of the various Human-In-The-Loop simulation, gaming and modelling techniques we have used, many of which had not been used before in the ATM domain.
- *Description of concept detailing activities*: this section explains how we have structured and consolidated the pre-existing concept material from the definition phase. It explains the main concept documentation produced: the 10 DODs and 26 Operational Scenarios and how this was used to support the validation exercises. The concept results provided through the validation exercises is summarised according the following areas: 4D Trajectory Operations, Network Management and Airport Operations.
- *Operability and process feasibility results*: results regarding the planning phase and the execution phases of the concept are presented, how the sub processes have been described, the roles and responsibilities, key findings on processes and in the

allocation of tasks to actors. Episode 3 has identified additional actors, and characterised new ATM processes, for example, the collaborative processes necessary to optimize utilisation of the ATM network should shortages of capacity occur.

- *Performance aspects*: the performance framework developed in Episode3 and the associated techniques developed to understand and quantify benefit mechanisms, i.e. the influence diagrams and influence models, are presented. The results obtained using this approach are explained, taking fuel efficiency as an example; individual results from local performance assessments are presented for a number of Key Performance Areas (KPA). In addition, the transverse approach developed by Episode for the safety and environment is explained.
- *Technology aspects*: these activities have looked at airborne and ground enablers linked to ATM Capability Level 2, key building blocks to support the technology envisaged for deployment in 2020. Using high-fidelity industry platforms, an air ground integration test bench has been developed and evaluation that has increased the maturity of the technology underpinning, trajectory exchange, use of Required Time of Arrival (RTA), and 3 basic manoeuvres in Airborne Separation Assistance Systems (ASAS). The results produced are in terms of technical feasibility, since the work involved the integration of real industrial products and acceptability of the solutions implemented solutions as operational pilots and controllers participated in the trials.
- *Lessons Learnt:* an important part of the project was the collection of lessons learnt that would be relevant to the SESAR projects. This activity targeted the main themes of Episode 3: concept detailing, validation process management, integration of validation results. A special assessment was made of the main techniques employed i.e. expert groups, gaming, prototyping sessions and modelling.

In summary, our conclusions are:

- We have produced consolidated documentation describing most of the major elements envisaged for the SESAR concept in 2020. However, in doing this, we have identified a number of hot topics where it is not currently clear how some aspects of the system will work.
- The maturity of the basic underpinning technology related to 4D trajectory operations and ASAS has been increased.
- The Performance assessment task has involved the development of various SESAR D2 Influence Diagrams that describe how the SESAR ConOps delivers benefits, these have been expanded to cover more of the KPA, refined and consolidated in a single database.
- The performance assessment itself was limited, both in terms of the number of OIs and KPAs considered and the scope of the assessments, mainly local rather than ECAC-wide. The local assessments showed positive trends, but generally could not be extrapolated with any confidence to an ECAC-wide assessment. Some of the local assessments demonstrated the need to compromise individual flight efficiency when providing the TMA capacity envisaged for core Europe in 2020. Early results on the ECAC performance of the concept in terms of flight efficiency and safety have been obtained, but this work is relatively immature and we have not been able to demonstrate how the concept meets the relevant performance targets.

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1 INTRODUCTION

1.1 BACKGROUND

In 2004 the European Commission and EUROCONTROL launched a TEN-T[1] call for an industry-led project to define and plan the research and implementation requirements necessary to develop the next generation European ATM system. As a result, the SESAR project was launched in April 2006.

As part of this overall initiative, the EC 6th Framework Programme 2004 call for proposals included an Integrated Project with the target of validating a mid-term (2017) concept of operations. After a number of evolutions, the Episode 3 (EP3) proposal was submitted to the EC in November 2005. After a period of negotiation to align with the developing SESAR Definition Phase results (Ref. [25]), EP3 kicked off in April 2007 with a target to take first steps in the validation of the SESAR concept for 2020, in order to pave the way for the SESAR Development Phase work programme.

EP3 has brought together multi-disciplinary team of key stakeholders in the European ATM research community including many organisations participating in the SESAR development phase and covering aspects of the system from strategic and tactical planning through to Air Traffic Control and Airport operations.

1.2 PURPOSE OF THE DOCUMENT

This document is the EP3 Final Report whose aim is to outline the main approaches taken, its achievements, the findings of the work programme, and its conclusions and recommendations.

The project's targets were:

- To provide detail on key concept elements in SESAR;
- To undertake initial operability studies and assess the performance of those key concepts;
- To perform an initial impact assessment of the supporting technical needs;
- To analyse the available tools and gaps for SESAR concept validation; and
- To report on the validation methodology used in assessing the concept.

In documenting the outcome of addressing these targets, this final report is structured into three parts:

- The first outlines the context of the EP3 project, the validation approach and the work of detailing the SESAR Concept of Operations;
- The second presents key findings based on validation exercises that focused on specific aspects such as operability, performance and technical issues;
- The third part reflects the conclusions of the project by addressing the lessons learnt on SESAR concept detailing and validation methodology, and the conclusions and recommendations for potential application in the context of SESAR development phase.

[1] Trans-European Transport Network

1.3 INTENDED AUDIENCE

The audience for this document is the European Commission who sponsored the EP3 project, the SESAR community at large, and more particularly the SESAR JU who will find results, lessons learnt and recommendations on the many challenges of validating the SESAR concept.

In addition, EP3 was a first opportunity for a distributed project team to start working on an integrated validation of the SESAR definition phase proposals. As such this document also intends to serve the ATM validation community and, in particular, those who will be engaged in the development and application of the validation process in SESAR.

This document is closely linked to a comprehensive set of EP3 deliverables: validation strategies, validation exercise plans, validation exercise reports, consolidated reports, lessons learnt report, Performance Framework reports, environment and safety reports.

All EP3 public deliverables are available through the Validation Data Repository (VDR) (http://www.eurocontrol.int/vdr).

Two tools are available through the web to guide the reader for more details:

- The ATM Information Navigator through the link http://atm-navigator.eurocontrol.fr;
- The EP3 web site through the link http://www.episode3.aero.

1.4 DOCUMENT STRUCTURE

The document is structured in three parts.

Validation approach	Section 2 describes EP3 context and scope Section 3 details the tools, techniques and methodologies for validation Section 4 addresses concept detailing (and/or development)
Key findings	Section 5 presents the results in terms of operational and process issues Section 6 describes performance results Section 7 describes technology aspects
Conclusions and recommendations	Section 8 presents the lessons learnt Section 9 presents conclusions Section 10 provides the recommendations from the project Section 11 lists applicable documents and references

A number of Annexes give more detail in support of the high level conclusions presented in the body of the report.

1.5 Glossary of Terms

Term	Definition
4D	4 Dimensions (i.e. Longitude, Latitude, Altitude and Time)
4D TM	4 Dimensions Trajectory Management
A-CDA	Advanced Continuous Descent Approach
ADD	Aircraft Derived Data
AFUA	Advanced Flexible Use of Airspace
ALAQS	Airport Low Quality Studies
AM	Assumption Management
AMAN	Arrival Manager (Tool)
ANP	Aircraft Noise and Performance
ANSP	Air Navigation Service Provider
AOC	Airline Operational Control / Airlines Operations Centre
AOP	Airport Operations Plan
A/P	Auto-Pilot
APOC	Airport Operation Centre
ASAS	Airborne Separation Assistance System
ASPA S&M	ASAS Enhanced Sequencing & Merging Operations
ATC	Air Traffic Control
ATFCM	Air Traffic Flow and Capacity Management
A/THR	Auto Thrust
ATM	Air Traffic Management
CAATS II	Cooperative Approach to Air Traffic Services II
C-ATM	Cooperative Air Traffic Management
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CLM	Concept Lifecycle Model
CNS	Communication, Navigation and Surveillance
ConOps	Concept of Operations
CTA	Controlled Time of Arrival
dB	Decibel
DCB	Demand and Capacity Balancing
DMAN	Departure Manager (Tool)
DMEAN	Dynamic Management of the European Airspace Network
DOD	Detailed Operational Description
DOW	Description Of Work
EC	European Commission
ECAC	European Civil Aviation Conference

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Term	Definition
ECHOES	EUROCONTROL Consolidated HMI for Operations, Evaluations and Simulations
EEC	EUROCONTROL Experimental Centre
EG	Expert Group
E-OCVM	European – Operational Concept Validation Methodology
EP3	Episode 3 Project
ESCAPE	EUROCONTROL Simulation Capability and Platform for Experimentation
ETA	Estimated Time of Arrival
ETMA	Extended TMA
EUROCAE	The European Organization for Civil Aviation Equipment
EXC	Executive Controller
EXCOM	Executive Committee
FAB	Functional Airspace Block
FABEC	Functional Airspace Block Europe Central
FANS	Future Air Navigation Systems
FMS	Flight Management System
FTS	Fast Time Simulation
GE	Global Emission
HIL	Human In the Loop
HMI	Human Machine Interface
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
INM	Integrated Noise Model
IOC	Initial Operational Capability
IP	Implementation Package (SESAR)
IRP	Integrated Risk Picture
KPA	Key Performance Area
KPI	Key Performance Indicator
LAQ	Local Air Quality
LEAS-It	Aviation Emissions Inventory Tools for Airports
LoC	Line of Change
MCDU	Multi-Purpose Cockpit Display Unit
MET	Meteorology
MTCD	Medium-Term Conflict Detection
ND	Navigation Display

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Term	Definition
NM	Nautical Miles
NOP	Network Operations Plan
OI	Operational Improvement
OLDI	Standard On Line Data Interchange
OS	Operational Scenario
OSED	Operational Services and Environment Definition
PENS	Pan European Network Service
PF	Performance Framework
PF/PNF	Pilot Flying/Pilot Not Flying
PLC	Planning Controller
PMB	Project Management Board
P-RNAV	Precision Area Navigation
PS	Prototyping Session
PTC	Precision Trajectory Clearances
R&D	Research and Development
R/T	Radio Telephony
RAMS	Reorganised ATC Mathematical Simulator
RBT	Reference Business/Mission Trajectory
RNAV	Area Navigation
ROT	Runway Occupancy Time
RTA	Required Time of Arrival
SBT	Shared Business/Mission Trajectory
SESAR	Single European Sky ATM Research in Air Transportation
SESAR JU	SESAR Joint Undertaking
SID	Standard Instrument Departure (Route)
SPF	Structured Planning Framework
STAR	Standard Terminal Arrival Route
STAR	Safety Target Achievement Roadmap
STATFOR	Specialist Panel on Air Traffic Statistics & Forecasts
STCA	Short Term Conflict Alert
SWIM	System Wide Information Management
SYSCO	System Supported Co-ordination
TAAM	Total Airspace and Airport Modeller
TBS	Time Based Separation Time Based Spacing
TEN-T	Trans-European Transport Network
TMA	Terminal Area

Term	Definition
	Terminal Control Area Terminal Manoeuvre Area Terminal Manoeuvring Area
TSA	Temporary Segregated Area
TTA	Target Time of Arrival
TTO	Target Time of Over-fly
UDPP	User Driven Prioritisation Process
VDR	Validation Data Repository
VERA	VErification of separation and Resolution Advisory
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
V-NAV	Vertical Navigation
WP	Work Package

Table 1 - Glossary of terms

1.6 Short Lexicon

A short lexicon is provided to support the reader less familiar with validation on some of the aspects of the project work.

Concept Storyboard

A concept storyboard explains a part of the concept using a graphical representation. The storyboard shows the actors, the sequence of activities and interaction of events (as well as any expert comments and or assumptions made) and is useful for simplifying the scenarios and providing a clear method for presenting information

Expert Group

The Expert Group (EG) Technique is based on gathering a group of people with specific professional profiles, i.e. backgrounds, knowledge and expertise, and using both the individual skills and the synergy of the group in a structured manner for developing a set of predetermined concepts.

Expert Groups are mostly suitable for the initial validation stage (concept definition and clarification) as well as to consider cross-functional issues, i.e. initial performance assessment and operational feasibility.

Gaming

Gaming is a Human-In-the-Loop validation technique used for playing “serious games” involving experts for concept clarification and obtaining performance trends for some KPIs. During the game, experts take various roles according to a script provided that implements part of the concept; this allows the exploration of concepts and definition of roles and processes in a structured way, focusing the players’ attention on the information flow and responsibilities associated with the processes. The games can be paper-based or use platforms of different levels of sophistication. Time can be slowed or accelerated to suit the needs of the validation activity i.e. it is neither purely real-time nor fast-time.

Hot Topics

In EP3 a hot topic is an unresolved issue regarding the concept where, either experts have strongly held diverging views, or where work is required to define exactly how an important part of the concept works.

Implementation Package

The specific and detailed changes (called “operational improvements [OI] steps)”) required to transition from today’s system have been structured in a series of ATM Service Levels (0-5) and organized in Implementation Packages 1-3 depending upon the date at which the corresponding capability can become operational (Initial Operational Capability (IOC) date):

- IP1 - Implementation Package 1 (short-term: IOC dates up to 2012) covering ATM Service Levels 0 and 1 , creates the foundations through short term initiatives (DMEAN, PENS, CDA, P-RNAV, Airport specific procedures, Runway Management, Conflict Detection, Flight Conformance Monitoring, …) and best practices through Operational Improvement Steps.
- IP2 - Implementation Package 2 (medium term: IOC dates in the period 2013-2019) covering ATM Service Levels 2 and 3, delivers the implementation of the ATM Target Concept through a wider information sharing environment (SWIM, AFUA, …).
- IP3 - Implementation Package 3 (long term: IOC dates from 2020 onwards) covering ATM Service Level 4 and 5, achieves the SESAR goals in the longer term.

Operability Assessment

An operability assessment is a validation activity where current operational controllers experience the proposed change in operational processes, procedures and tools and determine whether they are operationally sound.

Operational Scenario

Within the context of an operational concept, operational scenarios are a description of how a future system should work. Each scenario describes the behaviour of the users and the future system, interaction between the two, and the wider context of use. A fully detailed scenario should allow the identification of user requirements and potential business cases.

Process Simulation

Process Simulation is a technique that allows the operation of any type of organisation or system to be assessed. The technique is implemented through discrete event-based fast-time simulation that generates a detailed event log related to the system process operations. The logged data is then analysed and processed to provide outputs in the areas of interest. It can be used to complement a gaming exercise by reproducing the game played by human actors as a set of processes and thereby provide indicative numerical data on the system operation.

Prototyping Sessions

Prototyping Sessions are an iterative and incremental validation technique, based on successive real-time Human-In-the-Loop experiments. They involve operational controllers working on a limited number of sectors. They need to be supported by expert groups to guide the iterative development of the concept implemented on the real-time validation platform.

Shared Business Trajectory (SBT)

The published 4D business trajectory provided by the Airspace User that is available for collaborative planning purposes. The refinement of the SBT will be an iterative process.

Reference Business Trajectory (RBT)

The RBT is the 4D trajectory that the Airspace User agrees to fly and the ANSP and airports agree to facilitate subject to separation provision.

Use Case

A use case is part of a formal software development process. A use case captures a contract between the stakeholders of a system about its behaviour. The use case describes the system's behaviour under various conditions as the system responds to a request from one of the stakeholders, known as the primary actor.

2 EPISODE 3 CONTEXT & SCOPE

2.1 INTRODUCTION

The SESAR vision is to achieve a performance-based European ATM System. These performance-based objectives and targets were laid down in the Definition Phase D2-The Performance Target (Ref. [E]). The SESAR consortium developed D3-The ATM Target Concept in response to these performance needs, which was further detailed in SESAR Concept of Operations[2] (Ref. [J]) and was complemented by the description in D5-The ATM Master Plan (Ref. [H]) which detailed the Operational Improvement (OI) Steps required to achieve these goals. These documents were considered the authority on the concept to be validated in EP3.

In this context EP3 was tasked to take some early steps in the work of validating the concept against the targets (Ref. [B]). This encompassed concept detailing, operability, performance and technical aspects. The tools at the disposal of the project were various validation exercises including innovative tools and techniques. It was also required to apply the European Operational Concept Validation Methodology (E-OCVM) (Ref. [C]), the first time it would be used for integrated concept validation.

EP3 aimed to address all phases of flight, with a focus on the civil use of airspace. However, it has also been able to address a limited number of military aspects such as Advanced Flexible Use of Airspace (AFUA).

2.2 STATUS OF CONCEPT DEFINITION AND VALIDATION AT THE END OF SESAR DEFINITION PHASE

SESAR analysed the air transport value chain and needs, together with societal needs, and identified eleven Key Performance Areas[3] (KPAs) that described the set of initial targets as presented in its Performance Framework.

The ATM Target Concept developed was driven by these needs and addressed four domains: the Concept of Operations (ConOps), human roles, system architecture and CNS technologies.

The SESAR ConOps (Ref. [J]) determined the potential solutions considered as feasible to meet the performance targets. To ensure a logical and feasible implementation of the ConOps, an ATM deployment sequence was laid down using the notion of "Implementation Packages (IPs)" with three time periods: up to 2013 (IP1), up to 2020 (IP2) and beyond 2020 (IP3).

The deployment of the ConOps was described in terms of Operational Improvement Steps (OI Steps). These are changes to specific aspects of the ConOps, which can be implemented in a determined period of time and that have a direct performance enhancement. These OI Steps are grouped in main operational areas and in the evolution of the ATM environment known as Lines of Change (LoC).

SESAR also introduced the notion of ATM Capability Level, characterising the aircraft equipage to support ATM tasks and the ATM Service Level that describes the equivalent ATM service that should be available on the ground to exploit the aircraft capabilities. In this way, the evolution of performance characteristics of all components, both on board the aircraft and

[2] Referred to as the ConOps in this document

[3] Key Performance Areas are defined by ICAO in [30]

on the ground are linked and situated in time. These levels have been grouped together by IPs as follows:

- IP1 covers ATM Service Levels 0 and 1;
- IP2 covers ATM Service Levels 2 and 3;
- IP3 covers ATM Service Levels 4 and 5.

Each OI step is traceable through the Line of Change (LoC), its ATM Capability Level (for aircraft) or ATM Service Level (for ground systems) with the timing for R&D, implementation and in-service date.

SESAR proposed using the European Operational Concept Validation Methodology (E-OCVM) lifecycle model to describe the development and validation maturity phase of the ATM Target Concept. This approach is aligned with best practice in the management of projects and describes an eight stage lifecycle taking an immature idea in the early stages of research through to its implementation and final decommissioning. (Ref. [I] D6 p.77 Fig.32). The scope of the research tasks related to the SESAR concept was identified as related to V1, V2 and V3.

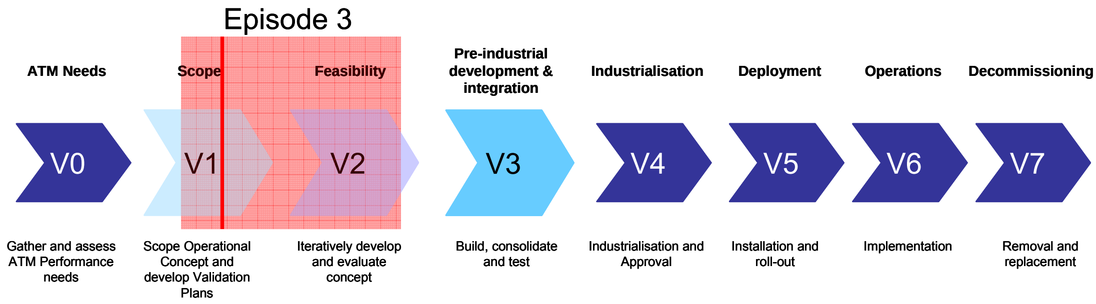

Figure 1 - SESAR Lifecycle

The validation that took place in the SESAR development phase was primarily focused on expert views and fast-time modelling. As this validation had been performed before EP3, the project was built on the assumption that its validation activities would contribute to the early V2 phase (Feasibility). However, as EP3 focused its effort on the refinement and clarification activities on the areas of the ConOps targeting 2020 deployment that were consequently less mature, this positioned much of the project activity on the early V1 maturity level.

2.3 Scope of EP3

The full clarification and validation of the SESAR concept is a major task and the remit of the SESAR JU activities. Given the time and resources available within EP3, it could only contribute to the first validation steps in a limited number of areas of the concept. Each of the targets given to the project (§1.2) could not be fully addressed; the contribution of EP3 to each of these is taken in turn.

2.3.1 Concept Detailing

EP3 detailed the concept envisaged for the 2020 timeframe through the development of Detailed Operational Descriptions (DODs) of the various processes. By focusing on 2020 operations, not all OI steps were addressed. The scope in terms of IP was towards IP2 (given the target date for the concept detailing), with fewer OIs in IP1, i.e. those that would still be in place in 2020, and the early IP3 OIs. The Operating Context, Network, Airport, TMA and En-Route were fully addressed for operations in 2020. In terms of Lines of Change, all aspects that should be in place in 2020 were addressed, other than Information Management. Information Management was not described as it was decided only to consider ATM aspects of the concept and to consider Information Management as an underlying capability.

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2.3.2 Initial Operability and Performance assessment

The performance and operability assessment work had two main elements, one was to develop a Performance Framework to support ECAC-wide assessment and the other was to conduct validation activities principally at the local level.

The Performance Framework was based on the definition phase work, which further developed the influence diagrams. EP3 produced 16 additional influence diagrams for focus areas in Capacity, Efficiency, Predictability, Environment, Safety, Flexibility and Cost Effectiveness, and developed an Influence Model addressing eight of the focus areas (see Figure 2).

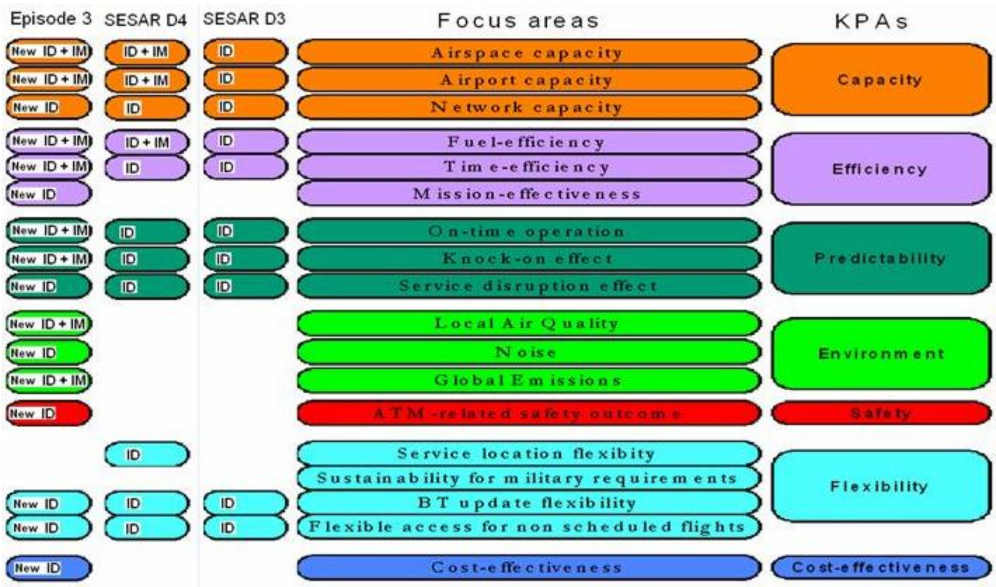


Figure 2 - Influence Diagrams (ID) and Influence Models (IM) developed per focus area

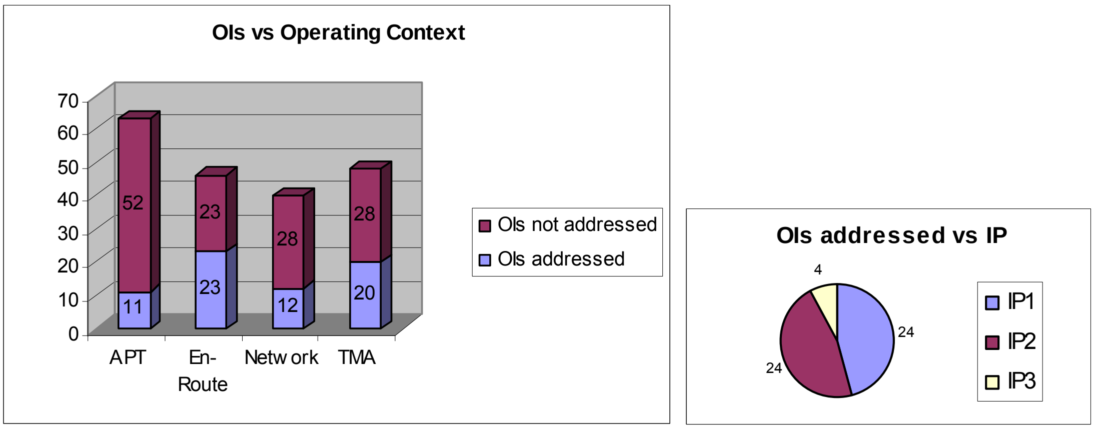


Figure 3 - Distribution of SESAR OI steps addressed in EP3 per Operating Context and overall (Ref. 13)

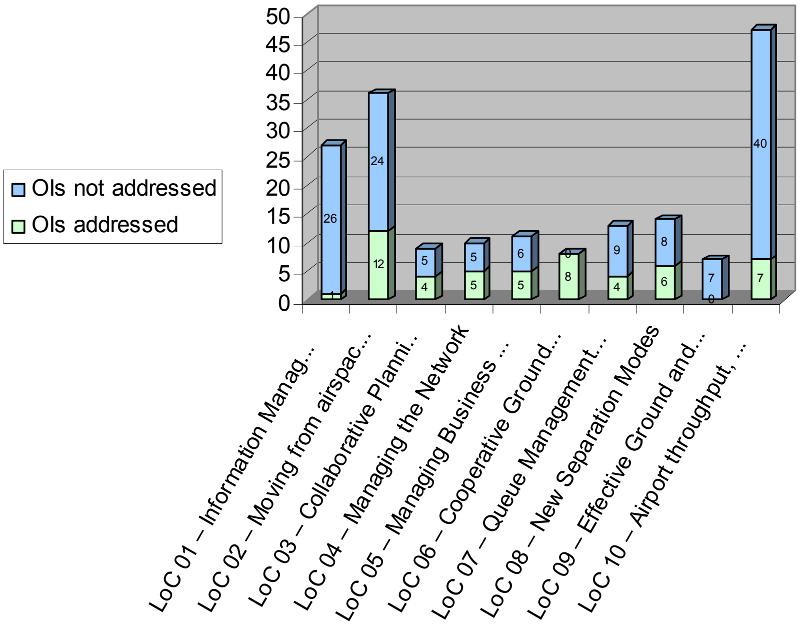


Figure 4 - Distribution of addressed SESAR OI steps per Line of Change

The majority of the validation activities undertaken to provide operability and performance assessment were at the local level, that is considering an airport, a single TMA or group of En-Route sectors. The techniques employed ranged from innovative techniques such as expert groups and gaming to more conventional fast-time simulations. Given the time available and the capability of platforms, the subset of OIs assessed was necessarily more limited than the scope addressed in concept detailing. Practical issues related to establishing a credible transition path to 2020 led to a bias towards IP1 OIs. Furthermore, direction was given to focus the validation activities towards the execution phase of ATC operations reducing the coverage of Airport operations, where the EC was funding projects such as EMMA 2 (Ref. 2.5.1) and long term collaborative planning which was considered to be a lower priority. Figure 3 and Figure 4 show the balance of work.

The military aspects were not a focus of the work programme and consequently were addressed only to a limited extent in the areas where the greatest interaction with civil users was anticipated; that is, in collaborative planning processes.

The operability and performance assessment was achieved through 17 validation activities listed in the table below, clustered according to the related ATM domain.

Final reports of each of these validation exercises are referenced in section 11.2.

Validation exercise
System-Wide Operability Analysis
Safety Assessment
Environment Assessment
Expert Groups on Collaborative Planning
Business Trajectory management and dynamic DCB
Airspace Organisation and Management

Validation exercise
Collaborative Airport Planning
Global Performances at Network-wide level. Macromodel
Expert Group En-Route Queue, Trajectory and Separation Management
Fast Time Simulation on 4D Trajectory management and complexity reduction
Gaming Exercise on Queue, Trajectory and Separation Management
Prototyping on Queue, Trajectory, and Separation Management
TMA Expert Group
Airport Expert Group
Runway Operations FTS
Multi Airport TMA
TMA Trajectory and Separation Management
Prototyping of a Dense TMA

Table 2 - EP3 validation exercises according to the related ATM domain

Ideally, the individual validation exercises should provide performance assessment that can be fed into the Performance Framework and so generate ECAC-wide performance figures. But as the requirement to perform such an assessment was not within the scope of EP3, only limited trials of the Performance Framework were performed using some data from the validation exercises to establish the feasibility of the framework.

2.3.3 Technology Needs

The technology needs impact assessment focused on the transitional OI steps for 4D trajectory management and Airborne Separation Assistance System (ASAS) and their integration. The exercises concerned are listed in Table 3 below.

Validation exercise
4D Airborne Navigation Capability for CTA / RNP
Air Ground Initial 4D Management
Spacing Performance Validation
Integration of 4D and ASAS

Table 3 - EP3 validation exercises related to Technological Enablers

The technology assessment only considered civil aircraft and ground systems and excluded any impact on military systems.

2.3.4 Suitability of available tools for SESAR Concept Validation

EP3 used a range of tools and techniques for its validation activities, both conventional and innovative for the ATM R&D community. In particular expert groups were used for providing direction to other validation activities, gaming exercises and process simulation for process validation and clarification of roles and responsibilities and prototyping sessions were used to assess operability. Fast-time simulations used Reorganised ATC Mathematical Simulator (RAMS), Total Airspace and Airport Modeller (TAAM) and other simulators for performance assessment and algorithm refinement and new macro-modelling tools were developed for network performance assessments.

The suitability of these tools and techniques for use within SESAR were assessed through a series of Lessons Learnt workshops. Their use was assessed against the level of maturity of the concept and the applicable ATM domain.

2.3.5 Methodology for Integrated Assessment

EP3 applied a systems engineering approach to ensure an integrated assessment. The concept detailing was structured using an ATM process model, a top-down approach was put in place for performance through the Performance Framework and the validation methodology applied was the E-OCVM.

The full benefit of applying the E-OCVM was limited in relation to the validation strategy, as the set of exercises was set in the contract rather than being the result of the development of a strategy. Despite this, validation strategies were developed at the project and ATM domain level and they 'made sense' of the exercises, ensuring that a coherent approach was taken and the inter-relations between related exercises were clear.

On the more practical side support on the application of the E-OCVM was provided through guidance material and templates for exercise plans and reports. This was supplemented through the central provision of validation experts who were on hand to review the documents produced and provide advice to the exercises.

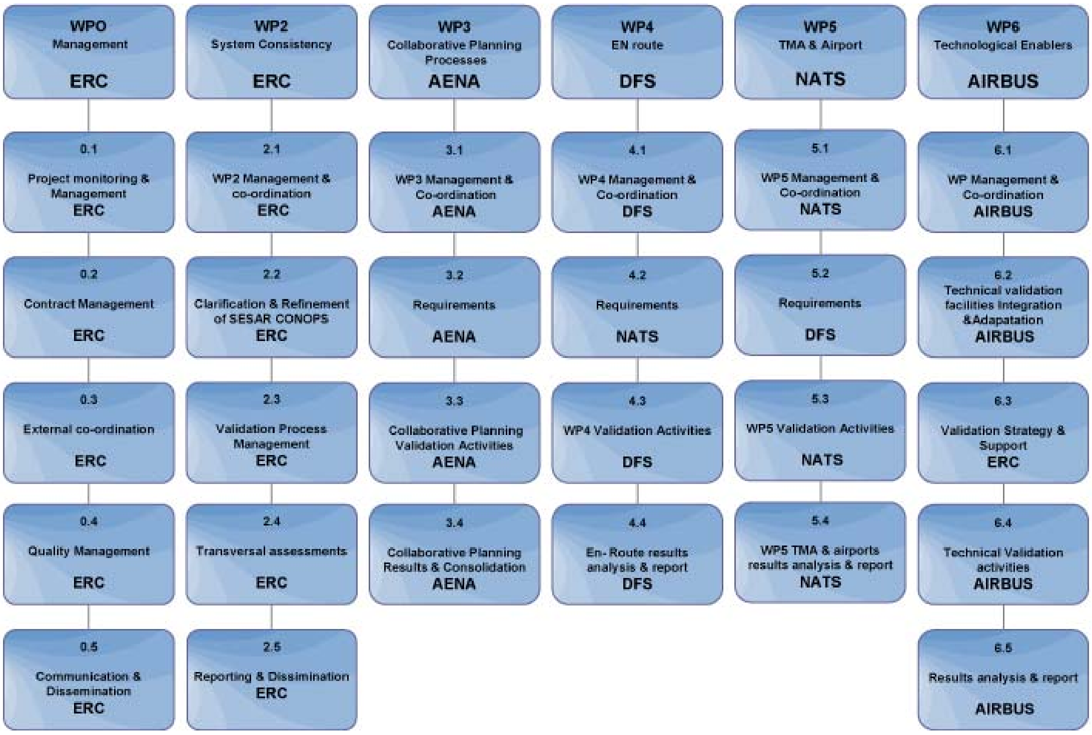
Towards the end of the project the Lessons Learnt activities addressed the benefits and limitations of the methodologies applied in EP3 in achieving an integrated validation of the SESAR concept.

2.4 Summary of Overall Approach of EP3

EP3 identified three operational contexts corresponding to a logical segmentation of the ATM system, and leading to three operational work-packages at project level: 'Collaborative Planning', 'En-route and Traffic Management' and 'TMA and Airport'. To complement these operational domains, a dedicated work-package 'Technical Enablers' handled technical issues co-ordinating with the other work-packages as required.

A 'System Consistency' work package was created to focus on the project's principal objectives providing an overall view and consolidation of the various ATM processes assessed in other work packages. While ensuring a common understanding of the operational concept, it also set up a common approach to the identification of validation issues and the conduct of validation exercises captured in the validation strategy. Transversal assessment validation exercises were performed in the domain of Safety and Environment. The development of the performance fell into this task, so a common framework has been produced to ensure a shared understanding of the key parameters of system performance and a systematic approach to data collection and interpretation.

The diagram below illustrates the work breakdown structure of the project.



Expert Groups played a fundamental role in the conduct of operational work packages (Collaborative Planning Processes, En-Route and TMA & Airport); they provided support to other validation exercises through review of the exercise objectives, the clarification of hypotheses and assumptions and the analysis of the conclusions. Seven Expert Groups fulfilled those tasks:

- Collaborative Network Planning;
- Collaborative Airport Planning;
- Analysis of the SESAR Collaborative Planning Information: Demand and Capacity;
- Airport Data Exchange;
- En-route queue, trajectory and separation management;
- TMA;
- Airport.

Each of the operational work packages had a task to co-ordinate the validation and concept detailing at the ATM domain level and a separate task for reporting the results of the work package.

The governance and management of the project was provided through three bodies:

- The Executive Committee (EXCOM), in which all consortium members were represented, provided high level steering;
- The Project Management Board (PMB) comprising the work package leaders and a representative from the Co-ordination Cell which managed and co-ordinated the work programme;
- The Co-ordination Cell comprising the leaders of the validation and concept tasks in the operational work packages and the task leaders in the technical work packages, provided guidance on validation and concept to exercise leaders.

The work of the project was supported through the project website, www.episode3.aero which provided a number of tools as well as general information on the project. These tools were developed specifically to support the needs of the programme:

- The EP3 Navigator which helped to manage the complexity of the project and its alignment with the SESAR definition phase and S-JU Work programme and acted as an easy to access encyclopaedia on all aspects of SESAR, i.e. the OIs, concept and KPA, and EP3, i.e. the exercises, DODs, Performance Framework;
- The library that eased the management required to produce the 120 deliverables of the project;
- The Review Room that allowed a multi-site team of reviewers to work with the document and the author to provide comments and build and record the agreements on how the document should be updated;
- The Discussion Room to promote, support and record debate on technical matters amongst team members.

2.5 Relationship with Other Projects

Projects linked to EP3 can be seen as related to single or multiple domains.

2.5.1 Multiple domains related projects

Cooperative Approach to Air Traffic Services II (CAATS-II)

CAATS-II is a 6th Framework Programme project funded by the European Commission running from November 2006 to November 2009. The work conducted was the management, consolidation and dissemination of the knowledge gathered in European ATM-related projects. The main outcome of the project was good practice manuals in the areas of Safety, Human Factors, Business, Environment and Validation. Cases will be developed on the basis of these manuals and will be integrated in the E-OCVM. EP3 and CAATS II have worked together to produce the version 3 of E-OCVM, combining the case-based approach promoted by CAATS II with the lessons learnt on validation of overall concept obtained from EP3. INECO, Isdefe and EUROCONTROL are partners of CAATS II.

http://www.caats2.isdefe.es.

Reduced Separation Minima (RESET)

RESET is a 6th Framework Programme project funded by the European Commission spanning from end 2006 to mid 2010. Its aim is to identify what reductions in Separation Minima (SM) could be realised in support of the SESAR objectives of increasing capacity, through the following approach:

1. Identifying per flight phase, feasible SM reductions contributing to safely reaching the x3 traffic increase.
2. Identifying what traffic growth and reduced SM mean for pilots and controllers roles, tasks and responsibilities.
3. Developing safety, efficiency & economy assessments for reduced SM and assessing their impact on technology needs.
4. Providing adequate evidence and justification to press for changes in SM.

The RESET project has used the EP3 E1 (Runway Management) DOD (Ref. [11]) and the EP3 E5 (Arrival and Departure) DOD (Ref. [12]) to study the SESAR concept elements relevant to their study.

Issued by the Episode 3 consortium for the Episode 3 project co-funded by the European Commission and Episode 3 consortium.

http://reset.aena.es/

C-ATM

Cooperative Air Traffic Management Phase 1 (C-ATM) is a 6th Framework Programme project that spanned from May 2004 to February 2006. Its aim was to develop a concept that could be deployed from 2012 onwards, based on 4D trajectory management, Collaborative Decision Making and ASAS. Its main output was a concept document, OSED's and a validation strategy, that was used to inspire the first instances of Episode 3 work plan, later re-aligned to the more long term SESAR concept. Some of the material and templates developed in C-ATM has been re-used in the Episode 3 DODs.

http://www.eurocontrol.int/vdr/

Gate-to-Gate

Validation of a European Gate-to-Gate Operational Concept for 2005-2010 is an EC funded project validating an integrated gate to gate operational concept, consistent with other on-going initiatives, that used large scale real time simulations and occur between 2002 and 2006. The experience gained in this attempt at validating an overall ATM concept was a key input to Episode 3 validation strategy.

http://www.eurocontrol.int/vdr/

www.g2g.isdefe.es

SWIM-SUIT

System Wide Information Management – Supported by Innovative Technologies (SWIM-SUIT) is a 6th Framework Programme project, that ran in parallel with Episode 3 and will complete mid 2010. Its objective is to demonstrate the feasibility of SWIM functionality for the Air Transport System, through architecture studies, drafting of requirements and development of a test platform. A tight coupling between SWIM-SUIT and EP3 was planned at first, but since the re-orientation of Episode 3 and the suppression of a second validation cycle, this was no longer feasible.

http://www.swim-suit.aero

CREDOS

Crosswind - Reduced Separations for Departure Operations (CREDOS) is a project of the 6th Framework Programme of the European Commission (DG-RTD) co-ordinated by EUROCONTROL.

The CREDOS project is investigating the possibilities of safe conditional reduction of wake turbulence separation minima. Information from the project was used during the identification of requirements for Noise Assessment tools.

http://www.eurocontrol.int/eec/credos/public/subsite_homepage/homepage.html

TMA 2010+

TMA 2010+ is a EUROCONTROL project building on Gate to gate results in order to provide requirements for advanced arrival management tools, including P-RNAV and CDA's. TMA 2010+ work has been considered in Episode 3 TMA validation exercises.

http://www.eurocontrol.int/vdr

2.5.2 Single domain related projects

2.5.2.1 Environment

The following projects had links with environment activities.

