EPISODE 3

Single European Sky Implementation support through Validation

Document information	
Programme	Sixth framework programme Priority 1.4 Aeronautics and Space
Project title	Episode 3
Project N°	037106
Project Coordinator	EUROCONTROL Experimental Centre
Deliverable Name	En-Route Expert Group Report
Deliverable ID	D4.3.1-02
Version	1.00
Owner	
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Contributing partners	
Entidad Publica Empresarial Aeropuertos Espanoles y Navegacion Aeréa	AENA
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Version history

Version	Date	Status	Author(s)	Justification - Could be a reference to a review form or a comment sheet
1.00	02/12/2009	Approved	Raquel García, Inés Solano, Amalia García	Approval of the document by the Episode 3 Consortium.

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TABLE OF CONTENTS

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

LIST OF TABLES

LIST OF FIGURES

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EXECUTIVE SUMMARY

This document describes the results of the Episode 3 (EP3) Work Package WP4.3.1 En-Route Expert Group focused on the definition of En-Route queue, trajectory and separation management. The objectives of this Expert Group exercise have been to provide expert support to other EP3 exercises regarding the Single European Sky ATM Research programme (SESAR) Target Concept queue, trajectory and separation management and provide concept clarifications on the related issues.

The EP3 WP4.3.1 En-Route Expert Group has contributed to the EP3 objective to support SESAR Development Phase activities, and thus focussed on supporting the following activities:

- Detail on key concept elements in SESAR;
- Support assumptions of the related exercises;
- Reporting on the validation methodology used in assessing the concept (validation methodology assessment).

The EP3 WP4.3.1 En-Route Expert Group has provided expert support to:

- WP4 – En-Route Exercises, and their feedback to the Detailed Operational Description documents (DODs), and Concept Refinement;
- WP2.4.1 – Influence diagrams;
- WP2.4.3 – En-Route Safety Assessment.

The main expert results and outputs are related to:

- 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;
- Queue Management.

More specifically, the expert group agreed that the Reference Business Trajectory (RBT) is not a gate-to-gate clearance; it is a medium term conflict minimized trajectory which must not end in a situation without solution. RBT is subject to tactical changes; an open issue is that it is not clear whether new adjustments to the RBT must be done with as little deviation as possible to the last agreed RBT or to the initial one, once an RBT is changed.

The expert group detected a gap in the responsibility time-line between the sub-regional manager and the planning controller, as well as in the main focus of responsibility: while the sub-regional manager focuses on traffic flows in their sub-region, planning controllers are focussed on the individual RBTs of flights that are about to enter their sector. The expert group determined that the Multi-Sector Planner (MSP), whose responsibilities are described in SESAR Roles and Responsibilities, covers this gap. The main task of the MSP would be to propose changes to the individual RBTs trying to reduce the complexity and minimize conflicts within the sectors and facilitating the work of the executive controllers.

The expert group agreed that in SESAR 2020, no open loop instructions will be used, There will be no directs as everybody will prefer to follow their RBT. There will be dynamic changes to the RBT that should have been agreed over a scenario during the planning phase.

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Regarding the En-Route execution phase operations, the expert group supports the statement from WP4.3.3 that the use of Collaborative Decision Making (CDM) processes which include the user are not always effective and desirable. There are processes that although not tactical, should not trigger this CDM process, as they will be repeated several times during normal operation, and 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 performing CDM process is not feasible is not limited to tactical interventions.

Regarding the AMAN, the expert group agreed with the expert group from WP5 that short term Demand and Capacity Balancing (DCB) will smooth the traffic to congested destinations to achieve a low variability of planned arrivals preventing heavy bunching to airports. This smoothing goes beyond what the Network Operations Plan (NOP) alone can achieve.

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1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

The goal of this document is to report the results of the activities performed in the WP4.3.1 Expert Group dedicated to "En-Route Queue, Trajectory & Separation Management". It also reports on the work performed in WP4.3.1.1.1 and WP4.3.1.1.2 of the previous organisation of Episode 3 ("Expert Group on Complexity Management" and "Expert Group on Separation Management" respectively). After the reorganisation of the Episode 3 project, both WPs were integrated into a single WP named "En-Route Queue, Trajectory & Separation Management".

The information provided by the Expert Group activities:

- Optimises and provides guidance on En-Route Queue, Trajectory and Separation Management;
- Supports the definition of EP3 WP4 exercises, providing the inputs needed for their development and providing feedback on the final results;
- Refines the Detailed Operational Description documents (DODs) and the Operational Scenarios.

This report integrates all the inputs provided by the EP3 WP4.3.1 Expert Group and the feedback that WP4.3.1 gave to other work packages.

1.2 INTENDED AUDIENCE

The intended audience of this report includes:

- EP3 WP4 En-Route and Traffic Management:
  - EP3 WP4.1 WP4 management and Co-ordination Leader;
  - EP3 WP4.2.2 Operational Concept Refinement Leader;
  - EP3 WP4.3 WP4 Validation Activities Leader;
  - EP3 WP4.3.2 FTS on Strategic de-confliction and 4D Precision Trajectory Clearance -PTC Leader;
  - EP3 WP4.3.3 Gaming on Queue, Trajectory and Separation Management Leader;
  - EP3 WP4.3.4 Prototyping on Queue, Trajectory and Separation Management Leader;
  - EP3 WP4.4 WP4 Final Report Leader.
- EP3 WP2 System Consistency;
- Expert Group Partners;
- SESAR Joint Undertaking (SJU) project leaders.

1.3 DOCUMENT STRUCTURE

The structure of this document is based on the EP3 Template for the Expert Group Report [19]. This introduction explains the purpose of the document, the audience involved and the background of the project. The next section contains the exercise scope and the justification for the assumptions, tools, techniques and methodology followed. The third section shows the results obtained in the Expert Group and the concepts refined in the DODs and Operational Scenarios (OS). The fourth section explains the feedback given to other WP by the WP4.3.1

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Expert Group. The fifth section contains the main conclusions and recommendations of the Expert Group. The sixth section contains the references and applicable documents. The last sections are the annexes, the first one is a list of participants in the expert group, the second one is about the questionnaires distributed during the expert group and the last one contains a summary of the Separation Management Expert Group and the Complexity Management Expert Group performed during the previous organisation of EP3.

1.4 Background

Episode 3 is responsible for the validation of the operational concept expressed by SESAR Task 2.2.2 [1] and consolidated in SESAR D3 [2], whilst ensuring preparation for partners SJU activities. So EP3 is focussed on providing:

- Detail on key concept elements in SESAR;
- Initial operability through focussed prototyping exercises and performance assessment of those key concepts, i.e. operability and performance studies;
- Initial support for identifying technical needs and initial technical impact assessment;
- Analysis of the available tools and gaps for SESAR concept validation;
- Reporting on the validation methodology used in assessing the concept.

The emphasis was placed on obtaining a first assessment of the ability of each concept element to contribute to the defined performance benefits in the 2020 time horizon corresponding to Air Traffic Management (ATM) Capability Level 2/3 and the Implementation Package IP 2. The validation process as applied in EP3 was based on version 2 of the European Operational Concept Validation Methodology (E-OCVM), which describes an approach to ATM Concept validation.

Based on the corresponding Expert Group plan [25] and validation exercise results, analyses have been performed to provide evidence (preferably measured) about the ability (of some aspect) of the concept to deliver on (some aspect) of the performance targets. According to step 4 of the E-OCVM [20], an Expert Group report should be produced to lay down the evidence of qualities and shortcomings together with issues and recommendations.

Very generally speaking, the Expert Group meeting took place before any other validation exercise and generated input for some of these exercises. Its key output consisted of a better understanding of how the concept needed to operate to be evaluated and a consensus on the best assumptions (which were then documented).

This Expert Group is included in EP3 WP 4, which addresses the operability and performance of the processes related to the day of operation when the plan developed through the collaborative planning processes is executed.

More specifically, the Expert Group exercise described in this document is included in EP3 WP 4.3.1, “En-Route Queue, Trajectory & Separation Management”, the objective of which is to explore En-Route procedures for performing Queue, Trajectory & Separation Management activities. The Expert Group has assessed the procedure’s impact on the Network Operations Plan NOP - i.e. distortion of the Reference Business Trajectory RBT- and considered the impact on capacity and efficiency. Methods to reduce complexity to a manageable level and their effects have also been discussed. After the gaming/prototyping is completed, the experts contribute to the interpretation of the results from these exercises. The interpretation is given in the overall report at the end of EP3 WP4.

1.5 Glossary of Terms

The acronyms used in the report are compiled in this section. Please refer to Episode 3 lexicon [4] for a definition of the different terms.

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Term	Definition
A/C	Aircraft
ACC	Air Traffic Control Centre / Area Control Centre
ADD	Airborne Derived Data
ADS	Automatic Dependent Surveillance
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
AOC	Airline Operational Control / Airlines Operations Centre
APOC	Airport Operations Centre
ARR	Arrival
ASAS	Airborne Separation Assistance Systems
ASAS C&P	ASAS Crossing and Passing
ASAS ITP	ASAS In Trail Procedure
ASAS S&M	ASAS Sequencing&Merging
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer / Air Traffic Controller
ATFMS	Air Traffic Flow Management System
ATM	Air Traffic Management
ATS Supervisor	Air Traffic Service Supervisor
ATSU	Air Traffic Service Unit
AU	Airspace Users
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CDTI	Cockpit Displays of Traffic Information
CFMU	Central Flow Management Unit
CL	Capability Level
ConOps	SESAR Concept of Operations
CPDLC	Controller Pilot Data-Link Communication
CTA	Controlled Time of Arrival
CTO	Controlled Time of Over-fly
DCB	Demand and Capacity Balance
DEP	Departure
DFS	Deutsche Flugsicherung GMBH
DOD	Detailed Operational Description document
DSNA	Direction des Services de la Navigation Aérienne
E-AMAN	Extended Arrival Manager
EC	Executive Controller
ECAC	European Civil Aviation Conference
EEC	EUROCONTROL Experimental Centre
EG	Expert Group
E-OCVM	European Operational Concept Validation Methodology
EP3	Episode 3

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Term	Definition
ETA	Estimated Time of Arrival
FAB	Functional Airspace Block
FC	Flight Crew
FDPS	Flight Data Processing System
FL	Flight Level
FMS	Flight Management System
FTS	Fast Time Simulation
GAT	General Air Traffic
GE	Gaming Exercise
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organisation
IFR	Instrumental Flight Rules
IP	Implementation Package
ISDEFE	Ingeneria de Sistemas para la Defensa de Espana S.A
KPA	Key Performance Area
KPI	Key Performance Indicator
MET	Meteorological Information Service
MIL	Military
MSAW	Minimum Safe Altitude Warning
MSP	Multi-Sector Planner
MTCD	Medium Term Conflict Detection
MTCD & R	Medium Term Conflict Detection and Resolution
NATS	National Air Traffic Services (UK)
NOP	Network Operational Plan
OAT	Operational Air Traffic
OI	Operational Improvement
OS	Operational Scenario
PROMAS	Process Simulator
PT	Predicted Trajectory
PTC	Precision Trajectory Clearances
RBT	Reference Business Trajectory
RNP	Required Navigation Performance
RTA	Required Time of Arrival
RTS	Real Time Simulation
SAR	Search and Rescue
SBT	Shared Business/Mission Trajectory
SDD	Safety Design Document
SESAR	Single European Sky ATM Research programme
SJU	SESAR Joint Undertaking
SL	Service Level
SWIM	System Wide Information Management
TCT	Tactical Controller Tool

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Term	Definition
TED	Trajectory Editor
TMA	Terminal Manoeuvre Area
TMR	Trajectory Management Requirement
TOC	Top of Climb
TOD	Top of Descent
TP	Trajectory Predictor
TTA	Target Time of Arrival
TTO	Target Time of Over-fly
UAV	Unmanned Aerial Vehicle
VFR	Visual Flight Rules
VLJ	Very Light Jet
WP	Work Package

Table 1-1: Glossary of Terms

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2 EXERCISE SCOPE AND JUSTIFICATION

2.1 STAKEHOLDERS

There are two groups of stakeholders involved: those external to Episode 3 and the internal project participants.