System For Airport Noise Exposure Studies (STAPES)

The STAPES project was jointly initiated by the European Commission, EUROCONTROL and EASA. The objective is to develop a new aircraft noise model capable of performing multi-airport noise studies that fully complies with the latest guidance provided by ECAC Doc.29. STAPES is developed at EUROCONTROL under its technical leadership and project management.

Environmentally Responsible Air Transport (ERAT)

This Sixth Framework Programme of the European Commission (EC) studies 2 concepts of Operations, one for London Heathrow and one for Stockholm Arlanda aiming for reduced environmental impacts through increased efficiency of operations in the extended terminal area (eTMA) and enabling Continuous Descent Approaches (CDAs) and Continuous Climb Departures (CCDs).

http://www.erat.aero

SAE–A21 & ICAO/CAEP

International guidance material for noise and emission estimation and modelling is developed by Society of Automotive Engineers (SAE) and Committee on Aviation Environmental Protection (CAEP) Working groups. EUROCONTROL is heavily involved and is one of the main contribution partners of the process.

2.5.2.2 Airport

EMMA 2

European Airport Movement Management by A-SMGCS (EMMA 2) is a 6th Framework Programme project that run between 2006 and 2009, following the EMMA project. The objective is to develop a concept for use of advanced A-SMGCS capabilities, and validate it through live trials at 4 European airports. EMMA 2 includes monitoring, conflict detection and guidance for all aircraft movements on the ground, with full integration of A-SMGCS in the ATM environment. EMMA2 concept has been used as a starting point in Episode 3 airport work.

http://www.dlr.de/emma2/

TAM

Total Airport Management (TAM) is a joint EUROCONTROL/DLR initiative aiming at the initial definition of a Total Airport Management operational concept and the related Airport Operation Centre architecture. This concept is based on the management of an Airport Operations Plan. The TAM concept was a starting point for Episode 3 collaborative airport planning work, and is also inspiring SESAR airport work.

http://www.bs.dlr.de/tam/

3 TOOLS, TECHNIQUES AND METHODOLOGIES FOR VALIDATION

3.1 INTRODUCTION

EP3 is the first large-scale validation project where E-OCVM [Ref. [C]] has been widely applied. EP3 mainly focuses on concept clarification, which is the focus of validation during early maturity phases but it also focuses on:

- Operability and Performance studies;
- Technical Impact;
- Validation Tools;
- Validation Methodology Assessment.

Due to the generally early stage of maturity of the concept and constraints on the project organisation, such as limitations on time and suitable validation platforms, an innovative approach to performing validation and new validation techniques were necessary.

3.2 APPROACH

A validation strategy was produced (Ref. [25]) with the aim of conducting a proper validation process and achieving the objectives of the project. EP3 applied a two-tier hierarchy of validation strategies. A higher-level project-wide validation strategy established a common validation framework, adapting the E-OCVM to the scope of the project and coordinating common working practices. This cascaded down through a set of Operational Domain Validation Strategies corresponding to the project's segmentation of the ATM system, which defined and managed the typical validation activities in the three work packages 'Collaborative Planning' (WP3, Ref. [1]), 'En-route and Traffic Management' (WP4, Ref. [2]) and 'ETMA/TMA & Airport' (WP5, Ref. [3]). These were complemented by Technical Enabler Validation activities undertaken in WP6 (Ref. [4]).

The main activities of this approach were:

- Support of Concept Clarification within a common Framework: describing the overall concept, an ATM process model, the DODs and finally the Operational Scenarios.
- Formulate and Elaborate the SESAR Performance Framework (PF). The EP3 PF (see 6.2) is organised in three layers, Top level Concept, Key Performance Areas and Focus Areas with the associated Performance Targets (2020) at the ECAC level. The PF also manages the initial work in developing the core set of Performance Influence Diagrams.
- Identify validation techniques adapted to the early stages of the validation lifecycle. There was a shortage of cost effective validation techniques, tools and methods to support ATM validation activity, particularly at the early stages of the concept lifecycle where the aspects of SESAR concept targeted by EP3 is currently situated (mainly V1 with some elements at V2, see Figure 5). Therefore, innovative techniques like Expert Groups, Prototyping and Gaming Techniques with specialist platform support (e.g. CHILL) and multi-agent modelling (PROMAS) were used (see section 3.4) in addition to more traditional techniques like Fast Time Simulation. Furthermore, EP3 took several initiatives to explore, identify or apply the following new techniques described below:
  - Influence Diagrams (see section 6.2);
  - Safety and Environmental Assessments (see section 6.3.6 and 6.3.7).

- Consolidate the results by organising two Lessons Learnt workshops and thus providing best practice and advice about what was good in EP3 and what can be improved. The workshops also helped in the consolidation of experience for applying E-OCVM to Integrated Validation Processes.
- Create and distribute easy to use templates in order to ensure consistency of e.g. validation plans, validation strategies and exercise reports.

3.3 Validation methodology

Concept Validation is about identifying, collecting and structuring information in order to provide evidence to the stakeholders that the concept is "fit for purpose" EP3 has applied the E-OCVM, which is an agreed methodology for establishing fitness for purpose of proposed concepts, focusing on the R&D activities involved in ATM concept development. It aims to provide a common approach for all projects contributing to the validation of operational ATM concepts from early identification of issues to full pre-operational validation. The E-OCVM uses three "perspectives" to capture different aspects of validation.

- Concept Lifecycle Model (CLM): Locates "Validation" processes within the broader context of system development. Figure 5 shows the different stages of this model;

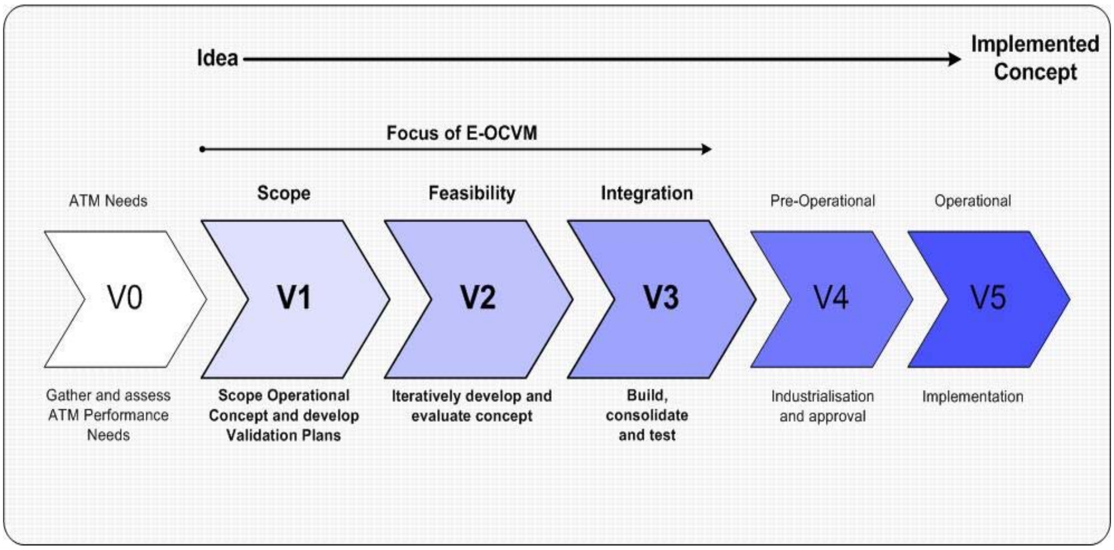


Figure 5 - The Concept Lifecycle Model (after E-OCVM V2.0)

- Structured Planning Framework (SPF): Provides a structure for the identification, planning, execution and analysis of appropriate validation exercises. To see which are the steps to follow during concept validation (see Ref. [C]);
- Case Based Approach: Focuses on capturing stakeholder expectations and concerns and on ensuring that validation activities provide the necessary results in an appropriate form to address them. There should be different cases for particular stakeholder concerns – safety, business case, environment, human factors, etc.

The three perspectives described fit together to form a process focused on developing a concept towards an application while demonstrating to key stakeholders how to achieve an end system that is fit for purpose. The Concept Lifecycle is the central aspect of the validation process and the other parts of the process fit with it.

On the one hand, Environmental and Safety cases have been created in EP3 and they have evolved along the project as project transversal areas. On the other hand, some of the outputs from the Structured Planning Framework captured in EP3 are contained in three main documents:

- Validation Strategy (see section 3.2);
- Validation Exercise Plan for each sub-WP, which describes the exercise needs;
- Validation Report, which captures the outputs of each individual validation exercise.

3.4 Assumptions

3.4.1 Introduction

An important aspect of validation is the use of assumptions. These provide the context of the validation exercise, either to ensure consistency across a set of validation exercises or simplifications required to make the validation process tractable. The assumptions should be understood to properly interpret the results of the validation exercises.

The main assumptions used in EP3 are provided in this section, as they are important to set in context our main results.

Initially, the EP3 validation strategy prescribed managing common assumptions at the project level. However, after the re-scoping of the project, coverage of exercises was not sufficient to justify such an approach, and the absence of performance results integration did not make coherent assumptions necessary.

However, a lot of the validation activities still had common assumptions, which will need to be evaluated in further validation, if our results are to be integrated in an overall assessment.

The assumptions can be grouped as follows:

- Assumptions on the demand;
- Assumptions on how the concept will be implemented;
- Assumptions on the environment and the enablers.

3.4.2 Assumptions on the demand

The project used the STATFOR long term traffic forecast for 2020, choosing the high growth scenario (aligned on the SESAR definition phase). However, some exercises had to reduce the traffic when they were assessing operability as the controllers did not have the time to learn the new tools and at the same time manage the substantially higher traffic forecast for 2020.

3.4.3 Assumptions on how the concept will be implemented

These are the main assumptions. As each exercise is only studying part of the concept, assumptions are made on the other concept elements. Most evaluations are not done in today's environment ceteris paribus and on the contrary, most exercises study their concept elements embedded in a SESAR-like environment.

Here is a list of such assumptions made in the project:

- En-route airspace will have no fixed route structure and aircraft will fly direct from Top of Climb to Top of Descent, however, when traffic is busy, some amount of structure will be set up to organise the traffic;
- Because of the way our project was structured (WP4 and WP5), airspace was divided between en-route and TMA, flights being delivered to the TMA in an organised way, through a control time (CTA). This was a simplifying assumption necessary in the context of our project. Note that SESAR itself has kept the same separation in its work programme;

- When fixed airspace structures are defined, they are in any case independent of national boundaries, and FABs are fully implemented (exercises have been done in FABEC, FAB Portugal-Spain and BlueMed);
- The demand will be organised during the planning phase through sub-regional network managers. Data will be exchanged on the NOP, and this will allow sub-regional managers and airspace managers to refine the SBTs and perform airspace reservations;
- SWIM will be fully in place, allowing all actors to share information during the planning and execution phases;
- Total Airport management will implement collaborative planning process for each airport, through an APOC (Airport Operation Centre). No assumption has been made on how APOC should be implemented, either as distributed systems or as a real control room, with new permanent roles. The APOC will build and refine the airport operations plan, which will be integrated in the NOP;
- In control rooms, multi-sector planner will prepare traffic for the sectors, and will work for 4 sectors maximum. When studying work at the sector, 2 persons sectors were still assumed;
- Controllers' role is slightly modified as pilots will follow their RBT, the controllers' role being to facilitate the RBT with as little interference as possible;
- Traffic before reaching the sectors being studied, was always subject to some de-complexification, supposed to be provided during planning phase, or in upstream sectors by traffic managers or sub-regional managers.

3.4.4 Assumptions on the environment and enablers

Most exercises assume a full SL 2 equipage, as at this level of maturity of the concept, it is very difficult to study the impact of mixed equipage. It was however felt that this was a very strong assumption as the impact of mixed equipage will be broad (in terms or airspace design and workload).

No system failures were studied, and there was no study of degraded modes of operations.

In performance studies involving airports, it was assumed that the runways were the limiting factor in terms of capacity.

All airports are equipped with Arrival Managers.

SWIM is available to all actors, with all trajectory changes shared instantaneously.

3.5 Innovative Validation techniques and Tools

This section describes briefly the EP3 innovative tools and techniques applicable during the early stages of the validation lifecycle (expert groups, gaming techniques, prototyping session techniques and modelling) in terms of their main characteristics, capabilities and limitations. The sub-sections are based on the results of the Lessons Learnt workshops, and on direct experience of the exercise leaders involved within Episode3, which was described in each exercise report and captured by means of a questionnaire. More guidance on these techniques is captured in [29].

3.5.1 Expert Groups

The EP3 Expert Group (EG) Technique is based on gathering a group of people with specific professional profiles, i.e. backgrounds, knowledge and expertise, and using both the individual skills and the synergy of the group in a structured manner for discussing and working on a set of predetermined concepts.

Expert Groups are suitable for the initial validation stage (concept definition and clarification) as well as for considering cross-functional issues, i.e. operational feasibility. Table 4 shows the most important capabilities and limitations of this technique as applied in EP3.

Capabilities
Provide experience based on judgemental analysis through a top-down approach to the concepts from all stakeholders' viewpoints for supporting the feasibility of the developments to be undertaken. Concept clarification.
Identify areas of risk when implementing a concept of operation and then helping focus project efforts on the critical aspects.
Take decisions. Always providing a rationale for both the decisions made and the options discarded, either when a consensus exists or not.
Support to other validation exercises – e.g. during design phase (definition of assumptions, hypotheses, validation scenarios) or analysis of results.
Limitations
Experts' judgement represents a qualitative contribution to the validation process. Thus EG are not able to provide quantitative results, but may provide quantitative estimations, i.e. an order of magnitude of a variable required, or as inputs for other validation exercises.
Quality of the results depends on the background, the knowledge and the expertise of the experts being part of it.
Repeatability and Accuracy: the Repeatability and Accuracy of the results depend on the constancy of the experts' participation.

Table 4 - Capabilities and Limitations of the Expert Group Technique

Based on these capabilities and limitations, the main validation objectives of an Expert Group were:

- Operational Concept Clarification and Refinement;
- Validation Exercises Support (requirements, design, planning, scenarios, execution and results);
- Assessment and Extrapolation of Validation results;
- Obtaining cross-WP consistency between different areas of the concept and different exercises.

During EP3, where most of the EGs were focused on concept refinement, the **Delphi Technique** (e.g. Ref. [26]) was often applied to obtain results and stimulate discussions within the Expert Groups. This method consists basically of collecting information from the experts through a set of questionnaires. These questionnaires were created in advance and deal with different topics related to the concepts to address by the EG. The results obtained from those questionnaires are presented and analysed in the following EG meeting(s) after which the conclusions are drawn. When experts do not reach an agreement about an issue the results are used as input for next questionnaires. As EG workshops and questionnaires were completed, the conclusions extracted from them were considered as consolidated outputs (when experts reached an agreement related with some issue).This technique allows each expert to answer the questions without any influence because questionnaires are individual and anonymous.

A useful working tool to present the results of an Expert Group are **Storyboards**, which show in a graphical way the actors, sequence of activities and interaction of events (as well as outstanding comments and assumptions made) useful for simplifying the scenarios and providing a clear method for presenting information.

Issued by the Episode 3 consortium for the Episode 3 project co-funded by the European Commission and Episode 3 consortium.

3.5.2 Gaming Techniques

Human-In-the-Loop (HIL) Gaming technique is used for playing "serious games", designed for a specific purpose. During the play, experts act as actors; this allows the exploration of concepts and definition of roles and processes in a structured way, focusing the players' attention on the information flow and responsibilities associated with the processes.

Role-based games were performed in three different ways:

- **Paper-based**

Paper-based games were performed using basic tools like presentations, papers and pens. The game had to achieve the general performance of the global scenario while at the same time ensure that the actors worked on their personal goals.

- **Web-based**

Web-based games (also "Flash games") are performed using a tool through a web server and are designed using the results from previous (mostly paper-based) games. As such, they are used to disseminate the results of paper-based games and to further refine roles and responsibilities based on the predefined work-flow in the game.

- **Hardware platform-based**

Platform-based games are performed using hardware platform and are recommended for operational assessments and also to explore new functionalities or requirements of tools. Configurable player positions can be used to support the different roles which can be part in the different ATM processes. This permits platform adaptation to the objective of the game, the situation, the scenario and the concept to assess. Its modular development supports the integration of interoperable modelling services and components

The gaming platforms used in EP3 were CHILL, DARTIS. CHILL (Collaborative Human-In-the-Loop) is a versatile collaborative ATM platform in which each role can configure its parameters to perform the game in the way the participants decide. DARTIS (Decision Aid to Real Time Synchronisation) enables the application of dynamic ATFCM measures managed through collaborative decision making between the different involved partners (air navigation service providers, network managers and the aircraft operators).

Furthermore, two platforms that were not specifically designed for Gaming were used to facilitate Gaming Sessions: ACCESS and PROMAS. ACCESS is a facility that is used as an airport operations centre (APOC). It provides a flexible infrastructure with up to ten operator working positions as well as a large power wall to show a situation overview to all operators. PROMAS (Processes Management Simulator) is a complementary, Gaming-compatible Fast-Time Simulations technique, which is used to assess complex systems.

The type of gaming technique to be applied depends on the maturity level of the concepts to be validated; while paper-based and web-based games fit better with V0-V1, hardware-platform based games fit better with V1-V2. Table 5 shows the main **capabilities and limitations** of the gaming techniques.

Capabilities
Validation, clarification and refinement of concepts.
Exploration of the interactions between actors and between actors and tools allowing the definition of: • Roles and responsibilities; • Information requirements, flows and processes;

• Tools requirements and functionalities.
Detection of show stoppers through the 'fast forward' events to see the result of that decision or input.
Adequate to obtain qualitative results.
Performance of **low-cost simulations** using only basic attributes (only for paper-based games).
Limitations
Less flexible to modifications (not applicable for paper-based games): No design changes of the game during its execution and configuration changes take time and should be programmed in advance.
Unsuitable for performance assessment: Paper-based method can not provide quantitative results unless designed to do so (not the case in EP3), and although the other two gaming methods can obtain some quantitative measures, performance assessment is limited to access, equity and participation assessment.
Results' dependence on the participants' expertise; Feedback obtained is limited and dependant on the players' knowledge.
Higher development costs for web-based and platform-based games. Development and improvements of the tools to support the game's performance has a higher cost, involving either hardware and/or software development.

Table 5 - Capabilities and Limitations of the three Gaming techniques

Based on the capabilities and limitations, the collective **objectives** of these three gaming techniques are:

- Definition of Roles and Responsibilities;
- Concept clarification and refinement;
- Feasibility and operability assessment;
- Evaluation of interactions and information exchanges;
- Exploration of supporting tools;
- Dissemination of the results provided by paper-based games (Web-based games).

When a complex concept is validated, a Gaming Exercise consists usually of several **gaming sessions**, each one studying a specific concept element or a specific expected benefit obtained by the concept. The results of each gaming session serve for the refinement of the design of the next gaming session, until the general objectives of the gaming exercise are achieved. Figure 6 shows the phases of a complete gaming exercise consisting of several sessions.

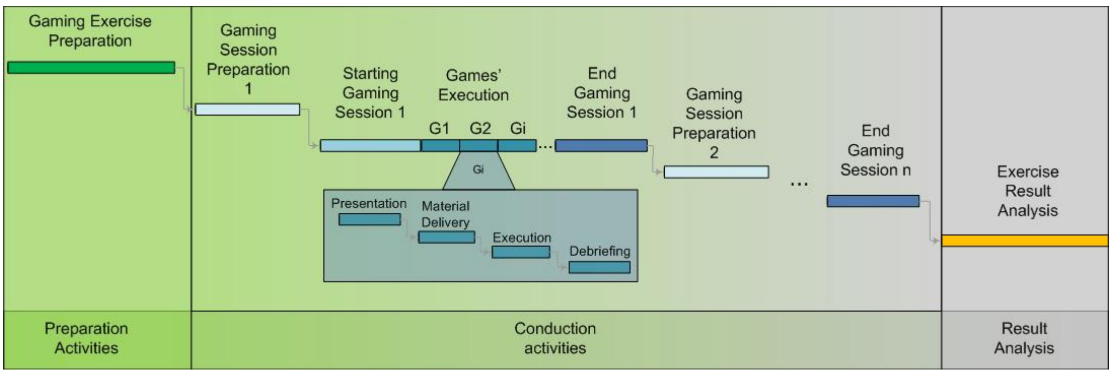


Figure 6 - Gaming exercise phases

Generally, the **design of a game** must address the following elements:

- Validation Scenarios;
- Selection of the gaming method and tool;
- Players;
- Rules;
- Methods to collect the outcomes.

3.5.3 Prototyping Sessions

Prototyping Sessions are an iterative and incremental validation technique, based on successive real-time Human-In-the-Loop experiments.

Prototyping Sessions are an intermediate step of validation between e.g. gaming exercises and larger-scale real-time Simulations and Modelling. This technique is suitable for use in the early stages of concept maturity, allowing putting the end user in a realistic context at an acceptable cost, and the recording of early feedback on the applicability of the operational concept. However, the operational concept has to be defined at a sufficient level of detail to allow for the identification of validation needs and for the setting-up of a "workable" operating environment and tools. In the context of the E-OCVM Concept Lifecycle (Ref. [C]), the technique is well adapted to the V1 and V2 phases.

Table 6 summarises the main **capabilities and limitations** of the Prototyping Session technique employed in EP3:

Capabilities
Involvement of operational end users, perception allowing a first assessment of feasibility and acceptability of tasks requiring humans in the loop. Useful to indicate trends or to refine some performance objectives.
Flexibility through small scale/iterative nature. Small-scale experiments allow quick implementation of unanticipated changes, thus enabling quick assessment of their potential benefits.
If continuity can be ensured, the main cost of the technique is in the setting up. Repeat costs are minimised.
Limitations
Complexity of platform and data preparation and analysis: to ensure quality in development, traffic/scenario definition and the preparation of data that may be quite complex, a lot of time and effort is required.
Limited time between and during sessions: to minimize training time, the same users should be available across the sessions to reduce the training needs.
Limited representativeness of results: given the limited number of participants, and the sessions limited in time and in number, the results can only be considered as first trends rather than statistically valid results.

Table 6 - Capabilities and Limitations of Prototyping Sessions technique

Prototyping Sessions are performed using rapid prototyping facilities or real-time simulation platform facilities. In EP3, the platform used was the real-time simulation ESCAPE platform provided by EUROCONTROL. The iterative prototyping approach was applied in two of the WPs through a series of small-scale experiments:

- As support for clarifying a defined set of concept elements, examining and refining possible options related to the concept implementation and based on outcomes from expert groups;
- Providing an initial assessment of the operability and acceptability of these options;

- Providing initial trends on some KPAs (FTS/Modelling are required to provide consolidated performance figures).

More generally, the main objectives that can be covered by the Prototyping Sessions technique are qualitative in nature and are related to the Human-In-the-Loop aspects. These are:

- To collect first feed-back and to obtain initial assessment of operability and acceptability of the concept elements from the end user perspective;
- To experience procedures in detail and to obtain qualitative assessment of their feasibility;
- To clarify roles and responsibilities;
- To assess the information exchange means and processes;
- To identify operability issues;
- To improve initial assessments on end user (controller) workload;
- To clarify requirements for the supporting tools and to assess the proposed HMI.

3.5.4 Modelling and Fast Time Simulations

Modelling and simulation techniques involve using computational models of ATM systems, normally for both airspace and airport operations. They use a (conceptual) representation of elements of the ATM concept (scenario) in order to assess performance or feasibility of the processes.

Modelling and simulation techniques are applied when it is impractical (for reasons of time, money, complexity etc.) to recreate the experimental conditions of the processes when aiming to produce quantitative performance figures with a large scope in geographic area and time or to prove aspects of feasibility.

Table 7 shows the main capabilities of the modelling and simulation techniques:

Capabilities
Large scope: All kinds of ATM and air transport processes and elements can be recreated through a model.
Models can be built **ad-hoc** or adapted to cope with specific needs.
Outputs of the simulations are always **quantitative**, and can be further analysed to obtain specific metrics and indicators with an associated level of confidence.
Models are best used to test the **sensitivity** of a proposed concept to different assumptions and scenarios.
Deterministic models provide – under the same initial conditions – identical results over repeated simulations. **Non-deterministic** models incorporate stochastic or statistical elements to allow for uncertainty associated with ATM operations or system.
Modelling is **cost-effective**. There is no need for expensive involvement of experts (HIL), or material (mock-up, prototypes etc).

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Limitations
Modelling is by definition introducing simplification of a real situation and hence inaccuracies in the results.
The output data are numerical and require careful analysis and interpretation to take account of the effects of the underlying assumptions model, data and scenarios.
The level of maturity of the concepts being addressed determines the available level of detail for the processes to be modelled. The lack of details must be supplemented with assumptions, which obviously have an impact on the accuracy of the results.

Table 7 - Capabilities and Limitations for Modelling

Based on the capabilities and limitations, the common validation **objectives** of modelling and simulation techniques are:

- Performance Assessment;
- Sensitivity Analysis;
- Safety related issues (e.g. conflict prediction);
- Process Feasibility.

Figure 7 below shows an ideal planning for a modelling validation exercise:

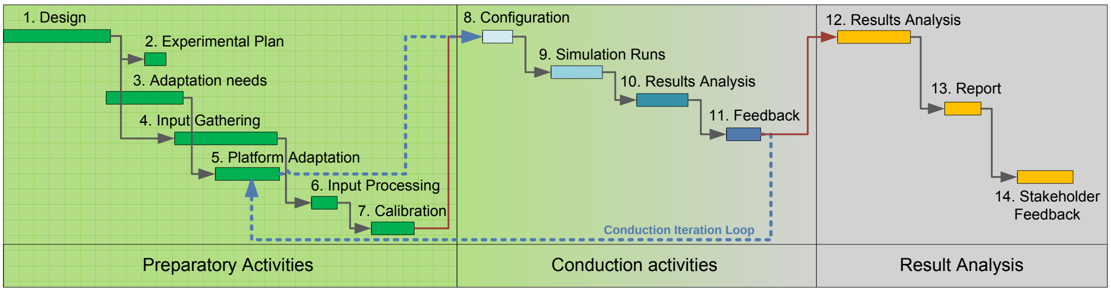


Figure 7 - Diagram of modelling validation exercise

Different **modelling and simulation techniques, tools and platforms** have been used within EP3. Some of them were developed within the EP3 project, such as PROMAS and ATM-NEMMO and for the already existing models and tools a certain level of innovation was achieved within EP3 in order to reflect the new concept envisaged by SESAR.

Technique	Tools / platform		Approach
	Name	Category	
Influence Modelling	ANALYTICA V4.1	Analytical	A graphical and mathematical representation of the sequences of interconnected factors that influence Key Performance Areas and with which the magnitude and nature of the effect of each influencing factor can be assessed.
Fast Time Simulation	CAST Ground-Handling	Multi-agent based	Integrated simulation of all airport processes related to passengers, vehicles, and aircraft. 3D virtual airport environment and multi-agent technology.
	CATS/ OPAS	Discrete event	The core of the CATS/OPAS system is an En-Route traffic simulation engine, based on a discrete, fixed time slice execution mode. Also provides built-in conflict detection modules and conflict resolution modules using horizontal manoeuvres.
	TAAM	Discrete event	Modelling air traffic, en-route, in the airport area, and on the ground: A model of any airport or air traffic environment can be created.
	RAMS Plus	Discrete event	Discrete-event simulation relying on high-level-of-detail network representations of airfields and airspace.
Process simulation	PROMAS	Discrete event	Representation of the operation of any type of organisation or system, based on discrete events.
Network management modelling	NAM	Analytical	Modelling of a simplified NOP of the kernel network of ECAC-wide operations that can be used to perform validation studies on use of airspace and on the regulation of traffic scheduling.
Macro-modelling	ATM-NEMMO	Analytical (stochastic)	Modelling of the macroscopic aspects of the air transport network and ATM system. Possibility to incorporate stochastic effects. Simulation of the traffic flows dynamically adapting the traffic diffusion to the network and ATM capacity constraints.

Table 8 - Modelling and simulation techniques, tools and platforms

3.6 Discussion

EP3 was the first large scale validation project where the E-OCVM has been applied with a focus on concept clarification, i.e. validation during early maturity phases. The validation strategy was defined at project level, adapting the E-OCVM to the scope of the project, and at work package level, according to the segmentation of the ATM System applied.

The main aspects of the validation approach were: support concept clarification, formulate and elaborate the SESAR Performance Framework, consolidate the results with Lessons Learnt Workshops and the most important, identify validation techniques and tools according to the level of maturity of the concept.

The techniques/tools used to achieve the results in EP3 were mainly focussed on validation activities in V1/V2 and there was wide use of innovative techniques, e.g. Expert Groups, Gaming Techniques and Prototyping. However other traditional validation techniques as Modelling and FTS were also used.

4 CONCEPT DEVELOPMENT

4.1 INTRODUCTION

The aim of EP3 is to initiate validation activities on the SESAR concept, therefore the starting place for these activities is the SESAR Definition Phase documentation on the concept, D3, the ATM Target Concept. SESAR D3 (Ref. [F]) immediately references SESAR ConOps[4] (Ref. [J]) for further detail but neither document was suitable for systematic validation activities as both were at too coarse a granularity as their prime purpose was to explain the principles that would be applied in the ATM paradigm proposed. The complementary view of the ATM system provided by the D5 SESAR Master Plan (Ref. [H]) provided a finer granularity of information on the enablers that would support these changes, but this was a fragmented view. Furthermore, there was a need to update the concept information in the light of the IP1 to IP2 task force (Ref. [34]).

It was therefore decided to rework the SESAR Definition Phase material into a more suitable format for validation work and, where possible, to add detail from relevant projects. The format chosen for the documentation is based on the ED-78A standard (Ref. [19]) and named the Detailed Operational Descriptions (DODs). The OSED format was considered inappropriate as there was a need to take a higher level view to support an integrated description of the concept. As concept development progressed, the description in the DODs was supplemented by Operational Scenarios, Use Case descriptions, and storyboards in support of the various validation activities.

4.2 APPROACH

The main purpose of the series of DODs is to refine and clarify the SESAR ConOps for 2020 in support of the EP3 validation exercises – i.e. operational and performance assessments.

The description of ATM operations provided by the DODs has been developed:

- Using the layered planning of ATM Operations, derived from the SESAR long/medium/short term planning and execution phases and its hierarchical breakdown into processes through the ATM Process Model (Ref. [18]);
- Detailing the roles of individual ATM actors and the use of key concept elements identified by SESAR ConOps, such as the business trajectory, and improved collaborative decision making (CDM);
- Establishing clear links between the proposed description and SESAR high-level operational concept elements - e.g. traceability to SESAR Operational Improvements, and documenting the assumptions made.

The analysis of the ATM system into processes, applying the SADT methodology, led to the following allocation of system descriptions to individual DOD documents.

[4] While D3 was a document accepted by the whole Definition Phase consortium, some partners had reservations about SESAR ConOps. However, SESAR ConOps provides much needed detail and the reservations were taken into account in EP3's work.

Long Term Planning Phase	Medium & Short Term Planning Phase	Execution Phase
Long Term Planning DOD (L)	Collaborative Airport Planning DOD (M1)	Runway Management DOD (E1)
	Medium & Short Term Network Planning DOD (M2)	Apron & Taxiways Management DOD (E2/3)
		Network Management in the Execution Phase DOD (E4)
		Conflict Management in Arrival & Departure High & Medium/Low Density Operations DOD (E5)
		Conflict management in En-Route High & Medium/Low Density operations DOD (E6)

Table 9 - DOD documents and SESAR planning phases (Ref. [12])

These individual DODs were supported by an overarching General (G) DOD and a Lexicon. The General DOD takes a similar approach to SESAR ConOps (Ref. [J]), by explaining the overall concept principles and the major system elements common to all DODs. The Lexicon provides definitions either derived from existing documentation or developed specifically by EP3 where definitions did not exist or existing definitions were, in the light of EP3 activities, ambiguous.

The life cycle of the DODs was iterative, as illustrated in the diagram below:

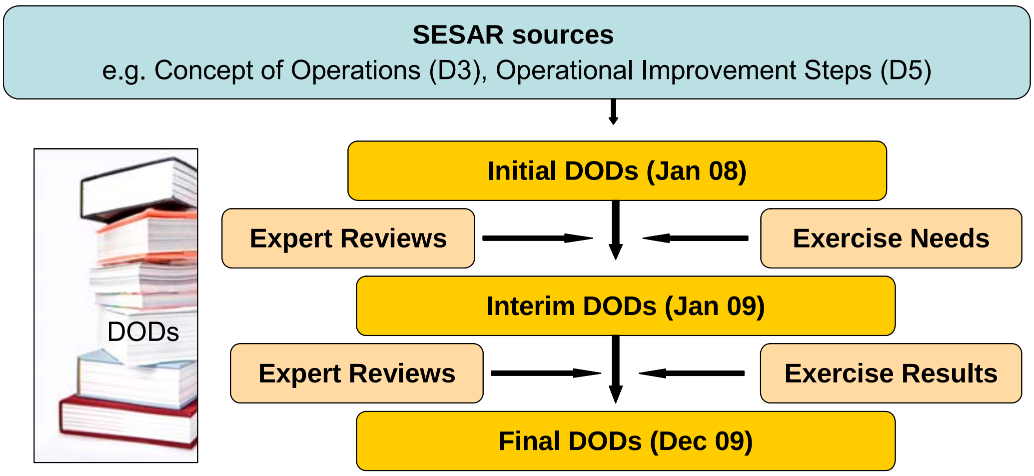


Figure 8 - Development Cycle of Detailed Operational Descriptions

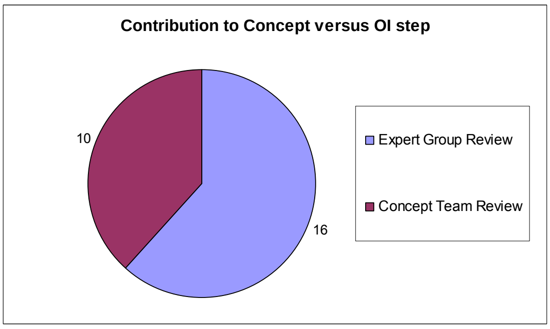
The aim of the DODs was to develop a set of documents that represented a consensus understanding of the concept and its detailing within EP3. The team working on the concept therefore encompassed a number of experts in both the preparation and the review process, with a team of around 15 who edited the DODs and a team of 60 who performed the reviews.

The main concept content of the DODs was the description of the ATM processes within the scope of each DOD, the actors involved in these processes, their roles and responsibilities and the general data requirements.

However, there was a need of a complementary approach to describing the concept for the validation activities. Thus, an alternative approach was taken that provided a transverse view of the operations that allow the coverage of "multi-DOD" areas and was presented through either an Operational Scenario (OS) or a Storyboard.

The OS consequently may describe longer time-frame operations than covered in a single DOD and/or involve multiple ATM functions – e.g. multiple airports or flights. In this task, EP3 has developed one high-level scenario describing how all the SESAR processes affect the planning and execution of a single flight work together. This was supplemented by 26 individual OS more focused on specific operations as shown below. Further OS to support understanding of the concept have been identified but development was not possible within project constraints (see Annex A – DODs and Operational Scenarios). The decision on whether to develop scenarios was based on the requirement by the validation activities for such concept detail to be produced and the availability of existing material, for example from the SESAR Definition Phase.

The OS developed were all reviewed within the concept detailing team, and several were further reviewed by expert groups or implemented in validation exercises including FTS, prototyping and gaming exercises. For the expert groups, a number of the OS were implemented as storyboards, representing them as flow charts that present the main operational steps and highlight the key issues. By working with a graphical format, storyboards are more suitable to support a group discussion than text-based documents. The figures below show the extent of review and implementation of the operational scenarios in EP3.



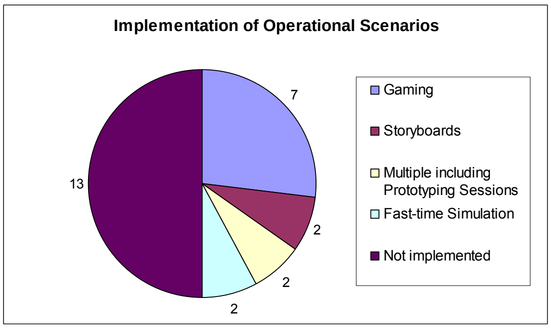


Figure 9 - Review and Implementation of Operational Scenarios

Use Cases provide further detail on how the concept works and 194 Use Cases were identified when developing the ATM Process Model. Given that EP3 focused on the less mature aspects of the SESAR concept, it was found that the Use Case level of detail was not needed. However, for illustrative purposes, a subset of fourteen Use Cases was produced.

These two complementary, independent approaches i.e. functional decomposition leading to the production of the DODs and operational descriptions provided in the OS, allowed the completeness of the concept detailing to be cross-checked. Both approaches should lead to the same set of Use Cases that will ultimately be part of the system definition (refer to Figure 10).

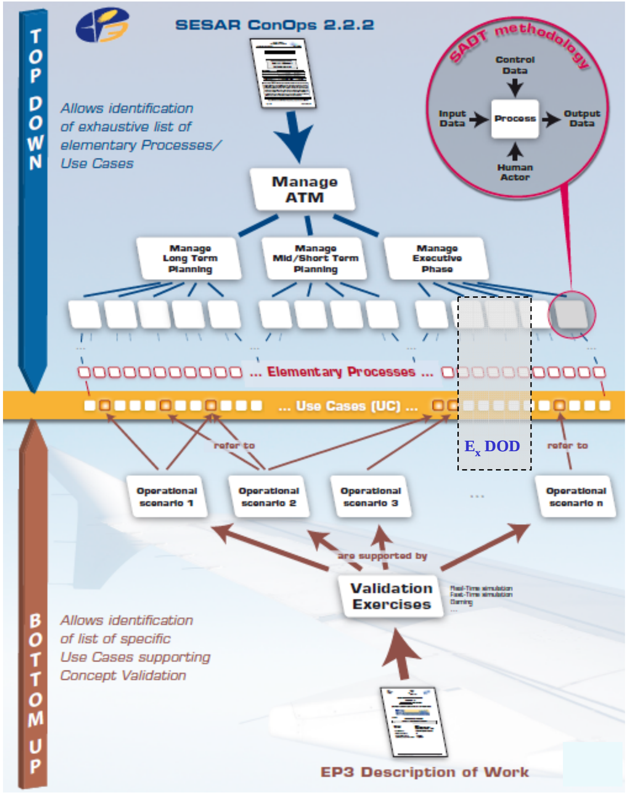


Figure 10 - Dependencies between Operational Scenario and ATM Processes

In order to have a complete view of the operations covered by a DOD, it is necessary to read the DOD, the associated OS and, where available, the Use Cases. However, a reasonable view can be obtained by only reading the DODs, starting with the General DOD.

4.3 Concept Detailing

4.3.1 Applicability of Concept Detailing

The target date for deployment of the concepts described in EP3 was 2020. An important step in EP3 concept detailing was therefore to identify what aspects would be deployed in this time-frame. The next step was to include the SESAR Definition Phase information into the ATM process model structure. This information, together with relevant, existing project results[5] was used to describe the various processes, the actors related to the processes and their data requirements. The diagram below shows how the concept detailing performed in Episode 3 contributes to the SESAR OI steps in D5 (Ref. [H]).

[5] These projects included EMMA 2, TAM, ASAS TN projects and SWIMSuit.

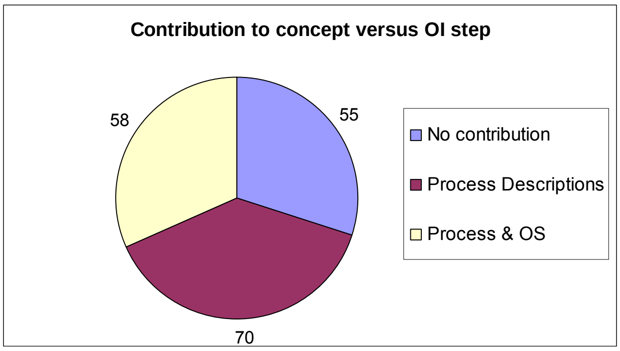


Figure 11 - Applicability of Concept Detailing to D5 OI steps

As it can be seen from the figure above, only around two thirds of the D5 OI steps were used in preparing the process descriptions in the DODs. D5 describes all the OI steps needed to transition from today's operations to the end-state concept foreseen for 2025+. The OI steps selected, just those relevant to 2020 operations, excluded transitional OIs towards 2020 and OIs with an In-Service date after 2020. Furthermore, in alignment with EP3's focus to operations the steps related to the operation of SWIM and other information services were also excluded.

A further analysis of the scope of the DODs versus the Research Topics identified in SESAR ConOps (Ref. [J]) was performed and the applicability is summarised below.

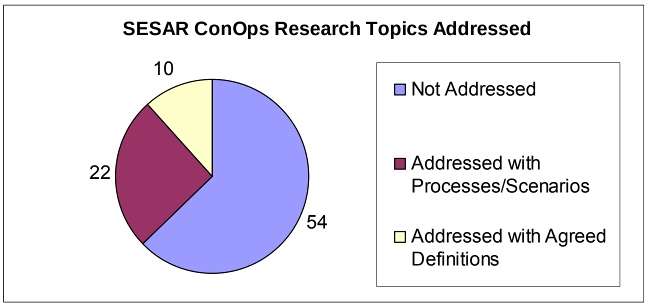


Figure 12 - Applicability of Concept Detailing to SESAR ConOps Research Topics

About one third of the SESAR ConOps research topics were addressed in the concept detailing work. There are three reasons that only a limited proportion were studied, firstly, these topics were not available during the preparation of the EP3 contract, so the exercises could not take them into account, secondly, many of the research topics do not relate to conceptual aspects and finally the topics focus on a level of detail significantly below that of the process descriptions in the DODs. The EP3 Lexicon does provide a finer level of detail and therefore some of the definitions provided there address these research topics to some extent.

4.3.2 Sources of Concept Detail

The Initial and Interim DODs were prepared as a starting point for the project with the objective of incrementally building the Final DODs. Additional detail on the concept beyond the structuring of available concept information was achieved through the review process of the DODs/OS, the results from the EP3 exercises and the EP3 discussion forum.

The figure below provides a count of the sources of new information on each DOD, i.e. number of reviewers, number of exercises. Where an expert group was split across two DODs, it is assumed that the effort is split equally. It can be seen that the En-route and

Medium/Short term planning DODs had the highest number of input sources, but that otherwise the inputs were almost equal across all areas of the concept.

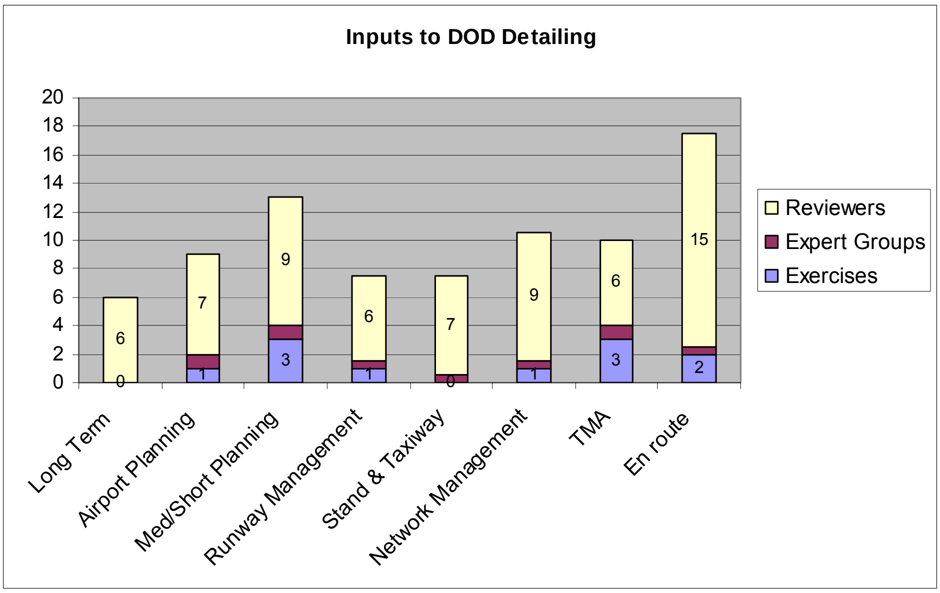


Figure 13 - Number of input sources to the DODs

4.3.3 Concept Development Achieved

The focus of the concept development achieved fell into the three areas listed below which are addressed in turn:

- 4D trajectory operations;
- Network management operations;
- Airport operations.

The result of the concept work was either new or confirmed concept detail or hot topics. The hot topics were areas where two or more interpretations of the concept were possible or the conclusions of the validation activity appeared to be in contradiction to the SESAR ConOps. Examples of the concept detail are provided below and the hot topics are provided in Annex 13.

4D Trajectory Operations

The fundamental element of 4D operations is the notion of the Business Trajectory that represents the business/mission needs of the users. The evolution and scope of the Business Trajectory has been fundamental to the work of EP3.

EP3 has described in detail the way the Business Trajectory (BT) evolves during planning and execution of the flight. The processes of sharing and evolving the Shared Business Trajectory during the planning phase have been defined and refined and the roles and responsibilities of the actors involved have been developed. In particular, the need for the Airlines Operations Centre to be an actor in a number of processes has been specified.

The timing and pre-conditions for the transition of the Shared Business Trajectory to the Reference Business Trajectory (RBT) have been proposed, but this is a hot topic. EP3 has defined additional BT transitions at the airport to manage aborted or delayed flights.

Definitions for updates and revisions of the RBT that will be required during flight execution have been agreed and the various air and ground interchanges involved for RBT revisions described. The nature and scope of collaborative processes in the execution phase is a hot

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topic. The timing of the RBT update that provides the taxi-in routing to take benefit from brake to vacate technology but is acceptable in terms of pilot workload, has been identified as a hot topic, but EP3 has not proposed a solution.

In the context of 4D Trajectory Operations, some of the SESAR Definition Phase information, (D3 and D5) was found to be ambiguous and if taken literally could lead to reduced efficiency of operations. The use of the term authorisation for a clearance and also for a datalink transmission implies that all flights will require multiple clearances, leading to a potential increase in controller workload per flight. In D3, it is implied that the Target Time of Arrival (TTA) and other target times are not constraints, but in working through the concept, it became clear that TTAs should be treated as constraints if they are to have a meaningful and impact on operations and a new definition has been proposed by EP3 as a result. The concept development incorporated the assumptions used in the validation activities which were -2/+3 minutes for a target time and +/-30 seconds for a control time.

The precise content of a Business Trajectory has not been proposed by EP3, but the validation activities have refined the understanding of what information will be required. For example, the minimum set of 4D points should include the change points for level and speed as well as conventional route waypoints. It has recognised that estimated times will exist at the same time as target times, but that a control time will replace the estimated time when it is applied.

Network Management Operations

Network Management is a key enabler for SESAR and EP3 has provided substantially more detail on this aspect of operations than was available in the Definition Phase. The main Demand and Capacity Balancing (DCB) processes involved in network management have been described and the roles and responsibilities of the related actors have been detailed. In this process a new actor, the airline co-ordinator has been identified.

The planning time horizons for the various elements of network management on the day of operation (DCB, dynamic DCB and complexity management) have been proposed, but this has also been recognised as a hot topic because it is not clear that there can be a single transition time that applies in all circumstances.

The process of adapting a TMA between low density and high density operations was detailed was identified as being part of the planning process, as it was not believed to be possible to change the pre-defined route structure to be applied at short notice.

In all of these phases, the use of the Network Operations Plan has been assumed and its scope and contents are now better understood.

Airport Operations

Airport Operations were only addressed to a limited extent within EP3 as there were other ongoing EC projects addressing airport operations. Despite this, the concept development work described the whole of the airport processes to the same level of detail as the rest of the concept. The analysis of the processes led to the identification of an additional actor at the airport, that is, the vehicle driver on the airport surface. Also, the work highlighted the need for the Airline Operations Centre to participate in an additional airport processes.

The planning phase of airport operations, based around the Total Airport Management concept has been further developed and fully integrated into the SESAR concept. The additional work has allowed the Airport Operations Plan to be described and the main contents determined, including the performance parameters. Naturally, the actors involved and their roles and responsibilities in relation to this plan have been defined.

A number of scenarios and storyboards have been developed that show how the concept works at the airport. This has raised the issue of applying speeds or target times to runway surface operations, essential if the RBT is to be four dimensional and ‘gate to gate’, but it is not clear to the experts how this can be managed when aiming to maximise runway throughput.

The process for agreement of the SBT as the RBT, which takes place when the aircraft is at the airport, were also discussed. The ConOps provides only a high level description of this process and the EP3 team have proposed a set of pre-conditions for RBT agreement.

4.3.4 Summary

In summary, EP3 took a structured, methodological approach to describing and refining the concept and had methods to check for completeness and consistency. This approach was taken to ensure that documentation presented an integrated description of the concept. Various approaches were taken to meet the needs of the document users, i.e. process descriptions in the DODs, OS and storyboards. There was a high level of involvement across the ATM community in the concept detailing work with around 60 individuals participating directly in the preparation of the DODs alone.

Much of the detail was provided through the expert groups, the authors of the OS and the reviewers. The questions from the modelling and prototyping sessions provided material to the expert groups to focus their discussions.

The analysis of the results of concept detailing indicates that EP3 contributed to the understanding of the concept underlying about two thirds of the OI steps and one third of the SESAR ConOps (Ref. [J]) Research Topics (Ref. Annex d – Concept Detailing work against SESAR ConOps Research Topics). Although the overall balance of the concept detailing was generally aligned with the research priorities of EP3 (Short/Medium Term Network Planning and ATC Execution), detail was added across all areas.

5 OPERATIONAL AND PROCESS FEASIBILITY

5.1 APPROACH

EP3 has employed a range of conventional and innovative validation techniques. In particular, expert groups and small-scale prototyping and gaming exercises have allowed operational experts to participate in the development and assessment of the ConOps, leading to valuable recommendations on trajectory management and collaborative planning.

5.2 KEY FINDINGS ON OPERABILITY

5.2.1 Mid and Short-Term Planning Phase

A synopsis of Medium/Short Term Network Planning is summarised as follows:

- Airspace Users declare their flight intentions and optimise their trajectory through SBTs, in accordance with their business model. Military users declare their airspace requirements. The NOP is visible to all of them at all times;
- The airspace is organised so as to respect their preferences and provide enough capacity, taking into account airspace requirements;
- The planned traffic and airspace demand and the planned capacity are evaluated by the Network Management function, so as to detect potential imbalances;
- In case of imbalance, a DCB Solution is selected in the Catalogue or elaborated with possible network impact assessment;
- The solution is then applied, resulting in capacity adjustments and possibly demand adjustments if advisories are notified or constraints are necessary. Airspace reservations are also optimised accordingly, if possible. UDPP is exceptionally triggered to prioritise flights;
- The foreseen ATM picture is reassessed after implementation of the DCB Solution;
- The DCB loop runs iteratively during the medium and short term planning phases so that demand and capacity are balanced when SBTs become stable: the execution of RBTs can start, being served by the optimal Capacity Plan and the optimal Airspace Use Plan.

In order to analyse the process feasibility aspects during the planning phase, innovative validation techniques that emulate the collaborative decision making processes have been applied (see section 3.5.2). These techniques can be classified in those with Human-In-the-Loop participation (gaming techniques) and those where the processes are modelled incorporating rule-based decisions that control the interactions between the actors being simulated (modelling techniques).

The EP3 approach to analyse the process feasibility has been focused in three parts of the concept at the planning phase:

- Business Trajectory management and Dynamic DCB on arrival congested situations have been studied through platform based gaming sessions (DARTIS platform) and modelling (PROMAS). The exercise demonstrated the ability of Gaming technique to provide effective support to concept refinement. The process modelling showed its ability to model a large range of ATM processes.
- The Advanced Flexible Use of Airspace (AFUA) and the Agreement of the Business / Mission Trajectories through collaborative flight planning when military changes its airspace reservation at short notice has been studied through paper based and

platform based (CHILL) sessions in a sequential way. Very important initial findings were detected during the sessions with cards that were refined in the following sessions with the dedicated software platform.

- And finally, the Total Airport Management concept processes performed from an Airport Operations Centre (APOC) were emulated with platform based sessions support (ACCES).

5.2.1.1 Roles and Responsibilities

When **military requests ad-hoc structures** to respond to short-term military users' requirements not covered by pre-defined structures and/or scenarios, the civil users are unavoidably affected. The Airspace Managers in close coordination with the Sub-Regional Manager must handle this military requirements trying to find the most suitable airspace organization that in an equitable way can cope with the new mission and business trajectories maintaining the expected levels of capacity and efficiency.

It was discovered that, when flexibility in the military area is possible, the dimension and location of this airspace reservation is not only a process where the Exercise Director and the Airspace Managers/Sub-Regional Manager are the involved actors but also the Civil Users. The civilians are a key active part of the collaborative process conveying their preferred trajectories and airspace reservation dimensioning. A new role/function, named Airline Coordinator, representing airspace users' interests was identified. This actor should always be aware of the negotiation process, ensuring the transparency of process for users and ensuring that the users' preferences are taken into consideration. The new role/function would intervene if the problem cannot be solved through direct negotiation between the civil airspace users and the Sub-Regional Manager and the Airspace Managers. In this way, the Exercise Director will intervene during all the process, willing to offer greater flexibility, if necessary, to minimise the impact on civil users.

Regarding shaping responsibilities when the **dynamic DCB concept** is applied to arrival traffic management at a congested airport, it is found that the AMAN sequence is under the responsibility of the APOC/TMA manager. In turn, the Sub-Regional Manager should be in charge of triggering and managing the dynamic DCB sequence (TTA allocation process) of the sub-region that has the congested airport. The decision to trigger the dynamic DCB solution must be coordinated with the APOC and the Regional Network Manager.

The Airspace Users are in charge of replanning the business trajectories to take into account the DCB time-based constraints. Only the flight crew is involved in the management of constraints issued by the AMAN process. However, the management of time-based constraints issued by the dynamic DCB process (TTAs) would be primarily under the responsibility of the AOC. For flights in execution phase, the AOC must work in close cooperation with the flight crew. This represents the most likely situation, but it may vary between airspace users depending on their organisation.

In the airport context, the collaborative processes are performed within the APOC, considered as an "agent-based" environment. These agents, effectively CDM representatives, will represent each of the principal actors at an airport and will provide the interface between the APOC and the internal decision making bodies of their own organisation. The APOC composition would consist of: AOC (Hub Control Centre), ATC (TWR Controller Supervisor), Ground Handling Agents, Meteorological Service Information Provider and Airport Operator. Not all agents will need to be physically present in the APOC even on a part-time basis but it should be possible for these actors to be contacted with a minimum of delay. The meteorological information service provider and the Ground Handling Agent will typically fall into this category.

The consistency of the Airport Operations Plan (AOP) and the Network Operations Plan (NOP) will be ensured thanks to coordination between the airport CDM Agents within the APOC and the Regional Network Manager Unit.

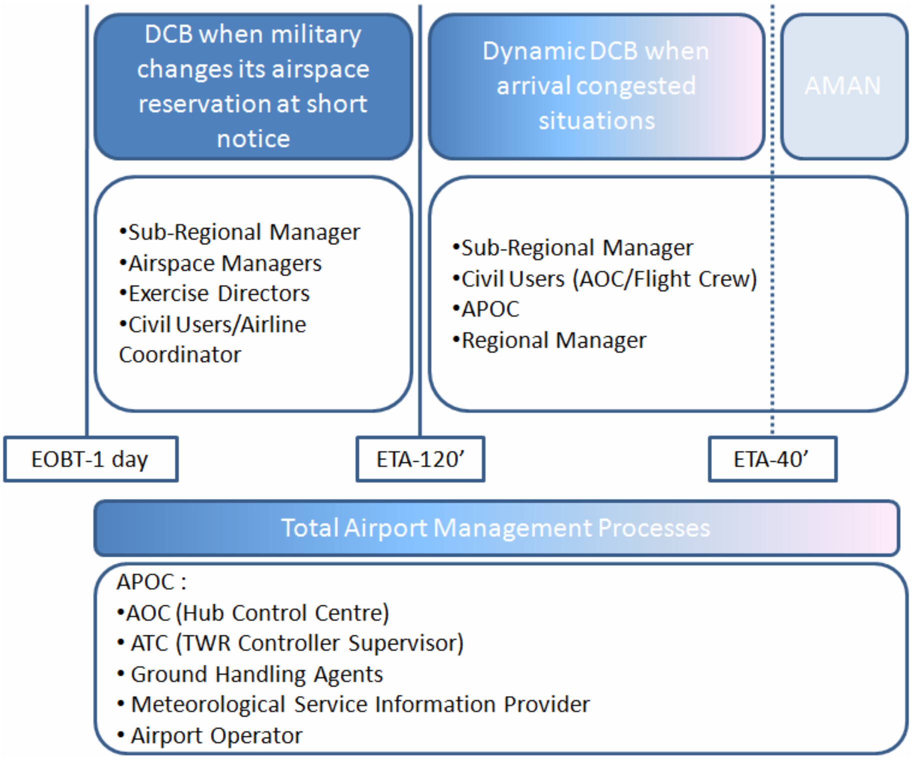

Figure 14 - Demand and Capacity Balance processes

5.2.1.2 Key findings on the CDM Planning Processes

The principle of the **business management ownership and its interpretation in the context of DCB processes remains an open issue** with diverging opinions. The Airspace Users claim their participation and trajectories changes decisions from the beginning of the DCB processes. Meanwhile the network managers state that in order to increase efficiency of the overall process and reduce risk of increased complexity when an imbalance is detected, business trajectories should first be determined by ATM taking into account network constraints and then proposed to airspace users who could then make counter-proposals.

In order to solve these opposing opinions, EP3 has worked on a new role/function that could convey the civil users interests integrated within the Airspace Management and Sub-Regional core: The Airline Coordinator. The Airspace and Regional Managers could take into consideration the users' preferences from the beginning. When shared use is conflicting with other performance expectations, such as capacity, the Airspace Managers and the Sub-Regional Manager would inform the civil users and the Airline Coordinator about the global restriction. The civil users with the help of the Airline Coordinator will decide who can access and for those who cannot access, the civil users will decide how to change their SBTs depending on their business models. The Airline Coordinator function will ensure the equity of the prioritised users (Equity Indicators such as Number of times that same civil users have been affected and Historical distortions degrees). The Airline Coordinator should always be aware of this negotiation process, but only intervenes if the problem cannot be solved through direct negotiation between the civil airspace users and the AMC/Sub-regional manager.

The **extension of the geographical range of an arrival queuing process** will fundamentally shift the nature of the process from a local to a network scale. This raises many issues related to the share of responsibilities between regional, sub-regional and local actors related to the definition and implementation of the dynamic DCB solutions. This issue was overcome by defining two ATM processes with different look-ahead time. On the one hand, a continuous AMAN process works mainly on airborne flights by managing accurate arrival sequences. On the other hand, an upstream dynamic DCB process pre-sequences flights when a significant imbalance is detected. This is done through the dynamic allocation/re-allocation of Target Time of Arrivals (TTAs) and the consequent adaptation of business trajectories by airspace users.

Nevertheless, the boundaries between AMAN and dynamic DCB processes need to be further examined in particular through the study of alternative options and the validation of operational parameters, in particular, the maximum response time allowed following the reception of a TTA.

The **Total Airport Management** philosophy is built on a hierarchical structure for an optimized reaction in adverse conditions. The introduction of the APOC reinforces considerably the collaborative element of the overall decision making process. The various CDM processes will be supported notably by the AOP. EP3 detected the AOP content needs: Demand / Capacity Assessment, Performance Trade-off Assessment, Monitoring the AOP, Decision making support and Management and Implementation of existing A-CDM procedures.

UDPP is triggered under exceptional conditions to prioritise flights if there is no suitable DCB solution and EP3 experts were not tasked to reach a common consensus about its nature and scope. However, a large majority of them considered that it should be limited to high severity or crisis situations and it should be limited to short-term planning phase without involving flights in the execution phase.

5.2.1.3 Supporting tools

In order to support the collaborative processes and ensure their feasibility, advanced tools/applications become essential to sustain not only the processes but also the different actors' tasks. Automation is the answer to guarantee the equitable treatment of airspace users, the consideration of their interests whilst maintaining the performance levels targets.

The **Civil Users** should have tools available to manage their business trajectory planning in reaction to ATM constraints (time and space constraints). In this way, the tool should be able to apply different strategies and optimise the trajectories according to a cost function. EP3 highlighted this function, identified as the Airline Operational Quality Indicator, which is a combination of the Quality of Service provided to the passenger (loss of connections, departure delays, affected passengers,...) and the cost-effectiveness of the operations (crew activity, fuel consumption, airport taxes,...).

The **Civil and Military Airspace Managers** would need tools to support the evaluation of the most suitable airspace organization by considering the airspace requirements (inc. military activity). What-if tools would allow them to evaluate the solutions in terms of airspace users' impact (equitable criteria), traffic complexity and balance ATC workload. The assessment should be done with the accurate trajectories provided by users.

The **Sub-Regional Manager**, working in close coordination with the Airspace Managers and the Network Manager, as the final responsible to get a DCB Solution at the FAB Level would need tools to support the DCB processes. In particular to manage the dynamic DCB sequence management (dynamic allocation of TTAs/TTO), he/she would need what-if tools to play with different strategies mixing flights in planning and execution phase depending on the severity of the situation, the accuracy of the traffic and the capacity prediction. In order to assign restrictions in an equitable way, the Airline Coordinator function support is vital. This role/function would have civil users' priorities information and historical data to select the ones affected by the restrictions.

The supporting tool in the hands of the **Airline Coordinator** would need to be connected to all the civil airspace users' supporting tools in order to ensure them to consider their different business models.

The supporting tool of the **Network Manager** should be able to support a real-time network monitoring function. The advance tool would assess the DCB measures impact at network level according to airspace users' replies by using indicators such as complexity and performance factors for en-route, TMAs and airports.

At airport side, the collaborative process performed in the **APOC platform** should provide different services such as Performance Planning Service, Monitoring and alerting Service, Decision Support Service and Analysis Service. In particular, the definition of the monitoring service was focussed on two separate processes, namely the 'aircraft process' and the 'passenger process' that should always be coupled.

Related to needed **enablers to support the process**, all actors involved in the negotiation processes should be supported by automation tools which guarantee the information sharing and its transparency. Real-time coordination is further enhanced through what-if functionalities and automated support. These supporting tools will be configurable and will be equipped with customisable alarms to alert actors/roles about changes affecting the progress of the negotiation.

5.2.2 Execution Phase

The operability aspects in execution phase were analysed by Human-In-the-Loop prototyping sessions and gaming exercises.

The methodology for En-route consisted of a series of three prototyping sessions (see section 3.5.3), which also built on preceding experiments. From session to session the scope of the en-route SESAR concept elements deployed was gradually increased. The prototyping sessions of one week each were performed in a SESAR Intermediate Timeframe En-Route Environment. The content and focus of the sessions were defined by Expert Groups. The sessions started by refining possible options (e.g. airspace, routes, and scenario), then assessed the operability and acceptability of both the Reference Business Trajectory (RBT) and the Controlled Time of Arrival (CTA) in the En-Route environment.

The focus of the TMA prototyping sessions is to build on the work previously carried out, in order to assess the operability of innovative (Precision) RNAV route structures in the TMA together with the provision of Continuous Descent Arrival procedures from the En-Route system down to the final approach segment. In addition, the link to 4D/time constraints (CTA) and ASAS sequencing and merging was also taken into consideration.

On the other hand, the gaming techniques were used to provide results on the acceptability of the roles and procedures required for the new separation modes and complexity management in the en-route phase. Thus, results from prototyping sessions were complemented with paper based gaming sessions, web based games and process modelling techniques with the PROMAS simulator (see section 3.5.2).

5.2.2.1 Roles and Responsibilities

While **pilots are responsible for achieving the 4D trajectory, controllers are tasked to facilitate the aircraft 4D trajectory** (RBT and including CTA), i.e. allow the aircraft to adhere as far as possible to the agreed trajectory. Controllers still had to ensure the separation, but their roles and tasks were slightly different from today's operations. The management of and the adherence to an agreed trajectory is a change from today's practices. Controllers were asked to avoid expediting traffic through the sectors by offering directs and the use of open loop instructions (for separation management only) which could degrade the predictability of the 4D trajectory. However, controllers were still responsible for separation of aircraft and conflict resolution and this may warrant a deviation. In this 4D environment they were tasked to respect essentially 2D adherence in avoiding as much as possible lateral deviation.

Compared to today's working methods, the 4D Trajectory Management in the en-route phase did not introduce any change in the **executive and planning controllers' tasks repartition**. However, findings from a previous simulation and successive prototyping sessions (sessions 1 and 2) showed that adherence to the trajectory, together with the use of Data Link, induced some changes in the planning controller (PLC) activities. As there was less pre-sector traffic planning and preparation, the PLC focused more on what was happening within the sector and supported the executive controller (EXC) more directly in his/her tasks – identifying and warning of potential conflicts, monitoring their evolution, informing the executive controller of any changes and advising on conflict resolution. In addition, some instructions usually issued by the EXC could be handled by the PLC (e.g. transferring aircraft).

A gap was detected in the responsibility time-line between the sub-regional manager (SBR) and the planning controller, as well as in the main focus of their responsibilities: while the SBR focuses on traffic flows, the PLC handles individual RBTs. The MSP covers this gap by proposing changes to the individual RBTs with the aim of reducing complexity and minimizing conflicts within the sectors under his responsibility. This decrease in the number of potential conflicts may lead to an increase in the capacity of the sectors.

On the other hand, the MSP cannot be directly involved in the aforementioned executive controller's tasks. As a consequence, an executive controller assistant may be introduced for safety reasons in certain areas if the planning controllers are totally replaced by the MSP.

The roles and responsibilities remained largely as for today in the TMA context. However in the light of the deployed concept elements (e.g. the introduction of CTA) the techniques changed. In ASAS Airborne Spacing applications the role of separator is retained by ATC, whilst the task to achieve a prescribed spacing (expressed in time or distance), with regard to another designated target aircraft, is temporarily delegated to aircrew under specific circumstances. The ASAS instructions can be applied from the En-Route phase down to the initial or final approach fix, however it should ideally be applied before descent commences.

Managing aircraft with different Capability Levels in the same airspace is achievable. Controllers will notice the main difference between aircraft in terms of communication, mostly when datalink equipped or not. Less capable aircraft will be assigned the most penalizing constraints. The mixture of the separation modes may result in airspace not being optimised due to the different equipages and capabilities, and potentially entailing loss of equity.

5.2.2.2 *Key findings on En-Route and TMA Processes and Operational Feasibility*

In the **En-route phase**, the controllers found the 4D trajectory management task challenging in the simulated environment. The high traffic load and the lack of route structure caused quite a high level of workload although the complexity management measures that were introduced made the 4D TM easier. Under high traffic load, the controllers raised the issue of the lack of predictability and related safety issues. This was mainly due to the agreed trajectories that may change from day to day, the unknown and changing conflict points, the larger bunching areas and the inability to predict aircraft behaviour (aircraft adjusting speed to meet the time constraint). The concept also implied a reduced degree of freedom (no use of lateral and speed control) which was not found acceptable by the controllers who felt more as reacting to the global plan (RBT agreed by all parties) than controlling the traffic according to their own plan.

However, despite the quite high level of workload the controllers efficiently facilitated the aircraft 4D trajectory mostly with the use of level instructions and a limited use of open loop heading or speed instructions. Most of the aircraft (~95%) followed their 2D planned trajectory and controllers' intervention had a very limited impact of the time achievement. On the contrary, the efficient management of the lateral and time dimensions was sometimes detrimental to the vertical dimension with some overflights (~20%) not flying their optimum profile and some departures performing step climbs. Therefore, the optimization of the whole ATM system predictability implied by 4D Trajectory Management could be detrimental to controllers' predictability and workload and may impair flight efficiency or capacity.

The controllers did not dismiss the concept viability, but some topics need to be deeply investigated as the airspace design – e. g. Fixed route network for arrival/departure flows; redesign sectorisation to suit traffic flows and segregated routes...- as well as advanced

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supporting tools – e. g. Sector Exit Lists required; Medium-Term Conflict Detection (MTCD) and Trajectory Editor ...

On the other hand, the feasibility and the nature of the CDM which includes airspace users during the execution phase have been questioned. There are situations that although not tactical, should not trigger this CDM processes, as they will be repeated several times during the normal operation. In addition, the time that the actor, MSP/planning or executive controller, needs to dedicate would prevent him/her from performing the rest of his/her tasks. This does not mean that there will not be CDM processes with users. It means that the period where it is not feasible to perform CDM processes is not limited to tactical interventions. The variable which limits the option to implement CDM processes is the time horizon not the phase of the flight.

In the **TMA context**, the PRNAV/Advanced CDA concept tested is operationally viable. With P-RNAV and A-CDA, the overall feedback was positive. The controllers found it easy to work with the procedures, providing a suitable and safe routes design.

P-RNAV and A-CDA enable a large reduction in R/T, freeing up cognitive resources. Teamwork and coordination, especially between approach and final ATC working positions were deemed essential for efficiency and throughput. The controllers found that the use of the CTA has potential for optimal delivery at metering point with increases 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).

The combined use of ASPA S&M, P-RNAV and A-CDA allows controller to focus more on the sequence leg management. The controller, having delegated spacing tasks to the cockpit, is better able to better monitor the traffic evolution on the arrival streams. The availability of ASPA S&M infringement tool was appreciated by controllers enabling them to have a timely warning in case of infringement. Controllers generally accepted the new working methods foreseeing a partial delegation of their tasks to the cockpit.

Following the results and outcomes of the TMA prototyping sessions the following items should be further investigated:

- The exact positioning of the RTA/CTA points;
- The reduction in the controller's situation awareness regarding the aircraft's speed schedule;
- The interdependency between RTA and A-CDA.

5.2.2.3 Supporting tools

In the **En-route phase**, tools were provided to the controllers for conflict detection (e.g. MTCD) and to especially support the 4D trajectory management (e.g. RBT/CTA time information, sector exit list and trajectory editing tool).

The controllers said that the Medium Term Conflict Detection (MTCD) used was not sufficiently accurate- (e.g. when two aircraft were slowly converging). Therefore, to assess potential conflicts, the controllers used the VERA tool, which they felt was more reliable and useful, particularly with user preferred trajectories[6].

It was suggested that the display of RBT and CTA deviation value should be displayed in the extended label window to be used only "on demand".

The design of the Sector Exit List was used to allow the controller to display one CTA waypoint list at a time by use of a toggle button.

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[6] As user preferred trajectories were mostly direct route, VERA (based on aircraft track) was used to assess medium term conflict rather than MTCD (based on aircraft trajectory).

A Trajectory Edition Tool enabling an uplink of route clearances was considered very useful in the 4D environment to solve conflicts with a low impact on the RBT and CTA. As opposed to a heading instruction, which can be used tactically to solve conflicts, the route clearance through the Trajectory Editor could be planned and instructed (up-linked) to the aircraft at an earlier stage. As the Trajectory Editor enables the uplink of a closed-loop instruction (entire trajectory), the aircraft remains under the RTA/FMS guidance and tries to achieve its time constraint[7], unlike an open loop heading where the aircraft FMS will revert to flying the cost index.

The Controller Working Position used for **TMA Prototyping Sessions** presented an advanced stripless HMI, including functions as Interactive radar labels and aircraft data lists, with colour coding of aircraft planning states; Standard On-Line Data Interchange (OLDI) of flight progress data, with SYSCO extensions specifically providing the support for aircraft transfer of communication (i.e. there is no co-ordination of flight parameters); Safety Nets: Short Term Conflict Alert (STCA); ASAS separation monitoring tool providing warning to controllers in case of infringement of ASAS time based separation.

The use of tools in the prototyping sessions described above were part of an initial proposal based on existing and evolving tools. It is essential to note that tools need to be tuned to the relevant ATM environment.

In this instance the availability of speed control was removed from the “controllers toolkit”. The MTCD was not tuned for this 4D direct route environment, therefore the use of conformance monitoring via VERA tool. The refinement of MTCD tools may change this. A need for closed loop ATM instructions via the TED, although in the planning role, proved to have some usefulness and requires further investigation.

The optimum combination and tuning of the controller toolset has yet to be refined.

[7] During open loop heading, in the cockpit, the RTA constraint is released and speed goes back to Cost Index speed instead of being adjusted to meet the time constraint.

6 PERFORMANCE ASPECTS

6.1 INTRODUCTION

The work undertaken by EP3 in terms of performance was contractually limited in scope and depth. The aim has been to respond in alignment with the approach chosen in the SESAR Definition Phase, i.e. that the development should be performance-driven, rather than technology-driven. In addition, the approach had to take into account the early stage of maturity of the concept description available at the start of EP3.

Consequently, the overall approach was characterised by two main activities. Firstly, the development of a comprehensive Performance Framework was undertaken complemented by the development of a model-based methodology allowing the combination of performance results from multiple sources to determine whether the proposed concept could meet the SESAR performance targets. Secondly, it was decided to run a small number of validation exercises addressing performance studies and use the results to exercise the performance model designed for future ECAC-wide assessment beyond EP3.

The output of the performance studies is therefore not a performance assessment of the SESAR concept, but a proposed approach (framework & initial model-based methodology) and an associated set of lessons derived from practical EP3 experience for the performance assessment that will be performed within the SJU programme.

The following section describes the Performance Framework and the contribution of the validation exercises to the assessment of the Key Performance Areas addressed in EP3 together with other lessons learnt during development and initial application.

6.2 PERFORMANCE FRAMEWORK

The objective of EP3 Performance Framework was to provide a systematic approach for future assessment of the SESAR concept performance (e.g. against 2020 performance targets) on an ECAC wide basis where no such approach previously existed. The proposed methodology supports the aggregation of validation measurements of different levels of granularity, e.g. local versus regional, and different levels of uncertainty, e.g. expert judgement versus simulation results.

The methodology, founded on the performance output from SESAR Definition Phase is described in detail in [14]. The principal activities included:

- Capturing an understanding of the elements that contribute to, and influence performance (through Influence Diagrams) (Ref. [15]);
- Developing an ECAC-wide Model that represents the elements that are linked and the mechanism to combine their influences. (Influence Models) (Ref. [16]);
- The definition of a catalogue of common Performance Indicators (PIs) (Ref. [17]) as references to ensure consistency and data capture about the influencing factors from exercises, expert group, current and past studies.

This integrated ECAC-wide performance approach has been complemented by specific approaches for safety and environment.

The EP3 Performance Framework has defined different layers of the Performance Indicators (PIs) according to the Performance Areas (PAs) as defined in the SESAR Definition Phase. The catalogue of PIs is divided into three layers:

- ECAC;
- European Generic for Airport, TMA, En-Route;

- Local Performance Indicators for Airport, TMA and En-Route.

A Performance Framework has been developed based on Influence Diagrams and Influence Modelling with the objective of integrating suitable validation data to provide future ECAC-wide assessments of the impact of SESAR ConOps against the performance targets.

In order to obtain an ECAC-wide assessment the model of the Performance Framework needs to be populated with validation data derived from a range of validation activities e.g. prototyping, expert groups, fast-time simulations, gaming; structured according to an appropriate validation strategy. For example, instead of setting up validation exercises to assess every aspect in detail of operations in 2020, a more cost-efficient approach would be to select a subset of representative days and extrapolate the results to the whole year. Similarly for airport assessment it could be better to focus on the top 133 airports that represent 90% of the traffic instead of assessing all 2,000 airports in ECAC.

Once an initial ECAC-wide assessment is obtained using the Performance Framework, sensitivity analysis can provide information on the uncertainty factors associated with results. This can allow better focusing of effort where there is greatest benefit and potentially allow the identification and prioritisation of future validation exercises.

The development of the framework also demonstrated that not all performance aspects should be computed within such a framework; for some Key Performance Areas (KPA) the complexity of the modelling requires validated models that provide performance data to be incorporated in the framework at the appropriate level. For example, the computation of CO_2, H_2O and SOX emissions can easily be derived from the fuel efficiency computations, whereas other emissions PM, NOX, HC, CO are highly correlated with engine thrust which requires a dedicated fast-time simulation.

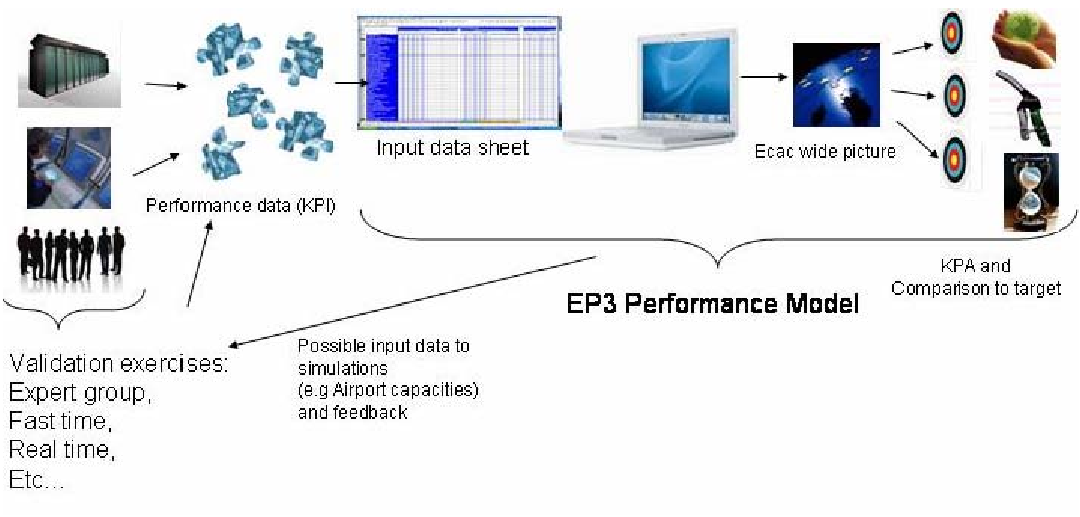

Figure 15 - Links to the Performance Framework model

A few local performance results for a limited number of KPAs have been obtained from EP3 validation exercises, described later, which could be used to populate the performance framework, but the resulting coverage would be sparse. Therefore to exercise the framework, an ECAC-wide assessment has been undertaken for a single focus area, fuel efficiency using information from several sources including some EP3 validation exercises.

With 11 KPA and 183 proposed improvements there is difficulty in managing the combinations between all of these elements, thus:

- Each proposed improvement may have a range of impacts on several KPAs;

- A proposed improvement designed to have a positive impact on one KPA, may have a negative impact on another KPA; traditionally, for example, a trade-off evaluation has been necessary between flight efficiency and capacity[8];
- Each validation exercise includes a particular combination of proposed improvements;
- Each validation exercise provides results about several KPA.

The solution to this is to be able to trace the contributions of a proposed improvement to KPAs provided by the validation exercises. Therefore, it is necessary to record the conditions and assumptions under which validation results are obtained, the OI steps included and any uncertainty about results.

The EP3 project made it clear that modelling rigor must be maintained. This includes: strict adherence to the methodology; and deployment of similar modelling techniques across the whole model; for example, the level of abstraction, the use of absolute or relative values, and the use of "phase of flight" as a criterion for structuring the model.