The main external stakeholder groups in air transport industry involved in the "En-Route Queue, Trajectory & Separation Management" process are described in the WP4 Validation strategy [21] .

The actual stakeholders of this Expert Group exercise are:

- Validation exercises within EP3 WP4 using the outputs from this Expert Group. These internal stakeholders are:
  - Fast Time Simulation, FTS, Strategic De-Confliction using 4D PTC, EP3 WP4.3.2 led by DSNA;
  - Gaming Exercise on Queue, Trajectory and Separation Management, EP3 WP4.3.3 led by ISDEFE;
  - Prototyping on Queue, Trajectory and Separation Management, EP3 WP4.3.4 led by EUROCONTROL;
  - Operational Concept Refinement, EP3 WP4.2.2 led by NATS;
  - En-Route Results' Analysis and Report, EP3 WP4.4 led by DFS.
- Various representatives of the air transport industry are involved in the preparation and conduction of this Expert Group. This ensures a realistic operational feedback and evaluation of the results.

2.2 DESCRIPTION OF ATM CONCEPT BEING ADDRESSED

The following text presents the description of the ATM problem and concept. Specifically the Expert Group (EG) addressed the DOD on "Conflict Management in En-Route High & Medium/Low Density Operations" E6 [22], section 4.1 "En-Route Support to De-Conflict and Separate Traffic", and, the DOD on "Network Management in the Execution Phase" E4 [23], sections 4.1.4.2 "Assess DCB Complexity", 4.2.4.1 "Adjust RBT" and the following Operational Scenario: "OS-38 Flights in the Execution Phase in a 4D Environment" [24].

2.2.1 En-Route Complexity Reduction

The issue under study in the Expert Group was En-Route complexity reduction/ management[1] which entails the detection of zones/volumes of high complexity to enable the following processes to ensure the safe and orderly management of air traffic:

- The timely transition from operations without route structures to periods when En-Route structures are essential to assure the required capacity with safety;

[1] Complexity Management is defined as "a process focused on managing overall Air Traffic Control (ATC) workload and primarily based on trajectory predictions using all information shared in the SWIM -e.g. RBTs, meteo information, NOP- with the aim of maximizing the network capacity." [9]

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- To determine the optimum sectorisation organisation to assure the efficiency of the separation provision service, including the use of dynamic sector configurations with multi-sector planning;
- The modification of individual trajectories to reduce complexity if it is considered that the efficiency of separation provision might be compromised.

Complexity has temporal and geographical dimensions. There are times of the day when airspace could feature high-complexity operations and appropriate procedures would apply. The requirement is that the periods during which the different procedures are in force must be clearly defined and controlled: users and ANSP (Air Navigation Service Provider), need certainty with regard to the procedures in use, see SESAR ConOps (SESAR Concept of Operations) F3.2.2 [1].

For a description of the main characteristics of the SESAR proposed solutions and the Operational Improvements concerned wholly or partially with the En-Route phase of flight please refer to EP3 WP4 Validation Strategy [21].

2.2.2 En-Route Queue Management

En-Route Queue Management addresses the relationship between Separation Management and aircraft flow optimization through the processes of Multi-Sector Planning and Complexity Reduction.

The following issues obtained from SESAR have been addressed through the Expert Group:

- Execution of NOP via constraint management;
- Queue management of transmission from ASAS (Airborne Separation Assurance System), into ATC (Air Traffic Control) controlled operations;
- Queue management of transition from unstructured into structured airspace;
- Queue management of transition from fully 4D into conventional operation and vice versa;
- Queue management – OAT, Operational Air Traffic, Transition.

2.2.3 En-Route Trajectory and Separation Management

A range of separation modes is available in SESAR to address various operational circumstances. These modes take advantage of trajectory sharing between air and ground and enhanced vertical and longitudinal navigational capabilities and fall into three broad categories:

- Conventional modes: in this context they refer to modes that are essentially unchanged by SESAR;
- New ANSP modes: these are new modes envisaged for SESAR that are purely applied by ATC:
    - Precision Trajectory Clearances;
    - Trajectory Control by Ground Based Speed Adjustment.
- New airborne modes: these are new modes that involve the aircraft and in which the pilot is the separator either by delegation or, in unmanaged airspace, as the standard case:
    - Cooperative Separation, ASAS-Separation;
    - Self-separation, ASAS-Self-Separation.

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The new separation modes envisaged in SESAR are:

Mode	ATM Level	Applies In Complexity
New ANSP Modes	L: low, M: medium, H: high complexity	
Precision Trajectory-2D (PTC-2D)	1-4	L/M
Precision Trajectory-3D (PTC-3D)	3-4	M/H
TC-SA	2-4	L/M/H
Precision Trajectory-4DC	4	M/H
New Airborne Modes		
Cooperative Separation: ASAS	3-4	M/H
Self-Separation: ASAS	4	L/M/H

Table 2-1: New Separation Modes envisaged in SESAR [2]

The WP4 expert group was centred on ATM Levels 2 and 3.

The new separation modes envisaged in SESAR on which WP4.3.1 has concentrated are briefly presented below based on the description given in the SESAR Concept of Operations.

Precision Trajectory Clearances (PTC): Precision trajectory clearances take advantage of the capabilities offered by ATM Capability Level 1/2/3 aircraft in terms of navigational performance and constraint management. The goal is to enable controllers, supported by conflict prediction and resolution tools and conformance and intent monitoring, to manage a significant increase in traffic while keeping total task load at acceptable levels.

2D Routes (PTC-2D): 2D routes (with lateral containment) may be defined for a given airspace volume. Whilst one specific route will be included in the RBT, alternative routes may be dynamically allocated in a trajectory revision process for separation provision reasons. The allocation of 2D routes is a de-confliction method with vertical and longitudinal separation (if required) provided by conventional techniques to complement the 2D route. This may be achieved through surveillance based separation and/or the dynamic application of constraints.

3D Routes (PTC-3D): 3D routes (with lateral and vertical containment) may be defined for a given airspace volume. The separation mode using 3D is applied dynamically to best match the aircraft's performance capability and "contain" the vertical evolution of the trajectory. The allocation of 3D routes is a powerful de-confliction method with longitudinal separation (if required) provided by ATC to complement the 3D route. This may be achieved through surveillance based separation and/or the dynamic application of constraints or delegated to flights that can utilise appropriate ASAS capabilities.

Cooperative Separation (ASAS Separation): In ASAS Separation applications the role of separator is temporarily delegated to aircrew to assure airborne separation with regard to other designated aircraft under specific circumstances. Supported by automation capabilities (including Air-Air Trajectory/Intent exchange and specific ASAS applications), flight crew may be best equipped to assure separation between their own aircraft and the designated aircraft.

Operational, technical and validation expertise was used to define exactly how these separation modes should be used and assessed in EP3 WP4 validation exercises.

2.3 Exercise Objectives

The main objectives of this Expert Group were to:

- Support the development of the EP3 WP4 validation exercises through producing the necessary Concept Clarifications required by the EP3 WP4 validation exercises mainly in terms of:

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- Exploring En-Route procedures for identifying and resolving complex situations.
- Assessing impact on the NOP.
- Considering capacity and efficiency trade-offs reducing complexity to a manageable level.
- Clarifying technical aspects related to SESAR new separation modes.

- Provide EP3 WP2 with support in the following areas:
  - Validation and Operational Scenario review and refinement.
  - Review of and commenting on the DOD provided by EP3 WP2.
  - Review and provide inputs to the influence diagrams provided by EP3 WP2.

These objectives are directly linked to the expected outputs described in the next section.

2.4 Expected Output

The expected outputs were described in the WP4 En-Route Expert Group Plan [25], section 2.4. They are listed and classified into three different categories related respectively with operational, technological and validation aspects. The description of the expected output appears together with the section of the report wherein the output is described.

2.4.1 Operational clarifications

The main operational clarifications of the expected outputs are:

- Definition of Queue and Trajectory Management including the involved operational improvements. See Section 3;
- The Roles, Responsibilities, Strategies, Objectives, Interactions and Procedures (including steps to be taken). See Section 3;
- Minimising the risk level related to the use of Queue & Trajectory Management, Complexity Management and Separation Management. See Section 3;
- Definition of Separation Management including the involved operational improvements. See Annex 2;
- Definition of Complexity Management including the involved operational improvements. See WP4.3.1.1.1 Expert Group report [5] and Annex 3;
- Functional and Operational hypotheses needed to implement all the above. See Section 3;
- Review and refinement of the Concept Scenarios of interest. See Section 3.

2.4.2 Technological clarifications

The main technological clarifications of the expected outputs are:

- Technical performance needed for operational use - i.e. in particular achievement of the operational targets set in the DODs produced in EP3 WP2 related to the EP3 WP4 scenarios. See Section 3 & 4;
- Understanding performance constraints. See Section 3;
- Validation of the Scenarios to support technical validation activities developed in EP3 WP6, including their alignment with the WP4 operational scenarios. This object

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was not achieved. WP6 experts participated in questionnaires and meetings of WP4 but no further alignment was performed.

2.4.3 Validation clarifications

The main validation clarifications of the expected outputs are:

- The criteria needed to start the transition from un-managed airspace to managed airspace and vice versa. See Section 3;
- The criteria needed to identify and categorise high-complexity operations, zones and/or volumes. See WP4.3.1.1.1 Expert Group report [5] and Annex 3;
- The criteria to select a separation mode ensuring the best compromise between foreseen technical feasibility and perceived benefits. See Annex 2;
- Precise and specific validation hypotheses to be considered in the validation process. Partly realised. The EG gave feedback to the WP4 validation exercises but no specific validation hypotheses where requested except for WP4.3.3. See Section 4;
- Precise KPI (Key Performance Indicator) definitions related to complexity management, queue & trajectory management, and separation management. Not realised. WP2 defined the KPI related to the EP3 validation exercises. The EG gave support to WP2 regarding a specific KPI. See Section 4;
- Scenarios to be used by the subsequent simulation exercises. What was obtained from the EG were not scenarios, but issues which helped to design them. The scenarios that were then designed were used by WP4.3.3 to develop different games played during the gaming sessions. See Section 4;
- Assessment of expected impact in SESAR KPAs (Key Performance Area), analysing the effects and considering the necessary trade-off between them due to the implementation of Queue & Trajectory Management, Separation Management and Complexity Management. Assessment of the impact of KPA was realised but the trade-off has not been studied. See section 3 and WP4.3.1.1.1 Expert Group report [5] and Annex 3.