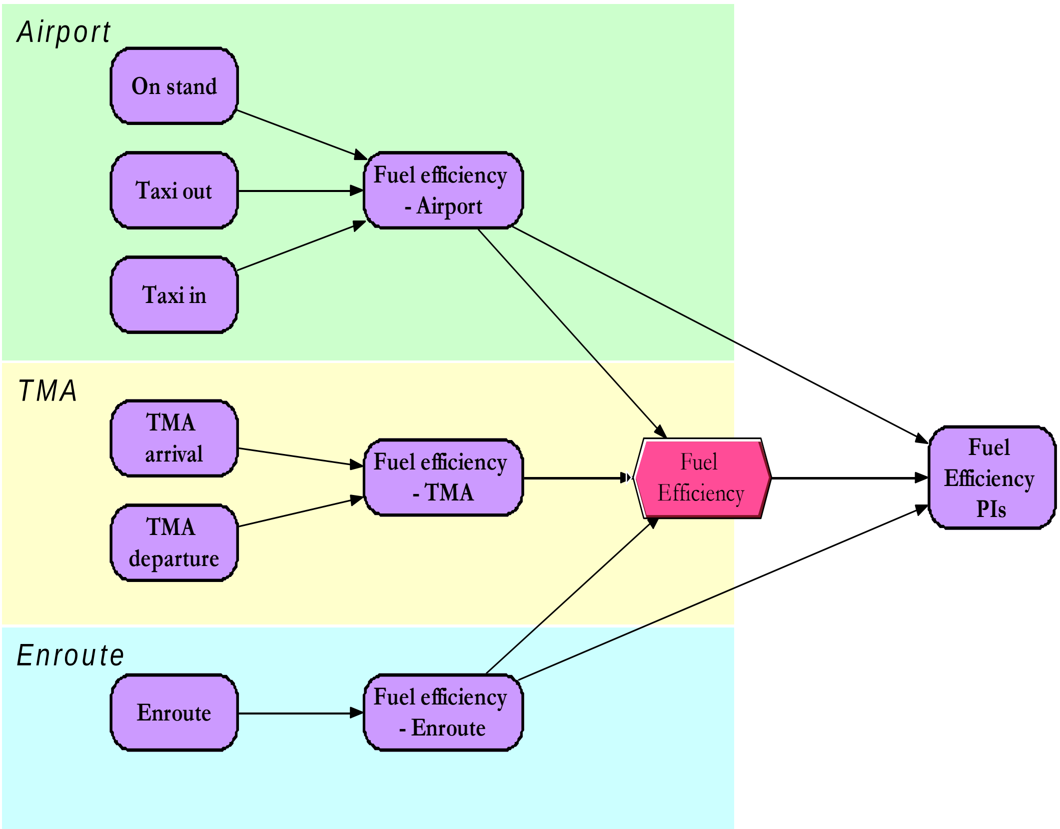

Figure 16 - Fuel efficiency Influence Diagram *(Source: EP3)*

Figure 16 presents the first layer of a top-level view of fuel efficiency in which Airport, TMA and En-route phases of flight are treated separately.

As an example, we will now examine in detail the content of the En-Route module.

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[8] Example: Continuous Descent Approach (CDA) improves fuel efficiency, but tends to degrade capacity.

The fuel efficiency diagram has been developed to compare the actual amount of fuel burnt with a reference target. This illustration is a representation of a first layer. Proceeding further, the content of the En-Route module shown in the diagram will now be examined in detail.

The main driver for the fuel burnt en-route is the trajectory that the aircraft flies. This trajectory is influenced by conflict management actions, such as vectoring and speed control, the design, availability and utilisation of the airspace, and the structure of routes. The trajectory flown is also influenced by factors such as designated military areas, meteorological conditions, and route charges. The Influence Diagram below represents a transcription of these main influence factors.

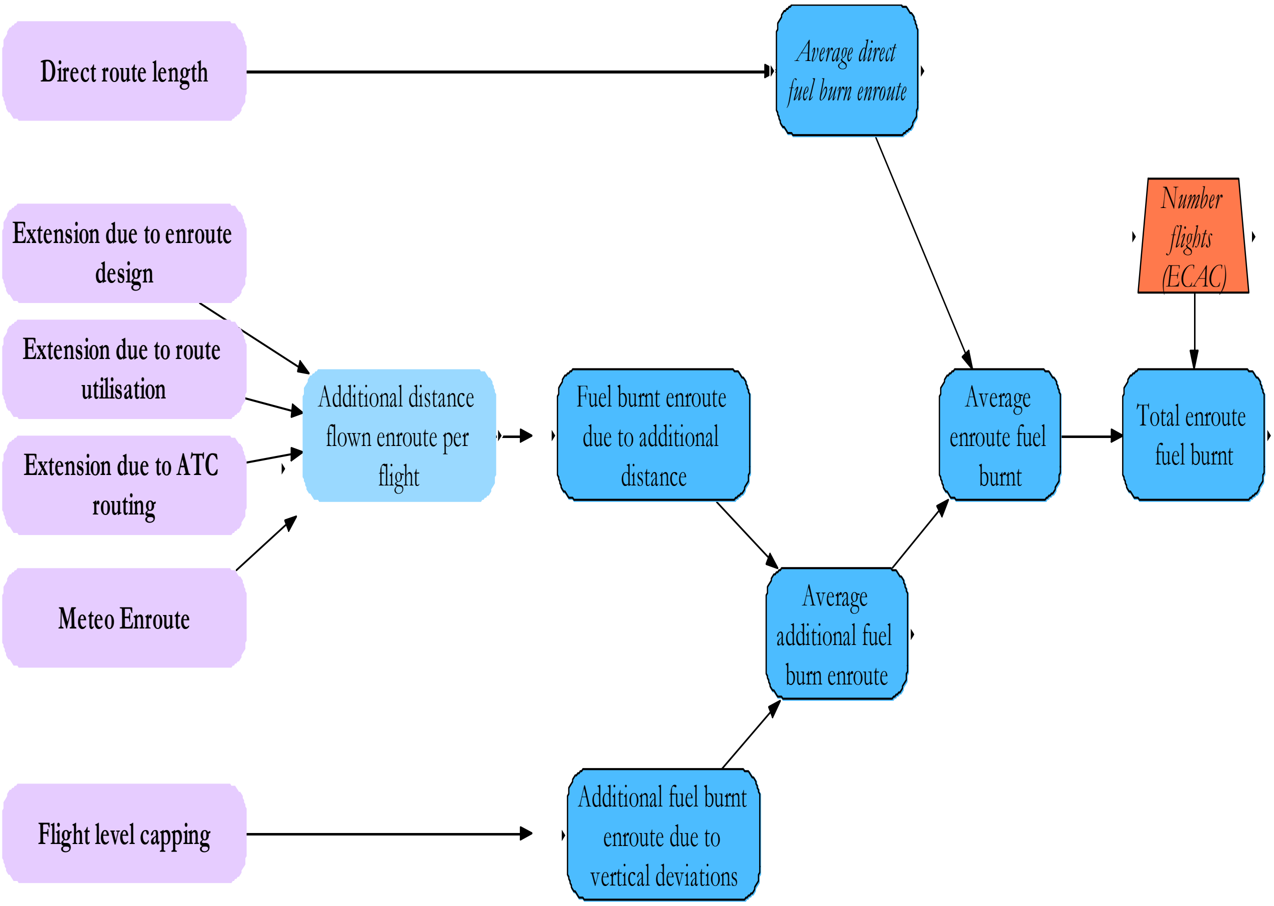

Figure 17 - En-Route Fuel efficiency influence diagram *(Source: EP3)*

This first step demonstrates the value of Influence Diagrams as a means of capturing influences. Integration of a series of influence diagrams enables the linkages between various KPAs - e.g. Efficiency (fuel) to Environment (global emissions, etc) - to be identified and the need for trade-offs established.

The next stage is quantification of performance and is crucial in establishing an understanding of the potential performance and trade-off between competing concepts.

The process of quantification requires data that derive from sources such as expert judgement, experimental observations, or - where possible - observed performance. Indeed, quantification is the process allowing this data to be used to estimate the performance gain from implementing a coherent set of proposed improvements and to assess the trade-offs between them.

Validation exercises are required to verify the correctness of expert judgement and vice versa, for the assessment of future horizons such as 2013 and 2020 where little data has been provided by EP3 validation exercises or elsewhere.

In the example presented above, the model has been populated with: illustrative data from the Performance Review Report (Ref. [13]); expert judgement; and some experimental results. In the future, results from future activities such as the SESAR Development Phase projects, may also be input to this model.

The input data for the initial/proof of principle ECAC-wide performance assessment on Efficiency is shown below.

Average Fuel burn (Kg/flight)

	Baseline values				Values with OI step influences			
	2006 IP0	2013 IP0	2020 IP0	Current source/Assumptions	2013 IP1	2020 IP1	2020 IP1+IP2	Current source/Assumptions
Average Fuel burnt on Direct (GCD) route	4 379	4 513	4 646	Use Eurocontrol simulation from August 2009. En-Route distance with 100NM TMA. Due to the change in demand for 2020 average direct distance flown has increased by 13% => fuel	4 513	4 646	4 646	Use Eurocontrol simulation from August 2009. En-Route distance with 100NM TMA. Due to the change in demand for 2020 average direct distance flown has increased by 13% => fuel
Average Fuel burnt in En-Route due to additional distance	254.0	261.7	269.5	5,8% inefficiency from Performance Review Report 2007 applied to 2006, 2013 and 2020 horizon	130.9	134.7	0	Apply optimitic 50% efficiency gain for IP1 and 100% efficiency gain for IP1+IP2
Average Fuel burnt in En-Route due to vertical deviations	23	23.3	23.7	Performance Review Report 2007 applied to 2006 horizon	11.7	11.8	0	Apply optimitic 50% efficiency gain for IP1 and 100% efficiency gain for IP1+IP2

Figure 18 - Example of the En-Route data input (Fuel and Time) *(Source: EP3)*

In the future, ECAC-wide performance assessments could allow for:

- The combination of local results from a number of small-scope validation exercises effectively providing the expected performance at a ECAC-wide level;
- Sensitivity analysis which can also provide useful information on the uncertainty of results, allowing better prioritisation of subsequent validation exercises by focusing effort where results are of most benefit.

Figure 19 below shows an example of Fuel Efficiency results obtained, showing how the fuel consumption is reduced as the SESAR OIs are deployed. IP0 is the 2006 baseline and IP1, IP2 represent the clusters of potential improvements that will be deployed at different time horizons (2013, 2020).

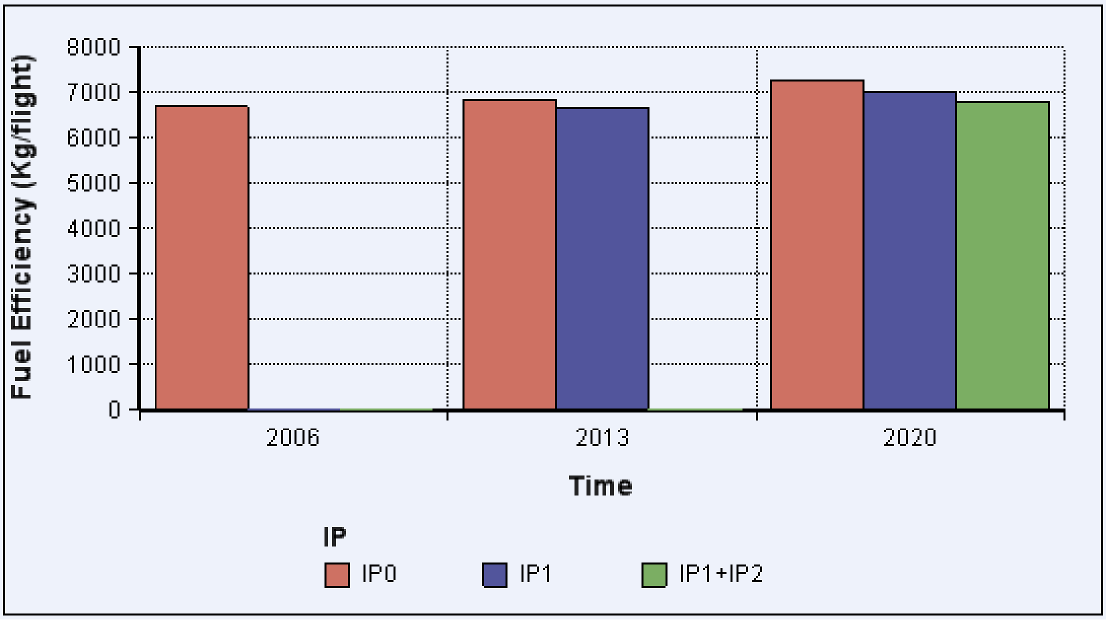

Figure 19 - Example of 2006, 2013 and 2020 fuel consumption per flight *(Source: EP3)*

It is possible to obtain results for any module defined through the Influence Diagrams.

Sensitivity analysis helps to identify which variables contribute the most to the overall results. Figure 20 below shows the amount of fuel burnt in each phase of flight (Airport on stand, taxi in, taxi out, TMA departure, arrival and En-Route). A tornado analysis is an appropriate representation for a sensitivity assessment. In this example, the tornado analysis shows the impact of a 10% uncertainty on the input for the fuel burnt in each phase of flight; this could be due to the simulator errors and the uncertainties of expert opinion. This figure shows that the en-route (+/-10% of 4646kg) and 100NM radius TMA departure (+/-10% of 1412kg) phases of flight contribute the most to the overall amount of fuel (6765kg) that is burnt in Europe. It is important to take into account the uncertainties and as an example a 10% uncertainty in this value can have significant implications on the overall result and help to prioritise future validation exercise efforts and the potential improvements required.

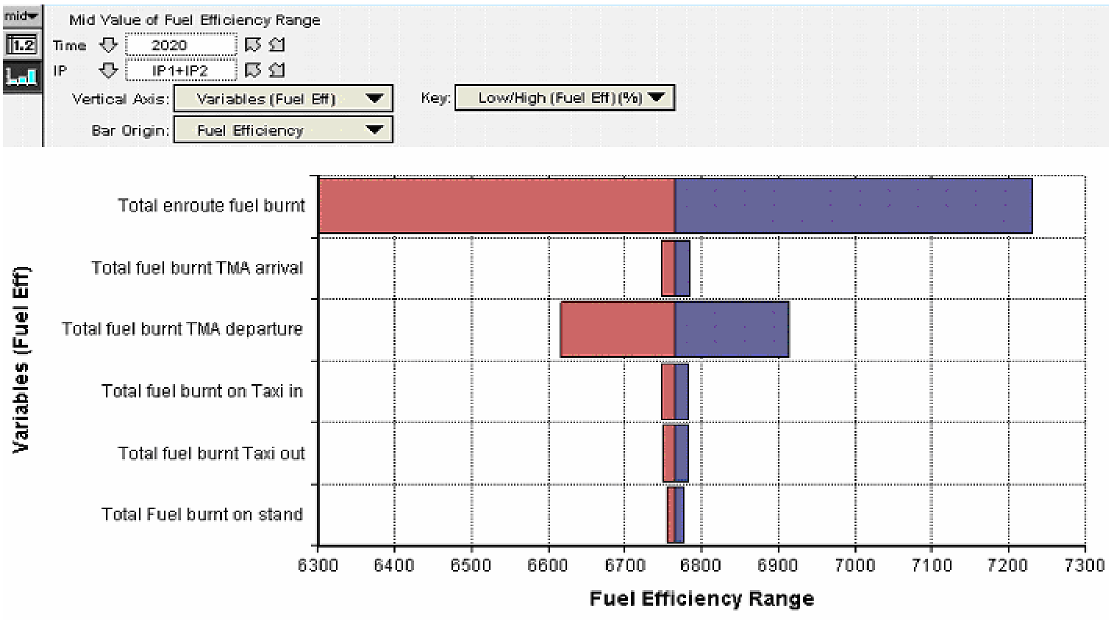

Figure 20 - Example of sensitivity analysis of 2020 fuel consumed per flight *(Source: EP3)*

Figure 21 shows a comparison of the 2020 ECAC-wide fuel consumption according to different scenarios, using the results of the performance model, with the 10% reduction targeted in SESAR.

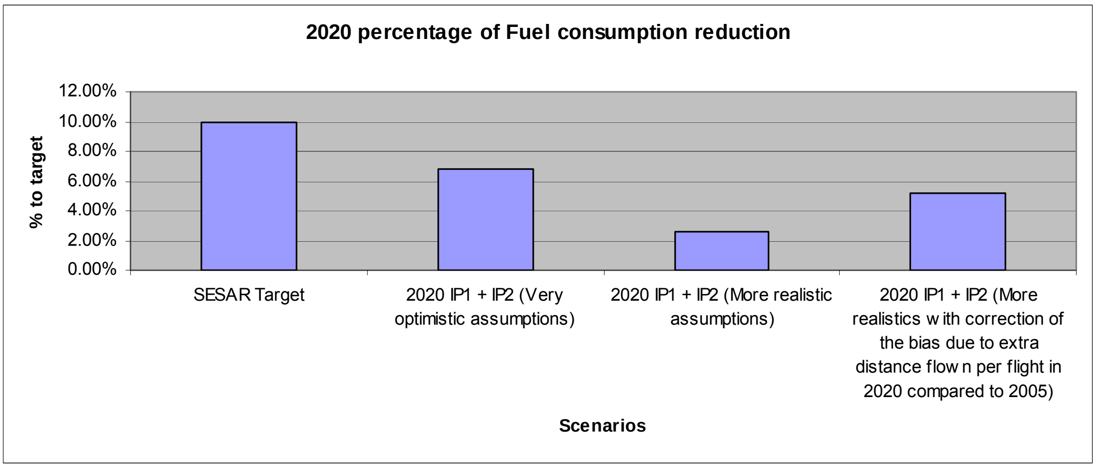

Figure 21 - Example of 2020 fuel consumption comparison to target *(Source: EP3)*

After the delivery and the acceptance of the Performance Framework, the performance model was used to assess three scenarios shown in the figure with different levels of assumptions, the most "optimistic" being:

- All aircraft flying direct at their optimal FL;
- All ECAC airports applying CDA;
- Taxi-in and taxi-out with 33% fuel saving using Airbus study on fuel efficiency;
- No more fuel consumption when aircraft is on stand;
- Optimised climb profile.

A less optimistic scenario considered the activity of some military areas, not all airports applying CDA at all times, etc…

In the last, and least optimistic scenario, the distance flown per flight took into account the different patterns of the demand between 2005 and 2020. The growth in 2020 is foreseen to be very unbalanced, increasing the distance flown in 2020 as compared to 2005, thus increasing fuel consumption in the En-route phase.

This exploration of this KPI using the performance model and our understanding of the performance impact shows that the 10% environmental target is difficult to reach.

The documents produced in EP3 through this activity, namely Performance Framework, Influence model, catalogue of Key Performance Indicators, describe a methodology to develop a model for future assessment of the SESAR concept on a 2020 ECAC-wide basis. The documents also explain how validation measurements at different levels of granularity and uncertainty can be aggregated and provide a common reference to the developers of validation strategies on "WHAT" to measure in a validation programme.

6.3 Assessment of the Key Performance Area

6.3.1 Introduction

EP3 applies two approaches for performance assessment of the concept:

- ECAC-wide validation exercises;
- Local validation exercises, focusing on specific geographic areas for a limited number of operational improvements. The modelling could either provide direct measurements of key performance indicators e.g. from fast-time simulations or was limited to observing general trends e.g. in gaming exercises.

6.3.2 Capacity

An increase of 73% in air traffic (annual IFR traffic growth in the European network from 2005 baseline) is foreseen for 2020. This means that the annual number of flights to be handled by the ATM System will increase from 9.1 million to approximately 16 million flights per annum during the period 2005-2020.

In accordance with the political vision and goal, the ATM target concept should be able to support a tripling or more increase in traffic capacity where required, which will also reduce delays, both on the ground and in the air (en-route and airport network), to be able to handle traffic growth well beyond 2020. However, these are average European design targets (at network level), and when transposing this to local targets, regional differences will exist.

The KPA on Capacity addresses the ability of the ATM system to cope with air traffic demand and to accommodate a maximum number of flights and an optimal distribution through time and space, adhering as tightly as possible to planning.

The focus areas involved in capacity assessment in the scope of EP3 were:

- Airspace capacity, which covers the capacity of any individual or aggregated airspace volume within the European airspace, related to volume per unit of time, for a given safety level;
- Network capacity, concerned with overall network throughput; and
- Airport capacity, focused on individual airports in terms of aircraft movements, and also in congested airports in low visibility conditions.

This aim involves improvements in the airports, by increasing the hourly capacity (instead of daily capacity) in nominal conditions, and decreasing the capacity gap between VMC and IMC conditions.

Congested airports will need a capability for sustained operations at maximum capacity during most hours of the day. Avoiding disruptions is top priority for those airports.

Capacity improvements have been assessed from the perspective of concept refinement during expert groups and gaming sessions and from the performance perspective with fast time simulations and/or prototyping sessions in airport, airspace and network. In this section we will focus on the last ones.

6.3.2.1 Airport Capacity

The only exercise dealing with airport capacity issues was focused on runway operations. The assessed scenarios through FTS techniques were either Charles de Gaulle or Malaga airports what means that results should be read as local.

Main conclusions were that **brake to vacate** technology can reduce Runway Occupancy Time, but further research is required to explore how reductions in ROT may be translated into increased runway throughput. Also **Time Based Separation** in approach allowed recovery of lost landing slots due to headwind conditions, but appropriate supporting tools, controller training, safety assessment and regulatory approval would be required prior to the application of the procedure. Similar framework is needed when reducing **wake turbulence separation** what results in an increase of runway throughput although weather conditions should be considered as a constraint. Regarding weather, results pointed out that the reduction of **ILS Critical and Sensitive Areas** under CAT II/III conditions increases runway throughput to a level close to operations under CAT I or better conditions.

Besides assessing the effect of each OI separately, a new exercise was performed combining some of them what did not bring any benefit greater.

6.3.2.2 Airspace Capacity

Several exercises were focused on OIs related to TMA airspace but they were validated in different locations: Dutch/Belgian/German airspace in a multi hub-airport environment and Rome, Barcelona and Dublin TMAs. Either FTS or prototyping techniques were used to validate those scenarios.

Schiphol Airport, Brussels Zaventem, Köln Airport and Düsseldorf Airport could operate increased demand with improved predictability and without excessive delays while applying the SESAR principles regarding **queue management, separation provision and collision avoidance**. Also **CDAs** can be accommodated, but these tend to lead to some delaying effects under 2020 conditions. Therefore, prioritisation of departures for congested destinations could contribute to obtaining the expected benefits even for these high-density operations.

New separation modes analysed in Rome TMA could increase capacity although there is little difference between 2D P-RNAV and P-RNAV + V-NAV capability. The combination of conflict management tools with the introduction of PTC-3D in the Barcelona TMA reduced taskload of controllers by 20%, which was compatible with SESAR goals in this type of TMA. The greatest capacity gain was achieved using **PTC-3D** together with conflict management tools and route allocation tools. On the contrary, the introduction of **PTC-2D** by itself provides a very slight capacity increase while **A-CDA** implementation does not produce any benefit on capacity, as expected. These conclusions obtained for Barcelona and Rome TMAs are considered to be relevant for any high density TMA within ECAC area.

Prototyping sessions were carried out in the airspace derived from Dublin and Rome TMAs, giving initial trends in terms of capacity. The series of exercises aimed to provide initial trends on the reduction in controller task load achieved by a reduced requirement for controller tactical intervention. This reduced workload might provide a potential for capacity increase but it has to be proved that freed cognitive resources are used for capacity.

It was proven that even under high traffic load the concept provided benefits at Dublin TMA in enabling to: keep aircraft on **lateral navigation**, carry out **A-CDA** and achieve consistent **inter-aircraft 4D spacing** on final. However the variability in working methods had an impact on capacity; deviation from the standard induced more tactical interventions with either closed or open loop instructions.

P-RNAV, A-CDA and ASPA S&M were considered a valuable technique in Rome TMA since the implementation of these new operational concept elements reduces open loop vectoring and controller workload. The new route structure and associated working methods allowed the controllers to manage high traffic loads with an acceptable workload thanks to a reduction of tasks associated with this new operational environment.

Two exercises provided results on en-route capacity. Both were developed in different en-route sectors from Madrid ACC and the core area of Europe (current Maastricht Upper Area Control Centre) respectively. Processes simulations and prototyping sessions were used to provide objective results.

The definition of a new controller position, the **Multi-Sector Planner**, increases capacity in all the sectors where it is involved, but not on the same scale. The capacity is linked to the workload of the executive controller, so the sectors in which more interventions are avoided by the MSP will have a higher increase in capacity. Besides, the sectors in the middle of the MSP Area get a bigger increase in their capacity than the border entry/exit sectors

The **4D Trajectory Management** could possibly increase the airspace capacity, based on controllers' comments. Adherence to the agreed flight plan (RBT with CTA) could lead to less congestion in sectors particularly over converging waypoints which create bottlenecks today. However the high traffic load reduces the controllers' capacity to facilitate 4D trajectories particularly in the vertical profile. With perfect planning, appropriate airspace design and complexity measures in place, the controllers felt the concept could help to increase capacity.

6.3.2.3 Network Capacity

Only one exercise provided results on network capacity during short-term planning phase. It was developed in an ECAC-wide scenario where airports and highly congested areas were represented by nodes. Analytical modelling techniques were used to provide objective results.

One of the main conclusions was that the ATM network is very sensitive to uncertainty, which is always present within the system in an intrinsic manner. When external disruptions/events occur, the ATM system presents a non-linear response. Dynamic ATFCM using RBT provides a significant improvement; it seems that this OI helps to increase effective capacity under any situation. On the other hand, the use of Network Management Function in case of severe capacity shortfall does not provide the foreseen output, since the number of overloads increases, even to a 60% in the worst case scenario.

6.3.3 Efficiency

Enhanced performance on cost-efficiency is one of the main drivers of ATM improvement of SESAR. The aimed cost reductions have to come partly from organisational improvements and enhanced effectiveness of ATM service provision, partly from cost reductions by reduced flight duration and the execution of efficient flight profiles. The latter part was subject of some of the concept assessment and validation experiments in EP3.

The planning of flight-efficient profiles is the responsibility of Airspace users, expressed by their SBTs and their RBTs, comprising agreements amongst stakeholders involved. The expectation is that ATM service provision will accommodate an unimpeded execution of the flight in unconstrained airspace and during low density operations in adherence to the planned RBT.

The execution of optimised flight profiles is challenged by ATM constraining conditions, and roughly, the possibly constraining conditions and trade-offs are determined by:

- **Capacity limitations:**
    - Increased capacity may have positive effect on flight efficiency under otherwise unchanged conditions. For example, extra runway, airport or airspace capacities have beneficial effects on flight efficiency as long as air traffic demand will not change.
    - However, capacity increase by tight sequencing and/or reduced separations may result in conditions that may limit the options to execute planned and agreed RBTs and may induce late updates in planning and execution of flights.
- **Predictability limitations:**
    - The ideal predictability of flight planning is challenged by inherent uncertainties in the planning of operations of airspace users and ATM service providers. Important constraints are imposed by uncertainties for example in flight preparation, in ground operations and in departure and arrival planning. This has negative effects on flight efficiency during dense traffic operations, and the concept of layered and convergent planning aims to mitigate these effects.
- **Environmental limitations:**
    - Minimal emissions and optimised fuel-efficient flight profiles are benefits enforcing each other by synergy and shared interests of stakeholders involved.
    - However, noise-abatement regulations may impose constraints on flying fuel-optimised profiles at lower altitudes, and best compromises have to be considered.
- **Flexibility requirements:**
    - Although most profitable deployment of Air Transport operations is benefited by accurate planning, as conceived by the 4D planning concept, real-life operations are characterised by incidental events and disruptive operational conditions. The requirement of airspace users is to mitigate disruptive effects with minimal impact on flight efficiency.

The operational concept of SESAR and the validation activities of EP3 were addressing conceptual areas that could benefit the efficiency of flight operations. The main interest of validation was to study those areas where flying optimal profiles was challenged by trade-offs and constraining conditions but with potential to validate concrete flight-efficiency benefits. Flight efficiency had to be judged according to SESAR (Ref. [E]) to three domains:

- The temporal efficiency with a focus on minimising delays;
- The fuel efficiency by assessment of flying optimised profiles; and
- The mission effectiveness, assessing the economic impact on military missions.

The first two domains were addressed by EP3. The most promising areas of interest were:

- **Optimised and direct routing:** Assessment of quantified benefits of improved flight efficiency by direct routing in the horizontal plane. The objective was to show potential of reduced flight distance and flight duration.
- **Optimised flight profiles:** Assessment of quantified benefits of improved efficiency by flying optimised profiles in the vertical plane. Profiles are evaluated for example to enable Continuous Descent Approaches (CDAs) on dense traffic flows and to assess flight duration and fuel consumption.

- **Demand and Capacity Balancing (DCB):** Flight efficient operations may benefit from pre-departure regulations in order to minimise traffic congestion and the need for in-flight updates on agreed RBTs. Also, in-flight dynamic DCB may contribute to flight efficiency by early anticipation on the structuring of air traffic flows under high density and possibly disrupted operational conditions.
- **High density arrival sequencing:** Early anticipation, accurate traffic demand regulations and a process of optimising the sequencing of arrivals on fuel efficient CDA profiles will benefit dense traffic operations to hub airports.
- **Optimal speed profiles:** Flights in the en-route flight phase, and in particular long-haul flights, may perform fuel-efficient operations by flying speed-optimised flight profiles as proposed by airspace users in their SBTs/RBTs. ANSP service provision is asked to benefit flight-efficient operations by accommodating direct routing and variations in speed profiles as proposed by airspace users.
- **Reduced separations:** Reduced in-flight separations will allow more flights to fly their planned optimal SBT than under referenced baseline operational conditions. This may benefit the efficiency of operations during dense traffic operations when flights are not able to operate their optimal profiles due to local traffic congestion conditions.

Several experiments in EP3 addressed Efficiency, as outlined above. Not all experiments were explicit in assessment of concrete results, but for example Gaming exercises often aim to improve Efficiency, although their concrete objective is to improve the process to reach agreement. The agreement assumes to represent the achievable optimum for all actors involved. The experimental results can be summarised as follows:

- Studying planning processes, three Gaming exercises aimed at achieving a collaboratively achievable optimum related to several KPAs. Also Efficiency was subject of interest:
    - In one Gaming Exercise, “Business Trajectory Management and dynamic DCB”, the objective was to reach an optimum in arrival queuing by addressing an in-flight dynamic DCB process. This process aimed at making best use of available airport arrival capacity under constraining conditions. It was assumed that small deficiencies in capacity could be managed in-flight, en-route, and before the arrival management process became active. In that case, early management by dynamic DCB could lead to a more flight-efficient solution by collaborative agreement on RBTs. The Gaming result was to provide clarification and procedural details of a feasible operational concept.
    - In the Gaming exercise, “Airspace Organization and Management”, the objective was to make more efficient use of airspace by a flexible and collaborative process to allocate airspace and to reach agreement on civil/military applications. Optimization of deployment of airspace will benefit efficiency of operations.
    - In the Gaming exercise, “Collaborative Airport Planning”, the aim was to optimise departure planning by collaborative planning under constraining conditions, e.g. capacity deficiencies by disruption. Sharing resources in a more collaborative way may comprise access to airport resources as well as access to the ATM network, and changes in RBT planning will impact both simultaneously. Airspace users may expose their interests and may reach an optimum in conduct of their flights in the most cost-efficient way by minimising delays and by minimising other operational costs.
- A Macro modelling experiment, Global performance at Network level, aimed to study performance effects at network level. The impact of bottlenecks and saturation leads to non-linear effects on the overall performance of the ATM network, and non-linear increase of delays is impacting cost-efficiency as well as flight-efficiency. Saturation

induced queuing may have significant impact on flight-efficiency; however, several operational concepts of SESAR are candidate to mitigate those inefficiencies. The Macro model offers the platform to analyse the integrated effect of these concepts on the overall efficiency of the ATM network.

- In the En-route flight phase, Efficiency, addressed rather the effectiveness of the ATM process. Highly accurate take-off planning was demonstrated to reduce complexity of operations in En-route airspace, and this would have potential to benefit capacity and safety. However, robust solutions were achieved against high delays and were compromising therefore the cost-efficiency of operations.
- In studying TMA and Airport operations, one Fast-Time Simulation experiment (FTS) addressed the subject of "Multi-Airport TMA operations in the core area of Europe". This experiment investigated an area that is characterised by constraining conditions due to traditional national border limitations, by neighbouring large/hub airports, by many regional airports and by military activities. It was investigated how arrival operations could be improved by:
    - Optimised use of airspace, deploying "Dedicated Arrival Flow Corridors" and assuming in other respects airspace available for flight-efficient descent operations;
    - Assuming priority for departures to high density arrival flows and highly accurately planned departure operations, ensuring low variability of demand at the start of the process of arrival management; and
    - Advanced arrival traffic sequencing as an enabler to accomplish high density CDA operations in lower airspace.

Fast-time simulation gave indicative values for benefits in flight duration, fuel and flown distance. Flight duration showed benefits which could be contributed to shorter routings, to more efficient vertical profiles (~70%), and savings due to on-time departures (~30%). Indicative upper-bound values for achievable savings may reach up to 50.000 ton fuel savings for four airports of interest in the area for 2008 traffic volumes. Also other areas in Europe might be appropriate for similar levels of savings, albeit that all results are obtained under assumed ideal and simplified conditions.

- In studying TMA and Airport operations, another fast-time simulation experiment addressed the increase of capacity in high-density TMAs through implementation of new separation modes. Although premature due to tools performance limitations, it could be concluded that PTC-3D clearances, allowing aircraft to fly their optimum climb or descent rate, could significantly improve flight performance. Improvement of efficiency is dependent, however, on conflict-free procedures.

In summary, EP3 performed experiments addressing several areas of interest regarding improvement of Efficiency, The emphasis was put on in-flight DCB and high density arrival sequencing, whilst there was also an experiment addressing reduced separations. Optimised and direct routing was addressed in the fast-time Multi-Airport TMA experiment. Only, optimisation of speed profiles and their impact on ATM was not addressed.

6.3.4 Flexibility

Air Transport operations are planned "by nature". The strongly planned nature of air transport operations stems from the use of costly resources, the requirement of airspace users to optimise deployment of their fleet and the complex network of dependencies of activities of all stakeholders involved in the ATM process.

Nevertheless, Flexibility is one of the primary Key Performance Areas (KPAs) to assess the quality of performance of the ATM system. Flexibility is defined in that context as the ability to

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make changes to the business trajectory, thereby permitting operational opportunities to be exploited as they occur (Ref. SESAR [E]). Flexibility has to be judged therefore as the capability of the ATM system to respond to event-driven requirements to change the planning, and possibly to change this planning at short notice. The performance regarding Flexibility can be measured as the capability to adapt the planning with minimal impact on other KPAs such as for example Capacity and Efficiency.

Due to its nature, Flexibility is not so much visible in new and advanced concepts of operations as for example Capacity and Efficiency; its visibility becomes evident rather from ATM performance under those conditions were Flexibility functions as a trade-off requirement against other KPAs such as Predictability, Capacity and Efficiency.

The following areas of interest can be considered as a summary of concept elements, relevant to validation in EP3 and critical with respect to Flexibility:

- **Layered and convergent planning**: Pre-departure planning becomes more specific and more accurate in planned allocation and assignment of resources compared to today's reference conditions, i.e. in 2008. Commitment to agreed RBTs and available headroom determines the flexibility to accommodate late changes and at the same time to ensure overall efficiency in use of available resources.
- **Demand and Capacity Balancing (DCB)**: Demand balancing as well as capacity balancing, are concepts to express early anticipation as well as flexible and late responses. Pre-departure DCB, followed by dynamic in-flight DCB, are developed to postpone decision making, if possible, and to decide on allocation of capacity and demand as late as possible. However, appropriate balancing is achieved at the same time as early as possible in order to avoid waste of resources and capacity, and to optimise efficiency of operations.
- **Sequencing and planning:** Dense queues are sequenced as early as possible in order to benefit efficiency. Nevertheless, flexibility is needed for example to accommodate not yet departed short haul flights and/or lately delayed flights, deviating from their planning unexpectedly. Moreover, Flexibility is key to be able to minimise queuing in tightly sequenced departure and arrival queues.

In summary, Flexibility is acting as a trade-off in all cases where planning is applied in order to reduce uncertainty and to ensure full and optimal deployment of available resources.

Several experiments in EP3 addressed the areas of interest, outlined above. The results of these experiments can be summarised as follows:

- Studying planning processes, two Gaming exercises, "Business Trajectory Management and dynamic DCB" and "Collaborative Airport Planning", both aimed at improving Flexibility by facilitating enhanced collaborative processes to reach agreement in planning-competitive situations. The two Gaming exercises were exploring options to allow airspace users to adapt their RBT planning and to give them better access to control the planning of their flights whilst managing this planning under varying constraining conditions. The Gaming exercise investigated the feasibility and acceptability of these options.
- The third Gaming exercise, studying planning processes, explored airspace management, offering airspace users enhanced flexibility in access to airspace. It was investigated how improvement could be established in making airspace available to users with a specifically planned civil or military interest, how flexibility of access could be improved and how appropriate response could be given to user requests. An increased early awareness by exchanged planning could promulgate a beneficial accommodation of flight operations.
- In the En-route flight phase, a Gaming exercise explored options for users' participation by a CDM process of decision making. It was concluded that users participation could not always be effective and desirable, causing instability and

workload, whilst not offering the benefits expected. This limits the flexibility for in-flight adaptation of the RBT.

- Also, the En-route flight phase experiences new constraints due the new concepts of 4D planning and early arrival sequencing. To fly a CTA will limit the controller to apply speed control and to accomplish metering and separation of air traffic. However, the trade-off is higher flight-efficiency and on-time operations. This was assessed by prototyping sessions during small-scale real-simulation experiments.
- In studying TMA and Airport operations, one small-scale real-time simulation experiment addressed prototyping of optimisation of descent procedures for dense TMA operations. The focus was to investigate feasibility and throughput capacity of operating dense flows of A-CDAs. The studied concept to fly CTAs, has potential for optimal delivery at a metering point benefiting regularity, punctuality, predictability and reduction of stack usage, however, it was observed as a trade-off that CTAs reduce the flexibility of Controllers and that those procedures might lack the required robustness against external factors of disruption.

In summary, none of the experiments in EP3 had their main focus on improvement of Flexibility; nevertheless Flexibility plays at least a role in all experiments performed by Gaming; for example in those experiments where enhanced interoperability aims to increase the update rate and robustness of planning. Also, the enlarged role of airspace users is an indication of significant increase of flexibility. On the other hand, the ATM system should have sufficient headroom and should be able to comply with Flexibility.

Evidently, Flexibility is most applicable and most beneficial in the early phases of flight, whilst flight-efficiency is most critical when arrival sequencing, metering and access to the runway determine the priorities.

6.3.5 Predictability

6.3.5.1 On-time operation

Three different exercises addressed the assessment of predictability KPA from the perspective of on-time operation. Validation scenarios were located in different areas: the current Maastricht Upper Area Control Centre (MUAC), the Dutch/Belgian/German airspace in a multi hub-airport environment and Rome, Barcelona and Dublin TMAs. Either FTS or prototyping techniques were used to validate those scenarios.

The indicators that potentially provided information on the impact of **4D Trajectory Management** on predictability during prototyping sessions were: the time spent on open-loop vectors and any deviations from 4D trajectory and the delivery conditions and the deviation from the sector exit list. The main benefit of this exercise was greater predictability in times and routing -less interference with planned trajectory by ATC ensuring flights arriving as planned in downstream sectors and on time Trajectory flown. In terms of lateral profile, an average of 95% of aircraft maintained their planned trajectory while the other 5% of aircraft spent an average of 3min 42sec on open loop vectors. The time constraint was generally maintained within the time tolerance window of [- 120s; +180s] indicating that controllers' interventions had little impact on time achievement.

The predictability in the core area of Europe is strongly improved when principles regarding **queue management, separation provision and collision avoidance** are in place. Careful planning, including DCB, can help to minimise inefficiency, but arrival traffic synchronisation and reiteration is required in order to realise the high precision sequencing and spacing over the IAF, needed to operate **CDAs** in lower airspace TMA. The FTS results showed some achievable benefits in addition to other effort to enhance planning and to increase predictability of flight execution. However, very likely the need for traffic synchronisation and the added value of reiteration is more essential than could be validated by the experiment. The FTS process is probably somewhat more predictable than can be expected from real-life operations.

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Initial trends on performance when operating **P-RNAV/Advanced CDA** showed that even under high traffic load, the concept provided benefits, in enabling to keep more than 99% of aircraft on lateral navigation (2D), carry out Advanced Continuous Descent Approaches (3D) and achieve consistent inter-aircraft spacing on final (4D). The analysis of trajectories also showed that when using standardised procedures, the controllers managed to contain these trajectories within a limited area. These two aspects contribute to the system predictability in terms of predicted trajectories, from both controllers and pilots' perspectives.

The negative effect of **weather conditions** on the predictability was observed, specifically in the approach sector. Difficulties to anticipate correctly aircraft positions and behaviour in the approach sector sometimes led to tactical interventions of the final controller to create the correct spacing at the runway.

6.3.5.2 Service disruption effect

No assessment has been performed in EP3 regarding this issue.

6.3.5.3 Knock-on effect

Only one exercise has analysed how local operational improvements impact ECAC wide predictability in the short-term planning phase. An analytical modelling technique has been used to achieve this aim.

This exercise shows which are the knock-on effects, in form of reactionary delays, produced when the capacity constrains are published and known in the system. One of the main conclusions was that the implementation of **SWIM enabled NOP** kept the number of reactionary delays unchanged and provides lesser improvement in overall arrival delays than expected. Similar results were achieved through the validation of the **Network Management Function**. However, the use of **Dynamic ATFCM using RBT** provided a drop on reactionary delays up to a 40% under specific conditions. When validating those three improvements together reactionary delays dropped even for a 50% under specific conditions.

6.3.6 Safety

EP3 addressed safety by providing preliminary answers to the following questions:

- Will the proposed ConOps and architecture meet the safety target for SESAR? If not, what additional safety defences or arrangements need to be in place?
- Given that SESAR aims to improve safety, where will this additional safety come from? Which OIs will add safety, which will be 'safety neutral', and which could increase risk (therefore requiring mitigation by safety-positive OIs)?
- How will safety be monitored throughout the Deployment phase? Which KPIs are practicable, insightful, sensitive (but not overly sensitive) to safety fluctuations, and accurate over short-term and medium-term timescales?
- As new OIs are implemented, what will be the 'safety tolerance' which might be allowable during their introduction? [There is always a period of adjustment or 'bedding in' with new systems or system changes]
- Which deployment sequences are safe in terms of ensuring that safety does not 'dip' below projected levels during the Deployment levels?
- What will be the flexibility in terms of different ANSPs being able to 'pick and mix' SESAR OIs and yet still achieve the required safety levels?

Building on the work carried out over the past on the development of the Integrated Risk Picture (IRP - the fore-runner of the Accident-Incident Model) and conceptual planning for the Safety Target Achievement Roadmap, EP3 completed a first preliminary risk picture for SESAR, at a level of detail appropriate for the current stage of development of the SESAR ConOps. Illustrative results have been extracted to illustrate initial answers to the questions

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above. In particular, EP3 provides preliminary comparison of the SESAR safety criteria, from which very tentative conclusions on the safety of the SESAR ConOps can be based. The results are also sufficient to begin to evaluate the face validity of the IRP results through review by a wider group of stakeholders.

Finally, a comprehensive methodology for a unit-specific IRP has developed. This has enabled the apportionment of all parts of the IRP fault tree model into generic airspace types/flight phases, which can then be used to estimate the risk picture for any individual ATM unit.

Data-based, static models such as the top-down accident-incident model cannot provide assurance that real-life operations will actually behave in practice like the model predicts, although the model provides a useful view of how ATM contribution to safety could look in the future. A model, truly reflecting real-life operations, however, requires more direct, and for some purposes, more dynamic, representations of safety contribution through the specification, modelling and simulation of the safety properties (functionality, performance, reliability and integrity) of the future ATM system. This need for direct assurance of the ATM contribution to aviation safety is the basis of the safety assessments / safety cases activities. For this, an evolved safety approach, both broader and more rigorous than traditionally applied in ATM, is needed. This approach is applicable to safety assessment of the major operational and technology changes that are planned for SESAR.

6.3.6.1 EP3 Expert Group Involvement in the Development of a Safety Assessment Process for SESAR

In parallel with the main EP3 programme, a broader approach to safety assessment suitable for SESAR has been developed that would conform to the principles of the SESAR Safety Management Plan. Because of the immaturity and evolving nature of the SESAR Concept, and because other EP3 activities were proceeding in parallel with the Safety Assessment work of EP3, much of the design task and initial safety analysis work had to be carried out by a very small team of systems / safety engineers with limited chance to submit formal safety-related operational input to other validation related activities in EP3, other than as DOD reviewers. The safety team was able to use a one-day sessions in both the TMA and En-route Expert Group meetings to provide some expert operational input to their Safety Assessment and feed safety issues into the expert group teams. In addition, the safety team attended one of the Airports Expert Group meetings.

Ideally, there would have been more opportunities for operational input to safety assessment work. However, this was not a major problem because safety assessment work had to be considered as development and proof-of-principle sessions rather than a formal safety assessment process. It did, however, highlight the benefit of operational feedback and coordination when a safety assessment process is undertaken for operational implementation.

What was achieved through the interaction with the expert groups was extremely valuable – and that is:

- Increased confidence that the safety assessment methodology that has been developed, will work also in practice;
- A clear demonstration that the models of the ATM system, being the barrier, functional and logical models, are a very effective way of communicating ideas between operational, safety, and system-engineering personnel. This is essential to the development of the SESAR Concept into design models that can be used in assessment and validation of the Concept at a number of KPAs, including safety;
- Design information which, though not guaranteed at this stage to be entirely complete and correct, has advanced the understanding of the implications of the SESAR Concept in terms of the functionality required of the system (*i.e.* human and equipment elements);

- A significant contribution to the development of a set of exemplary safety deliverables, as a very valuable input into the main SESAR Programme.

6.3.6.2 EP3 contribution to the wide-ranging ATM safety assessments

Activities on risk modelling and safety assessment described above and the work closely related to EP3 have provided a very useful trial of the methods and processes. The full validation activities will have to await the further development of the concept and will be completed within the S-JU programme.

Indeed:

- SESAR building on the work carried out in EP3 will take the ideas much further however, in the following ways:
    - Deepening the database in the current Accident-Incident Model making it more accurate and more sensitive to variability in traffic density and patterns across Europe;
    - More precise estimates of safety impacts of OIs, OI clusters, and safety defences;
    - Delivery of an updated SESAR safety target achievement roadmap (STAR) with implications for the SESAR ConOps & architecture;
    - Calibration of predicted safety impacts using real-time simulations and human factors laboratory, in particular ensuring that benefits foreseen are not over-estimated;
    - Refinement of KPIs so that safety monitoring and management during deployment is practicable and accurate.
- SESAR will further develop and refine the detailed safety methods, tools and techniques to provide a complete, coherent and integrated approach known as the "systems-engineering approach" to safety assessment. This will the following to be answered:
    - Will the ATM system have sufficient safety functionality & performance?
    - Will it work properly, under all normal conditions of the operational environment that it is likely to encounter?
    - What happens under abnormal conditions of the operational environment?
    - What happens in the event of a failure within the ATM system?
    - Are the Safety Requirements realistic – i.e. could a system be built to deliver them?
    - Can we believe the answers to the above?

6.3.7 Environment

The work performed in the relation to the Environment KPA covered four tasks:

- Development of the "Environmental Validation Assessment Framework" to complement the Overall EP3 Performance Framework;
- Environmental and Meteorological Screening and Scoping of the concept for Operational Improvement Steps (OIs), to identify those OIs, which are of particular relevance for the environment and are expected to provide improvement with regards to the impact aviation causes;
- Identification of requirements for the current generation of Noise Assessment tools to be able to assess the Noise relevant OIs identified during screening and scoping;

- A first attempt to assess the environmental benefit of SESAR OIs on local air quality around the airport.

6.3.7.1 Environmental Assessment Validation Framework

The objective of this task was to tailor for EP3 a consistent, pragmatic and applicable Environmental Assessment Validation Framework allowing the assessment of the environmental performance of the proposed operational concept.

EP3 approach for environmental assessment provides a systematic approach based on available, usable and expert community accepted components for environmental assessment of air traffic management programmes and projects before implementation. Environmental management or monitoring after implementation were not covered since considered outside of the scope of EP3.

EP3 has delivered the following:

- The description of the structured and step-wise methodology for the top-down environmental assessment of the concept;
- The description of the methodology for environmental assessment of individual programme OIs;
- Description and list of tools/models available and suitable for the environment assessment during EP3 project duration including the required input data and data structures;
- Identification of the KPI for Global Emissions, Noise and Local Air Quality in alignment with the overall EP3 Performance Framework;
- Identification of the activities to be performed to gather the required information about the environmental performance of the system.

Methods, Metrics and Tools to do a systematic environmental performance assessment pre-implementation of the concept were accepted as pragmatic solutions.

The conclusions and recommendations for this task are:

- Environment guidance and assessment framework projects should use as input the EP3 results together with CAATSII Environmental Case material;
- Effort should be invested to develop a bottom up integration approach of local results for specific OIs via the regional level to the sub-system and overall system level;
- Emphasis should be placed on the understanding of trade-off effects between the environmental effects of the different OIs and impact on the Influence Model, e.g. an OI beneficial with regards to Noise might be penalising with regards to fuel burn, emissions and cost.

6.3.7.2 Screening and Scoping

A screening and scoping study determines whether an environmental assessment of a proposed OI is necessary (screening) and it determines the issues to be included (scoping) in the further detailed impact assessment.

The screening and scoping was applied to four focus areas, i.e. Meteorology (MET), Noise, Local Air Quality (LAQ) and Global Emissions (GE). The results are based on the analysis of the documentation on the OIs available in the SESAR Concept of Operations and the EP3 ATM Process Model. As a result, proposals have been made for each of the above-mentioned focus area as a list containing the most ‘promising’ OI steps for more detailed impact assessment. This is important for the political decision making process at European level, since it would allow the estimated environmental benefits to be compared with the required costs for implementation.

Given the improvement of the maturity level of the concept since the beginning of EP3, the screening and scoping should be repeated using the identified OIs per Focus Area as a starting point.

Meteorological aspects are felt not to be sufficiently addressed under EP3, despite the requirement that the future concept shall provide full capacity even under adverse weather conditions. It is recommended to rethink the priorities given to the dependency of the ATC/ATM system to weather, using as input the developed list of meteo relevant OIs.

6.3.7.3 Required Enhancements of existing assessment noise models to validate SESAR OIs Noise reduction

A study was carried out with the aim to evaluate the capability of the current Noise assessment tools in characterising the OIs correctly.

The capability to model these Operational Improvements and to weigh their true mitigation potential is key for their implementation, comparison and future development and enhancement.

The study listed the wide number of Noise models currently existing on the market, and focused on the widely and most commonly used ones (standard) which are based on the same methodology (contained in DOC 29 3rd Edition) and noise assumption (an integrated segmentation model assumption). Among this list, two main Noise Assessment models have been analysed in depth against the OIs: these are the INM Enhance/INM and STAPES. The information concerning the ANCON 2 model was estimated to be insufficient for this in depth analysis, although many results can be applied to it since it is based on the same methodology.

Expert judgment, literature review and past projects' experience, were used to analyse all the OIs against the models. This resulted in a list of requirements and proposals. The study has proposed three main solutions/requirements to overcome the models' limitations in characterising the OIs, these include:

- The update of the ANP/INM database through new NPD curves and a/c performance data (specifically for CDAs), together with the introduction of multi-configuration NPD curves (specifically for the approach segment of flight);
- Expanding the models capability to calculate new metrics as NA (Number of Aircraft Above XdB) and possibly exposure to low frequencies;
- Improving sensibility to weather conditions (since they influence the a/c performance) and topography for noise propagation (although this applies to a second order of influence).

The benefit of implementing certain OIs is strictly linked to the capacity of the models to reflect this enhancement through quantitative data, and to be able to support the decision maker and the public with certainty.

6.3.7.4 Measures to reduce local aircraft emissions

EP3 developed a methodology for the assessment of LAQ mitigation measures at airports next to describing the estimated effects of a number of OIs.

To give insight into the effect of the investigated OIs on local aircraft emissions, EP3 attempted to:

- Calculate the KPIs defined for LAQ (Ref. [14], [17] and [27]) for the investigated OIs (calculated on a per flight basis);
- Give an indication of the effect of the OIs on an ECAC-wide scale.

Applying the methodology developed for assessing the impact of OIs on the local air quality, values were calculated to provide the average emissions per flight for the 20 busiest

European airports, for a baseline scenario and for several scenarios with the effects of one or more OIs incorporated.

Applying the Environmental Validation Assessment approach, the activity provided the following results:

- OIs that lead to a decrease in queuing time and taxiing with a reduced number of operating engines does reduce local emissions;
- According to the calculations, reduced engine taxiing and towing are the most effective measures to reduce local emissions (specifically CO, HC and SOx), while the use of electrical ground power and Pre-Conditioned Air Units instead of auxiliary power units result in the largest reduction of two of the KPIs (NOx and PM10);
- The optimization of surface movements leads to a reduction of the emissions of all considered pollutants (Ref. [28]).

The results were obtained using the tools ALAQS and LEAS-iT. However due to missing input data some OIs relevant to LAQ could not be analysed.

6.3.7.5 ECAC wide effects of implementing the OIs

The calculated environment KPIs provided a first indication of the ECAC-wide effects of the different OI steps. But this transfer of effects of KPIs to ECAC-wide scale, was not, and cannot be a simple extrapolation of the calculated local values of a KPI.

The emissions on the airport surface are influenced by the local situation, i.e. runway configuration, traffic composition and taxi-route lay-out. This means that if an OI leads to a certain result at one airport, this does not automatically imply that this OI causes a same effect to the same extent on another airport.

The approach followed aimed at giving an indication of ECAC-wide effects on the Local Air Quality by providing generic results for a range of airports but as each airport is unique, this was not possible.

7 TECHNOLOGY ASPECTS

The focus is the technical validation of Airborne and Ground Enablers linked to ATM Capability Level 2. Its objective is to reach a TRL4 for the tested functions. It corresponds to an early validation process that enables to refine the system specification of the function, to demonstrate that the function is feasible and measure function performances.

Industrial maturity assessment is based on the TRL (Technology Readiness Level) concept based on NASA initial definitions, which can be applied to technologies, functions, architectures, or methods & tools.

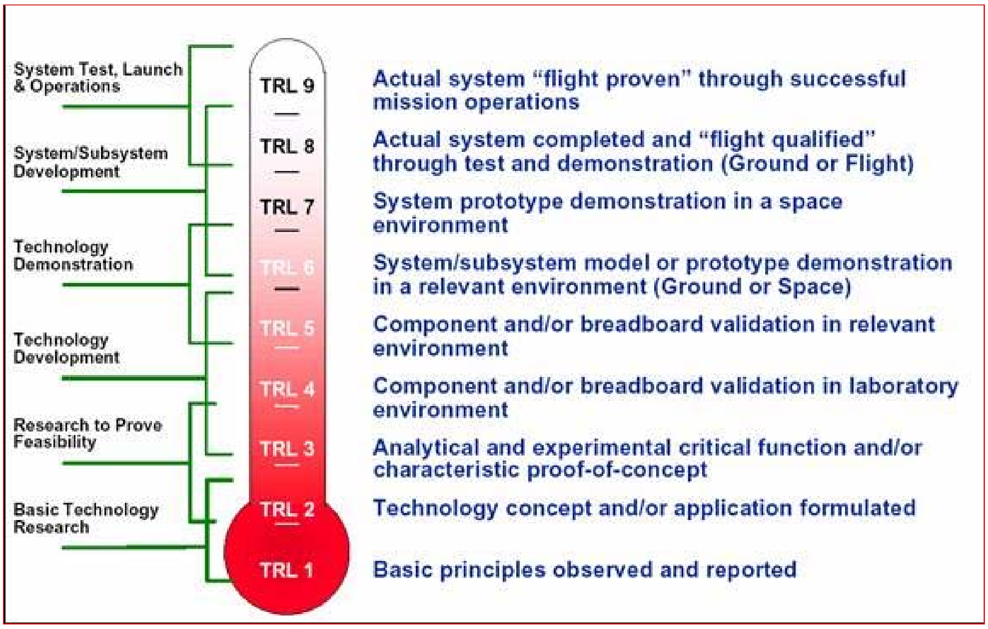

Figure 22 - NASA TRL scale

The TRL scale can be roughly linked to E-OCVM concept maturity levels as presented below.

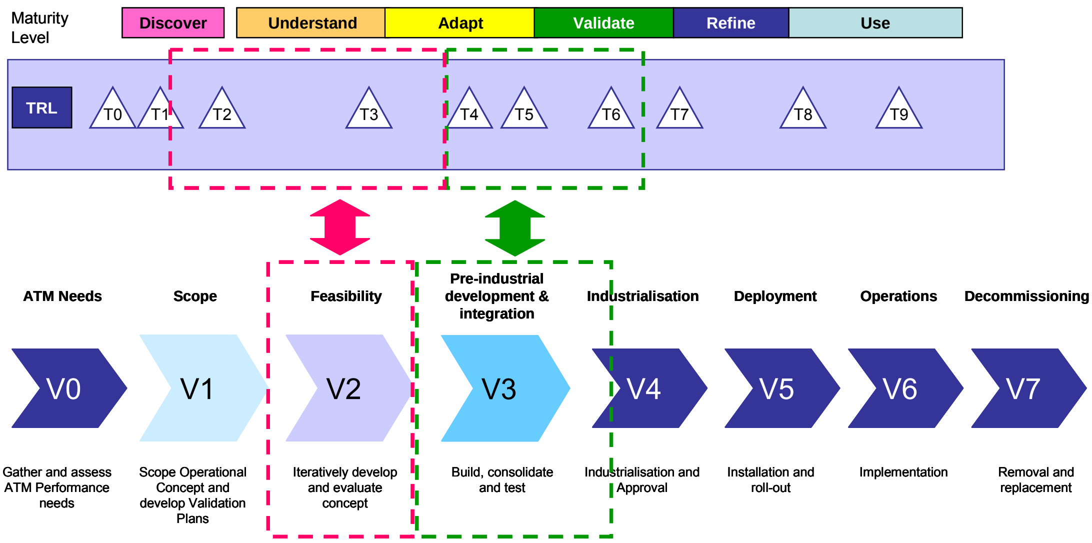

Figure 23 - Rough correspondence between TRL and E-OCVM scales

The evaluation concentrated on ATM service level 2 (ready for initial deployment in 2013 – i.e. revenue flight trials and specific sites in trials operations).

Two concept elements were studied in more details:

- Initial 4D Trajectory Management;
- ASAS (ASPA) Sequencing & Merging.

These concept elements were investigated further in terms of RTA performance, Initial 4D trajectory exchanges and further work on ASAS (ASPA) Sequencing and Merging and the results are summarised in the following sections.

7.1 RTA PERFORMANCE EVALUATION

This evaluation ran several batches of scenarios to collect statistical results on RTA accuracy achieved by the FMS. This used the same simulated FMS as the one used in the evaluation platform (AIRLAB). The successive batches were run varying key parameters, such as wind data.

Results of the study gave a good confidence in the capability of the airborne system to comply with the RTA performance requirement.

Another aim was to confirm the batch tool as a mean to measure FMS performance. The study shows that this kind of tool is adapted to get statistical results, but also to highlight and analyse implementation problems. Some potential improvements were identified to have better simulation models (simulation of the airbrake extension in the pilot model, simulation of the wind and temperature in the meteo numerical model).

7.2 INITIAL 4D TRAJECTORY EXCHANGE

This assessment used the following platform:

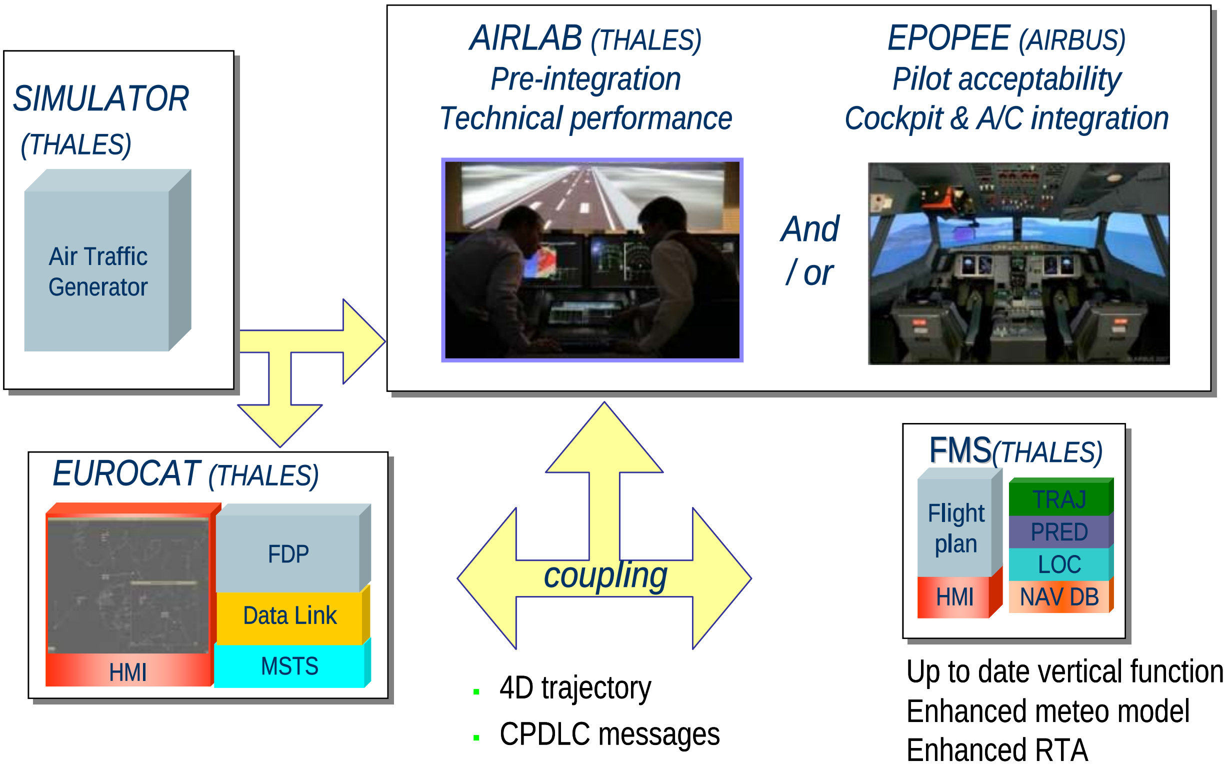

Figure 24 - Technical Validation Platform

The main objective of evaluations done on this platform was to assess the relevance of Initial 4D functionality in regards to the ATM concept of operations. Secondary objectives were to verify operational acceptance from a flight crew perspective and to identify potential issues related to the function design.

The main operational evaluation points addressed during the evaluation campaign were related to:

- Global integration of Initial 4D function with other tasks performed by the crew and with the other functions available in the cockpit;
- Aircrew and air-ground task sharing in the context of the Initial 4D procedure;
- Initial 4D usability and information usability regarding use of the MCDU, with ATC.

The operation of Initial 4D was based on the synchronization of the trajectory (predicted, trajectory remaining to be flown ...) between air and ground being accomplished transparently.

The datalink functions were implemented as in FANS, that is, datalink was used, and datalink messages were loaded into FMS. RTA was managed by the FMS.

It was important that up to date weather on trajectory ahead of the aircraft was received to have accurate RTA.

Main results on Initial 4D function from the airside are:

- It is easy to use as it does not impose extra task load on condition that the actions are performed before the approach preparation;
- RTA was met with ±10s accuracy at various altitudes, including below FL100 in 95% of cases when the RTA was set within the boundaries of the initial ETAmin/max window;
- Need to clearly know if, and when, the RTA that was requested becomes unachievable (although noted that monitoring this – especially if a weather change occurred was not a priority for pilots, and particularly in the descent / approach phase);
- PF / PNF Task sharing is not significantly modified;
- Transparent ETAmin/max synchronization with ATC appreciated;
- Route clearance loading considered a required feature - on condition that the actions are performed before the approach preparation;
- MET Data update through datalink is a mandatory required feature.

The main feedback from ATC controllers were:

- The optimum location of the CTA-waypoint need to be determined;
- More awareness needed on the behaviour of an A/C flying RTA;
- How ATC would handle a mix of aircraft equipped with A/G datalink and aircraft not equipped need evaluation;
- Initial 4D does reduce the number of tactical actions needed, as aircraft are more likely to adhere to their planned trajectory.

7.3 ASAS (ASPA) Sequencing and Merging

The 3 following manoeuvres were evaluated:

- Remain behind;

- Merge behind;
- Radar vector then merge behind.

These manoeuvres are depicted on the figure below:

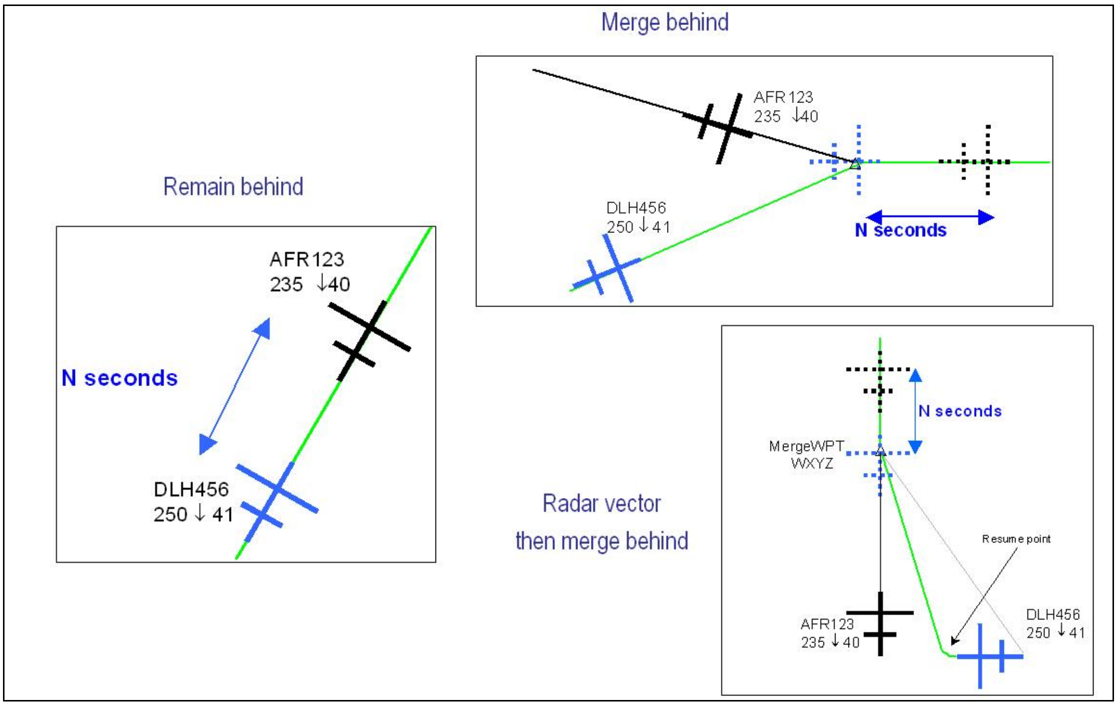

Figure 25 : ASAS manoeuvres

The main conclusions were:

- The functions were easy to use, they do not bring extra task load to the crew;
- Easy navigation through MCDU traffic pages;
- Relevant and readable spacing information on ND+;
- Global behaviour of the aircraft during acquisition and maintaining of the spacing is satisfactory (dynamics of the algorithm seem acceptable).

Some elements required further investigation:

- Make the ASPA S&M function robust to any unwanted disconnection of A/P (auto-pilot) or A/THR (auto-thrust);
- Cockpit task sharing between PF and PNF to be studied;
- Controllers require behaviour / trajectory / excursion of an A/C in ASAS manoeuvre (particularly vector then merge where the exact trajectory is not controlled).

7.4 Transition 4D to ASAS

The scenarios consisted in a nominal transition between Initial 4D and ASAS sequencing & merging. This case represents what is foreseen as an operational use: Pre-sequencing of aircraft using Initial 4D at the end of cruise, and then, in the TMA area, use of ASAS sequencing & merging to maintain the sequence thus easing the management of the different aircraft flows.

The main feedback from pilots and ATC controllers were:

- Preparing an ASAS instruction may take a non-negligible time. Tasks need to be distributed between planning controller (who could prepare the ASAS instruction) and executive controller (who would validate it and instruct the pilot) in order to limit the load of the executive controller and optimize the time taken in the ground for issuing the ASAS instruction to the aircrew.
- For the Merge and Remain behind manoeuvre, when both routes of the aircraft are converging with a small angle, the time spacing should not be guaranteed only from the merge point but also before it in order to also respect the separation in the route segment preceding the merge point.
- The integration of instruction parameters into the aircraft systems thanks to the LOAD command proposed was considered as necessary so as to avoid entry errors and ease the evaluation of the feasibility or not of a given manoeuvre by the flight crew.
- There was no difficulty to understand the transition (reference change) between the 4D RTA and the ASAS sequencing & merging instruction. Even if aircraft speed management for 4D is based on a fix reference whereas ASAS sequencing & merging function is based on a moving reference, it is agreed that it is transparent for the crew.

The main conclusions were:

- Initiation of the ASAS S&M manoeuvre “Remain behind” does not necessitate that both aircraft have the same altitude profile: only an identical lateral route is necessary,
- The later the ASAS procedure is triggered, the shorter are the available times for the controller and aircrew to achieve their tasks, the larger is the risk of overload for one or both of them and possibly the unfeasibility of the manoeuvre.
- Further investigations are needed about feasibility in a large scale of ASAS-based procedures and conventional procedures in the same environment while there is still a small proportion of ASAS capable aircraft.
- As regards the FMS, speed constraints management needs to be analysed and discussed with ATC and regulations, and automatic flight plan insertion at manoeuvre engagement is appreciated but has to be confirmed with flight crew evaluation and a representative task sharing.

7.5 ADDITIONAL WORK

A specific study has been carried out by NATS investigating the potential benefits delivered to ground-based controller tools by use of parameters available from aircraft. It forms part of the technical validation activities, and delivers expert opinion on how tools and systems already available can be combined and enhanced to provide an important initial step towards full trajectory-based operations. The research was carried out internally within NATS, with support from other EP3 contributors, and demonstrates that there is considerable potential for using DAPs to support ATC system in the relatively near-term:

- Aircraft equipage already exists for many airline aircraft for Mode S parameters;
- ADS-B out aircraft equipage is growing;
- The performance of many existing or near-term controller tools systems could be improved by the use of air-derived information, with relatively little modification to the ground systems.

DAPS parameters of particular value for improving Trajectory Prediction performance include:

- Mode S Selected Altitude/Flight Level: This parameter is already in use to assist controllers in reducing the number of level busts in the London TMA. It has a proven record of providing safety benefits.
- Indicated Airspeed & True Airspeed: For trajectory prediction based tools including Short-term Conflict and Medium Term Conflict Detection the use of airspeed data from the aircraft could improve performance. The EUROCONTROL ADD Impact study noted the importance of speed information for trajectory prediction.
- Aircraft Mass: Aircraft Mass is known to be one of the critical factors to predicting the climb rate of aircraft and is important also to other flight phase. Both the ADAPT (Ref [36]) and EUROCONTROL ADD Impact studies (Ref [35]) showed the importance of Aircraft weight information during the descent. Existing Trajectory Predictors which have no mass data or very limited data incur significant climb prediction errors.

In the context of this study, two groups of Mode S DAPs have been quantitatively assessed for the improvement they may offer to the trajectory prediction process in iFACTS, NATS' near-operational set of controller tools. These are Ground Velocity (derived from True Track Angle and Groundspeed) and Indicated Airspeed/Mach Number. The testing and analysis of these parameters leads to the following preliminary conclusions:

- Use of Mode S Ground Velocity may offer some improvement to TP accuracy in all phases of flight, particularly in the along-track dimension.
- Use of Mode S Indicated Airspeed/Mach number offers considerable benefits to TP modelling in both climb and descent phases of flight, in the along-track dimension. It offers no appreciable benefit in the across-track dimension. It is assumed that this parameter offers no benefit in the cruise phase of flight, due to the information being easily derivable from existing data sources.

8 LESSONS LEARNT

8.1 CONCEPT LESSONS LEARNT

EP3 took a systems engineering approach to concept detailing, but then adapted the documentation produced to meet the needs of the users of the concept material in the project. The detailing process involved almost 100 people in around 20 organisations. This provided the task with a wide range of expertise and potential buy-in for the outputs, but this was balanced by the difficulties in managing such a large team.

The lessons learnt presented below are taken from a project-wide Lessons Learnt workshop held in September 2009 and a meeting within the team of DOD editors.

The lessons learnt presented below are taken from a project-wide Lessons Learnt workshop held in September 2009, a meeting within the team of DOD editors and through the use of Validation Tools and Techniques (Ref. [31][32][33]).

8.1.1 The ATM Process Model

The ATM Process Model was used as the structure to build the concept description and to check for consistency and agree interfaces between ATM domains. The workshop agreed that the process model was essential to produce the DODs as it gave a common structure and was easy to understand. It gave a reference that could be used across the project. The model broke down the ATM system to about the right level as a lower level decomposition would take a lot of effort to maintain.

The negative views reflected that process model could have been used more widely across the project and in particular that the technology work package did not link to this approach.

8.1.2 The Concept Documentation Produced

The DODs were seen as one of the major outputs of EP3. The overall structure and content of the DODs was seen as good, but the use of tables to show compliance with the definition phase work made the documents over-long and difficult to digest. Though there was a lot of content in the DODs, it was not in a suitable content for all validation exercises. Consequently, it was not easy to see how the results of the exercises could be used to update the DODs. It was recommended that the structure of the DODs was reviewed, in particular with the technology work package to see how the documents could be lightened and made more relevant to all stakeholders in the project.

It was agreed that while a shorter DOD would be more readable, it would not necessarily require less effort to write. In fact the requirement to maintain usability, high standards and relevant detail might make it hard to be concise therefore it would take just as much time. However, it was agreed while it may take the same time to write, it would take less time to read and this would be beneficial for review and buy-in.

Scenarios (OS) and storyboards were produced to address the weaknesses in the DODs in relation to the validation exercises. The OS format was seen to be clear and straightforward to understand and they could be easily understood by operational personnel and hence be used as a basis for discussions. They also provided a good step for integrating exercise results. Although the OS were seen to be clearer than the DODs, as they went to a lower level of detail, it was recognised that both approaches were needed. There were practical issues in the process of producing and updating the OS due in part to lack of familiarity with the format and the process. The biggest risk is that the views of experts and the rationale for decisions can be lost if the process is not managed properly.

Storyboards were a new format used within EP3 for describing the concept. The approach was developed within the expert groups. The format was very acceptable to the participants in the Expert Groups and provided an efficient way to explain the concept and gather comments and additional detail.

It must be recognised that by having three sets of documents to represent the concept, there must be a strong process to ensure consistency of the content.

8.1.3 Process of Concept Detailing

It was agreed that the team of authors and reviewers, which included operational and SESAR concept experts, provided the correct expertise to perform the task of concept detailing. In particular, the value of the review process was seen as an important element of the maturing of the concept description. However there were a limited number of individuals available with the knowledge of the concept and validation exercises to perform the update process.

The most significant issue was seen to be the lack of a Concept Authority (an individual rather than the set of pre-existing documents) for the project. The inputs from the definition phase were not always complete and sometimes reflected unrecorded disagreements within the SESAR concept drafting group. As such, the EP3 team had to find assumptions to resolve these issues to allow exercises to progress. The Lessons Learnt workshop attendees believed that providing a Concept Authority would have reduced the impact of these problems, where certain areas were continually reopened for debate, even when it was believed that an agreement had been reached. The role of managing these debates needs to be performed sensitively as free thought can provide a more robust concept and the reason for the continued disagreement is not always immediately obvious.

The value of communication was agreed to be an important issue in the process of concept detailing, both in the early stage when a consistent view of the concept needs to be presented to the validation activities and then during the process of detailing as new information becomes available and decisions on interpretation or assumptions are made. If there is a Concept Authority in the future, but no resources provided to ensure the decisions are promulgated, the situation will be little better than has been the case in EP3. EP3 was intended to use the Co-ordination Cell as a tool to achieve this, but this avenue of communication was possibly too gentle and the project would have benefited from a stronger central body to achieve this.

8.2 Validation Methodology Lessons Learnt

EP3 was one of the first projects to attempt the application of the E-OCVM to validate an operational concept of the scale and complexity of the SESAR ConOps. It therefore presented a unique opportunity to anticipate and explore the requirements and issues to be addressed in achieving effective integrated performance based validation on a concept of this scale. The experience gained is captured in Ref. [23] which was based on material from three main sources:

- A workshop addressing the topic organised with project participants involved in applying E-OCVM, in developing validation strategy, in planning and in conducting validation activities;
- A consolidation of issues and assumptions identified in the course of the project;
- Integrated validation requirements work already undertaken by EP3/WP2.3 under a previous version of the EP3 DOW.

Furthermore, from a second workshop near the end of the project useful lessons learnt in the areas of Validation Techniques, Assumptions Management and Performance Framework were collated (Ref. [24]).

This section summarizes the Lessons Learnt on the areas mentioned above.

8.2.1 Validation Process Management

Lessons and issues in this section are drawn from the experience of project staff involved in Validation Process Management.

- When applied to a large and diverse concept of the scale and complexity of SESAR, the already difficult task of initial validation maturity assessment becomes much more difficult and more critical. With hindsight, resources should have been specifically focused on this area much earlier.
- In order to be effective, a clear document review process has to be put in place and the supporting tools should be ready and available at the outset of the project.
- In a validation process, there is a need for guidance material and templates tailored to the type of validation exercise, both provided in a timely manner and easily accessible.
- Direct and immediate access to 'live' advice and coaching on validation issues and matters is highly beneficial to the validation practitioners.
    - At the start of the EP3 project, there was a general lack of understanding of a number of important validation issues, i.e. how to express assumptions, how to design exercises, and to make effective measurement. This lack stresses the importance of having the right skill profiles and appropriate training materials to ensure that the right competences are made available to perform effective validation.

8.2.2 E-OCVM

For the E-OCVM (and wider validation community) the main recommendation is for the provision of more guidance related to the Concept Lifecycle Model (CLM), elaborating on the definition, characteristics and transition criteria of the concept lifecycle phases, concept and performance breakdown and integration, and more practical guidance on applying the methodology. The E-OCVM should also provide guidance and reference to the newer validation techniques such as those used in EP3.

To be more specific, the E-OCVM should:

- Provide guidance on how to incorporate a better approach to project definition using validation strategy to ensure that the planning of validation activities and exercises, reflects ATM performance and strategic priorities, whilst recognising the practical constraints of programmes and projects;
- Provide more guidance or illustration on how the methodology applies to larger, more complex projects and concepts;
- Provide more guidance on the Concept Lifecycle Model, how to define concept maturity and how to recognise transition from one level of maturity to the next;
- Explain the need to anticipate possible changes in validation priorities and ensure appropriate resource re-allocation mechanisms;
- Provide guidance on how concept and/or performance results from various projects and exercises can be consolidated together into more global results and cases;
- Provide guidance on or include reference to the newer validation techniques such as those used in EP3.

8.2.3 Assumptions Management

The importance of Assumptions Management (AM) in a large validation project like EP3 is that assumptions set the scope of the contextual information. Although this importance was

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recognised early in the project, it was not until halfway the project that the validation experts observed that the assumptions found in the Experimental Plans were rather unclear, disorganized and imprecise and that there was a clear need for a better Assumption Management / Assumption Guidelines. A separate Assumptions Management activity was started in order to analyse the assumptions to evaluate the exercise results and to define lessons learnt to this respect for the SJU and other validation projects [22][24]. The main results of this activity are:

- The definition of "Assumption" should be well described and be understood and agreed by all persons involved;
- It is important to recognise the differences between assumptions management for mature concepts and that for less mature concepts;
- The process of identification of assumptions should follow a top-down approach. This process should be part of the validation methodology from the very beginning, because the value of the results will be as good as the initial assumptions considered. This AM provided consistency among the different WPs, given the final results a greater value;
- The collation of Assumptions should make use of a template (database) in order to centralise and manage the process;
- The definition of the assumptions should be made transparent and traceable. All the assumptions should be described clearly in the experimental plans, and, if necessary, be summarised in a separate section.

8.2.4 Validation Tools and Techniques

Most of the important validation results were achieved through the use of Validation Tools and Techniques. Lessons Learnt were extracted from the application of these Validation Tools & Techniques along EP3 and they are summarized in Table 10 (Ref. [24]). They have been grouped in relation to several themes including level of maturity, key performance area, concept scope, quality of results, cost benefit of technique, links to other techniques, support available for the technique and unknowns of the technique.