2.5 Tools, Techniques and Methodologies

The Delphi Method was identified as an appropriate technique for the conduct of this Expert Group when further detailing the SESAR ATM target concept. This method consists of the systematic solicitation and collation of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses.

The Delphi Method does not suggest any kind of meetings where experts are able to discuss some key points, share information and consolidate the results. Since these kinds of meetings are considered important, the present Expert Group has used a modified Delphi method, by including some meetings where the analysed information coming from the questionnaires has been presented and studied by all participants.

The Expert Group management method proposed here aims to extract and maximize the benefits that every Expert Group method presents and minimize its disadvantages. It takes advantage of the synergy of the group discussion and removes undesirable social interactions that exist within any group [6], so that the consensus reached is as reliable as possible. The Expert Group management is based on three main features:

- Anonymity: Various sets of questionnaires are distributed to all experts and the answers of each one gathered prior to the subsequent meeting. The proposals and opinions of each member of the group are anonymous, being disseminated to other

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experts in an integrated form, without specifying the author of each clarification. This has the following positive aspects:

- Avoids one group member from influencing the others;
- Allows a member to re-establish their former view without any loss of reputation;
- Allows members to express their arguments without worrying about their correctness (this allows people to commit mistakes without losing reputation).

- Controlled feedback and iteration process. There are various rounds of questionnaires plus meetings, which allow the members of the Expert Group to know other member opinions and thus modify their former opinions.
- The final results are given in a statistical form. The presented information of the group is not just the opinion from the point of view of the majority. Moreover, this gives the grade of consensus reached by the group. The number of experts is very low to make a complete statistical analysis. The average, the mode and the variance are given in the analysis. This analysis is included in D4.3.1-02a - Annex to D4.3.1-02 En-Route expert group report - questionnaires [18], for an example see Annex: Questionnaires.

The method used when giving feedback to other EP3 WP was different. These meetings were structured as a set of presentations followed by a workshop. At least one week before the meeting a summary of the exercise was distributed among the experts together with the list of related documents - e.g. DOD E6 [22], DOD E4 [23]. The summary of the exercise was created by the Expert Group management team using as baseline the reports and experimental plans of the exercise. These summaries were reviewed by the exercise leaders before submission.

At the meeting, the owner of the WP presented a summary of the exercise. Members of the Expert Group management team presented a summary of the documents related to the exercise. After the presentations, cards were distributed among the experts. On these cards the experts wrote their expert opinion regarding the feedback asked from the exercise - e.g. the main impacts of the exercise on a DOD, the influence of an Operational Improvement (OI).

Each card was read aloud, explained by the author, discussed by all the experts, and classified under a general title. The title grouped the comments related to the same concepts or issues.

The Expert Group management team wrote minutes of the meetings and distributed them to the experts for general agreement. Non-agreements were discussed in the next meeting.

2.6 Interactions, Relationships or Dependencies

Conclusions and outputs obtained in this WP have been used by the EP3 WP4.3 exercises to obtain deeper knowledge and first indications about the potential of these management procedures. Figure 2-1 summarises the global structure for EP3 WP 4.3 and the relationships between all tasks. Each box represents a session that took place.

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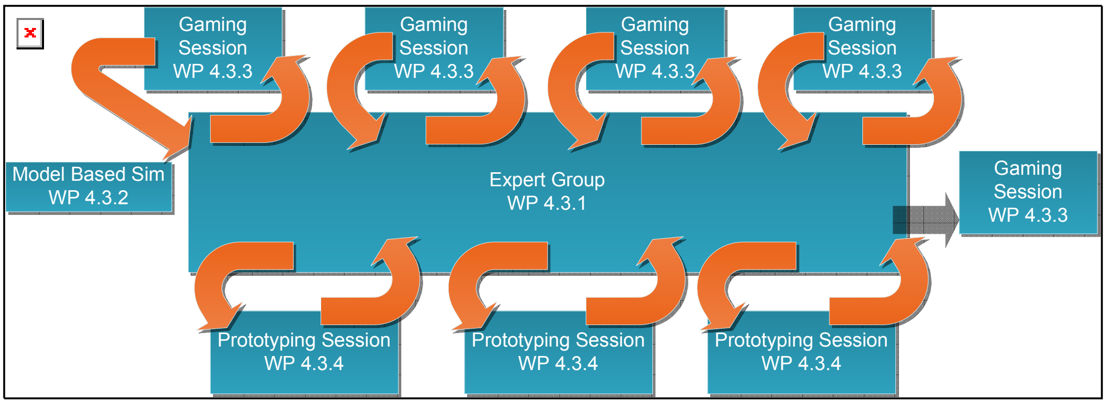

Figure 2-1: Sequence of Validation Activities in WP4.3 (source [25])

Figure 2-2 summarises the interactions between EP3 WP4.3.1 and the other EP3 WPs. As it is described in the figure, the interactions were mainly between WP4 exercises, although there was close interaction with WP2, where the EG collaborated with them, giving feedback on the DODs, scenarios and on the influence diagrams. There were also interactions with WP3 and WP5 expert groups.

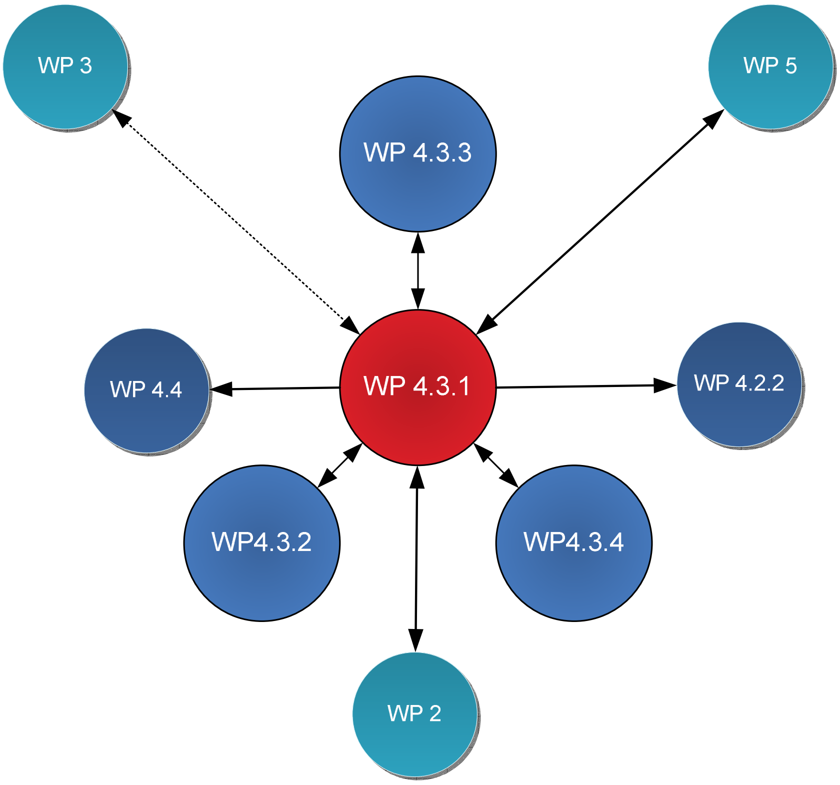

Figure 2-2: Inputs and Relationships of WP4.3.1 (source [25])

2.7 ASSUMPTIONS

The assumptions made in order to carry out the exercise are described in the following text:

- It is assumed that the state of maturity of the SESAR Target Concept [2] and the Detailed Operational Descriptions for En-Route Execution Phase [22] i.e. The main working documents for the Experts participating in the discussion - at the beginning of the Expert Group exercise is sufficient for further clarification and refinement.[2]

- The environment discussed is a SESAR 2020 environment which includes aircraft from different Capability Levels (CL), up to CL3.[3]
- Aircraft fly RBTs which are user-agreed trajectories. These agreements may not coincide with the user-preferred trajectories.

[2] This assumption proved to be true regarding some parts of the target concept whereas, in other parts several discussions took place regarding the definition and area of application, e.g. equity is understood differently by the different stakeholders.

[3] SESAR 2020 was not always the focus of discussion of the Expert Group. Initial 4D trajectory management, which is due by 2014, was also discussed. This is indicated in the report where necessary.

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3 OPERATIONAL DETAILS RELATED TO THE ATM CONCEPT BEING ADDRESSED

3.1 GENERAL OPERATIONAL DETAILS

The following sections contain the descriptions and conclusions extracted from the Expert Group meetings together with the questionnaires directly related to DODs, the SESAR ConOps and the OI's concepts.

The Expert Group wants to highlight that the time references included in the text are given for a better understanding of the text and are not compulsory or fixed. The exact time of a negotiation will always depend on the circumstances.

Open issues that need further investigation and hot topic that need further discussion are highlighted in section 5, Conclusions.

3.1.1 Flight in Managed Airspace

The concept of flight in managed airspace defined in the SESAR ConOps [1] has been refined by the outputs of the WP4.3.1. Expert Group. The following information shows part of the SESAR ConOps concept refined with these outputs.

"*In the SESAR area, airspace is either managed or unmanaged. Any airspace not specifically designated as managed is by definition unmanaged airspace. Both managed and unmanaged airspace are established and organised in a service oriented approach based on their characteristics*".

"*Managed airspace is the airspace in which all traffic is known to the Air Traffic System*". Some characteristics of managed airspace are:

- All traffic has to share its information;
- *The airspace will not have a fixed route structure except when necessary*. *Users fly in a RBT environment*;
- There is a separation provision service provider who is responsible for maintaining the separation. "*The role of separator in managed airspace may be delegated*".

SESAR defines that the RBT is the agreed trajectory *which the Airspace User agrees to fly and the ANSP and the airport agree to facilitate*. To start from this definition, the expert group agreed different statements.

The RBT is a predefined 4D trajectory as it includes times. It is not a gate-to-gate clearance, it is a medium term conflict minimized trajectory which must not end in a situation without solution. RBT is subject to tactical changes; an open issue is whether once an RBT is changed, new adjustments must be done with as little deviation as possible to the last agreed RBT or to the initial RBT (if there is no time to go through a CDM process with the airspace users). The reasoning behind both viewpoints is:

- Conformance to the initial RBT. This RBT is the best output that the Airspace User (AU) achieved taking into account all the constraints of the system, and the planning of the Airspace User is adapted to this RBT;
- Conformance to the last agreed RBT. As the constraints may have changed since the initial agreement it is the last agreed RBT that best reflects the AU preferences. The initial RBT does not reflect the real preferences of the AU but the agreed ones. If a new agreement was achieved, the AU will adapt their planning to this last situation rather then to the initial one.

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There should be a place where the initial RBT is recorded if conformance to the initial RBT has to be maintained. The record of the initial RBT will also be useful as a metric to measure to what degree the requirement of the airspace users have been achieved.

The most significant change to an RBT is a change in a Controlled Time, Over/Arrival.

Controllers will use different support tools to manage the traffic. Traffic assessment and decision support tools will offer controllers different ways to solve conflicts depending on the constraints – e.g. density, complexity, capacity- that caused the problem. These tools have to be consistent in the sense of using the same data; this does not mean that all the tools will propose the same solutions, as each tool will focus on different aspects. These tools should have knowledge of the aircraft performance capabilities in order to propose or assess feasible changes to the RBT.

The expert group agreed that in the SESAR 2020, no open loop instructions will be used, There will be no directs as everybody will prefer to follow their RBT. There will be dynamic changes to the RBT that should have been agreed over a scenario during the planning phase. If possible these agreed scenarios will be applied.

The expert group defined three different levels involved in the issue of instructions:

- Human, who can handle open loop instructions;
- Ground systems, which cannot handle open loop instructions; ground systems automatically close the loop for internal purposes;
- Avionics, which actually can handle them.

Although all the instructions will be closed loops in 2020, care must be taken when designing the avionics and procedures because the aircraft must not perform close loop instructions (automatic instructions) without the knowledge of the controller.

During the execution phase, actors will have a catalogue of solutions. The solution catalogue is a set of scenarios that contains standard problems and their solutions. Standard problems are understood here as situations that are not planned but may happen during the flight operation. These solutions have been negotiated and pre-agreed with the involved actors - i.e. AU - during the planning phase. The catalogue of solutions available to one role may differ from the catalogue available to other roles, depending on the airspace managed by each one, the timeframe, and the different type of problems they will face. The fact that there is a solution catalogue, does not limit the solutions to those in the catalogue. The solutions catalogue must be able to be implemented in a short period (to be defined by validation exercises).

The main actors of the En-Route execution phase are the flight crew, executive controller (EC), planning controller, and sub-regional manager.

The flight crew responsibility is to conduct the flight according to the agreed RBT and applicable rules.

The executive controller is responsible *for providing separation (if not delegated) for the aircraft executing their RBT within his/her area of responsibility*. Executive controllers deal with separation: their main concern is safety/separation and, afterwards, facilitating the execution of the RBT of the aircraft.

The planning controller is responsible *for establishing the entry and exit conditions of the aircraft that are about to enter/exit his/her area of responsibility and checking the planned trajectory of aircraft intending to enter the sector for potential separation risk*.

The sub-regional manager is responsible for all operations in an area or sub-region that includes several executive controllers. The sub-regional manager responsibility starts in the medium-short term planning phase which for one specific area ends around 30 minutes before the designated executive controller performs his/her work. His/her focus is the optimization of the flows and resources in the area of responsibility. In the execution phase,

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the sub-regional manager continues with his responsibilities as a back up to the work performed by the controllers, to limit the network effect of unexpected events. The sub-regional manager is also the point of contact and negotiation for the AU - i.e. the Airline Operational Centre - during the execution phase to perform the CDM processes.

The expert group detected a gap in the responsibility time-line between the sub-regional manager and the planning controller, as well as in the main focus of the responsibility: while the sub-regional manager focuses on traffic flows in their sub-region, planning controllers are focussed on the individual RBTs of flights that are about to enter their sector. The expert group determined that the Multi-sector Planner, MSP, whose responsibilities are described in SESAR Roles and Responsibilities [3], covers this gap. The MSP is an evolution of the planning controller that serves several executive controllers. The responsibility of supervision of the MSP would cover the time between the sub-regional manager and the executive controller. The number of sectors that a MSP supervises must be decided on a case by case basis. Preceding projects and studies, see e.g. Multi_Executive Sector real time simulation [16] and Analysis of Multi-sector planner concept [17], point to the necessity of studying the different characteristics of the environment and the necessity of having one executive assistant per executive controller to avoid a degradation in situation awareness[4].

The main task of the MSP would be to propose changes to the individual RBTs trying to reduce complexity and minimize conflicts within the sectors, and to facilitate the work of the executive controllers. The MSP, as a planning controller and not as a EC assistant, is responsible for negotiating the changes proposed with the flight crew when these changes must not be performing now and the current EC is not directly informed about them (for the current EC, the information will be available through the NOP). When and how this communication will be performed needs further investigation.

Typical solutions in the MSP catalogue are changes in the RBT, dynamic constraints in the RBT, activate predefined route structures around military areas, and local dynamic resectorisation. The sub-regional manager issues regulations on traffic flows which the MSP receives and further refines; applying them to individual trajectories.

Discussions were held on the following aspects:

- The ANSP support tools should be able to identify the cause of any detected problem. The discussion was centred on the fact that some experts held that the users of these tools have to be able to detect the cause of a problem due to their training and experience and there is no need of such tools which may mislead the final decision. Other experts indicated that this characteristic of the tool would be helpful for the users;
- Air traffic measures to reduce complexity should only be applied if there is sufficient level of accuracy in the prediction of the trajectories (known aircraft (a/c)). The level of accuracy must be balanced against the necessity of applying the measures as soon as possible to promote their effectiveness.

However, no consolidated agreements or conclusions were achieved and, therefore, further discussion is needed for hot topic explained in the first point and further investigation is needed for the open issue explained in the second point.

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[4] Initial definition of the MSP role was close to the current PC. After experiencing the MSP role, controllers have detected the need for considering some changes in the MSP role. That means MSP could be more a planner than an assistant. So, if this is the case and there is no longer a PC, ECs lose their second pair of eyes which results in a lack of situational awareness for the ECs'. To remediate that, the Expert Group mentioned the role of the EC assistant discussed in other projects. EC assistants can do some of the tasks presently allocated to the PC, supporting the EC in its work.

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3.1.2 Queue Management

The purpose of Queue Management is the establishment and maintenance of a safe, orderly and efficient flow of traffic.

In the En-Route operation phase, Queue Management includes the management of queues generated by Arrival Manager (AMAN) horizons extending into En-Route airspace, the management of network queues from the NOP, and the management of queues to facilitate the delivery of traffic to airports without AMAN.

En-Route controllers have to manage queues in coordination with Terminal Manoeuvre Area (TMA) controllers and adjacent En-Route control authorities. The coordination is necessary to facilitate the adjustments required to achieve the assigned time constraints and to integrate individual traffic flows (MSP and Executive Controllers) using one or more merging points as part of the dynamic or predefined routes. This coordination will be mainly performed through:

- Planned queues: they will be designated along with merge points by Sub-Regional Manager and AMAN. These planned queues will include the order and TTA (Target Time of Arrival) /CTO (Controlled Time of Over-fly);
- The definition of the activated resources (merging points);
- More coordination: there will be coordination between sectors for initiating queues further upstream. There will be also coordination between the local traffic manager and Airlines Operations Centre (AOC) to prioritize intra-company flights when possible.

Experts disagree with the statement that the Sub-Regional Manager and the Airport Operations Centre (APOC) staff generate DCB arrival queues (with the typical time horizon up to 2h). It is the NOP and the AMAN that generate the arrival queues.

3.1.3 4D Trajectory Management

4D trajectory management is defined as a situation where an aircraft is flying its RBT and it is able to follow one or more time constraints at each route clearance – i.e. TTAs, CTAs, CTOs and/or speed adjustments - with the required avionics performance (Flight Management System (FMS) and Required Time of Arrival (RTA) function). In 4D trajectory management aircraft are not responsible for separation in managed airspace which is conducted by the controller, applying the most suitable mode. In this environment, the 4D function is the function in the aircraft system that provides the capabilities needed.

This environment includes the capability of sharing the trajectory with the NOP to enable the trajectory to be used for planning and tactical purposes as it provides the controller with a more reliable means of predicting the future position of an aircraft and particularly its relationship to the trajectories of other concerned flights.

The WP4 expert group discussed trajectory management with special focus on initial 4D trajectory management in which an aircraft flies its RBT following only one single time constraint at each route clearance (TTAs, CTAs, CTOs and/or speed adjustments). As the initial 4D trajectory management is not a 2020 concept, the clarifications defined for initial 4D trajectory management have been revised to consider the full capability of the 4D trajectory management. The clarifications that are only related to initial 4D function are indicated in the text.

The main processes involved in 4D trajectory management, sequenced in time, are:

- Trajectory preparation process (including Shared Business Trajectory (SBT) and RBT/4D trajectory);

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- Taking into account aircraft capabilities to adhere to the RBT (performance base clearances);
- Downlink of 4D data: current position, predicted positions· (Altitude, Latitude, Longitude, Time Over Significant Point, Point Type), and FMS status (managed, selected, etc.);
- Providing the controllers with accurate trajectory information, intent information, and trajectory change mechanisms;
- Data link close loop between the airborne and ground systems, enabling the sharing of the same RBT for the purpose of using it in the Ground Based Trajectory prediction tool.

Several roles, actors and systems take part in 4D trajectory management; these roles are air traffic controllers - i.e. executive controller, multi-sector planner-planning controller and airport ATC - flight crew, network manager, military airborne and ground systems, System Wide Information Management (SWIM), Airline Operations centre, and Meteorological Information Service (MET).

Experts considered the following Operational Improvements (OIs), as directly applicable to initial 4D trajectory management. They are therefore essential for full 4D trajectory management:

Code	Title
AUO-0301	Voice Controller-Pilot Communications (En-Route) Complemented by Data Link
AUO-0302	Successive Authorisation of Reference Business / Mission Trajectory (RBT) Segments using Data-link
AUO- 0303	Revision of Reference Business / Mission Trajectory (RBT) using Data-link
AUO-0304	Initiating Optimal Trajectories through Cruise-Climb Techniques
CM-0301	Sector Team Operations Adapted to New Roles for Tactical and Planning Controllers
CM-0302	Ground based Automated Support for Managing Traffic Complexity Across Several Sectors
CM-0401	Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number
AOM-0504	Optimum Trajectories in Defined Airspaces at Particular Times
AOM-0701	Continuous Descent Approach (CDA)
AOM-0801	Flexible Sectorisation Management
IS-0301	Interoperability between AOC and ATM Systems (FDPS, Flight Data Processing System)
IS-0302	Use of Aircraft Derived Data (ADD) to Enhance ATM Ground System Performance
IS-0303	Use of Predicted Trajectory (PT) to Enhance ATM Ground System Performance

Table 3-1: OIs applicable to the Initial 4D Management

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Selection criteria for the list of OIs, and for new OIs that may appear along the SESAR lifecycle, are to:

- Facilitate the air to ground or ground to ground data exchange;
- Provide a common view of aircraft trajectories (between ground and board);
- Contribute to collaborative decision making (CDM);
- Contribute to complexity reduction;
- Contribute to Airspace capacity management;
- Be related to new separation modes;
- Be related to minimising segregation.