The left hand side of the table shows summaries of the main points raised in relation to each theme. The right hand side shows the 'score' each technique achieved. A positive score (coloured amber or green depending on score) means the technique is in agreement with the summary statement. A negative score (coloured red) means the technique is not in agreement with the summary statement.

	Summary Statement: The technique…..	Expert Groups	Gaming	Proto-typing Sessions	Modelling
Level of Maturity	…is useful during V0-V1	3	3	2	1
	…is useful during V2-V3	1	1	2	3
	…is useful during ALL phases		1	2	
KPA	…can help detect show stoppers and refine early requirements	2	3		
	…has performance assessment capability	-1	-1		2
	…is suitable for operability assessment		1	3	
	…is suitable for ECAC wide solutions		-1		1
	…is suitable for quantification assessment	-2	-2		3
	…is suitable for qualitative assessment of process		1	1	
	…is suitable for safety assessments				1
	…can be used by experts to define KPA	1			

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	Summary Statement: The technique…..	Expert Groups	Gaming	Proto-typing Sessions	Modelling
Concept Scope	…can be used for defining roles & responsibilities		2		1
	…can be used for addressing flow management			1	1
	…can be used for concept clarification	3	1		
	…can be used for evaluation of interactions and information exchange		1		1
	…is applicable for all ConOps and associated maturities	1			1
	…is suited for the execution phase		1	1	
	…is suitable for all phases of flight		2		
Quality of Results	…confidence in results difficult to achieve cost effectively.		2		1
	…results lack accuracy but reliable in outcome		1		
	…results are sensitive to the individuals involved	2	2		
	…results useful for clarifying/detailing ConOps	1		1	1
	…results are first trends to refine objectives			1	
	…outputs fed into other validation techniques	1	1		1
Cost Benefit of Technique	…planning is cost effective		2		1
	…execution is cost effective		2	-1	
	…requires experts, who can be expensive		1	1	
	…is cost beneficial when combined' with other techniques	1			
	…cost benefit depends on the method.		1	1	
Links	… links well with Expert Groups		3	3	
	… links well with Gaming	3		1	1
	… links well with Prototyping Sessions	3	1		4
	… links well with Modelling		1	4	
Support	…has limited support available	2	1		
	… support on ATM applicability is limited		1		
	…has tools available to facilitate technique		1		4
	…has guidelines available for supporting tools	-1	-1	-1	1
	…has a reliance on assumptions				1
	…requires training sessions & material		1	2	
Unknowns	…participants/facilitators must understand concept	2	3		
	.. has limitations imposed by availability/complexity of platform/software			1	2
	…is not a validation technique - but support to validation	1			

Table 10 - Lessons Learnt on Validation Techniques and Tools

It was concluded (Ref. [32]) that combinations of different validation techniques are necessary to improve results of one method. The use of three different gaming techniques has expanded the cost effective validation techniques available. The paper-based technique is adequate to assess and define information flows, roles and responsibilities and detect gaps. The use of process simulation supports the defined processes with quantifiable metrics. Finally the use of a web-based game allows the validation of the results through the exposition of the scenario to a broader expert community. The combination of the expert group and the gaming sessions in a two day meeting has been agreed as adequate to be an inexpensive and focussed technique to validate the feasibility of the information flow processes, and to detect gaps and inconsistencies in concept description. These techniques should be used as an preceding step before prototyping sessions. Regarding to conduct prototyping sessions the following major lessons learnt were encountered: To cope with the limited time available for training, continuity of participants is essential to avoid additional training time. Continuity also enables the participants to mature the concept between sessions. Sufficient time between sessions is needed to enable analysis and refinement of remaining objectives, technical development of new functions, conduct of acceptance test and preparation of briefing and experimental material.

8.2.5 Performance Framework

The lessons in this section are derived from the experience of the team involved in establishing a project wide Performance Framework.

- To establish a common basis for validation and ensure consistency of all the exercise results, a Performance Framework describing the targeted performance areas, indicators and metrics, has to be made available from the start of the project.
- Influence modelling and the identification of uncertainties can be very useful in the prioritisation of the validation activities.
- It is important in the performance modelling to have continuity of the work team and to have someone responsible and dedicated to the process of integration and maintenance of the models. In addition to a strong modelling expertise, the development team needs to include the right balance of wide ATM operational design, safety and environmental expertise.
- There is still a need to do basic work to generate taxonomies allowing the linking of performance at global and local levels in En-route and TMA.
- It is important to be able to identify when a target can really not be achieved by the selected concept in order to either revise the concept or recognise when the target is unachievable and has to be revised.
- More emphasis should be placed on the representativeness of validation data. Often when validated at a local level (airport, portion of airspace), its validity at the global European level is uncertain or unknown.

9 CONCLUSIONS

The main achievements of the EP3 Consortium in building on the work of the SESAR Definition Phase have been:

- Concept refinement and its maturing through the development of the Detailed Operational Descriptions, Operational Scenario, Storyboards and Use Cases;
- Development of the ATM Process Model and refinement of these processes including the definition of the related actors and their roles and responsibilities;
- Development and refinement of the Performance Framework, including integrating the underpinning Influence Diagrams and building an integrated set of Influence Models to allow quantification of system performance;
- The maturing of SESAR's main underpinning air and ground technologies, Initial 4D, ASAS spacing applications and integration of air/ground systems;
- Extension of the E-OCVM methodology to support integrated validation of a complex concept, this includes the use of standard templates agreed criteria for the selection of the appropriate validation technique given concept maturity and validation aims, and methods for combining their results;
- Lessons Learnt and Recommendations were produced to benefit SESAR in its future concept validation activities.

This contribution needs to be recognised in the context of the start of the project when there were no documented instances of the systematic application of the E-OCVM to the validation of concepts approaching the scale and complexity of the concept proposed in SESAR. The lessons learnt from this approach were used in collaboration with the CAATS II project to prepare version 3 of E-OCVM, the methodological companion of the SESAR validation.

EP3 applied new validation techniques efficiently on those parts of the SESAR ConOps that are in the early stages of concept development. Expert groups were combined with various kinds of gaming techniques for parts of the concept dealing with the planning phase, and also with prototyping sessions for parts dealing with the execution phase. EP3 explored new roles needed in the SESAR concept, some identified during the definition phase, as well as some not yet identified when EP3 started. The role of MSP was clarified in conjunction with that of the planning controller and the sub-regional manager, for the processes required for RBT revision negotiations. Further issues were identified for SESAR projects, for instance the exact role repartition between Multi-Sector Planner, the planner controller and the executive controller, and the exact procedure to be used for RBT revision between these actors. The 4D- trajectory concept was studied in En-Route and in TMA, highlighting some issues of acceptability of the CTA technique for controllers. Controllers felt that by removing the possibility of applying speed techniques for control, they lost an important part of their toolkit, EP3 also realised that applying the CTA coincident with the Intermediate Approach Fix was not feasible but that the CTA point needed to be brought upstream, for instance at the TMA entry point. The trade-off between increased organisation of the traffic achieved with the CTA and the reduced situation awareness by controllers will need to be addressed in SESAR, for instance by down-linking additional information on request to the controller on aircraft speed intent. Similarly, the absence of route structure in SESAR also reduces situation awareness, which will need attention as the concept objective is to keep the controller (human) at the heart of the system. Current MTCD tools were not considered sufficient to alleviate this.

In TMA, scenarios excluding the use of open-loop instructions concluded that a reduction in controller workload can be achieved with better monitoring of traffic, and more stable pressure on the runway. This was also demonstrated to work when combined with CDA and ASAS/ASPA sequencing and merging. EP3 showed that flight efficiency when applying CDA was increased through dedicated arrival flow corridors. Specific studies in the Barcelona

TMA highlighted that 2020 traffic could be handled with these new TMA procedures provided that the supporting controller tools achieved a 20% workload reduction.

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

Detailed working through of DCB processes in a context where airspace users are involved represented an important part of the project. New roles were defined in order to find a compromise between extra users' involvement and network efficiency. Future studies will need to refine the tools proposed and prototyped in EP3 gaming sessions for these new roles. The various traffic management processes from DCB to arrival management were clarified to be part of a continuous process with successive sets of actors.

A technology evaluation platform including off-the-shelf ATM systems, FMS and cockpit elements was developed that allowed the evaluation of the impacts of trajectory based operations for air and ground actors and systems. EP3 advanced the maturity of the associated concept elements (4D trajectory exchange, with a single RTA) and demonstrated that the integrated platform developed during the project has the potential for use in further evaluations. EP3 demonstrated the feasibility of achieving CTA with the required precision in 95% of cases with a Thales Avionics FMS, and highlighted the improvements in the ground trajectory predictor brought by downlinking certain FMS data.

The work of EP3 has paved the way for a full validation of the concept which the SESAR Joint Undertaking now has the task of performing. The main added value that EP3 has contributed can be considered on two main axes:

- From a complex ConOps document, and a list of 183 OIs, EP3 proposed an approach, based on a functional decomposition, which structured detailed concept information into 9 DODs, and 26 operational scenarios. This approach was successful in capturing validation results to further elaborate the concept description.
- From the SESAR D2 results, EP3 extended the Performance Framework, and proposed a method for measuring and understanding concept benefits, through the use of influence diagrams. EP3 was not able to use the majority of the EP3 validation exercise results directly, but a global model was built, that should be re-used in SESAR development phase. Furthermore, validation exercises not only explored the concept through operational feasibility and performance aspects but also increased the know-how through innovative validation techniques and tools.

For the first time a consistent approach was proposed to conduct validation over a broad set of concept elements and to provide evidence that the right system will be built to deliver expected performance improvements and to address today's and future problems.

In looking at the project results as a whole, two important points should be highlighted:

1. Proof that a concept can deliver the expected performance in all KPAs, based on validation exercise results, remains elusive. Current modelling techniques do not provide results that can be integrated simply in an overall performance model. The methodology that EP3 developed can definitely help to structure the work programme against performance targets and to understand the mechanisms that bring performance, but aggregating individual fast-time simulation exercises results is more difficult. If SESAR wants to achieve that, significant effort needs to be spent to develop a methodology and then designing specific exercises that can feed a bottom up performance assessment. This should be evaluated against a more qualitative approach where expert judgement provides high-level performance figures supported by selected validation exercise results.
2. In the current context, some SESAR objectives in environment and cost-effectiveness need to be looked at urgently. The objective of 10% improvement in fuel efficiency

through ATM measures looks extremely challenging, and the cost reduction required by SESAR looks difficult to achieve, especially if there is limited traffic growth. Increased costs are anticipated as EP3 identified the need for additional staff and tools, and, in particular, experts remain strongly attached to the notion of 2-person sectors. .

In summary in a very short time frame, around one year of active research, EP3 has fast-forwarded through all the validation activities to be undertaken by the SESAR JU. The high level conclusions on the SESAR ConOps are:

- No significant operational or technical feasibility issues related to the concept have been found;
- Operational experts were positive towards the new operational processes proposed;
- Positive trends in performance were observed, though the ability to achieve the SESAR performance targets was not demonstrated.

A specific task was undertaken to collect the lessons learnt from the validation activities (see section 8). EP3 believes that these lessons learnt reflected in recommendations presented in the next chapter should be considered by the stakeholders in the SESAR Development Phase.

10 RECOMMENDATIONS

The following recommendations aim at providing guidance in the areas of management, validation, concept clarification and integration as well as use of validation techniques for future validation projects and programmes, especially the SESAR Joint Undertaking. They are based on the results of EP3 validation activities and the lessons learnt workshops (see section 8). When considered as really mattered good practices were recalled.

Management

- Ensure the project is driven by a strategic top-down approach which provides a flexible DOW that in turn permits the Validation Strategy to identify key elements of the concept and needs for validation, to select, modify and prioritise validation activities while also ensuring the best possible coverage of the concept;
- Ensure a strong link between operational and technical work packages;
- Promote communication among project members. Establish regular teleconferences/meetings to steer and guide the project, discuss the status of current activities and handle open issues, e.g. Project Management Boards, Co-ordination Cell and project meetings;
- Provide support tools which facilitate the work in terms of communication, sharing and reviewing of documents as well as concept discussion, e.g. web based platforms like the EP3 web page [21];
- Provide tools which help project members to find relevant project information like the EP3 Information Navigator [20];
- Offer training on the concept, validation methodology, and tools to be used to ensure a common understanding and level of knowledge among all project members;
- Develop templates and guidelines, e.g. for project deliverables;
- Reduce size of documents;
- Establish and monitor a transparent delivery process while planning enough time for document review;
- Provide a central and accessible location where outputs of discussions, questions and answers as well as assumptions and other important information can be stored, e.g. on the project website. Also establish a feed back process to integrate the information into project deliverables;
- Apply the Lessons Learnt of EP3 and also derive own Lessons Learnt at the end of the project to obtain more guidance for future validation activities.

Validation

- Perform a maturity assessment and clarify the concept before selecting and starting the validation techniques and activities;
- Ensure a throughout review of experimental plans before starting the validation activities;
- Ensure a top-down approach to a common and consistent assumptions management across all work packages and validation activities. This will serve to

set up the validation activities in a coherent way, help to interpret results and enable the Performance Framework to extrapolate results;

- Further develop the safety methods, tools and techniques to provide a complete, coherent and integrated "systems-engineering approach" to safety assessment;
- Further refine methods, metrics and tools to develop a systematic environmental performance assessment, investigate trade-off effects between environmental effects of the different OIs;
- Further develop the Performance Framework as a methodology which describes what Performance Indicators need to be measured and how validation results can be integrated and extrapolated to obtain an ECAC wide assessment of the SESAR concept.

Concept Clarification and Integration

- Build on and further refine the input material provided by EP3, e.g. Detailed Operational Descriptions, Operational Scenarios, Use Cases, Storyboards, and provide this to the project work packages in a timely manner;
- Involve recognized experts on the concept and establish a concept authority that has a mandate to challenge or change the current concept in order to mediate discussions and find approved solutions.

Validation Techniques

- Make use of the experience gathered with new validation techniques and tools developed in EP3 [29];
- Use Expert Groups to clarify the concept. They can also be a link to or between other validation exercises, e.g. by discussing experimental plans and assumptions, and giving advice on continuation of iterative validation activities;
- Use Gaming to study processes and interactions, roles and responsibilities;
- Conduct (iterative) Prototyping Sessions for concept clarification and operability assessment;
- Use Modelling and fast-time simulation as economic means for quantified performance assessment;
- Combine validation activities in a sensible way. Combine Expert Groups with Gaming or Prototyping. Also combine Gaming with Modelling, fast-time simulation and Prototyping [29].

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Applicable Documents

(The contents of these documents are considered to be relevant and applicable to all aspects of the present document)

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12 ANNEX A – DODS AND OPERATIONAL SCENARIOS

DOD	Scenario
Long Term Planning DOD (L)	OS-15 Airport Operational Plan Lifecycle for the Long Term Phase
	OS-14 Long Term Capacity Planning
	OS-37 Business Development Trajectory Creation
Collaborative Airport Planning DOD (M1)	OS-16 Turn-round Management
	OS-18 Airport Operational Plan Lifecycle for the Medium/Short/Execution Phase
	OS-19 Severe (UDPP) capacity shortfalls affecting departures in the short term
	OS-20 Airport Capacity Shortfalls in the Medium Term
	OS-21 Departure from non-Standard Runway
	OS-26 Non-severe capacity shortfalls affecting departures in the short term
	OS-30 Handle Planned Closure of an Airport Airside Resource
	OS-31 Handle Unexpected Closure of an Airport Airside Resource
Medium & Short Term Network Planning DOD (M2)	OS-11 Non-severe capacity shortfalls affecting arrivals in the short term
	OS-34 Military Collaboration in the Medium/Short Term
	OS-36 Non-severe (no UDPP) capacity shortfalls impacting multiple nodes in the network in the short term
	OS-19 Severe (UDPP) Capacity Shortfalls impacting Departures in the Short-Term
Runway Management DOD (E1)	OS-12 Landing and Taxi to Stand
	OS-13 Taxi-out and Take-off
	OS-17 Solve Hazardous Situations during Taxiing
	OS-19 Severe (UDPP) Capacity Shortfalls impacting Departures in the Short-Term
	OS-21 Departure from non Standard Runway
	OS-26 Non-Severe (No UDPP) Capacity Shortfalls impacting Departures in the Short-Term
	OS-29 Closely Spaced Parallel Operations in IMC
	OS-30 Handle Planned Closure of an Airport Airside Resource
	OS-31 Handle Unexpected Closure of an Airport Airside Resource
	OS-32 Management of Vehicles on Manoeuvring Area
	OS-39 Aborted Take-off
Apron & Taxiways Management DOD (E2/E3)	OS-12 Landing and Taxi to Stand
	OS-13 Taxi-out and Take-off
	OS-17 Solve Hazardous Situations during Taxiing
	OS-18 Airport Operational Plan Lifecycle for the Medium/Short/Execution Phase?
	OS-21 Departure from non Standard Runway
	OS-30 Handle Planned Closure of an Airport Airside Resource
	OS-31 Handle Unexpected Closure of an Airport Airside Resource
	OS-32 Management of Vehicles on Manoeuvring Area
	OS-39 Aborted Take-off

DOD	Scenario
Network Management in the Execution Phase DOD (E4)	OS-11 Non-Severe (no UDPP) Capacity Shortfalls impacting Arrivals in the Short-Term
	OS-33 Negotiating a proposed ATC revision to the RBT due to queue management
	OS-36 Non-severe (no UDPP) capacity shortfalls impacting multiple nodes of the network in the short-term
	OS-40 Traffic complexity assessment and application of dynamic DCB solutions
Conflict Management in Arrival & Departure High & Medium/Low Density Operations DOD (E5)	OS-11 Non-Severe (no UDPP) Capacity Shortfalls impacting Arrivals in the Short-Term
	OS-19 Severe (UDPP) Capacity Shortfalls impacting Departures in the Short-Term
	OS-26 Non-Severe (No UDPP) Capacity Shortfalls impacting Departures in the Short-Term
	OS-27 Allocation of Departure Profile
	OS-28 Allocation of Departure Route
	OS-35 High Density TMA Arrival – Flying CDA Merging
Conflict management in En-Route High & Medium/Low Density operations DOD (E6)	OS-33 Negotiating a proposed ATC revision to the RBT due to queue management
	OS-38 Flights in the Execution Phase in a 4D Environment

Table 11 - List of Operational Scenarios associated to DODs

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13 ANNEX B - OPERATIONAL IMPROVEMENT COVERAGE

Validation exercise title labelled in italics means that the OI was assumed but not addressed in the exercise.

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
L01-01	**Improving Flight Data Consistency and Interoperability**						
DCB-0301	Improved Consistency between Airport Slots, Flight Plans and ATFM Slots	IP1	L M1 M2/3				
DCB-0302	Collaborative Management of Flight Updates	IP1	L M1 M2/3				
IS-0101	Improved Flight Plan Consistency Pre-Departure	IP1	M1 M2/3				
IS-0102	Improved Management of Flight Plan After Departure	IP1	E4 M1				
L01-02	**Improving Aeronautical and Weather Information Provision**						
IS-0201	Integrated Pre-Flight Briefing	IP1					
IS-0401	Automatic Terminal Information Service Provision through Use of Datalink	IP1	E1 E2/3 E5 M1				
IS-0402	Extended Operational Terminal Information Service Provision Using Datalink	IP1	E1 E2/3 E5 M1				
L01-03	**From AIS to AIM**						
IS-0202	Improved Supply Chain for Aeronautical Data through Common Quality Measures	IP1					
IS-0203	Harmonised Aeronautical Information through Common Data Model	IP1					
IS-0204	Facilitated Aeronautical Data Exchanges through Digitalised Information	IP1					
L01-04	**Implementing SWIM**						
IS-0701	SWIM - baseline an initial common information model based on existing and consistent standards	IP1					
IS-0702	SWIM - European Ground Communication Infrastructure	IP2					
IS-0703	SWIM - governance & supervision	IP2					
IS-0704	SWIM - Ground-Ground limited services	IP2					
IS-0705	SWIM - Ground-Ground extended services	IP2					

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
IS-0706	SWIM - European Air-Ground Communication Infrastructure	IP2					
IS-0707	SWIM - Air-Ground limited services	IP2					
IS-0708	SWIM - Ground-Ground full services	IP3					
IS-0709	SWIM - Air-Ground extended services	IP3					
IS-0710	Air-Air Exchange services	IP3					
L01-05	**Airspace User Data to Improve Ground Tools Performance**						
IS-0301	Interoperability between AOC and ATM Systems (FDPS)	IP1	E4				
IS-0302	Use of Aircraft Derived Data (ADD) to Enhance ATM Ground System Performance	IP2	E1 E4 E5				
IS-0303	Use of Predicted Trajectory (PT) to Enhance ATM Ground System Performance	IP2	E1 E4 E5			FTS-5.3.4	Wp 6.4.2
IS-0305	Automatic RBT Update through TMR	IP3	E1 E4 E5 E6				
L01-06	**Weather Information for ATM Planning and Execution**						
IS-0406	Aircraft Dissemination of Information on Weather Hazards to Other Aircraft	IP3					
IS-0407	Interoperability between AOC and Weather Information Systems	IP1	E4				
IS-0501	Use of Airborne Weather Data by Meteorological Service to Enhance Weather Forecast	IP2	E4				
L02-01	**From Traditional Airspace Classes to Airspace Categories**						
AOM-0101	Harmonised ICAO Airspace Classification at FL195 and below	IP1					
AOM-0102	Three Categories of Airspace	IP2					
AOM-0103	Two Categories of Airspace	IP3	L				
L02-02	**Optimising Airspace Allocation and Usage**						
AOM-0201	Moving Airspace Management Into Day of Operation	IP1	E4 M2/3				
DCB-0203	Enhanced ASM/ATFCM Coordinated Process	IP1	E4 M2/3				
L02-03	**From FUA to Advanced FUA**						
AOM-0202	Enhanced Real-time Civil-Military Coordination of Airspace Utilisation	IP1	E4 M2/3	Game-3.3.3			
AOM-0203	Cross-Border Operations Facilitated through Collaborative Airspace Planning with Neighbours	IP1					
AOM-0204	Europe-wide Shared Use of Military Training Areas	IP2	L M2/3				

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
AOM-0205	Modular Temporary Airspace Structures and Reserved Areas	IP1		Game-3.3.3			
AOM-0206	Flexible Military Airspace Structures	IP2		Game-3.3.3			
AOM-0208	Dynamic Mobile Areas (DMA)	IP3	E4 L M2/3				
L02-04	**Facilitating OAT Transit**						
AOM-0301	Harmonised EUROCONTROL ECAC Area Rules for OAT-IFR and GAT Interface	IP1					
AOM-0302	Harmonised OAT Flight Planning	IP1					
AOM-0303	Pan-European OAT Transit System	IP1					
AOM-0304	OAT Trajectories	IP2	L M2/3				
L02-05	**Increasing Flexibility of Route Network**						
AOM-0401	Multiple Route Options & Airspace Organisation Scenarios	IP1	M2/3				
AOM-0402	Further Improvements to Route Network	IP1	M2/3				
L02-06	**Use of Free Routes / 4D Trajectories**						
AOM-0403	Pre-defined ATS Routes Only When and Where Required	IP2	E4 L M2/3			FTS-5.3.5	
AOM-0501	Use of Free Routing for Flight in Cruise Inside FAB Above Level XXX	IP2	M2/3				
AOM-0502	Use of Free Routing from ToC to ToD	IP2	M2/3				
AOM-0503	Use of Free Routing from Terminal Area Operations-exit to Terminal Area Operations-entry	IP3	E6 M2/3				
L02-07	**Enhancing Terminal Airspace**						
AOM-0601	Terminal Airspace Organisation Adapted through Use of Best Practice, PRNAV and FUA Where Suitable	IP1	M2/3			Proto-5.3.6	
AOM-0602	Enhanced Terminal Route Design using P-RNAV Capability	IP1	E4 L M2/3			FTS-5.3.5 Proto-5.3.6	
L02-08	**Optimising Climb/Descent**						
AOM-0701	Continuous Descent Approach (CDA)	IP1	M2/3			Proto-5.3.6	
AOM-0702	Advanced Continuous Descent Approach (ACDA)	IP2	E1 E5 M1 M2/3			FTS-5.3.4 FTS-5.3.5 Proto-5.3.6	

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OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
AOM-0703	Continuous Climb Departure	IP1	E5 M1 M2/3				
AOM-0704	Tailored Arrival	IP2	E1 E5 M2/3			FTS-5.3.5	
AOM-0705	Advanced Continuous Climb Departure	IP2	E5 M1 M2/3				
L02-09	**Increasing Flexibility of Airspace Configuration**						
AOM-0801	Flexible Sectorisation Management	IP1	M2/3		Game-4.3.3		
AOM-0802	Modular Sectorisation Adapted to Variations in Traffic Flows	IP1	L M2/3		Game-4.3.3		
AOM-0803	Dynamically Shaped Sectors Unconstrained By Predetermined Boundaries	IP3					
AOM-0804	Dynamic Management of Terminal Airspace	IP3				FTS-5.3.5	
CM-0102	Automated Support for Dynamic Sectorisation and Dynamic Constraint Management	IP1					
SDM-0201	Remotely Provided Aerodrome Control Service	IP3	L				
SDM-0202	Transfer of area of responsibility for trajectory management	IP3	E6 L				
SDM-0203	Generic' (non-geographical) controller validations	IP2	E6 L				
L03-01	**Collaborative Layered Planning Supported by Network Operations Plan**						
DCB-0101	Enhanced Seasonal NOP Elaboration	IP1	M1				
DCB-0102	Interactive Rolling NOP	IP1	M1	Game-3.3.4			
DCB-0103	SWIM enabled NOP	IP2	E4 L M1 M2/3	Game-3.3.2 Mod-3.3.5		FTS-5.3.4	
DCB-0201	Interactive Network Capacity Planning	IP1	L M1				
L03-02	**User Driven Prioritisation Process**						
AUO-0101	ATFM Slot Swapping	IP1	M1				
AUO-0102	User Driven Prioritisation Process (UDPP)	IP2	E2/3 E4 L M1 M2/3	Game-3.3.2 Game-3.3.4			
L03-03	**Planning the Shared Business Trajectory (SBT)**						
AUO-0201	Enhanced Flight Plan Filing Facilitation	IP1	M1				

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
AUO-0203	Shared Business / Mission Trajectory (SBT)	IP2	M1	Game-3.3.2			
AUO-0204	Agreed Reference Business / Mission Trajectory (RBT) through Collaborative Flight Planning	IP2	M1	Game-3.3.2 Game-3.3.3	FTS-4.3.2		
L04-01	**Improving Network Capacity Management Processes**						
DCB-0204	ATFCM Scenarios	IP1	E4 L M2/3				
DCB-0205	Short Term ATFCM Measures	IP1	E4		FTS-4.3.2		
DCB-0206	Coordinated Network Management Operations Extended Within Day of Operation	IP1	M1 M2/3	Game-3.3.4			
DCB-0207	Management of Critical Events	IP1	E4 M1 M2/3				
DCB-0208	Dynamic ATFCM	IP2	E4	Game-3.3.2 Mod-3.3.5			
DCB-0303	Improved Operations at Airport in Adverse Conditions Using ATFCM Techniques	IP1	E4 M1				
DCB-0305	Network Management Function In Support of UDPP	IP2	E4 M2/3	Game-3.3.2 Mod-3.3.5			
L04-02	**Monitoring ATM Performance**						
SDM-0101	Network Performance Assessment	IP1	L M1	Game-3.3.4			
SDM-0102	Civil-Military Cooperation Performance Assessment	IP1	L				
SDM-0103	Sustainability Performance Management of the ATM Network	IP1	L M1				
L05-01	**Management / Revision of Reference Business Trajectory (RBT)**						
AUO-0301	Voice Controller-Pilot Communications (En Route) Complemented by Data Link	IP1					
AUO-0302	Successive Authorisation of Reference Business / Mission Trajectory (RBT) Segments using Datalink	IP2	E1 E2/3 E5 E6	.	*Proto-4.3.4*		
AUO-0303	Revision of Reference Business / Mission Trajectory (RBT) using Datalink	IP2	E1 E2/3 E4 E5 E6		Proto-4.3.4		
AUO-0304	Initiating Optimal Trajectories through Cruise-Climb Techniques	IP1					
L05-02	**Managing Air Traffic Complexity**						

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
CM-0101	Automated Support for Traffic Load (Density) Management	IP1					
CM-0103	Automated Support for Traffic Complexity Assessment	IP2	E4		Game-4.3.3		
CM-0104	Automated Controller Support for Trajectory Management	IP2			Proto-4.3.4		
L05-03	**Enlarging ATC Planning Horizon**						
CM-0301	Sector Team Operations Adapted to New Roles for Tactical and Planning Controllers	IP1	E5				
CM-0302	Ground based Automated Support for Managing Traffic Complexity Across Several Sectors	IP2			Game-4.3.3 Proto-4.3.4		
L05-04	**Moving to coordination-free environment**						
CM-0201	Automated Assistance to Controller for Seamless Coordination, Transfer and Dialogue	IP1					
CM-0402	Coordination-free Transfer of Control through use of Shared Trajectory	IP2	E6		Proto-4.3.4		
L06-01	**Introducing Ground based Automated Assistance to Controller**						
CM-0202	Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace	IP1			Proto-4.3.4		
CM-0203	Automated Flight Conformance Monitoring	IP1	E5 E6		Proto-4.3.4		
CM-0204	Automated Support for Near Term Conflict Detection & Resolution and Trajectory Conformance Monitoring	IP2	E5		Proto-4.3.4		
L06-02	**ATC Automation in the Context of En Route Operations**						
CM-0401	Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number	IP2	E5		Proto-4.3.4		
CM-0403	Conflict Dilution by Upstream Action on Speed	IP2			*Proto-4.3.4*		
CM-0404	Enhanced Tactical Conflict Detection/Resolution and Conformance & Intent Monitoring	IP2	E5 E6				
L06-03	**ATC Automation in the Context of Terminal Area Operations**						
CM-0405	Automated Assistance to ATC Planning for Preventing Conflicts in Terminal Area Operations	IP2	E5			FTS-5.3.5	
CM-0406	Automated Assistance to ATC for Detecting Conflicts in Terminal Areas Operations	IP2	E5				
L07-01	**Arrival Traffic Synchronisation**						
TS-0102	Arrival Management Supporting TMA Improvements (incl. CDA, P-RNAV)	IP1	E1 E5			FTS-5.3.4 FTS-5.3.5	
TS-0103	Controlled Time of Arrival (CTA) through use of datalink	IP2	E1 E2/3 E5		Game-4.3.3	FTS-5.3.4 Proto-5.3.6	Wp 6.4.1 Wp 6.4.2

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OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
TS-0104	Integration of Surface Management Constraint into Arrival Management	IP2	E2/3 E5 M1				
TS-0106	Multiple Controlled times of Over-fly (CTOs) through use of data link	IP2	E1 E5				
TS-0303	Arrival Management into Multiple Airports	IP2	E1 E5			FTS-5.3.4	
TS-0305	Arrival Management Extended to En Route Airspace	IP1	E1 E5 E6			FTS-5.3.4	
L07-02	**Departure Traffic Synchronisation**						
TS-0201	Basic Departure Management (DMAN)	IP1	E1 E2/3 M1				
TS-0202	Departure Management Synchronised with Pre-departure Sequencing	IP1	E1 E2/3 M1				
TS-0203	Integration of Surface Management Constraint into Departure Management	IP2	E2/3 M1				
TS-0302	Departure Management from Multiple Airports	IP2	E2/3 E5 M1				
TS-0306	Optimised Departure Management in the Queue Management Process	IP2	E1 E2/3 E5 M1				
L07-03	**Managing Interactions between Departure and Arrival Traffic**						
TS-0301	Integrated Arrival Departure Management for full traffic optimisation, including within the TMA airspace	IP1	E1 E5				
TS-0304	Integrated Arrival / Departure Management in the Context of Airports with Interferences (other local/regional operations)	IP2	E5 M1				
L08-01	**4D Contract**						
CM-0501	4D Contract for Equipped Aircraft with Extended Clearance PTC-4D	IP3					
L08-02	**Precision Trajectory Operations**						
CM-0601	Precision Trajectory Clearances (PTC)-2D Based On Pre-defined 2D Routes	IP2	E1 E5		Proto-4.3.4	FTS-5.3.5	Wp 6.4.2
CM-0602	Precision Trajectory Clearances (PTC)-3D Based On Pre-defined 3D Routes	IP2	E1 E5		Proto-4.3.4	FTS-5.3.5	
CM-0603	Precision Trajectory Clearances (PTC)-2D On User Preferred Trajectories	IP2	E1 E5 E6		Proto-4.3.4		
CM-0604	Precision Trajectory Clearances (PTC)-3D On User Preferred Trajectories (Dynamically applied 3D routes/profiles)	IP3					
L08-03	**Airborne Situational Awareness**						
AUO-0401	Air Traffic Situational Awareness (ATSAW) on the Airport Surface	IP1	E1 E2/3				
AUO-0402	Air Traffic Situational Awareness (ATSAW) during Flight Operations	IP1					
AUO-0503	In-trail Procedure in Oceanic Airspace (ATSA-ITP)	IP1					

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
L08-04	**ASAS Separation**						
CM-0701	Ad Hoc Delegation of Separation to Flight Deck - In Trail Procedure (ASEP-ITP)	IP2	E6				
CM-0702	Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P)	IP3	E5 E6				
TS-0105	ASAS Sequencing and Merging as Contribution to Traffic Synchronization in TMA (ASPA-S&M)	IP2	E1 E5			*Proto-5.3.6*	Wp 6.4.3 Wp 6.4.4
TS-0107	ASAS Manually Controlled Sequencing and Merging	IP1	E1 E5				
L08-05	**Self-separation**						
AUO-0504	Self-Adjustment of Spacing Depending on Wake Vortices	IP3					
CM-0704	Self Separation in Mixed Mode	IP3					
L09-01	**Safety Nets Improvements (TMA, En Route)**						
CM-0801	Ground Based Safety Nets (TMA, En Route)	IP1	E5 E6				
CM-0802	ACAS Resolution Advisory Downlink	IP2	E5 E6				
CM-0803	Enhanced ACAS through Use of Autopilot or Flight Director	IP1	E5 E6				
CM-0804	ACAS Adapted to New Separation Modes	IP3	E5 E6				
CM-0805	Short Term Conflict Alert Adapted to New Separation Modes	IP3	E5 E6				
CM-0806	Improved Compatibility between Ground and Airborne Safety Nets	IP3	E5 E6				
CM-0807	Enhanced Ground-based Safety Nets Using Wide Information Sharing	IP2	E5 E6				
L10-01	**Improving Safety of Operations on the Airport Surface**						
AO-0101	Reduced Risk of Runway Incursions through Improved Procedures and Best Practices on the Ground	IP1	E1 E2/3				
AO-0102	Automated Alerting of Controller in Case of Runway Incursion or Intrusion into Restricted Areas	IP1	E1 E2/3 E5				
AO-0103	Improved Runway-Taxiway Lay-out, Signage and Markings to Prevent Runway Incursions	IP1	E1 E2/3 E5				
AO-0104	Airport Safety Nets including Taxiway and Apron	IP2	E2/3				
AO-0201	Enhanced Ground Controller Situational Awareness in all Weather Conditions	IP1	E1 E2/3 E5				
AO-0202	Detection of FOD (Foreign Object Debris) on the Airport Surface	IP1	E1 E2/3				
AUO-0605	Automated Alerting of Runway Incursion to Pilots (and Controller)	IP2	E1 E2/3 E5				
L10-02	**Improving Traffic Management on the Airport Surface**						

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
AO-0203	Guidance Assistance to Airport Vehicle Driver	IP1	E1 E2/3				
AO-0204	Airport Vehicle Driver's Traffic Situational Awareness	IP2	E2/3				
AO-0205	Automated Assistance to Controller for Surface Movement Planning and Routing	IP2	E2/3 M1				
AO-0206	Enhanced Guidance Assistance to Airport Vehicle Driver Combined with Routing	IP2	E2/3				
AO-0207	Surface Management Integrated With Departure and Arrival Management	IP2	E2/3 M1				
AUO-0602	Guidance Assistance to Aircraft on the Airport Surface	IP1	E1 E2/3 E5				
AUO-0603	Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing	IP1	E1 E2/3 E5				
AUO-0604	Enhanced Trajectory Management through Flight Deck Automation Systems	IP2	E1 E2/3				
L10-03	**Improving Airport Collaboration in the Pre-Departure Phase**						
AO-0501	Improved Operations in Adverse Conditions through Airport Collaborative Decision Making	IP1	M1	Game-3.3.4			
AO-0601	Improved Turn-Round Process through Collaborative Decision Making	IP1	M1	Game-3.3.4			
AO-0602	Collaborative Pre-departure Sequencing	IP1	M1				
AO-0603	Improved De-icing Operation through Collaborative Decision Making	IP1	E2/3 M1				
DCB-0304	Airport CDM extended to Regional Airports	IP1	M1				
L10-04	**Using Runways Configuration to Full Potential**						
AO-0402	Interlaced Take-Off and Landing	IP1	E1 E2/3 E5 M1				
AO-0403	Optimised Dependent Parallel Operations	IP1	E1 E5				
AUO-0701	Use of Runway Occupancy Time (ROT) Reduction Techniques	IP1	E1 E5				
AUO-0702	Brake to Vacate (BTV) Procedure	IP1	E1 E5			FTS-5.3.3	
AUO-0703	Automated Brake to Vacate (BTV) using Datalink	IP2	E1 E5				
L10-05	**Maximising Runway Throughput**						
AO-0301	Crosswind Reduced Separations for Departures and Arrivals	IP1	E1 E5			FTS-5.3.3	
AO-0302	Time Based Separation for Arrivals	IP1	E1 E5			FTS-5.3.3	
AO-0303	Fixed Reduced Separations based on Wake Vortex Prediction	IP1	E1 E5			FTS-5.3.3	

OI/OI Step Code	OI/OI Step Title	IP	DODs	WP3 EXEs	WP4 EXEs	WP5 EXEs	WP6 EXEs
AO-0304	Dynamic Adjustment of Separations based on Real-Time Detection of Wake Vortex	IP2	E1 E5				
AO-0305	Additional Rapid Exit Taxiways (RET) and Entries	IP1	E1 E5				
L10-06	**Improving Operations under Adverse Conditions incl. Low Visibility**						
AO-0502	Improved Operations in Low Visibility Conditions through Enhanced ATC Procedures	IP1	E1 E2/3 E5				
AO-0503	Reduced ILS Sensitive and Critical Areas	IP1	E1 E5			FTS-5.3.3	
AO-0504	Improved Low Visibility Runway Operations Using MLS	IP1	E1 E5				
AO-0505	Improved Low Visibility Runway Operations Using GNSS / GBAS	IP2					
AUO-0403	Enhanced Vision for the Pilot in Low Visibility Conditions	IP2	E2/3				
AUO-0404	Synthetic Vision for the Pilot in Low Visibility Conditions	IP3	E2/3				
L10-07	**Visual Conducted Approaches**						
AUO-0501	Visual Contact Approaches When Appropriate Visual Conditions Prevail	IP1	E1 E5				
AUO-0502	Enhanced Visual Separation on Approach (ATSA-VSA)	IP1	E1 E5				
L10-08	**Implementing Sustainable Operations at Airport**						
AO-0701	Effective Collaboration between ATM Stakeholders Supported by Environmental Management Systems	IP1	L M1				
AO-0702	Improved Relations to Neighbours	IP1	L M1				
AO-0703	Noise Management to Limit Exposure to Noise on the Ground	IP1	L M1				
AO-0704	Optimised Design and Procedures for Airport manoeuvring Areas to Reduce Gaseous Emissions and Noise Disturbance	IP1	L M1				
AO-0705	Reduced Water Pollution	IP1	L M1				
AO-0706	(Local) Monitoring of Environmental Performance	IP1	M1				
AUO-0801	Environmental Restrictions Accommodated in the Earliest Phase of Flight Planning	IP1	L M1				
AUO-0802	Ground Movement Techniques to Reduce Gaseous Emissions and Noise Disturbance	IP1	E1 E2/3 L M1				
AUO-0803	Reduced Noise Footprint on Departure	IP1					