Experts believe that 4D trajectory management will improve mainly the Capacity, Predictability and Efficiency of the trajectory management. It will also impact on the other KPA. Next figure shows the average of the WP4 expert judgement of the related impact per KPA, where 3 is a high positive impact and -3 is a high negative impact. Access & Equity, Security and Environmental sustainability are very slightly positively impacted.

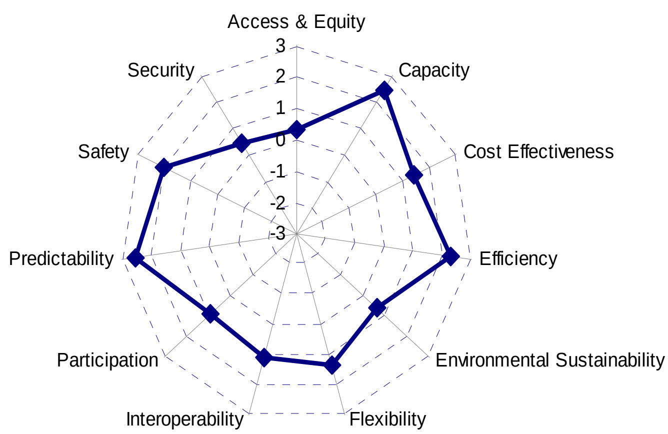

Figure 3-1: Impact per KPA in 4D trajectory Management

There are show-stoppers that would prevent the use of this type of trajectory management if present in its validation; the main one is that the 4D function in the aircraft system must be safe. Another show-stopper is the requirement for 4D trajectory management to prove itself as being efficient and reliable in resolving complex scenarios. Validation goals for the tools and procedures that will be developed are that the ATC system and controllers have the capability to use the 4D information.

The main technical constraints foreseen for its implementation are:

- The failure to provide a system to system capability for the exchange of trajectories;

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- The assurance of the overall integrity of the RBT data;
- Speed and reliability of data exchange means;
- Obtaining sufficient accuracy and predictability in the information exchanged; and
- The controller workload due to the 4D trajectory management tools.

Regarding the operational constraints a caveat appears: a high level of coordination and harmonisation between involved stakeholders to develop operational rules in En-Route airspace is required to achieve seamless operation in European Civil Aviation Conference (ECAC) airspace. Other operational constraints that will hinder the use of the 4D trajectory management are the ratio of 4D equipped aircraft, that is, the threshold of availability at which system wide efficiencies will be realised; the stability of the solution in case of simultaneously required adaptations; procedural redundancy in case of individual aircraft failures; and the coexistence of several separation modes in one airspace.

Related with this last topic, in a mixed equipage environment the expert group detected the need for a clear definition of the different responsibilities, and the possibility that airspace organisers and managers might establish zones where ATM capabilities match the same requirements to decrease complexity and controllers workload. The principle of operation will be that the best equipped aircraft receive less onerous constraints. The less capable aircraft, which are flying conventional modes of separation, are more dependent on the real time traffic conditions and are the first candidates for receiving tactical restrictions. Nevertheless, aircraft flying their RBTs (2D and 3D) are also candidates for receiving trajectory changes or RBT revisions due to the requirement for tactical intervention and, if time permits, for receiving short to medium term negotiated complexity reduction constraints.

Different events may impact the operational use of 4D trajectory management, such as:

- Air-Ground data link not available (for one or many aircraft);
- Airborne systems data not available (for one or many aircraft);
- Unavailability of Trajectory Prediction data;
- ATC Tactical instructions are not updated in the aircraft (either because the aircraft is not updating it, or because the pilot is not introducing the input); also related to tactical instructions is the use of intense tactical interventions which eliminates the usefulness of 4D trajectory management;
- Use of open loop instructions;
- Inability to comply with 4D operation through Trajectory Management Requirements;
- Incoherence between “on board” and ground trajectories.

Keeping in mind that the WP4 expert group is related to the execution phase, the classification of the most important tools has been divided in three groups; 1) real time execution - when a designated aircraft is in one sector and it is under the supervision of an executive controller; 2) some minutes before the designated aircraft enters the sector, e.g. 5-20min; 3) around 25-35min before the aircraft is to enter the sector.

1) The most important supporting tools during the real time execution of the 4D trajectory are related to the exchange of information and the “real time” management of the aircraft. The main user of these tools is the executive controller. In this timeframe, two different types of tools should be available; the first category of tools facilitates communication and identifies potential conflict without providing solutions whilst the second, developed from the first, will provide resolution advisories:

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- Separation Assistance Tool: For Executive Controller. Aid for separation and sequencing aircraft in real time;
- FMS capable of down/uplink of trajectory data (Trajectory Management Requirement (TMR) changes, time and speed constraints);
- Intent and Conformance Monitoring Tool. Automatic prediction and detection of deviations from RBTs. Close loop trajectory change proposals;
- Ground tools capable of communicating trajectory to the a/c for direct loading into the FMS;
- What if tool.

2) With the concept advocating giving responsibility for complexity/conflict detection into the hands of planning controllers, tools to predict possible conflicts in the medium term acquire importance. Some minutes before aircraft enters the sector - e.g. 5-20min, the most important supporting tools of 4D trajectory management are:
   - De-confliction Console: Medium Term Conflict Detection and Resolution (MTCD&R) for Complexity Manager and Planning Controller. De-conflicting options, negotiation and solutions within a given anticipated period of time;
   - FMS capable of down/uplink of trajectory data (TMR changes, time and speed constraints);
   - FMS capability of RTA function to comply with CTO/CTA on a waypoints and speed adjustments;
   - Data correlation tool: for monitoring and correlate trajectory data from shared airborne and ground systems;
   - Trajectory management tools to display 4D-information and to modify 4D-trajectories.

3) In the preceding time -e.g. 25-35min before a designated aircraft enters a sector-, the tools to plan, modify and see the effects of changes on the trajectory become most important. The main user of these tools is the MSP.
   - Trajectory Management tools to display 4D-information and to modify 4D-Trajectories;
   - What if probing;
   - CDM process support tools;
   - Extended potential problem detection & resolution tool.

As high level requirements, these supporting tools should be accurate, effective, easy to use, fast and efficient. They also should improve the trajectory prediction compared with current tools, and must be able to integrate and analyse a great number of request and constraints, and quickly find an appropriate trajectory.

In the context of an environment of 4D trajectory management, the change between ASAS and 4D can be requested by both, aircrew - i.e. ITP ASAS - and controller, or be an integrated part of the 4D trajectory. The change to ASAS self separation probably will also take place when the aircraft enters unmanaged airspace from controlled airspace.

The transition from 4D trajectory management to ASAS starts with the request from the pilot/airspace user for ASAS separation or as a proposal from the controller. The request is

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assessed, and if the air traffic situation seems appropriate, it is studied through a what-if assessment. Several factors are taken into account for this assessment - e.g. the sector adverse or positive effects, controller workload, complexity level, estimated duration of the ASAS separation mode, and the point where the separation delegation returns to the controller. Then, coordination and preparation take place: these include the message exchange between ground and onboard in order to define the transition points - in time or position-, duration of the ASAS mode, and any frequency change. Afterwards, either the transfer phase starts and the pilot begins the action, or the transfer is denied and the actors wait for another situation. Finally, the change of separation mode is implemented.

3.1.4 Strategic complexity reduction using 4D PTC

The use of the knowledge of the full 4D trajectory for strategic complexity reduction was discussed in the expert group. This section presents the main conclusion related to this theme. The 4D PTC it is not understood as a 4D contract but as the use of very accurate information by the ANSP.

Strategic complexity reduction using 4D PTC is a procedure with which the network management can increase traffic flow, decrease complexity and avoid frequent transitions through fixed routes. At the same time, it can reduce coordination with military authorities. An algorithm is used to calculate the precise model of 4D trajectories to ensure that there is no complexity between tracks to achieve the purpose of optimizing the network.

Strategic complexity reduction using 4D PTC could compare 4D trajectories and detect complexity according to Trajectory Management Requirement (TMR) limits. The time horizon when this could be used is before entry in the sectors where complexity will be reduced to consolidate these sectors. Strategic complexity reduction using 4D PTC could also be used to develop 4D clearances (new trajectories) that would put aircraft on separated trajectories – e.g. an off-track trajectory will be assigned to an aircraft that needs to descend and cross one or several aircraft flying below, or to create safe separation on converging trajectories –e.g. a speed change or alternate trajectory to pass at a predefined distance from another aircraft. The time horizon corresponding to “strategic” is an open issue that has to be defined.

4D-PTC enables the ANSP to validate that an aircraft will be complexity free for a longer portion of flight. Strategic complexity reduction will be considered for traffic without a 4D contract in a mixed environment.

Several processes will be involved in strategic complexity reduction using 4D PTC. The first one is the request process for a 4D Nominal Trajectory revision. This request can be triggered by different reasons like - e.g. separation provision, sequencing, short to medium de-complexifying action, weather, changing arrival constraints, pilot request, controller request, or disruptive events. In the next process the proposed trajectory is compared with the 4D trajectory data of all potential traffic for the next 20 to 30 minutes, which is the time necessary for a flight to go through a Functional Airspace Block (FAB) or ACC Area Control Centre (ACC), to know if it is possible to accept the 4D revision. After that, the complexity has to be calculated, the possible solutions have to be assessed by a what-if analysis combined with complexity reduction measures. Other processes involved are the combined air/ground trajectory correlation process, the FMS 4D route intent and conformance monitoring process, and the ground 4D route intent and conformance monitoring process. Finally, depending on the situation, the coordination with the military process may be necessary.

The different roles, actors and systems involved in the process of strategic complexity reduction using 4D PTC are:

- Multi-Sector Planner/ planning controller;
- Ground System: Display Scenarios and De-confliction / Separation Options. RBT calculation and correlation;

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- Airborne System: PT Calculation, RBT Correlation, RTA Function;
- Complexity Manager;
- ATC Operational Manager;
- Network Operation Manager;
- Flight crew: Monitoring flight, comply with CTAs/CTOs/Waypoints and TMRs;
- ATC – Executive controller: Trajectory Clearance Process. Separation Tactical intervention.

The Expert Group came to the conclusion that the best operational procedure to use strategic complexity reduction using 4D PTC would be as follows:

> An aircrew – or its AOC- files a preferred 4D trajectory for a certain flight. This RBT is then adapted through a number of iterations - e.g. because the most preferred runway slots might not be available, the aircraft on the gate is slightly delayed, weather changes, the taxi time is longer then expected, the line up is slightly delayed due to bird control. These RBT changes are executed between aircrew – or its AOC - in terms of requests, acknowledgements and options to choose from. A last resort is "no RBT available" corresponding to the lack of an airway clearance
>
> The strategic complexity reduction process actuates once the RBT is loaded into the FMS. If no change is needed, aircraft proceed to the next authorised flight section of the trajectory. If the Planning Controller detects conflicts in advance in any point of the trajectory then a change in the RBT is needed as an strategic complexity reduction process. The RBT change process occurs either by RBT revision, or as an automated RBT update, proposing changes in CTOs/TTAs/CTAs to the AOC/Pilot or in other flight parameters of the Trajectory. In addition, new TMRs can be given in order to save events that require tight parameters.
>
> The revision of the RBT is initiated by the detection of loss of separation and the definition by the system on the ground of a safe new 4D trajectory. This proposition goes to the concerned pilot for agreement (or rejection) and then the new active 4D trajectory is inserted in the FMS.

The simplest procedure for managing constraint changes is when RBT changes are done automatically, known as an RBT update. They are minor deviations from the initial agreed RBT resulting from variations in wind speed and aircraft performance. Strategic complexity reduction is always applied in advance reducing conflicts and maintaining flight efficiency. These are closed loop deviations.

The accuracy of trajectory conformance to ensure the benefit of this process should be around 1NM lateral, 100ft vertical, and 1-2 minutes in time. Nevertheless, there will always be some inaccuracy that will probably include the 10% of the aircraft with a deviation of around 5%.

Strategic complexity reduction using 4D PTC can be implemented using the initial 4D trajectory management process, but it will not offer full benefits and could produce some adverse effects; for this reason some experts are sceptical regarding its use before 4D trajectory management is fully developed. There should be a trade-off study to determine if initial 4D aircraft trajectories should be used in complexity reduction actions (through RBT revision) due to its better flexibility to adapt to changes or whether it should be based upon less capable aircraft. It is presumed that it will depend on the number of better equipped aircraft that pass through a particular sector. Strategic complexity reduction methods will be more effective and have fewer adverse effects if a high number of aircraft are equipped with the required systems to perform 4D trajectory management.

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Strategic complexity reduction using 4D PTC can also be applied to reduce complexity locally because it depends on the uncertainty of the aircraft position. It does not depend on the geographical context if the uncertainty levels are low enough. In high level of uncertainty, strategic complexity reduction should not be applied, as it may produce more complexity instead of reducing it. In that sense, local events that are predicted sufficiently in advance can be de-complexified using this method. But, again, it will depend on the level of aircraft ATM capability of the flights involved to take in 4D TMRs changes. In time-critical situations, tactical intervention will be better.

The timeframe of strategic complexity reduction using 4D PTC applications depends on the required accuracy for trajectory prediction, trajectory conformance and the availability of that information (still under research). However, it is possible to give approximate values. It is about 10 to 20 minutes for local events in a specific place, for a determined time frame and in a short time horizon.

To optimize complex situations it could work on the following parameters:

- Average delay time and amount of de-conflicted flight;
- Minimum separation distance;
- A high rate of change;
- Accurate flight time and distance (predictable);
- Minimum flight time and distance;
- Reducing potential conflicts through optimizing take-off time, sector workload will be reduced.

In strategic complexity reduction using 4D PTC some uncertainties can be encountered:

- Accuracy and compliancy of the trajectory;
- Unexpected events (thunderstorm, emergency, etc);
- Operational procedure with military authorities;
- Data link: time needed to compose, send and acknowledge the message;
- Open loop instructions.

3.1.5 Separation Modes

New separation modes will be used in 2020, together with conventional separation modes, which will continue to be used as today but with more accurate data. These include precision trajectory clearances, PTC, which will take advantages of the navigation performances of the aircraft. The available types of PTC in 2020 include PTC-2D, and PTC-3D. Another type of separation management includes the temporal delegation of the separation provision from ground controllers to flight crew, through the use of the Airborne Separation Assurance System, ASAS, of the aircraft.

Airspace Users can not decide the type of separation modes they want to use, this is done by controllers taking into account the aircraft characteristics. Controllers can accept proposals from users - e.g. ASAS in trail procedure - but controllers are responsible for the final decision.

The information about separation modes has been completed with information from SESAR ConOps.

3.1.5.1 Change from PTC-2D to ASAS procedures

Precision trajectory clearance in 2D will be used to authorise the execution of a 2D route with the required precision. The precision with which the 2D route should be flown will be specified

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and combined with the lateral spacing of the routes. The 2D route design will ensure separation between the subject aircraft and other aircraft on adjacent 2D routes, subject also to ground and airborne monitoring requirements.

ASAS S&M (ASAS Sequencing & Merging) has the objective of redistributing tasks related to sequencing (e.g. in-trail following) and merging of traffic between the controllers and the flight crews. The controllers would use new instructions to direct the flight crews to undertake a new task, establishing and maintaining a specified spacing distance or time from a designated, preceding, aircraft.

There are five possible environments in which it is possible to operate with flights using PTC-2D and ASAS S&M, three operational environments and two technical environments.

The technical environments are:

- When a temporary 'fixed routes' airspace has to be applied; this type of separation mode can contribute to assisting the controller in spacing actions for aircraft flying the same fixed route and will also contribute to building the arrival sequence;
- In airspace with mixed operation modes, ASAS 2D S&M may be used by lesser equipped aircraft to achieve more regular runway flows and optimise the runway throughput. In that way the more accurate separation modes available to the more capable aircraft may be utilized with the lesser equipped flights interspersed via ASAS, maximising the throughput of the global network.

The operational environments are:

- In a managed airspace where all aircraft intentions are known, all aircraft that are involved in ASAS procedures are correctly equipped and pilots and controllers are equipped with a monitoring system for the trajectories;
- When the flights are in low capacity airspace;
- When the aircraft are flying in fixed or temporary airspace.

The operational procedure to use ASAS S&M from a PTC-2D environment in the operational and technical context described above has to follow the next four steps. The first one is to identify the target aircraft. Next, it is necessary to transmit the clearance to the flight in charge of the manoeuvre and, if the pilot agrees, he/she execute the S&M procedure while the controller/pilot monitors the separation.

During the transition between 2D and the use of ASAS, the system in charge of ATC (ATCO, Air Traffic Controller, + tools) will be in charge of the consistency of the air situation with the transmission of the appropriate clearances. This way of sharing out the responsibility produces a decrease in the capacity of the airspace.

2D separation mode is used in low complexity airspace, but ASAS is used in high complexity airspace. In this mixed mode, aircraft performing conventional spacing and ASAS S&M will coexist. Apparently, this will have no negative effect in stabilizing and correcting the sequence, provided ASAS operating aircraft have a stable trajectory evolution; and this will free controller resources.

The supporting tools associated with the use of ASAS S&M in a PTC-2D environment separation mode will be, in order of importance:

- Automatic Dependent Surveillance (ADS) B/out for Surveillance spacing;
- Monitoring tool for the pilot;
- A trajectory definition tool for the pilot;
- SWIM linked Data Correlation Tool for monitoring and correlating Trajectory Data from shared Airborne and Ground Systems;
- Device enabling the display of the new trajectory (on the radar picture for instance);

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- Assessing tools/flow management procedure/special coordination procedure;
- Intent and Conformance Monitoring Tool (Predict and detect deviations from RBT's).

These supporting tools need the following high level requirements:

- Responsibility sharing definition;
- Accurate;
- Fast;
- Effective;
- Easy to use;
- Cheap.

To assess the operational feasibility of changing from PTC-2D and ASAS S&M, a carefully designed procedure is needed. The first step of this procedure is to assess the situation using fast-time simulations and extract the conclusions. After that, if the simulation indicates as a result that the separation mode can be implemented, coordination between the actors involved will take place and flow management coordination applied if needed. As a final step, the separation mode is implemented.

3.1.6 Extended AMAN Horizon

The Extended AMAN (E-AMAN) Horizon is a concept refined by the WP4.3.1 Expert Group. Some statements are completed with information from SESAR ConOps [1].

The Expert Group of WP4 and the Expert Group of WP5 exchanged emails and had a meeting to coordinate regarding the En-Route –TMA interface, specifically regarding the kind of traffic delivery from En-Route sectors to TMA sectors, and the degree of complexity reduction that could be expected from the planning phase.

Agreed assumptions in both groups are that short-term DCB will smooth traffic to congested destinations in order to achieve low variability of planned arrivals, this smoothing goes beyond what the NOP alone can achieve. Experts agreed that days of heavy "bunching" into congested aerodromes will be gone with SESAR.

The AMAN is a tool that is used to provide arrival sequence time information into the TMA and En-Route decision making. Extended AMAN Horizon is the same tool but with a longer horizon; this extended horizon corresponds to around 200NM, longer than the present horizon that is 100NM. These figures are examples as the exact horizon of the Extended Arrival Manager (E-AMAN) depends upon the place of application.

The AMAN horizon can assign target times or constraint times to flights; these times are indicated "*in the RBT are estimates, some may be target time (TTA) to facilitate planning and some of them may become constraints (CTA, CTO) to assist in queue management when appropriate*". TTA is assigned for planning reasons whilst CTA is assigned only when the aircraft is flying. The assigned CTA will be reasonable close to TTA and will be assigned in order to specify the landing sequence in the AMAN airport. The CTA sequence will be different from the TTA sequence due to the CTA sequence includes the delay.

The extended AMAN horizon will be used to provide arrival sequence time information into the En-Route decision, providing earlier planning than nowadays. This enlargement of the horizon will improve the level of predictability and time reliability as it provides an enhanced and more consistent arrival sequence and more time for En-Route controllers to facilitate the de-bunching of the traffic and the preparation of the queue. Another of the advantages of the extended AMAN horizon is that aircraft departing from inside this horizon - e.g. an hour from

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the destination aerodrome – will receive trajectory adjustments while still on the ground to optimise the DCB sequence, which is an easier solution than adjusting those in cruise.

In this context, Extended AMAN Horizon could have a lot of uses:

- Negotiate short trajectories to fill the gaps and to assign TTA as appropriate when the aircraft that are filling the blanks become known;
- Distribute advisories which influence the trajectory;
- Provide the TTA as early as possible, thus facilitating compliance even if the aircraft is still on the apron of the departure airport;
- Improve sequencing and merging of aircraft under tactical control;
- Provide an enhanced and more consistent arrival sequence;
- Reduce time holding by using speed control to absorb some of the queuing time;
- Increase predictability: If we consider that airports sharing the same AMAN horizon because of their proximity can build the arrival sequence with greater stability, issuing CTAs instead of TTAs or estimated times, the traffic flow between these airports has a greater level of predictability and time reliability;
- Assist queue management in areas with multiple TMAs (London-Amsterdam-Paris).

To know how AMAN works and the expected outputs, it is necessary to define what kind of inputs are needed. One of the most important inputs is the kind of traffic delivery which can be expected upon entry into the AMAN horizon of congested aerodromes. This traffic could be:

- Traffic which is close to minimum radar separation;
- Traffic with low speed and low altitude;
- Traffic which crosses the AMAN horizon at a certain CTO at a certain point separated from other aircraft;
- Traffic that has the same Initial Approach Fix (IAF) even if the aircraft land at neighbouring airports because the sequencing value will depend upon several issues;
- According to SESAR ConOps [1], if the flight is outside the AMAN horizon, no TTA is given. So it is expected that the arriving flow rates meet in average value the capacity of the destination airport. As soon as the flight reaches this horizon, a TTA is requested if an AMAN sequence is in action and de-bunching is beginning.