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14 ANNEX C – HOT TOPICS

#	Hot Topic Title	Description	DOD Reference	SESAR Research Topic
1	BUSINESS TRAJECTORY MANAGEMENT	Should an SBT, compliant with network constraints, be proposed by the ATM Service Provider or by the Airspace User?	M2, E4	14, 21, 22, 26, 75
2	TRANSITION FROM SHARED BUSINESS TRAJECTORY TO REFERENCE BUSINESS TRAJECTORY	When and under what pre-conditions should the RBT be agreed? Should the agreement be time-based or event-based? Can it take place after the aircraft has pushed back?	M1, M2, E4	1, 6, 21, 25
3	TRAJECTORY MANAGEMENT REQUIREMENTS	How do Trajectory Management Requirements affect the criteria for separation management? Are the criteria for Trajectory Management Requirements fixed for the whole flight?	E5	60, 78
4	AUTHORISED PORTION OF THE REFERENCE BUSINESS TRAJECTORY	How does the authorised portion of the flight equate to the ICAO definition of a clearance?	E5, E6	36
5	SUCCESSIVE AUTHORISATION OF THE REFERENCE BUSINESS TRAJECTORY	Does the notion of successive authorisation of the RBT imply that there always needs to be active controller intervention to reauthorize or can it be transparent to the controller and pilot?	G, E5, E6	-
6	CONTROLLED TIME OF ARRIVAL NON-COMPLIANCE	What are the obligations related to issue and acceptance of a CTA? What happens when a CTA cannot be met?	E5	19, 45
7	TARGET TIME OF ARRIVAL	Is the TTA in effect a constraint?	G, E5	23, 45
8	COLLABORATIVE DECISION MAKING MECHANISM DURING EXECUTION PHASE	What extent/level of CDM is possible during RBT execution?	E5, E6	48
9	REFERENCE BUSINESS TRAJECTORY REVISION INITIATED BY AIR	In self-separation, will the aircraft revise its RBT when it manoeuvres to ensure separation is maintained?	E5, E6	59
10	TRAJECTORY CONTROL BY SPEED ADJUSTMENT	How can a controller manage separation when s/he is not aware that an automatic speed adjustment has been implemented?	E6	-
11	CONTENT OF THE BUSINESS TRAJECTORIES	Exactly what parameters should be in the business trajectory? Should these parameters by limited by the FMS representation of the trajectory?	G	79

#	Hot Topic Title	Description	DOD Reference	SESAR Research Topic
12	USER PREFERRED TRAJECTORY	Is this term needed, or is it the same as the SBT/RBT? Is it the same as User Preferred Routing? Usage of the terms in the Definition Phase literature is inconsistent.	G	52, 53
13	ROUTE STRUCTURE IN THE TMA	Should there always be some route structure in the TMA? Is it possible for there to be direct routes in a TMA even when traffic levels are low?	E5	9, 11, 41
14	MULTIPLE CONSTRAINTS IN THE RBT	Can an aircraft FMS manage a single point on the RBT to achieve both a time and speed constraint?	E5	-
15	TIMING OF TAXI ROUTE UPDATE	When is the best time to update or revise the RBT with the taxi route? When is this possible given pilot workload and stable information on airport surface movements?	E2/3	7
16	USE OF SPEED IN TAXI ROUTE	To what extent can the speed profile of a taxiing aircraft be planned prior to push-back or landing?	E2/3	7
17	BOUNDARY BETWEEN DCB AND DYNAMIC DCB	Should the boundary between DCB and dDCB be variable (between 2 hrs and 40 mins lookahead) or should it be a fixed value?	M2, E4	21, 22, 24, 28
18	HOW RBT IS MANAGED WITH OPEN LOOP INSTRUCTIONS	Exactly how does an aircraft return to the RBT after an open loop instruction? What happens to the RBT during an open loop instruction? What series of instructions and data interchanges are required?	E5, E6	-
19	AIRLINE CO-ORDINATOR ROLE	A new role/function, the Airline Coordinator, representing airspace users' interests has been identified. Is this in alignment with the ConOps principles?	M2	14
20	RBT STATUS AT COMPLETION OF PROCEDURES	What is the RBT status at the end of a flight or when a flight is aborted?	E2/3	-
21	REQUIREMENT FOR 'DYNAMIC DCB AT AIRPORT LEVEL' PROCESS	Is it necessary to have a dynamic DCB process to solve local airport imbalances? Are the existing queue management or dynamic DCB processes sufficient? Alternatively are these kinds of problems handled by activation of the UDPP?	M1, E1, E2/3, E4	48, 75

Table 12 - Hot Topics from Concept Development

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15 ANNEX D – CONCEPT DETAILING WORK AGAINST SESAR CONOPS RESEARCH TOPICS

#	Research Topic	Concept results	DOD
1	Study of airport processes associated with common understanding of a common planning process, common situational awareness and a common Performance Framework, as well as the tools to visualise the predicted performance (capacity, environmental load, delay etc.), as these do not exist today, nor do the procedures.	Process and data detail on Airport Operations Plan	M1
2	Study on the operational impact and potential environmental gains that may be made through increased use of aircraft towing to/from runway.	No work	
3	Study on the use of advanced, automated, aircraft systems such as 'auto-brake' that makes it impossible for an aircraft to cross selected 'stop bars'. Identify the advantages on runway incursion prevention.	No work	
4	Evaluation of improvements to 'all weather operations' with the aim of maintaining constant declared capacity in all weathers. Particular focus should be placed on reduced or even no protection for navigational aids that currently reduces runway throughput during low visibility conditions.	No work	
5	Study of all aspects of the equity portfolio in relation to airport access. Evaluation of the ways to resolve a potentially complex series of trade-offs between aircraft size, environmental impact, commercial costs and benefits.	No work	
6	Evaluation of available options related to pre-departure sequencing. Should it be based on successful completion of milestone events or is the concept of 'sequence when ready to start-up or push-back' more robust?	Discussions on SBT to RBT transition, definition proposed	All
7	Study of ways to optimise the predictability of surface operations.	Scenarios produced on airport surface operations	E2
8	Some of the most difficult and highly loaded controller working positions are located in control towers. Studies should evaluate ways in which controller workload can be reduced at airports.		

#	Research Topic	Concept results	DOD
9	Study to be made of the impact of revising departure routing at any time from push-back to climb-out. What are the periods when from an operational and safety viewpoint, when it is not desirable to issue a revised departure routing clearance (study should identify periods when flight crew are unable to dialogue with ATC - during take-off roll for example). This issue is to be investigated on the basis of procedures development, prototype system development and sound validation of feasibility, performance benefits and human factors issues.	Scenarios on allocation of departure routes and profiles prepared	E5
10	Study to be made of techniques to achieve advanced dynamic sectorisation in which sectorisation is efficiently adapted to changing demand (including Multi Sector Planning).	Processes detailed, scenarios prepared	E4
11	Study to be made of techniques for dynamic airspace management in which appropriate structures including dynamic routes are applied as traffic increases to an appropriate density and then revised or removed as traffic density changes.	Concept detail provided for adapting TMA route structure against demand	E5
12	Because of the new requirements for dynamic airspace management it will be necessary to study new appropriate methods to calculate capacity.		
13	Study to be made of all aspects of the operation of UAS and their integration with other managed air traffic.		
14	Study to be made of the impact of business trajectory 'ownership'. What does it imply and to what extent does it impact other aspects of the concept.	Impact of principle of trajectory ownership proposed	All
15	Study of the following automation topics: • Human-machine authority sharing; • Impact of multiple separators in the same airspace volume (may be air+ground or more than one ground authority); • Automated separation tools and safety; • Impact of automation on capacity; • Impact of loss of situation awareness and tools to manage exceptions associated with loss of situation awareness.	New automation tool, trajectory editor, implemented	E6
16	Evaluation of ground based de-confliction automation support tools with particular focus on how to ensure feasible solutions with a minimum of constraints on the users' trajectory.		

#	Research Topic	Concept results	DOD
17	The in-depth study of the coordinated presentation of warnings and other information to flight crew and ATCO to avoid cockpit and ATCO reaction being out of synchronisation.		
18	A Cost Benefit Analysis to be conducted to assess whether the costs associated with 4D avionics are justified by the potential benefits.		
19	Required accuracy of the FMS RTA function to be assessed and optimum values determined through modelling.	Consistent assumption on accuracy of RTA function applied in exercises	All
20	Issues associated with aircraft and ground system capability to be addressed. Both air and ground must have consistent capability and both should be consistently upgraded, Options need to be considered for incentives, mandates and the appropriate length of transition periods.		
21	All aspects of collaborative planning and agreement on 4D gate to gate trajectories need to be studied. The data and the data accuracy needed/included in a business trajectory at different planning states and time horizons (e.g. 6 month in advance, 7 days in advance, 2 days in advance, 2 hours in advance) need to be defined and agreed.	Planning processes defined, scenarios produced	M2
22	Study to made of the way in which Network Management will facilitate dialogue through CDM processes and how Network Management's role of 'arbitrator' and/or 'decision maker of last resort' will actually work.	Scenarios proposed and CDM processes described	M2
23	Modelling is required of Traffic Demand and Capacity Balancing (DCB) scenarios in the SESAR context.	DCB scenarios developed and processes defined	M2
24	Study of the interface of Demand and Capacity Balancing with queue management processes.	Consistent descriptions of DCB and queue management processes produced	M2
25	Evaluation of the precision with which demand should be adjusted to the available capacity before an accurate take-off time is known.		
26	Study of the practical ways in which non-airline airspace users will have effective access and participation in CDM processes. Validation of the feasibility of this issue.		

#	Research Topic	Concept results	DOD
27	Evaluation of new ACAS modes and functionality. Proposed TCAS improvements need: • Concept refinement; • Technical development / prototype development; • Validation of feasibility, benefits and safety aspects.		
28	Study to Complexity Management in the context of SESAR including the definition of the optimal parameters for the following aspects at each of the ATM capability levels: • Time horizon in which it is possible to envisage with sufficient precision the future position of the aircraft for separation purposes; • Definition of a conflict risk when outside the time horizon determined above; • Speed variation capabilities for various aircraft types under all weather conditions; • Controller perception concerning speed variation and aircraft trajectory alteration; • Operational (and environmental?) constraints.	Complexity scenario produced	E4
29	Study of ways in which the trade-off between environment, capacity and efficiency should be evaluated. This will include the development of processes and tools to visualise the predicted and actual performance. The study should take into account that many environmental friendly initiatives are contrary to the capacity increasing initiatives. The feasibility of the goal of SESAR to bring both together should be evaluated.		
30	Study of the environmental impact of various braking (deceleration on landing) regimes.		
31	Study of the impact of differential aircraft performance on the environmental and economic outcomes of ASAS spacing.		
32	Study of the environmental, economic and capacity impacts of sequencing at TMA entry.	Scenarios produced and implemented for TMA entry based on pre-sequenced traffic	E5
33	Evaluation of the use of shared airborne data. Should this be in the form of forecasts or direct update of weather models.		
34	Evaluation of the current performance and expected performance of weather forecasting.		

#	Research Topic	Concept results	DOD
35	Study of any legal issues that may be raised by the implementation of the SESAR concept.		
36	Evaluation of the compatibility and consistency of the SESAR concept with ICAO and the subsequent necessary actions.		
37	Evaluation of the merits of controller and pilot applied relative spacing techniques. Both techniques appear to have merits under different circumstances. Are there local issues that influence the answer?		
38	Evaluation of the potential effects of the application of multiple RTA and the constraints resulting form the aircrafts performance envelope, flexibility or economic profile.		
39	Studies to be conducted to address the appropriate scope of AMAN operations (for example out to what range from subject airport?).	Scenarios produced, processes described, definitions proposed and existing definitions updated	E5
40	Evaluation of the use of CTA techniques by AMAN in a mixed environment where not all aircraft are CTA (RTA) capable.	Mixed fleet scenarios implemented for arrival management process	E5
41	Evaluation of terminal route structure design involving alternative arrival techniques with multiple or single merging points.	Terminal route structure design implemented with multiple merge points	E5
42	Evaluation of Time Based Separation (TBS) on merging points focussing on accuracy requirements and benefits.		
43	Study of the management of multiple time constraints to address both airspace and airport capacity shortfalls.	Scenarios proposed and processes described	M2
44	Study of the management of multiple time constraints arising from both departure and arrival restrictions.		
45	Evaluation of the appropriate time at which CTA become a binding constraint including the needs for short route flights which are within the AMAN horizon before departure. Should a TTA become a CTA before departure in view of the likely uncertainty of the take-off time?	Decision that TTA should not become a CTA before departure	All
46	Evaluation of the impact of mixing of capable and non-capable aircraft in queue management processes.	Mixed fleet scenarios implemented in TMA	E5

#	Research Topic	Concept results	DOD
47	Evaluation of the merits of relative (ASAS) or absolute (RTA) Time Based Separation (TBS) techniques; in terms of runway throughput. Both techniques appear to have merits under different circumstances. Are there local issues that influence the answer? Associated is the issue on evaluation of feasibility and safety of less than 50 second spacing on final approach, especially if this involves late clearance to land.		
48	Study of the feasibility and scope of CDM process in arrival management.		
49	Study on dynamic risk modelling and management techniques for on-line measurement of safety risk. Study on the assessment of the overall safety of the ConOps. For now, it is not obvious that the concept's ideas all together are 'safe in principal' (as stated e.g. in Episode 3 objectives).		
50	Evaluation of the security issues associated with CDM and SWIM.		
51	Model complex scenarios of new trajectory based arrival/departure techniques plus existing SID/STAR and also with the SID/STAR from nearby airports plus transit traffic.		
52	Evaluate the feasibility of UPT and User Preferred Routing in medium density traffic situations.		
53	Evaluate the transition from UPT / User Preferred Routing in medium density situations to a more structured environment in high density operations.		
54	Study controller acceptability of ASAS Spacing versus ASAS Separation during the organisation of streams of traffic.		
55	Study the possibility to delegate both vertical and longitudinal separation to make flown TMA profiles more environmental friendly. This also makes the case for the need to pursue the investigation of ASAS separation. Could be an alternative to V-RNP.	Scenarios proposed and implemented for CDA in the TMA	E5
56	Investigation of ASAS Separation to assess its benefits/drawbacks against ASAS Spacing applications (and other concept elements). Validation of the hypothesis that delegation of separation can provide benefits in terms of ATCO availability to handle non-equipped traffic, especially in the airspace structure proposed by SESAR.		
57	Study of fallback options if aircraft declares 'unable' in mid-ASAS Separation manoeuvre.		
58	Study of the impact of 'non-deviating' or priority status afforded to 4DC aircraft on the workload associated with handling conventional aircraft in the same environment and on associated capacity issues.		

#	Research Topic	Concept results	DOD
59	Study of the feasibility and compatibility of ASAS Self Separation in mixed mode environment with the variety of other separation modes that may be applied in a mixed environment. In addition to this, for ASAS SSEP: • Procedures need to be developed; • Certification needs are to be defined; • System support including proper HMI design is to be defined and developed. These issues need to consider both, ground and air systems.		
60	Evaluation of the appropriate separation minima applicable to routes defined in 3D.		
61	Evaluation of the safety and capacity benefits of the 3D high density concepts.	Scenarios proposed for the TMA	E5
62	Development, evaluation and agreement on separation minima for each separation method included in the concept.		
63	Evaluation of the safety aspects associated with different predetermined separators for different hazards in the same airspace and different aircraft in the same airspace having different predetermined separators for aircraft hazards (mixed operations). Proof is required that this is safe.		
64	The new separation modes described - at least Dynamic Route Allocation, 4D Contracts and ASAS-Self Separation in mixed mode environment - shall be assessed with regard to maturity and potential performance: New separation modes shall be assessed with regard to maturity and potential performance: • The safety, capacity, environmental and cost-benefit outcomes of each method (any required trade-offs); • The robustness and stability of the various methods in the face of unexpected events (even of small magnitude) is to be investigated; • The impacts on pilot/controller workload and predictability. Estimations in term of ANSP and ATM system cost reduction are needed.		
65	Study of 4D Contracts to assess the required navigation accuracy and to address containment issues.		

#	Research Topic	Concept results	DOD
66	ASAS Separation procedures foresee flight crew being entrusted with separation provision tasks whilst retaining full situation awareness. Where controller task automation involves the provision of separation being entrusted to a machine, what level of controller or flight crew situation awareness should be assured.		
67	Evaluation of the transition path and the ability to achieve minimum airspace segregation.		
68	Evaluation of the relationship of airborne separation methods and automation support to ACAS.		
69	Study all aspects of integration of ground calculated with air calculated 4D trajectory components.		
70	The development of simulation tools to support Airspace Reservation dimensions and locations.	Scenarios proposed and processes described	M2
71	Studies are required to further elaborate and then demonstrate the feasibility and benefits of the advanced flexible use of airspace (AFUA), the military variable profile area (MVPA), the variable geometry area (VGA) and the dynamic mobile area (DMA).	Scenarios proposed and implemented, and processes described	M2
72	The need for and the concept of improved predictability of airspace availability based on business trajectories need elaboration. Feasibility and benefits have to be demonstrated and validated.		
73	The development of methodology and tools for complexity prognosis or complexity detection in a given airspace with a business trajectory environment. Feasibility needs to be demonstrated, benefits need to be validated.	Scenario developed and process described	E4
74	The evaluation of assumption that a 4D contract is less fuel efficient than other separation modes. This assumption is to be validated in the light of the overall ATM system performance.		
75	Evaluation of operational procedures, roles, feasibility and benefits of UDPP.		
76	The interaction of different actors in the system is not yet well understood. This is valid for all different time horizons. Due to this, the following actions are needed: • Identify all actors and their interactions; • Define the criticality of the different interactions; • Develop new methodologies for assessment of interactions (e.g. gaming); • Assess the feasibility, benefits and shortcomings of the critical and / or non-beneficial interactions; • Assess system support needed for optimising the interactions.	Actors and their interactions with processes identified, roles and responsibilities detailed	All

<table>
<tr><th>#</th><th>Research Topic</th><th>Concept results</th><th>DOD</th></tr>
<tr><td>77</td><td>Full evaluation of existing CDM implementations and future requirements to prove that CDM processes put benefit into the ATM system. It may be envisaged that e.g. different CDM processes or different support tools (several AMAN's or AMAN/DMAN/CMAN) counteract for a negative benefit to the ATM system. Thus,
Counteracting mechanisms need to be identified on all layers;
Rules for operating a CDM environment need to be deduced or developed, validated and established;
The interconnection of different stakeholder systems (e.g. FOC, APOC, ACC, TWR) need to be studied from technical and operational point of view;
Feasibility and benefit of a CDM process based system need to be demonstrated and validated.</td><td>Scenarios proposed and implemented, processes described</td><td>E4</td></tr>
<tr><td>78</td><td>Assessment of the exact definition, applicability, and information processing of trajectory management requirements (TMR) with regard to infrastructure, processes and capacity benefits (e.g. 'what is the optimum TMR for an 4D contract environment?').</td><td>Definitions discussed and proposed</td><td>All</td></tr>
<tr><td>79</td><td>Further development of the flight planning process, mechanisms and data items is needed ('A complete Flight Planning concept should define all of the information that is needed by ATM from the Airspace User at all stages leading up to (and even during) the flight.').</td><td>Processes described, scenarios developed</td><td>M2</td></tr>
<tr><td>80</td><td>Elaboration of high density separation concepts and associated airspace issues in terms of detail procedures which should be then validated with a focus on feasibility.</td><td>Processes described, scenarios developed and implemented</td><td>E5</td></tr>
<tr><td>81</td><td>Elaboration of the medium density separation concepts and associated airspace issues in terms of detail procedures which should be then validated with a focus on feasibility.</td><td>Processes described, scenarios developed and implemented</td><td>E6</td></tr>
</table>

Table 13 - Concept Detailing Work against ConOps Research Topics

Scenario Name	Exercise Use	Type of use/validation
OS-11 Non-Severe (No UDPP) Capacity Shortfalls impacting Arrivals in the Short-Term	WP3.3.1 Expert Groups on Collaborative Planning WP3.3.2 Business Trajectory management and dynamic DCB WP3.3.5 Global Performances at Network-wide level. Macromodel	Reviewed by DOD team representatives and reviewed and refined by expert group and implemented through gaming and within a process simulation and at a high level in a network model
OS-12 Landing and Taxi to Stand	WP5.3.2 Airport Expert Group	Modelled as a storyboard, reviewed by DOD team representatives and reviewed and refined by expert group
OS-13 Taxi-out and Take-off	WP5.3.2 Airport Expert Group	Modelled as a storyboard, reviewed by DOD team representatives and reviewed and refined by expert group
OS-14 Long Term capacity planning		Reviewed by DOD team representatives
OS-15 Airport Operational Plan Lifecycle for Long-term Phase		Reviewed by DOD team representatives
OS-16 Turn-round Management	WP5.3.2 Airport Expert Group	Reviewed by DOD team representatives and reviewed and refined by expert group
OS-17 Solve Hazardous Situations during Taxiing	WP5.3.2 Airport Expert Group	Reviewed by DOD team representatives and reviewed and refined by expert group
OS-18 Airport Operational Plan Lifecycle for Medium/Short/Execution phases	WP3.3.4 Collaborative Airport Planning WP5.3.2 Airport Expert Group	Reviewed by the Expert group and implemented in a fast-time simulation and gaming exercise

Scenario Name	Exercise Use	Type of use/validation
OS-19 Severe (UDPP) Capacity Shortfalls impacting Departures in the Short-Term	WP3.3.4 Collaborative Airport Planning WP3.3.5 Global Performances at Network-wide level. Macromodel	Implemented in a fast-time simulation and gaming exercise and at a high level in the network model
OS-20 Airport Capacity Shortfalls in the Medium-Term		Reviewed by DOD team representatives
OS-21 Departure from non Standard Runway	WP5.3.2 Airport Expert Group	Reviewed by DOD team representatives and reviewed and refined by expert group
OS-26 Non-Severe (No UDPP) Capacity Shortfalls impacting Departures in the Short-Term	WP3.3.5 Global Performances at Network-wide level. Macromodel	Reviewed by DOD team representatives and implemented at a high level in a network model
OS-27 Allocation of Departure Profile	WP5.3.5 TMA Trajectory and Separation Management	Implemented in a fast-time simulation and revised as needed
OS-28 Allocation of Departure Route	WP5.3.5 TMA Trajectory and Separation Management	Implemented in a fast-time simulation and revised as needed
OS-29 Closely Spaced Parallel Operations in IMC		Reviewed by DOD team representatives
OS-30 Handle Planned Closure of an Airport Airside Resource		Reviewed by DOD team representatives
OS-31 Handle Unexpected Closure of an Airport Airside Resource		Reviewed by DOD team representatives
OS-32 Management of Vehicles on Manoeuvring Area	WP5.3.2 Airport Expert Group	Reviewed by DOD team representatives and discussed in expert group
OS-33 Negotiating an ATC revision to the RBT (for En-Route queue management purposes)		Reviewed by DOD team representatives

Scenario Name	Exercise Use	Type of use/validation
OS-34 Military collaboration in the Medium-Short Term	WP3.3.1 Expert Groups on Collaborative Planning WP3.3.3 Airspace Organisation and Management	Reviewed by DOD team representatives and reviewed and refined by expert group and implemented in gaming exercises
OS-35 High density TMA Arrival - Flying CDA merging	WP5.3.1 TMA Expert Group WP 5.3.4 - Multi Airport TMA WP5.3.6 Prototyping of a Dense TMA	Reviewed by DOD team representatives, modelled as a storyboard by the expert group that reviewed, refined it accordingly, implemented in fast-time simulation and in four prototyping sessions.
OS-36 Non-Severe (No UDPP) Capacity Shortfalls impacting Multiple Nodes of the Network in the Short-Term	WP3.3.1 Expert Groups on Collaborative Planning WP3.3.2 Business Trajectory management and dynamic DCB WP3.3.5 Global Performances at Network-wide level. Macromodel	Reviewed by DOD team representatives and reviewed and refined by expert group and implemented through gaming and within a process simulation and at a high level in the network model
OS-37 Business Development Trajectory Creation		Reviewed by DOD team representatives
OS-38 Flights in the Execution Phase in a 4D environment	WP4.3.1 Expert Group En-Route Queue, Trajectory and Separation Management WP4.3.3 Gaming Exercise on Queue, Trajectory and Separation Management WP4.3.4 Prototyping on Queue, Trajectory, and Separation Management	Reviewed by DOD team representatives, modelled as a storyboard by the expert group that reviewed it and was refined accordingly, implemented in a gaming exercise and partly addressed in three prototyping sessions.

Scenario Name	Exercise Use	Type of use/validation
OS-39 Aborted Take-off		Reviewed by DOD team representatives
OS-40 Traffic complexity assessment & application of dynamic-DCB solutions	WP3.3.1 Expert Groups on Collaborative Planning WP3.3.2 Business Trajectory management and dynamic DCB	Built after Expert Group discussions

Table 14 - Level of validation of OS (see section 4.2)

16 ANNEX E – EPISODE 3 INPUT TO SESAR PROJECTS

The following table provides a list of SESAR projects that should use Episode 3 material as an input to their work.

In general, most SESAR work packages should consider the information provided in the DODs and other WP2 input. At the level of SESAR projects, individual exercise reports are useful to consider.

The following 2 tables present:

- A high level view of the inputs to SESAR work packages;
- A detailed review of Episode 3 exercise reports that can benefit SESAR projects.

The following table provides an overview of the SESAR work packages that can benefit from Episode 3 work.

SESAR		Episode 3	
WP	**Name**	**EP3 WP**	**Useful outputs for SESAR**
WP B	**Target Concept and Architecture Maintenance**	WP2	ATM process model, DODs, performance framework
WP C	**Master Plan Maintenance**		
WP 03	**Validation infrastructure adaptation and management**	WP2	Lessons learnt on validation techniques, validation strategy documents
WP 04	**En Route Operations**	WP4&WP2	E6 DOD, related operational scenarios and WP4 exercise results
WP 05	**TMA operations**	WP5&WP2	E5 DOD, related operational scenarios and WP5 TMA exercise results
WP 06	**Airport operations**	WP3, WP5, WP2	M1, E1, E2/3 DODs, related operational scenarios WP3 results on airport planning, APOC and WP5 results on runway and surface management
WP 07	**Network operations**	WP3, WP2	M2/3 and E4 DODs and related scenarios, WP3 results related

SESAR		Episode 3	
WP	**Name**	**EP3 WP**	**Useful outputs for SESAR**
			to network planning
WP 08	**Information Management**		
WP 09	**Aircraft**	WP6, WP2	E6 DOD and WP6 exercise results
WP 10	**En-Route & Approach ATC Systems**	WP4, WP5, WP2	E5 and E6 DODs, results from WP6 exercises, conclusions from WP4 and WP5 (TMA) expert groups
WP 12	**Airport system**	WP3, WP5	WP3 results on airport planning , APOC and WP5 results on runway and surface management
WP 13	**Network Information Management System**	WP3	WP3 results related to network planning and DCB
WP 14	**SWIM Technical Architecture**		
WP 15	**Non Avionic CNS System**		
WP 16	**R&D Transversal Areas**	WP2	Environment, and safety approach for SESAR validation, validation lessons learnt, influence diagrams for trade-off study

The following table provides a more detailed information for each SESAR project. Only the SESAR projects for which an Episode 3 input has been identified are figuring here. This information is non exhaustive and SESAR project leaders should first analyse this document and the WP's consolidated reports in order to better identify where Episode 3 results may benefit their project.

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
WP B	Target Concept and Architecture Maintenance	DFS			
P B.4.2	Update and maintain the development of the Concept of Operations (CONOPS) and associated ATM Services	DFS	2.2 - Clarification and Refinement of SESAR ConOps	D2.2-X - G-DOD and lexicon	First step to providing a specification for SESAR 2020 Concept

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P B.4.3	Development of the high level logical system architecture (SOA) and the technical system architecture (SoS)	ERC	2.2 - Clarification and Refinement of SESAR ConOps	D2.2-01 ATM process model	Decomposition of CONOPS that can inspire definition of ATM services for SESAR
SWP B.5	Performance analysis of ATM target concept	AENA	3.3.5 - Global Performances at Network-wide level. Macromodel	D3.3.5-02 - Simulation Report on Global Performances at Network-Wide level	Development of a High-Level ATM Performance Model - Macromodel - using Complex Networks Theory First attempt to use a Macromodel to extend the validation results & conclusions obtained at local level to the ECAC-Network level Preliminary assessment of metrics/indicators related to operational KPAs at network SESAR level.
			2.4.1 - Performance Framework	D2.4.1-03 - Performance Framework Update (including Influence Diagrams)	Performance Indicators, Influence Diagrams, and Influence Model providing the picture of the ATM Target Performances
			2.4.1 - Performance Framework	D2.4.1-04 - Performance Framework Update (including ECAC Model)	Performance Indicators, Influence Diagrams, and Influence Model providing the picture of the ATM Target Performances.
WP C	Master Plan Maintenance	ERC			
WP 03	Validation infrastructure adaptation and management	ENAV			
P 3.1.1	Validation Infrastructure Needs Management	AENA			

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P 3.1.2	Validation Tool Types and Techniques Analysis	DFS	3.3.2 - Business Trajectory management and dynamic DCB	D3.3.2-02 - Simulation Report on Business Trajectory Management and Dynamic DCB	DARTIS (Decision Aid to Real Time Synchronisation), a platform that will provide facilities for the management of human in the loop simulation involving network management actors. PROMAS (Processes Management Simulator), a process simulation tool that performs the role of the components of a complex system and reproduces the activities involved in it. PROMAS should be focused on the study of non-consistencies, processes bottle-necks, useful procedures, information flows, actions triggered by modifications of parameters, etc.
			3.3.3 - Airspace Organisation and Management	D3.3.3-02 - Simulation Report on Airspace Organization and Management	CHILL (Collaborative Human in the Loop Laboratory). This is a versatile collaborative ATM validation platform that will be adapted according to gaming requirements (rules, protocols of performance of the different actors, processes and interactions between automatic and human agents...).
			3.3.4 - Collaborative Airport Planning	D3.3.4-02 - Simulation Report on Collaborative Airport Planning	ACCES (Airport Control Centre Simulator). This is a facility equipped with a large powerwall and several operator working positions. Agents of the main stakeholders (airport, ANSP, airlines) will work together to refine the AOP at a pre-tactical level.

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
			3.3.5 - Global Performances at Network-wide level. Macromodel	D3.3.5-02 - Simulation Report on Global Performances at Network-Wide level	NETWORK-WIDE MACROMODEL. This tool consists of a dynamic model of the ECAC ATM system at a macroscopic level, based on complex network theory (Network/graph theory provides mathematical framework for proper complex simulations, while Statistical physics techniques provide fitted focuses in order to address global/coupled network effects). The model is based on deterministic equations plus stochastic components, and composed of the following layers: Network Definition, Interactions Underlying Topology (topological and geometrical information), Variables Definition (local and global, dependent and independent) and Local Dynamic Rules
			4.3.3 - Gaming Exercise on Queue, Trajectory and Separation Management	D4.3.3-02 - Gaming Exercise Report	PROMAS (Processes Management Simulator), a process simulation tool that performs the role of the components of a complex system and reproduces the activities involved in it. PROMAS should be focused on the study of non-consistencies, processes bottle-necks, useful procedures, information flows, actions triggered by modifications of parameters, etc. Role play based Exercise: Evaluation of roles and responsibilities and actor interactions.
			4.3.4 - Prototyping on Queue, Trajectory, and Separation Management	D4.3.4-02 - Prototyping Session Consolidated Report	Prototyping sessions are an intermediate step of validation between expert groups, gaming exercises, and full scale fast-time and real-time simulations. They enable an iterative approach: specific aspects of the concept being assessed separately (possibly in a simplified environment), and then gradually integrated when sufficient maturity is reached.
P 3.1.3	Validation Infrastructure Requirement Consolidation	ENAV	2.4.4 - Environment Assessment	D2.4.4-03 - Requirement enhancements of Noise Assessment models	These two studies identify the SESAR OIs for Env and Met which need to be assessed in more detail by the Validation Infrastructure. An in-depth analysis of those identified OIs will help to define the requirements and allow to compare those against available infrastructure.

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P 3.2.2	Validation Infrastructure Specifications	ERC	6.2 - Technical Validation Facilities Integration & Adaptation	D6.2-01 - Platform Description	This activity will provide the principles of an air ground integrated platform that allows performing technical validation of ATM services and functions. The actual platform developed in EP3 will allow validating these principles and will also be provided as a potential platform for SESAR work programme.
WP 04	En Route Operations	DSNA			
SWP 4.2	Consolidation of operational concept definition and validation including operating mode and air-ground task sharing	DSNA	2.2 - Clarification and Refinement of SESAR ConOps	D2.2-048 + Operational Scenarios	First step to providing a specification for SESAR 2020 Concept.
SWP 4.5	En Route – trajectory management framework in En Route	NATS	4.3.1 - Expert Group En-Route Queue, Trajectory and Separation Management	D4.3.1-02 - En-Route Expert Group Report	First analysis of En-Route operations and trajectory management.
			2.2 - Clarification and Refinement of SESAR ConOps	D2.2-X - G-DOD and lexicon	Refinement of concept regarding SBT RBT revision of trajectories.
			6.3 - Technical Validation Strategy and Support	D6.3-02 - Report on the benefits of using airborne data	Identification of data exchanged between air and ground that could provide improvements to TP.
			6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Results of feasibility A/G 4D management at ATM service level 2.
P 4.7.1	Complexity Management in En Route	AENA	4.3.1.1.1 - En Route complexity management	D4.3.1.1.1-02 - Complexity management expert group report	Intermediate results of expert group (suspended in April 2008).
			3.3.3 - Airspace Organisation and Management	D3.3.3-02 - Simulation Report on Airspace Organization and Management	First analysis of the operational feasibility of the SESAR DCB Negotiation Processes at local/sub-regional level among Civil Airspace Users, Military Users, Civil/Military Airspace Manager and the Sub-Regional Manager when a change of airspace reservation by military is produced
			4.3.1 - Expert Group En-Route Queue, Trajectory and Separation Management	D4.3.1-02 - En-route Expert Group Report	First analysis of En-Route operations and definition of complexity measurement

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
			4.3.4 - Prototyping on Queue, Trajectory, and Separation Management	D4.3.4-02 - Prototyping Session Consolidated Report	First analysis of En-Route operations and definition of complexity measurement
P 4.7.2	Separate Task in En Route Trajectory based environment	DSNA	6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D)
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D)
			4.3.4 - Prototyping on Queue, Trajectory, and Separation Management	D4.3.4-02 - Prototyping Session Consolidated Report	First analysis of En-Route operations and trajectory management under the help of prototyping sessions
			4.3.3 - Gaming Exercise on Queue, Trajectory and Separation Management	D4.3.3-02 - Gaming Exercise Report	Analysis of roles and responsibilities in En-Route sectors regarding separation tasks
			4.3.2 - Fast Time Simulation on 4D Trajectory management and complexity reduction	D4.3.2-02 - Exercise report on FTS on 4D-Trajectory Management and Complexity Reduction	First analysis of a ground holding method to reduce complexity en-route
P 4.7.5	Self Separation in Mixed Mode Environment	DFS	4.3.1 - Expert Group En-Route Queue, Trajectory and Separation Management	D4.3.1-02 - En-Route Expert Group Report	First analysis of En-Route operations with assumption of self separation in a mixed mode environment
P 4.7.6	En Route Trajectory and Separation Management – ASAS Separation (Cooperative Separation)	ENAV	6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D)
P 4.7.7	Implementation of the Dynamic Capacity Management in a high density area	AENA	4.3.1 - Expert Group En-Route Queue, Trajectory and Separation Management	D4.3.1-02 - En-route Expert Group Report	First analysis of En-Route operations and airspace management in a high density area and complex situations
P 4.7.8	Controller Team Organisation, roles and responsibilities in a trajectory based operation	NATS	2.2 E6 DOD	D2.2-048 E6 DOD	Analysis of roles and responsibilities in En-Route sectors
			4.3.3 - Gaming Exercise on Queue, Trajectory and Separation	D4.3.3-02 - Gaming Exercise Report	First analysis through gaming exercises of definition of roles and responsibilities in En-Route operations

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
	within En Route airspace (including multi-sector planner)		Management		
			4.3.4 - Prototyping on Queue, Trajectory, and Separation Management	D4.3.4-02 - Prototyping Session Consolidated Report	First analysis with prototyping sessions of definition of roles and responsibilities in En-Route operations
WP 05	TMA operations	NATS			
SWP 5.2	Consolidation of Operational Concept Definition and Validation	NATS	2.2 - Clarification and Refinement of SESAR ConOps	D2.2 + Operational Scenarios	First step to providing a specification for SESAR 2020 Concept
P 5.5.1	Trajectory Management Framework in TMA	ENAV	5.3.5 - TMA Trajectory and Separation Management	D5.3.5-02 - Separation Management in the TMA Report	Key Concepts: TMA Trajectory and Separation Management – alternative complex 2D, 3D PRNAV route structures, clearances (2D/3D PTC) and transition to/from surrounding user preferred trajectories (UPT) – (IP2)
P 5.6.1	QM1 – Ground and Airborne Capabilities to Implement Sequence	NORACON	6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	
P 5.6.4	QM-4 – Tactical TMA and En-route Queue Management	ENAV	5.3.4 - Multi Airport TMA	D5.3.4-02 - Multi Airport TMA and CDA FTS Report	5.3.4 - Key Concepts: Arrival Management and Trajectory Management – enabling advanced CDAs in a multiairport TMA (IP2)
			5.3.6 - Prototyping of a Dense TMA	D5.3.6-02 - Prototyping of a dense TMA Report	Key Concepts: Queue Management, TMA Trajectory and Separation Management – CTA, complex 2D PRNAV route structure, vertical constraints, CDA (IP2) in a high density TMA environment
			6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D)
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D)

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SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P 5.6.6	QM-6 – ASAS Sequencing and Merging (TMA-8)	ENAV	6.4.3 - Spacing Performance Validation	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR ASAS ATM service (ASAS Spacing)
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR ASAS ATM service (ASAS Spacing)
P 5.6.7	QM-7 – Integrated Sequence Building/Optimisation of Queues	DFS			
P 5.7.2	Development of 4D Trajectory Based Operations for separation management using RNAV/PRNAV	AENA	6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D)
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D)
WP 06	Airport operations	AENA			
SWP 6.2	Coordination and consolidation of operational concept definition and validation	AENA	2.2 - Clarification and Refinement of SESAR ConOps	D2.2 (M1, E1, E2/3 DODs)+ Operational Scenarios	First step to providing a specification for SESAR 2020 Concept
P 6.3.1	The Airport in the ATM environment	ERC			
P 6.3.2	Airport ATM performance (execution phase)	ERC	5.3.2 - Airport Expert Group	D5.3.2-02 - Airport Expert Group Report	Review and refinement of Execution Phase Scenarios and provision of Landing and Taxi to Stand Storyboards, Stand and Taxi to Departure Storyboards
P 6.3.3	Full integration of Airport Planning & Execution	ERC	5.3.2 - Airport Expert Group	D5.3.2-02 - Airport Expert Group Report	Review of Execution Phase against Planning Phase (WP3.3.1)