The AMAN should also take into account that traffic will be given with constraints like speed, time, fix, altitude or combinations, and fly fixed paths.

Open issues that need further investigation are, please see Table 3-2 :

1. Single airports with overlapping individual AMANs.
2. Multiple airports with single AMAN.
3. Single airports with individual AMAN overlapping multiple airports with single AMAN.
4. Multiple airports with single AMANs overlapping with the same type of clusters.

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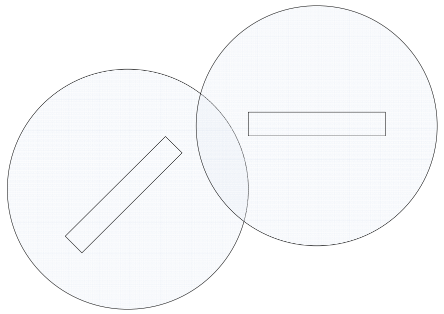
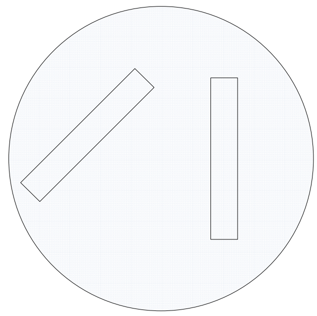
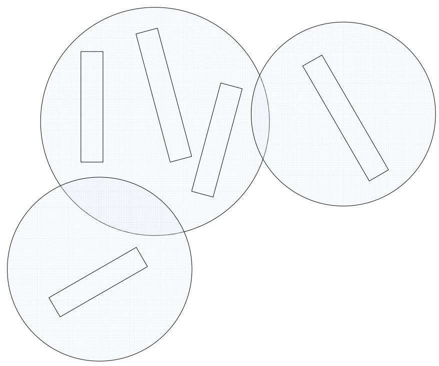
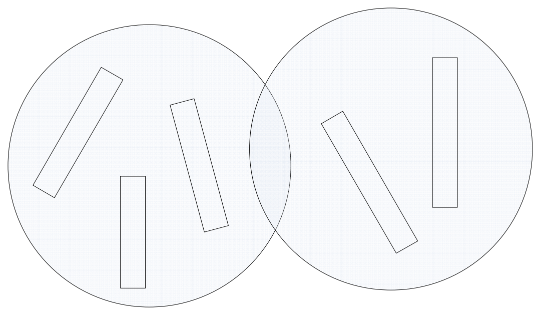
1. Single airports with overlapping individual AMANs.	2. Multiple airports with single AMAN.
	
3. Single airports with individual AMAN overlapping multiple airports with single AMAN.	4. Multiple airports with single AMANs overlapping with the same type of clusters.
	

Table 3-2: Open issues related to the AMAN in single and multiple airports

DCB provides a balanced flow but it is not able to deliver aircraft with the precise time intervals required to maintain a maximum flow rate and minimum spacing. The AMAN calculates the requirements that are necessary and applies de-spacing / de-bunching. Finally, the controller fine tunes the sequence. When flights enter the AMAN horizon, it will stabilize the arrival sequence, and help queue managers to manage flights with sufficient confidence to plan and issue the appropriate CTAs and CTOs. Apart from arrival sequence building up through the NOP, queue managers can propose tactical changes to executive and planning controllers in order to smooth the arrival sequence.

Extended AMAN horizon will assign a time constraint with a certain threshold. An estimation of an acceptable threshold which does not compromise the usefulness of this tool is less than 30 sec to a point at the boundary of the AMAN. It is currently possibly to predict the time of arrival at some TMA boundary point within 10 or 20 seconds, so the nominal AMAN does not seem to impose much difficulty for the En-Route constraints in terms of accuracy; The exact value of the degree of accuracy can vary depending on the situation and experts feel that this should be determined through validation exercises.

The AMAN tool has to be improved to provide stable arrival sequence time information into En-Route decision making. To improve the quality of the AMAN, RBTs and the Trajectory Management process should be taken into account.

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3.1.7 Structured and non-structured airspace

Structured and non-structured airspace is a concept defined in the SESAR ConOps [1]. The outputs of the WP4.3.1 Expert Group contributed to the refinement of this concept.

SESAR ConOps states that the future airspace will be based on a RBT environment. Even so, structured routes are still necessary to maintain the operability of non-capable aircraft or special situations that impose restrictions. These non-capable aircraft that are dependent upon conventional route structures will be affected when changes from non-structured into a structured airspace occur.

In a managed airspace, route structures have to be available for operations that require such support, but in normal situations flight crew can apply RBTs "*without the need to adhere to a fixed route structure*". When an especially congested airspace appears, a fixed route structure can be activated to assure the flight efficiency and the capacity required. These fixed routes are "*suspended when traffic density no longer requires their use*".

The sub-regional manager is responsible for determining the "*optimum airspace configurations, route structures and any essential constraints or strategies to assure the most efficient flow*" in each situation. The sub-regional manager negotiates with airspace users to remove the imbalance produced due to the temporary route structure. To help him/her to manage traffic in temporary periods and in the transitions to/from these temporary periods, he/she may take advantage of the new performance of the aircraft under his/her area of responsibility.

The complexity manager can propose the activation of a temporary route structure to the Sub-Regional Manager. In the activation of this temporary route structure there will be a coordination that can include the Sub-Regional Manager, Regional Managers, Civil and Military airspace managers, Complexity Manager, Air Traffic Service Supervisor (ATS Supervisor) and MSP.

When the route structure is deployed, aircraft are not segregated according to their performance and are not constrained by the aircraft with the lowest performance. At the moment that activation is decided, APOC and sector controllers will be informed.

When structured airspace is already activated, there are predefined entry and exit points to/from the temporary route structure to facilitate the transition between the non-structured volume and the complexity volume.

"*For high-complexity operations or transition to/from terminal area, an efficient airspace structure combined with advanced airborne and ground system capabilities will be deployed to deliver the necessary capacity and ensure separation is maintained*".

The hot topic that needs further discussion is the degree of involvement of the airspace users in terms of impact on the SBT/RBT when a route structure area is activated – e.g. airspace users can decide if they want to delay the flight on the ground or if they want to enter the high complexity area taking into account that MSP has the possibility of doing tactical changes in the RBT to accommodate and fine-tune all the flights and facilitate the task of the executive controllers of the transition areas.

3.1.8 Military activity

The concept of military activity defined in the SESAR Target Concept [2], has been refined by the outputs of the WP4.3.1 Expert Group. The following information shows part of the SESAR ConOps concept refined with these outputs.

The military are involved in the air traffic network. As a part of their activity, the roles that they can develop are: flight crew, air navigation services provider, aerodrome operators and, as well, exercise director. In the execution phase, the military activity is mainly based on "*training and exercises to establish and maintain capabilities and readiness postures as required by the States*". However, they can also conduct a flight inside civil airspace. Military flights flying

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under civil rules (GAT, General Air Traffic, En-Route flight) are subject to the same constraints as civil flights.

The airspace has to be available to satisfy the needs of the armed forces. For this reason, air navigation service providers have to provide them "*routing options according to military mission requirements, including temporary segregation of non-participating air traffic when required*". To ensure that this is possible, airspace delegation has to be flexible. To protect this type of operation, the segregated airspace structure will continue to exist and it will be activated when necessary. This temporary airspace is managed by all concerned partners in co-operation.

When the military activate a training zone, the information is published in the NOP. The information that the military provide to civil control about the activation or deactivation of a military zone has to be accurate, but the secure and sensitive military data will be protected. The rest of the information not subject to protection has to be "*shared with all involved participants and it will be update progressively if changes occur*".

When the military activate a restricted area, the military control coordinates with civil control. Armed Forces may have flexibility in their MIL area definition, so civil control could negotiate with military control with MIL area boundary adjustments in time and space. This kind of negotiation and the fact that military control also inform the civil control about the high prioritized flights – e.g. SAR (Search and Rescue) –, will help the civil control to fine-tune the sectorisation and to cope with any imbalance using complexity reduction management and demand/capacity balancing.

In activated military restricted areas, sometimes a corridor will be defined in the military zone through which civil aircraft can operate; this will be a special case not a normal case. The aircraft flying through this corridor will be controlled by a civil executive controller.

The trajectory-based approach always has to be able to provide "*sufficient airspace volumes to meet military operational and training requirements*". "*Military coordination and information sharing requirements will need to be accommodated*" in the trajectory-based approach. This means that the users have to take into account that some airspace volumes are susceptible to restriction for military reasons when they negotiate their SBT. In nominal cases, the activation or deactivation of military areas will be known well in advance to minimise the impact to the users. Nevertheless, after having an agreed RBT, it is also possible to activate special provisions and specific route structures to accommodate and assure military operations.

The interoperability between civil and military activities has to improve. To achieve this, it is necessary to improve communications particularly "*during interceptions in support of incident management".* It is also necessary to optimise "*the military and State activity processes in the basis of the enhanced cooperation between the various users*". If civil and military authorities work in close co-operation, a dynamic airspace will be available and the civil and military aircraft will operate in harmony. "*The cooperative process will be done by civil and military authorities according to the military requirements and the demand from civil traffic". "This cooperation should assure the smooth transition to/from periods of airspace reservation with as much prior notice as possible so that any opportunities can be fully exploited*".

3.2 Refinement of the Operational Scenarios

The main scenario refined by the WP4.3.1 Expert Group is OS-38 [24]. The OS-38 scenario describes a flight in the execution phase in a 4D environment. General recommendations to the OS-38 are to include the agreed definition of RBT revision/update that appears in the final DOD E6; and to be consistent with other EP3 documents regarding the times assigned to each situation – e.g.: in the execution phase, the time-frame for including airspace users in negotiations is 30 minutes.

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The most important changes that have to be incorporated into the operational scenario OS-38 are:

- Instead of using "used-preferred trajectories" when referring to RBT, use "agreed trajectories";
- RBT executed are not exactly the agreed trajectories; the RBT reflects the stakeholders' preferences but does not have to be exactly what they finally do;
- The types of changes described in the scenario imply a RBT update, not a revision. (See DOD E6 for more information about RBT updated/revised);
- Time constraints will be achieved by pilots, but controllers should facilitate this task for them;
- RBTs do not have *"at a given point a required time of arrival (RTA)"* because the RTA is an aircraft's function. RBTs have planned time of arrival;
- The TTA definition should appear in the glossary and it should state that the RTA is a function of the FMS;
- The system works smoothly with closed loop instructions because while it is open the final conditions are not known and the actors who have to agree on the changes do not have enough information;
- WP4.3.3 said that in the Execution phase, when there are only 30 minutes before the designated EC performs his/her work, the users cannot negotiate. However, some experts said that the CDM process should not be based on the time because it depends on the situation;
- The data of flights are recorded in the NOP;
- Minimum Safe Altitude Warning (MSAW) is not a controller tool, it is a safety net. It should be deleted from the list of controllers' tools;
- In the SESAR Environment the AMAN horizon will be of the order of 200 NM from the destination airport;
- The reference to 4D-Capable aircraft should be removed from OS-38, as this is beyond 2020;
- OPEN ISSUE: Related to the airspace users' negotiation there can be a problem: will AOC allow the flight crew to negotiate with the controller? –e.g.: will flight crew negotiate a change to the TTA?