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P 6.5.1	Airport Operations Plan Definition	SEAC	3.3.1 - Expert Groups on Collaborative Planning	D3.3.1-05 - Collaborative Airport Planning Expert Group report	Provides an initial proposal on the AOP content as the vehicle for the realisation of the various collaborative airport services
P 6.5.2	Airport Operations Plan Validation	ERC	3.3.1 - Expert Groups on Collaborative Planning	D3.3.1-05 - Collaborative Airport Planning Expert Group report	Definition of the processes underlying an APOC
			3.3.4 - Collaborative Airport Planning	D3.3.4-02 - Simulation Report on Collaborative Airport Planning	Provides an initial insight into one of the possible tools by which the AOP content can be validated
P 6.5.4	Airport Operations Centre Definition	SEAC	3.3.1 - Expert Groups on Collaborative Planning	D3.3.1-05 - Collaborative Airport Planning Expert Group report	Definition of the processes underlying an APOC
			3.3.4 - Collaborative Airport Planning	D3.3.4-02 - Simulation Report on Collaborative Airport Planning	Prototype implementation of an APOC including decision support tools.
P 6.6.1	Operations in adverse weather and/or exceptional operating conditions / Recovery Management		3.3.4 - Collaborative Airport Planning	D3.3.4-02 - Simulation Report on Collaborative Airport Planning	In adverse conditions the AOP must be replanned, since the original plan is no longer feasible. The exercise will demonstrate how collaborative planning may be used to find an optimal solution in a given adverse condition.
P 6.6.2	Integration of airport – airline/ground handlers – ATC processes (incl. turnaround) in ATM	NORACON	3.3.1 - Expert Groups on Collaborative Planning	D3.3.1-05 - Collaborative Airport Planning Expert Group report	Definition of the processes underlying an APOC
			3.3.4 - Collaborative Airport Planning	D3.3.4-02 - Simulation Report on Collaborative Airport Planning	
P 6.7.2	A-SMGCS Routing and Planning functions	DSNA	5.3.2 - Airport expert group	D5.3.2-02 - Airport Expert Group Report	Updated Operational Scenarios (Storyboard) including Experts View on ASMGCS proposals
P 6.8.1	Flexible and Dynamic Use of Wake Vortex Separations	ERC	5.3.3 - Runway Operations FTS	D5.3.3-02 - Runway Operations FTS Report	Fast Time Simulation results on Crosswind reduced wake vortex separations for departures and arrivals / Reduced ILS protection zone - Fixed reduced wake vortex separations / Reduced ILS protection zone.
P 6.8.2	Brake To Vacate	ERC	5.3.3 - Runway Operations FTS	D5.3.3-02 - Runway Operations FTS Report	FTS showing benefits of Brake to Vacate at CDG and Malaga airports

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SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P 6.8.3	Separation minima reductions across flight phases	AENA	5.3.3 - Runway Operations FTS	D5.3.3-02 - Runway Operations FTS Report	Initial findings of TBS and reduced wake turbulence separations
WP 07	Network operations	ERC			
SWP 7.2	Co-ordination and Consolidation of Concept Definition and Validation	ERC	2.2 - Clarification and Refinement of SESAR ConOps	D2.2 + Operational Scenarios	First step to providing a specification for SESAR 2020 Concept
P 7.5.2	Advanced Flexible Use of Airspace	ERC	3.3.3 - Airspace Organisation and Management	D3.3.3-02 - Simulation Report on Airspace Organization and Management	Clarification on AFUA concept and Operability Assessment: - Real-time coordination to design, allocate, open and close military airspace structures on the day of operations; - Possibility for ad-hoc airspace organization at short notice; - Agreement of the Business / Mission Trajectories through CDM when military changes/needs airspace reservation.
P 7.6.1	Collaborative NOP	ERC	3.3.1 - Expert Groups on Collaborative Planning	D3.3.1-03 - Analysis of the SESAR Collaborative Planning Information: demand and capacity	Review of current processes and collection of future needs related to information to be included in the NOP along the layered planning phases.
P 7.6.2	Business/Mission Trajectory Management	ERC	3.3.2 - Business Trajectory management and dynamic DCB	D3.3.2-02 - Simulation Report on Business Trajectory Management and Dynamic DCB	Collaborative management of time-based DCB constraints in business trajectories.
P 7.6.4	UDPP	ERC			
P 7.6.5	Dynamic DCB	DFS	3.3.2 - Business Trajectory management and dynamic DCB	D3.3.2-02 - Simulation Report on Business Trajectory Management and Dynamic DCB	The Dynamic DCB process applied to arrival traffic congestion situations. In this context, the exercise will analyse the roles and responsibilities of local, sub-regional and regional actors; the interaction with business trajectory management and the frontiers / interactions with connected ATM processes (AMAN queuing, en-route complexity management, UDPP).
WP 08	Information Management	NORACON			
WP 09	Aircraft	AIRBUS			

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
SWP 9.1	Airborne Initial 4D-Trajectory Management	AIRBUS	6.4.1 - 4D Airborne Navigation Capability for CTA / RNP	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
SWP 9.1	Airborne Initial 4D-Trajectory Management	AIRBUS	6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
SWP 9.5	ASAS – ASPA	AIRBUS	6.4.3 - Spacing Performance Validation	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR ASAS ATM service (ASAS Spacing).
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR ASAS ATM service (ASAS Spacing).
WP 10	En-Route & Approach ATC Systems	THALES			
P 10.2.1	ATC Trajectory Management Design	ERC	6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
P 10.2.2	Trajectory Management Exchange Formats Definition	ERC			
P 10.2.3	ATC system support to RBT/MT Creation and Revision	THALES	6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P 10.3.2	ATC support to ASAS sequencing and merging operations	SELEX	6.4.3 - Spacing Performance Validation	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR ASAS ATM service (ASAS Spacing).
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
P 10.7.1	Enhanced Datalink Features	THALES	6.4.2 - Air Ground Initial 4D Management	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
			6.4.4 - Integration of 4D and ASAS	D6.5-01 - Consolidated validation report	Industrial feasibility of airborne and ground ATM functions supporting the mid term SESAR 4D trajectory management ATM service (Initial 4D).
P 10.8.1	Complexity Assessment and Resolution	THALES	3.3.3 - Airspace Organisation and Management	D3.3.3-02 - Simulation Report on Airspace Organization and Management	Development of a first module to measure the traffic complexity (in terms of controller's workload) and react to this complexity by adapting the VGA (Variable Geometry Area) and changing dynamically the configuration of sectors. This module will be integrated in a prototype of the sub-regional manager and airspace manager positions.
			4.3.1.1 - Complexity management expert group	D4.3.1.1.1-02 - Complexity management expert group report	Definition of complexity, roles involved, possible tools for identifying high complexity areas.
P 10.9.1	Integration of Queue Management	INDRA			
P 10.9.2	Multiple airport arrival/departure management	THALES	5.3.4 - Multi Airport TMA	D5.3.4-02 - Multi Airport TMA and CDA FTS Report	Multi Airport TMA Operations in SESAR (Schipol/Dusseldorf).
P 10.9.4	CDA and CCD in high density traffic	THALES	5.3.6 - Prototyping of a Dense TMA	D5.3.6-02 - Prototyping of a dense TMA Report	5.3.6 - CDA (IP2) in a high density TMA environment.
			5.3.4 - Multi Airport TMA	D5.3.4-02 - Multi Airport TMA and CDA FTS Report	Key Concepts: Arrival Management and Trajectory Management – enabling advanced CDAs in a multiairport TMA (IP2).

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
WP 12	Airport system	INDRA			
P 12.3.3	Enhanced Surface Routing	INDRA	5.3.2 - Airport expert group	D5.3.2-02 - Airport Expert Group Report	Updated Operational Scenarios (Storyboard) including Experts View on ASMGCS proposals.
P 12.3.4	Enhanced Surface Guidance	SELEX	5.3.2 - Airport expert group	D5.3.2-02 - Airport Expert Group Report	Updated Operational Scenarios (Storyboard) including Experts View on ASMGCS proposals.
P 12.6.2	The Airport Operations Plan (AOP), decision support tools and conflict detection tools to be integrated in APOC for managing the overall performance of the airport	INDRA	3.3.1 - Expert Groups on Collaborative Planning	D3.3.1-05 - Collaborative Airport Planning Expert Group report	Definition of the processes underlying an APOC.
WP 13	Network Information Management System	ERC			
P 13.1.4	Impact of new Roles & responsibilities on local/sub-regional/regional Network (Sub)-systems	THALES	3.4 - Collaborative Planning Report and consolidation	D3.4-01 - Collaborative planning consolidated report	Results of the studies made in WP3.
			2.2 - DODs and Operational Scenarios	D2.2-043 - M2/3 DOD and D2.2-046 - E4 DOD	Concept detailing and operational scenarios (OS-11, OS 33, OS-36 and OS-40.
WP 14	SWIM Technical Architecture	SELEX			
WP 15	Non Avionic CNS System	SELEX			
WP 16	R&D Transversal Areas	ERC			
P 16.1.1	Develop a top-down accident-incident model and a Safety Target Achievement Roadmap(STAR)	ERC	2.4.3 - Safety Assessment	D2.4.3-02 - "Top-down" SESAR systemic risk assessment	Prototype of a SESAR representative accident-incident model: methods and modelling aspects.
P 16.1.2	Ensuring ATM with SESAR is kept resilient	NORACON	2.4.3 - Safety Assessment	D2.4.3-04 - Method for systemic risk assessment for Units of Operation	Method to develop accident-incident models for individual ATM Units As first prototypes, they allow to compute the risk of an accident from: the pre-existing, aviation hazards (and their frequencies); the probability of success of each barrier in removing those hazards; and the frequency with which

SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
					failure of each barrier introduces new hazards. Alternatively, it provides informed judgements about what performance are required to be in order to satisfy SESAR safety criteria.
				D2.4.3-01 - White Paper on the SESAR Safety Target	Within the framework of the requirements engineering approach promulgated in SESAR, this gives the scope of activities to which the target refers, i.e. as a whole define what is meant by the ATM contribution to safety and risks.
P 16.3.1	Development of the SESAR environmental validation framework (metrics, methods, models, tools)	ERC	2.4.4 - Environment Assessment	D2.4.4-01 - Environmental Assessment Validation Framework	Metrics, Methods, Models and Tools for the SESAR Environmental Validation Framework.
P 16.3.2	Support to development of performance indicators	ERC	2.4.4 - Environment Assessment	D2.4.4-01 - Environmental Assessment Validation Framework	Metrics, Methods, Models and Tools for the SESAR Environmental Validation Framework.
P 16.3.3	Develop framework to establish interdependencies vs. other performance areas	NATS	2.4.1 - Performance Framework	D2.4.1-03 - Performance Framework Update (including Influence Diagrams)	Links between the different Environmental KPAs (Noise, Local Air Quality, Global emissions) and interdependencies to other KPAs (Capacity, Cost, Fuel Efficiency….).
P 16.3.4	Options to Mitigate Future Environmental Risks to ATM System Capacity	ERC	2.4.4 - Environment Assessment	D2.4.4-02 - Screening & Scoping of the SESAR OIs	
SWP 16.6	TA coordination and support function	ERC	2.3 - Validation Process Management	D2.0-01 - Consolidated Validation Strategy	Validation Framework and the Validation Methodologies to be used in the various Operational and Technical SJU Work Packages.
			2.3 - Validation Process Management	D2.3-06 - Consolidated Requirements for the Application of E-OCVM to integrated Validation Processes	Validation Framework and the Validation Methodologies to be used in the various Operational and Technical SJU Work Packages.

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SESAR WBS	SESAR DOW title	Leader	EP3 exercise ID and name	EP3 Deliverables if applicable	EP3 input to the SESAR project
P 16.6.1	Safety support and coordination function	ERC	2.4.3 - Safety Assessment	D2.4.3-03 - Note on risk model validation	Using IRP as a candidate for the accident-incident modelling and use in the overall safety assurance process for SESAR, it explains how the IRP can be considered to be validated. It considers various possible meanings of "validation", and outlines a validation strategy based on a combination of all of them. It then explains the extent to which the IRP has been validated by work to date, and recommends further work where necessary. Similar principles are proposed as applicable to the SESAR accident-incident model.

17 ANNEX F – SIMULATION PLATFORMS

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
ACCES – Gaming platform	Airport Control Centre Simulator	DLR	WP3.3.4 Airport Collaborative Planning	Facility equipped with a large powerwall and several operator working positions where agents of the main stakeholders (airport, ANSP, airlines) have worked together to refine the Airport Operations Plan.	
AIRLAB	Technico-Operational Simulation for Air Transport System	Thales	WP6.4.2 - Air Ground Initial 4D Management	Real time simulation environment, offering the capability of technical and operational validation of Avionics simulated functions, including representative cockpit HMI displays and devices, avionics equipment simulations, aircraft dynamics and environment, ground operations environment. It has been used in Episode 3 as a validation platform for FMS EVEREST: • Pre-integration for Technical Validation Platform (including pre-integration with EUROCAT), • Technical performance validation.	None
CAST – Modelling tool	ATC Simulator	Airport Research Center (Aachen-Germany) and EUROCONTROL	WP3.3.1 Airport Expert Group	A fast time simulator developed for assessing impact of CDM applications at airports. It has been used in Episode 3 to understand and evaluate the links between passenger check in processes at airports and the TOBT (Target Off Block Time) of the aircraft.	

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
CATS/OPAS	En-Route Fast Time Simulator	DSNA	WP4.3.2 Fast Time Simulation on 4D Trajectory Management and Complexity Reduction	An En-Route traffic simulation using discrete, fixed time slice execution mode.	A new functionality was added to CATS/OPAS, enabling an optimisation algorithm to take as input the delays allocated to aircraft.

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
CHILL – Gaming platform	Collaborative Human in the Loop Laboratory	ISA Software	WP3.3.3 Airspace organisation and management	A versatile collaborative ATM validation platform which has been used to reproduce the negotiation process between the Civil airspace users, Military, Civil/Military airspace manager and Sub-Regional Manager when military changes in airspace reservation. It has been adapted according to the gaming requirements (rules, protocols of performance of the different actors, processes and interactions between automatic and human agents...).	• Creation and design of ad-hoc military airspace areas in real time • Users' trajectories modifications consistent with their business models due to airspace reservations at short term • Dynamic selection of airspace configurations according to demand and capacity balancing constraints • Improvements to GUI for all network-based interoperable gaming positions (Network Mgr, Military, AOC, Regional Mgr, Area Supervisor/Game manager) • Enhance interoperability / exchange / sharing of 4D business trajectory data to support collaborative decision making • Modelling of dynamic Variable Geometry Military Airspace (VGA) • Dynamic airspace reservation/cancellation processes • VGS 'what-if' impact assessment tool • Support for dynamic sectorisation / re-sectorisation in response to projected traffic (business) trajectories • Multiple business trajectory 'what-if' assessment support • Enhancement to existing capacity/demand balancing tools • Capacity/Demand/Delay information sharing between user positions

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
CHILL – Gaming platform (cont)	Collaborative Human in the Loop Laboratory	ISA Software			• Support of multiple problem solution sets in CDM-process • Local and global business trajectory sharing model • AOC user trajectory planning support enhancements • Experimental scenario design/development support • ATM capacity model enhancement • Evaluator toolkit for metrics assessment • Complexity assessment tools • Enhancement of CHILL System Wide Information Management (SWIM) model
DARTIS– Gaming platform	Decision Aid for Real Time Synchronization	EUROCONTROL	WP3.3.2 Business Trajectory Management and Dynamic DCB	The DARTIS platform was initially developed by EUROCONTROL in support to the CAMES project (Cooperative ATM Measures for a European Single Sky) to perform ATFCM real-time simulations or on site trials in a pre-operational context. The EP3 release is an intermediate step in the process of building a validation platform enabling to demonstrate and validate concepts defined by the SESAR program such as “Business/Mission Trajectory Management & Demand Capacity Balancing”.	Business trajectory management DCB queue management Airspace User (AOC) HMI. Network monitoring functions (alerts, TTAsTTOs monitoring).

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
EPOPEE	Airbus Cockpit Simulator	AIRBUS	WP6.2 Technical Validation Facilities Integration & Adaptation	A research simulator for multi aircraft research activities: • Cockpit displays and system concepts evaluation with pilot in the loop; • HMI evaluation in representative operational environment, cockpit operations, crew workload; • Flight control laws concepts and handling qualities evaluation; • Development and test platform for new models, simulations and architecture.	
ESCAPE (and ECHOES as the HMI)	ATC Simulation Capability and Platform for Experimentation	EUROCONTROL	WP4.3.4 Prototyping on Queue, Trajectory and Separation Management WP5.3.6 Prototyping of a dense TMA	Used as a small scale real-time simulation platform with prototyping capabilities. ECHOE HMI was initially developed for CAMES project for the European Commission.	None

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
EUROCAT (including ATG)	Approach/En-Route Air Traffic Control System including Air Traffic Generator	Thales Air System	WP6.4.2 Technical Validation Facilities Integration & Adaptation WP6.2Air-Ground Initial 4D Mgt WP6.4.3 Spacing Performance Validation WP6.4.4 Integration 4D and ASAS	EUROCAT used as real-time ATC system in the Airbus air/ground simulation platform. An Air Traffic Simulator (ATG) was added to EUROCAT to simulate the air traffic surrounding the aircraft in the Airbus air/ground simulation platform.	• Ability to receive and process the downlinked 4D trajectory from the aircraft. • Improvement of the Ground Flight Data Processing, and particularly the Ground Trajectory Prediction function (improvement of the predicted trajectory). • Ability to request an ETA and a time window frame to the aircraft (ETAmin/max), within which a CTA can be selected. • Ability to issue ATC constraint to modify the reference trajectory. • Ability to transmit a whole Route clearance including final approach (STAR + VIA + Final Approach + Runway) to the aircraft. • Human Machine Interface (Initial-4D, ASAS S&M). • ATG-X interface adaptations and functional improvements.

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Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
EVEREST	Flight Management System	Thales Avionics	WP6.4.1 - 4D Airborne Navigation Capability for CTA / RNP WP6.4.2 - Air Ground Initial 4D Management WP6.4.3 - Spacing Performance Validation WP 6.4.4 - Integration of 4D and ASAS	Used as simulated FMS in the EPOPEE platform. Used in the batch tool to evaluate CTA performance of the FMS.	Ability of the FMS : • To downlink 4D trajectory from airborne to ground system periodically and on predefined events • To apply ATC constraint modifying the reference trajectory (PTC 2D, CTA) • To define an ASAS S&M procedure, including the manoeuvre 'vector then merge".
NAM – Network Analysis Model	Network Analysis Model	NLR	WP3.3.4 Airport Collaborative Planning WP5.3.4 FTS on Multi Airport TMA and CDA	Network throughput model to evaluate an ATM (aggregated) network on throughput, queuing and bottlenecks.	New was to add options for network aggregation in order to adapt a network towards more robustness.
NEMMO	Network-Wide Macromodel	Isdefe	WP3.3.5 Global Performances at Network-Wide level	A dynamic model of the ECAC ATM system at a macroscopic level, based on complex network theory.	
Opt-ATFCM	Optimising ATFCM model	NLR	WP3.3.4 Airport Collaborative Planning	ATFCM model to apply prioritisation and optimisation on ground holdings in mitigating capacity constraints in ATM networks.	Local optimisation was tested aiming to replace First Come-First Served by minimal delays to solve a bunch.
PROMAS – Process simulation platform	Processes Management Simulator	INECO	WP3.3.2 Business Trajectory Management and Dynamic DCB WP4.3.3 Gaming on Queue, Trajectory and Separation Management	A process simulation tool that performs the role of the components of a complex system and reproduces the activities involved in it focusing on the study of non-consistencies, processes bottlenecks, useful procedures, information flows.	PROMAS is a new tool specifically developed for these exercises and fulfils the original description. Tool fully described in the scope of EP3.

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
RAMS PlusTM - Fast Time Modelling tool	ATM Simulation platform used for Fast Time Simulation	ISA Software	WP5.3.4 FTS on Multi Airport TMA and CDA WP5.3.5 FTS on TMA Trajectory Management	Fast Time Modelling allows a quick method of setting up and performing an exercise providing mathematical and statistical information on ATC operations. It includes trajectory-based modelling features and new concept modelling for 4D trajectory based management and complex TMA modelling	• Advanced arrival/departure modelling for complex TMA analysis • Precision Trajectory Clearance (PTC) departures including 3D and 4D departure clearance • Alternate SID modelling concept • Use of departure cones/tubes • Required Time of Arrival (RTA) modelling • Target Time of Arrival / Metering concepts • Implementation of Path-object modelling concepts and Point-Merge model enhancements • Enhancement of existing 4D trajectory based model components Aircraft equipment based separation models • Modelling of equipment-based separation management • 2D, 3D and 4D clearances • P-RNAV operation in TMA including CDA modelling

Simulation Platform	Title	Provider	EP3 Exercise which used the platform	Description	Upgrades implemented for Episode 3
TAAM - Total Airspace and Airport Modeller - Fast Time Modelling tool	ATM Simulation platform used for Fast Time Simulation	Jeppesen	WP5.3.3 FTS on Runway Performance WP5.3.4 FTS on Multi Airport TMA and CDA WP5.3.5 FTS on TMA Trajectory Management	Fast Time Modelling allows a quick method of setting up and performing an exercise providing mathematical and statistical information on ATC operations. Fast Time Simulation tool to simulate small-scale scenarios, like Airports and ETMA/TMA scenarios, as well as large-scale scenarios, i.e. ECAC-wide. Assessment of KPIs like flight duration, delays, throughput, conflicts and workload.	For WP5.3.3, a specific customer requested development was carried out to model a non-linear deceleration rate on the runway.

18 ANNEX G – LIST OF PUBLIC EPISODE 3 DOCUMENTS

EP3 Deliverable Id	Full name	Description
D2.0-01	EP3 Consolidated Validation Strategy	It provides a consistent validation methodology based on the application of the European Operational Concept Validation Methodology to the Operational Concept developed within the SESAR Definition Phase (E-OCVM, V2). It consolidates the shared view and assumptions constructed across Episode 3 to develop the work-package validation strategy documents and support planning and conduct of appropriate validation exercises.
D2.2-040	SESAR DOD G - General Detailed Operational Description	As the first of a set of ten Detailed Operational Description (DOD) documents, it provides a description of the main assumptions and principles underlying the mode of operations, the overall view of the operational services and the description of some key elements such as Business Trajectory Management, the collaborative processes and the Network Operations Plan (NOP). It presents the environmental characteristics and constraints, related to traffic and airspace, applicable to the overall ATM system and common to the various DOD documents.
D2.2-041	SESAR DOD L - Long Term Planning Detailed Operational Description	This Detailed Operational Description (DOD) document focuses on the operating principles relevant to the Long Term Planning Phase which begins years before the day of operation, terminates six months before day of operation with the first publications of the shared business trajectories and is followed by the Medium Term Planning Phase. It addresses the following operational layers: network management, airspace and airport organisation and management, airspace user operations, when interacting with the network management function.
D2.2-042	SESAR DOD M1 - Collaborative Airport Planning Detailed Operational Description	This Detailed Operational Description (DOD) document, it focuses on the operating principles which are foreseen specifically within the medium/short term planning phase of airport operations. It also describes the Total Airport Management concept which is the result of a convergence between the SESAR Concept of Operations and the medium term Airport Operational Concept.
D2.2-043	SESAR DOD M2 - Medium-Short Term Network Planning Detailed Operational Description	This Detailed Operational Description (DOD) document it focuses on the operating principles within the medium/short-term planning phase at network level, at airspace level, and at airport level when interacting with network management function, with the objectives to plan demand and capacity, and also to balance demand and capacity.

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EP3 Deliverable Id	Full name	Description
D2.2-044	SESAR DOD E1 - Runway Management Detailed Operational Description	This Detailed Operational Description (DOD) document, it focuses on the operating principles related to runway management during the execution phase, with the objectives to increase runway throughput, to increase runway utilisation, and to eliminate runway incursions.
D2.2-045	SESAR DOD E2/3 - Apron & Taxiways Management Detailed Operational Description	This Detailed Operational Description (DOD) document, it focuses on the operating principles related to apron and taxiway movement management during the execution phase, with the objectives to balance actual demand and capacity, manage traffic queues, de-conflict and separate traffic.
D2.2-046	SESAR DOD E4 - Network Management in the Execution Phase Detailed Operational Description	This Detailed Operational Description (DOD) document, it focuses on the operating principles within the execution phase at network level, at airspace level, and at airport level only as far as airport when interacting with network management function, with the objectives to balance actual demand and capacity, and also to adjust airspace traffic and requirements.
D2.2-047	SESAR DOD E5 - Conflict Management in Arrival & Departure Operations Detailed Operational Description	This Detailed Operational Description (DOD) document, it focuses on the operating principles within the execution phase of arrival/departure operations in high and medium/low density environments, with the objectives to manage traffic queues, to de-conflict and to separate traffic and to apply safety nets.
D2.2-048	SESAR DOD E6 - Conflict Management in En-Route Operations Detailed Operational Description	This Detailed Operational Description (DOD) document, it focuses on the operating principles within the execution phase of en-route operations, with the objectives to de-conflict and to separate traffic and to apply safety nets.
D2.2-049	SESAR DOD - Glossary of Terms and Definitions (Lexicon)	This Detailed Operational Description (DOD) document, it is a complementary document which provides the glossary of terms (i.e. acronyms) as well as the description of the main definitions and terms used in the set of DODs documents.
D2.2-050	Annex to SESAR DOD G - Operational Scenarios	Annexed to the General Detailed Operational Description (DOD G), it contains the Operational Scenarios developed in various Work Packages, i.e. “Operational Concept Refinement” (WPX.2.2) of the Episode 3 project.
D2.2-051	Annex to SESAR DOD G - Use Cases	Annexed to the General SESAR Detailed Operational Description (DOD G), it contains the Use Cases developed in various Work Packages “Operational Concept Refinement” (WPX.2.2) of the Episode 3 project.
D2.3-02	Validation Requirements for Performance Framework	It identifies the system level validation requirements to be supported by the Performance Framework with the objectives to guarantee an effective performance-based validation and a system level view of the concept’s ability to meet performance targets in 2020.

EP3 Deliverable Id	Full name	Description
D2.3-06	Lessons learnt for the Application of E-OCVM to integrated Validation Processes	It presents a synthesis of the EP3 lessons learnt in the application of E-OCVM to an initial validation of a large scale, complex operational concept, such as the one described in SESAR CONOPS.
D2.3-07	Assumptions Management Lessons learnt report	Based on the EP3 experience, it presents the lessons learnt and the best practices concerning Assumption Management.
D2.4.1-04	EP3 Performance Framework	It sets out the initial structure and objectives of a Performance Framework to be used within the EP3 project and it is a key document to provide common reference for the catalogue of metrics to be used by the validation exercises, covering six of the SESAR's Key Performance Areas (KPAs): Capacity, Efficiency, Flexibility, Predictability, Safety, and Environment. It comes with four annex documents, i.e. Influence Diagrams, Catalogue of PIs, User Manual for the Influence Model, Input data and Model.
D2.4.1-04a	Influence Diagrams - Annex to EP3 Performance Framework	Complementing the EP3 Performance Framework it provides a description of the influence diagrams produced by the EP3 Influence Model Study.
D2.4.1-04b	Catalogue of PIs and Traceability OI Step vs ECAC PIs - Annex to EP3 Performance Framework	Complementing the EP3 Performance Framework it provides the Catalogue of Performance Indicators compiled and derived from SESAR. It also provides the traceability between the OIs Steps (Operational Improvement Steps) and the PIs (Performance Indicators).
D2.4.1-04c	User Manual for the Influence Model - Annex to EP3 Performance Framework	Complementing the EP3 Performance Framework and relevant software user manuals, it is a manual that explains how to get started in using, reviewing and changing the influence model.
D2.4.1-04d	Input data and Model - Annex to EP3 Performance Framework	Complementing the EP3 Performance Framework it is a .zip file that provides an ECAC wide Performance model and the associated input data repository.
D2.4.3-02	"Top-down" SESAR systemic risk assessment	It presents how the Integrated Risk Picture (IRP) has been developed and applied as a prototype to model SESAR, identifying the main uncertainties and information gaps that would need to be addressed to complete the work. It presents the preliminary estimates made by IRP of the accident risks in the SESAR ConOps.
D2.4.3-03	Note on risk model validation	It explains how far the Integrated Risk Picture (IRP) can be considered to be validated. It considers various possible meanings of "validation", and outlines a validation strategy based on a combination of all of them. It then explains the extent to which the IRP has been validated by work to date, and recommends further work where necessary.

EP3 Deliverable Id	Full name	Description
D2.4.3-04	Method for systemic risk assessment for Units of Operation	It presents the development study of the Integrated Risk Picture to represent individual ATM units such as airports, airspaces, countries or individual flights. Some example results are provided. It is a first step towards improving confidence in this model.
D2.4.4-01	Environmental Assessment Validation Framework	Complementing the EP3 Performance Framework, it provides the Environmental Assessment Framework and Guidance material. It explains the principles of the proposed approach for environmental assessment with regards to methods and tools to be used with EP3, gives an introduction on how the Key Performance Area (KPA) Environment relates to the other KPAs under analysis within the EP3 Performance Assessment Framework and develops environmental Key Performance Indicators (KPIs) applying the levelled approach of the EP3 Performance Matrix system.
D2.4.4-02	Environmental and Meteorological Screening & Scoping of the SESAR OIs	It promotes the first two steps of the European Commission Strategic Environment Assessment (SEA) which firstly determine whether an environmental assessment is necessary (screening) and secondly determine the issues to be included (scoping) in the further detailed impact assessment. It identifies OI steps which are of particular relevance for the environment, i.e. meteorological, 'noise', 'local air quality', 'global emissions'.
D2.4.4-03	Requirement enhancements of Noise Assessment models	It reports on a study to evaluating the capability of the current Noise assessment tools, taking into account the results coming from document Environmental and Meteorological Screening & Scoping of the SESAR OIs concerning Noise. It highlights the basic limitations of the current models and their strengths when conducting a noise impact assessment, the specific limitations when the tools are applied to the validation of the Noise OIs (as highlighted by the Scoping and Screening process). It emphasizes the features and functionalities (if available) needed to evaluate thoroughly the OIs and proposes possible solutions to solve these limitations.
D2.4.4-04	Study report on reduction of local aircraft emissions	It describes the methodology used to assess the impact of OIs on the local air quality (LAQ) to assure that new concepts do not result in an increase in local emissions at and near airports. It summarizes the results and provides insight into the study on measures to reduce local aircraft emissions.

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EP3 Deliverable Id	Full name	Description
D2.5-01	Episode 3 Final Report and Recommendations	Consolidated summary of EP3 achievements, it provides the findings, the conclusions and the recommendations in order to pave the way for the SESAR Development Phase work programme.
D3.3.1-02	Network Collaborative Planning Expert Group Report	It reports the results of the activities of EP3 Network Expert Group regarding Medium and Short-Term Network Planning and Collaborative Network Planning. The information provided by EP3 Network Expert Group contributes to provide guidance on SESAR Collaborative Planning Processes procedures, to support the definition of EP3 WP3 validation exercises, to refine the Detailed Operational Descriptions (DODs) and the relevant Operational Scenarios, to consolidate and analyse the main results and outcome provided by EP3 WP3 validation activities on Medium and Short-Term Network Planning, and to provide feedback on Expert Group as a validation technique.
D3.3.1-03	Analysis of the SESAR Collaborative Planning Information	It provides an initial assessment of the data to be shared between the stakeholders identified in the EP3 ATM Process Model. The report identifies the priorities of many stakeholders, and produces evidence about the feasibility of some aspects of the SESAR Concept of Operations while performing a preliminary work for its clarification. It covers collaborative planning in the short, long and medium terms, including processes such as the design of airport infrastructure, the airlines' scheduling, the capacity planning by ANSPs, the network management, the flight planning, and the civil/military coordination.
D3.3.1-04	Airline/Airport Data Exchange	It summarises the deliberations of an expert group comprising individuals from Air France, LVNL and EUROCONTROL which considered the question of the utility of a “European portal” of relevant information relating to airports. Such a portal should provide a “quick-look” capability for an airline Operations Control Centre to rapidly access relevant information for airports of their choice, so as to be able to take operational decisions in a timely manner.
D3.3.1-05	Collaborative Airport Planning Expert Group Report	It describes the results of a number of Expert Group meetings held with the stakeholders at the airport of Palma de Mallorca (PMI). The aim of these meetings was to elaborate both the potential content of the Airport Operations Plan (AOP) and a number of early ideas in the domain of situational awareness and monitoring. It provides key lessons learnt and makes recommendations.

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EP3 Deliverable Id	Full name	Description
D3.3.2-02	Simulation Report on Business Trajectory Management and Dynamic DCB	It reports results and key findings, raises issues and makes conclusions and recommendations on the validation exercise Business Trajectory Management and dynamic DCB which purpose is to provide an initial contribution to the concept clarification of DCB applied to arrival traffic management and to initiate the building of a validation infrastructure – including methodology, techniques and platforms – to support future validation work for SESAR network operations.
D3.3.2-02a	Gaming - Annex to Simulation Report on Business Trajectory Management and Dynamic DCB	Annexed to the validation exercise Business Trajectory Management and dynamic DCB, it describes the gaming experiment using a platform called DARTIS, focusing on arrival congestion management and management of TTAs in relation to business trajectory management.
D3.3.2-02b	Process Simulation - Annex to Simulation Report on Business Trajectory Management and Dynamic DCB	Annexed to the validation exercise Business Trajectory Management and dynamic DCB, it describes the process simulation experiment using a platform called PROMAS, with which collaborative planning processes were assessed extending the conclusions obtained in the gaming exercise.
D3.3.3-02	Simulation Report on Airspace Organization and Management	It reports results and key findings, raises issues and makes conclusions and recommendations on the validation exercise Airspace Organization and Management which purpose is to clarify the collaborative processes related to the AFUA Concept and airspace organization and management, considering the civil and military requirements, the process feasibility when Airspace Reservations are changed by military users, and the applicability of Human-in-the-Loop Gaming as a new validation technique.
D3.3.4-02	Simulation Report on Collaborative Airport Planning	It reports results and key findings, raises issues and makes conclusions and recommendations on the validation exercise Collaborative Airport Planning which purpose is to evaluate collaborative airport planning processes and to get some insights into possible elements of the Airport Operations Centre (APOC), using a gaming exercise and network management modelling. It analyses the interaction between operations at network level and planning at airport level, through the concept of Total Airport Management (TAM).

EP3 Deliverable Id	Full name	Description
D3.3.5-02	Simulation Report on Global Performances at Network-Wide level	It reports results and key findings, raises issues and makes conclusions and recommendations on the validation exercise Global Performances at Network-Wide level which purpose is to show evidence on the main expected performance improvements at the ECAC wide level associated to the implementation of OIs defined in the SESAR ConOps. It explores novel approaches such as Complex Systems theory and stochastic and simulations techniques (through the simulation platform ATM-NEMMO) for the quantification of performance benefits at ECAC level.
D3.4-01	Collaborative Planning Results and Consolidation	It integrates the results from all EP3 validation activities dealing with the planning phase. It provides results and key findings on Business Trajectory Management, Airspace Organization and Management, and Collaborative Airport Planning. It draws conclusions and makes recommendations on validation tools and techniques.
D4.3.1-02	En-route Expert Group Report	It describes the results of Expert Group activities focusing on the definition of En-Route queue, trajectory and separation management. It provides operational details related to the addressed concept, including trajectory management in a 4D environment, strategic complexity reduction, use of the Extended Arrival Manager (AMAN) Horizon, transition from non-structured to structured airspace, separation Management and queue Management, has given feedback to related validation exercises, issues and hot topics on the concept, and lessons learnt on the validation techniques.
D4.3.1-02a	Annex - En-route Expert Group Report	It contains the questionnaires sent to the Expert Group by using the Delphi Method and addressing the following topics: 4D Trajectory Management /Initial 4d Trajectory Management, Change From 2D PTC To ASAS S&M Operation, Strategic Complexity Reduction Using 4D PTC, Extended AMAN Horizon, Flight In Managed Airspace, Structured & Non-Structured Airspace, Multisector planner Role.
D4.3.2-02	Simulation Report on 4D Trajectory management and complexity reduction - final report	It reports results and key findings, raises issues and makes conclusions and recommendations on the FTS 4D trajectory management and complexity reduction which purpose is to assess a method to allocate takeoff times that aims at de-complexifying En-Route traffic.

EP3 Deliverable Id	Full name	Description
D4.3.3-02	Gaming Report on Queue, Trajectory and Separation Management - final report	It reports results and key findings, raises issues and makes conclusions and recommendations on the gaming validation exercise Queue, Trajectory and Separation Management which purpose is to validate technologies, processes and procedures related to the en-route area of the execution phase. It reports on the use of different gaming technique supporting tools, namely paper-based games, process simulation and web-based games.
D4.3.4-02	Consolidated Report on Prototyping on Queue, Trajectory and Separation Management	It reports results and key findings, raises issues and makes conclusions and recommendations on the prototyping validation exercise Queue, Trajectory and Separation Management which purpose is to assess the operability and acceptability of both the RBT and the CTA in the En- Route environment.
D4.4-01	En-Route Consolidated Assessment	It integrates the results from all EP3 validation activities dealing with the en-route execution phase. It provides results and key findings on Queue, Trajectory and Separation Management, looking more specifically the operability of CTA facilitation and RBT handling. It draws conclusions and makes recommendations on validation tools and techniques.
D5.3.1-02	TMA Expert Group Report - Final	It describes the results of Expert Group activities focusing on the definition of Arrival and Departure management processes. It provides operational details related to the addressed concept, feedback to domain related validation exercises but also to the initial safety assessment of the overall ConOps and to the technical validation activities addressing 4D operations and ASAS applications. It also provides lessons learnt on the Expert Group techniques (such as meetings, storyboard, Q/A spreadsheet, brainstorming), conclusions and recommendations.
D5.3.2-02	Airport Expert Group Report	It describes the results of Expert Group activities focusing on execution phase of runway and apron/taxiway for a future airport concept based around improved sharing of information and use of the latest tools. It describes the Expert Group sessions using workshop and storyboards. It provides conclusions and recommendations on the concept and the techniques.
D5.3.3-02	Runway Operations FTS Report	It reports results and makes conclusions and recommendations on the FTS Runway Operations which purpose is to reduce capacity and throughput constraints at airport runway level, and to test a number of Operational Improvements which may lead to increased runway capacity, achieving maximum runway throughput in all weather conditions.

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D5.3.4-02	Multi Airport TMA and CDA FTS Report	It reports results and key findings, raises issues and makes conclusions and recommendations on the FTS Multi Airport TMA and CDA which purpose is to enable advanced CDA in a TMA.
D5.3.5-02	Separation Management in the TMA Report (TS1, FTS2, CRE exercises)	It reports results and key findings, raises issues and makes conclusions and recommendations on validation exercise Separation Management in the TMA which purpose is to provide evidence on the expected increment of Capacity in High density TMAs through the implementation of new separation modes included in the ConOps. It describes the results of analysing how the introduction of certain ATC supporting tools might improve the conflict management, and also how the transition from one structured TMA to a smaller or larger TMA could affect both the TMA and the surrounding En-route airspace, where a User Preferred Route environment is assumed.
D5.3.6-02	Prototyping of a dense TMA Report	It reports results and key findings, raises issues and makes conclusions and recommendations on the validation exercise Prototyping of a dense TMA which purpose is to assess the operability, from the controller perspective, of the SESAR IP2 foreseen improvements of the route structures in a dense TMA, combined with the optimisation of descent procedures i.e. A-CDA, CTA constraints, and with ASPA S&M application.
D5.4-01	TMA and Airports Consolidated Assessment Report	It integrates the results from all EP3 validation activities dealing with Airport and TMA. It gathers the results, the findings and the lessons learnt concerning tools, techniques and methodologies for validation, and also operability and performance aspects. It draws conclusions and recommendations on all these aspects and raises the hot topics to be addressed in further ConOps validation activities.
D6.2-01	Platform description	It describes the architecture of the technical validation platform for ground and airborne systems, and also the required system capabilities and adaptation required to cover the technical validation requirements for Initial 4D and ASAS Sequencing & Merging evaluation.
D6.3-02	Report on the benefits of using airborne data	It reports on the work carried investigating the potential benefits delivered to ground-based controller tools by use of parameters available from aircraft, in which experts delivered opinion on how tools and systems already available could be combined and enhanced to provide an important initial step towards full trajectory-based operations.
D6.5-01	Technological Enablers Consolidated Validation Report	It gathers the results of technical evaluation of Airborne and Ground Enablers linked to ATM Capability Level 2 (Initial 4D and ASAS Sequencing & Merging), which purpose is to reach a Technology Readiness Level 4 for the tested functions. It also describes tools, techniques and methodologies used for validation.

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