3.3 Refinement of the DODs

The feedback on the DODs from the WP4.3.1 Expert Group is intended for DOD E6 [22], DOD E4 [23] and DOD G [26]. The main conclusions extracted from the Expert Group and agreed by all the participants are listed below categorized by impacted DOD:

DOD E6:

- When an aircraft has deviated from its RBT, the clearances/authorisation the aircraft will receive are intended to return it to its position. This is considered as an update, not a revision of RBT;
- The RBT is the trajectory that the users agreed. To modify something it is necessary to negotiate;

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- Some experts commented that the owners of the RBT are the users, but other experts said that this is a concept that will disappear and, finally, the owner of the RBT will be the ground system;
- The RBT automatic update process needs to consider the whole future trajectory, not just current conformance. As TMR are flexible, the ground system should be aware of the parameters in the different areas;
- **HOT TOPIC**: Definitions needed for RBT update and RBT revision. No agreement was reached about the exact definition of the two items, but the general idea behind each definition was agreed. Please see DOD E6 [22];
- **HOT TOPIC**: How will the aircraft return to a RBT after an open loop instruction? The confidence of the downstream portion of the RBT is not clear. After an open loop instruction the RBT will be frozen. The open loop instructions are limited to updates but not used in revisions. There are two kinds of open loop; one that the (ground) system will automatically close, and another that is permanently open loop (e.g. permanent heading). The latter will not be used in the SESAR environment. No open loop instructions will be used in SESAR 2020;
- **HOT TOPIC**: the feasibility and the nature of the CDM which includes AU during the execution phase has been questioned. Further research may be required regarding the effectiveness, or even desirability given the limited time window that might be available of this procedure;
- Clarification should be included in DOD E6 [22] that from the point of view of the flight, the En-Route phase covers from Top of Climb (TOC) to Top of Descent (TOD), but from the point of view of the airspace it covers from the boundary of the TMA, which may not coincide with TOC-TOD. Indicate also that some of the processes performed by En-Route controllers are therefore defined in DOD E5 [27];
- A TTA is not a constraint but a CTA is a constraint;
- Sometimes it could be possible to assign time constraints to reduce the complexity of an area;
- **HOT TOPIC**: the RBT includes the arrival time and the flight level that the flight has to follow. In the flights that are not flying into an AMAN horizon, ETA (Estimated Time of Arrival) and TTA will be the same in the sense that all actors involved work together to achieve it;
- **HOT TOPIC**: Definition of TTA. The time windows related to ETA (if any), TTA and CTA should be defined, as well as the consequences of not achieving them. The way each of them is implemented should also be defined. In order to obtain a better understanding of TTA, it is proposed to write a small scenario to demonstrate its application;
- Review E6 consistency with the capability level addressed in DOD E6 document [22].

<u>DOD E4:</u>

- In a revision of an RBT, actors downstream from the changes should have a service to allow them to indicate whether the change is acceptable or not;
- The assumption made in DOD E4 page 42 [22] needs further explanation: "Flight duration exposed to dynamic DCB should be long enough to make it effective with respect to the active AMAN horizon or other techniques.";
- Update E4 complexity management with outputs from the Expert Group Complexity Management Report [5].

<u>DOD G:</u>

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- **HOT TOPIC**: There is a need to define equity clearly, as different experts understand it in different ways;
- Include in all DODs the note that, times included are just examples for a better understanding. The exact times will always depend on the situation;
- **HOT TOPIC**: Need for clarification between clearances and authorisation: If you are flying your RBT do you receive clearances or authorizations?

More feedback is given to the DODs from WP4.3.2, WP4.3.3 and WP4.3.4. To see feedback from WP4.3.2 refer to section 4.3.3, to see feedback from WP4.3.3 refer to section 4.4.3, and to see feedback from WP4.3.4 refer to section 4.5.3.

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4 FEEDBACK TO OTHER WORK PACKAGES

4.1 WP2.4.1

4.1.1 Objectives, Description and Methodology of the Exercise

WP2.4.1 developed the Performance Framework in which appear the influence diagrams for the following KPA: Capacity, Efficiency, Predictability, Environment, Flexibility and Safety, [7]. These diagrams are based on SESAR D4 and SESAR D3.

WP2.4.1 asked WP4.3.1 for support in the KPA efficiency. This KPA is divided into fuel-efficiency, time-efficiency and mission-effectiveness. The support task consists of quantifying the fuel-efficiency performance. The fuel efficiency diagram has been developed to compare the actual amount of fuel that is burnt with a reference value. By comparing these two results the fuel efficiency is calculated. To do this, the OIs are grouped into airspace availability, route structure and conflict management.

So, the objective is to quantify how the fuel efficiency OIs affect distance, time and fuel burnt (WP2.4.1 is looking for a minimum, maximum and average indication).

The methodology followed to carry out this support to WP2.4.1 is based on different steps:

- Divide the experts into three groups, one per OI list;
- Each group classifies OIs taking into account whether it contributes positively or negatively to the distance, time and fuel;
- Each group has to give an indication on min/max/average of distance, time and fuel burnt per OI group (the indications are percentages related to an average flight);
- Each group presents their findings to the other groups.

4.1.2 Feedback on the KPAs

The following summary is extracted from the internal document supplied by WP4.3.1 to WP2.4.1. For more information please consult [7] & [8].

The results extracted from the support task are divided into three groups of OIs:

- Route structure: this group contains CM-0701 OI that has no significant influence in fuel efficiency. Other OIs from the group have a positive influence on fuel efficiency. They are: AUO-0304 (influence on time), AOM-0402 (time and distance), AOM-0401 (time, distance), AOM-0403 (time and distance), AOM-0501 (time, distance) and AOM-0502 (time, distance);
- Conflict management: this group contains AOM-0801 OI that has no significant influence on fuel efficiency. It also contains two OIs with a negative influence on fuel efficiency, those are: CM-0104 (time) and AUO-0204 (time, distance). Two other OIs that have a positive influence on fuel efficiency are: CM-0202 (time, distance) and IS-0102 (time, distance);
- Airspace availability: this group contains SDM-0102 OI that has no significant influence on fuel efficiency. Other OIs that have a positive influence on the fuel efficiency are: AOM-0201 (time, distance), AOM-0202 (time, distance), AOM-0203 (time, distance), AOM-0205 (time, distance) and AOM-0303 (time, distance).

In general, the OIs' positive influence on the fuel efficiency will not be higher than 2% per flight.

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4.2 WP2.4.3

4.2.1 Objectives, Description and Methodology of the Exercise

WP2.4.3 applies a top-down approach to safety assessment considering the SESAR System and the ATM capability levels from 0 to 3. A prototype of an accident-incident model was developed showing the more critical areas of change in the gate-to-gate ATM cycle, and the safety impacts of the future ATM developments in SESAR.

The safety group asked for feedback on the properties of a "typical" En-Route operational environment, the ATM service and the ATM system design in which have been studied the functional model, the logical model and a thread analysis of logical model operation.

The objectives of the workshop were:

- To give to the EG an understanding of the overall approach to the SESAR Safety Assessment;
- To get EG general agreement on the Barrier Model interpretation of the SESAR Operational Concept (circa 2020);
- To give the EG an understanding of the Functional and Logical representations of the SESAR ATM System, from a safety perspective;
- To answer, as far as possible at this stage, questions concerning the SESAR Operational Concept as applied at the level of the Logical Model.

It was emphasized that the first three items were the most important as far as the safety assessment schedule is concerned, at this stage in the process.

The methodology followed to carry out the task was a series of presentations regarding the safety information by an Expert on Safety Assessment to the Expert Group, who provided comments and suggestions.

4.2.2 Feedback on the Exercise Results

The workshop concluded that the Expert Group agreed with the applied methodology, which is logical and helps experts to understand the development of the exercise, for the safety case. However, the confidence level in the final results was not high enough due to the lack of maturity in the description of SESAR. The safety case contains several assumptions that define a possible final SESAR system, but it is not the only one and it is not necessary that it has to be definitive.

The following text summarizes the main conclusions extracted from the minutes of the Expert Group meeting held on 23rd and 24th June in Madrid, [9].

4.2.2.1 Properties of a "typical" En-Route Operational Environment

There is a need to establish a suitable operational environment for the safety assessment, as discussed above. The following is the proposed description and some comments made during the Expert Group:

- The Airspace is classified as "Managed";

  Comment from EG: This safety assessment should not worry about aircraft in the unmanaged airspace, because the system has procedures to treat them: they will be treated as other aircraft entering the ECAC airspace
- Users of the airspace will include commercial airlines, military, general aviation, UAVs (Unmanned Aerial Vehicle) and VLJs (Very Light Jet);

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- Routes will be user-preferred except when/where[5] traffic complexity/demand and/or adjacent Arrival (ARR)/ Departure (DEP) operations require predefined route structures to be applied – regular changeover will occur between user-defined routes and pre-defined routes, according to the traffic situation;
- Route design and spacing will be based on ATC separation minima and, where applicable, obstacle-clearance criteria;
- Dynamic airspace management will be a key feature of the SESAR En-Route operational environment;
- A substantial amount (typically up to 30%) of the total volume of En-Route airspace will be subject to reservation by the military;
- Users will be allowed to fly their RBT to the maximum extent possible, including following cruise-climb and continuous-descent profiles when practicable;

  Comment from EG: Some of the experts thought that aircraft would prefer to fly in flight levels.
- The aircraft fleet using En-Route airspace will have ATM Capability Levels varying between CL0 and CL4 – aircraft equipage and performance will <u>mixed</u>;

  Comment from EG: Some experts felt that CL0 may need to be regulated – i.e. not to be allowed in a "Typical busy airspace" due to capacity needs.

  Comment from EG: Airspace will have ATM Service Level that describes the services that will be available in that airspace. It should be included as, for example, aircraft with CL4 in a, Service Level, SL1 will not fully use their advantages.
- The annual average traffic throughput will be 1.7 times higher than in 2005;
- A substantial amount (typically up to 40%) of traffic will overfly a particular block of En-Route airspace;
- Both ground-based and airborne separation modes will apply;
- ATC separation minima (minimum of 5 nm horizontal for surveillance and 1000 ft vertical up to, Flight Level, FL410) will apply to ground-based separation modes;

  Comment from EG: This separation applies now between two aircraft longitudinally and laterally. RESET (Reduced Separation Minima Project, 6th Framework) introduces time based separation (currently not approved in ICAO, International Civil Aviation Organisation), changes the lateral separation and introduces the separation of 500 ft between Flight Levels. En-Route experts did not like this change in flight level minima as they felt it seriously compromises safety.
- Separation minima for airborne separation modes are to be defined by future exercises and are assumed to be less than those for ATC separation modes;
- Adjacent airspace is assumed to be a typical busy ARR/DEP airspace as per the Safety Design document (SDD) for ARR/DEP Operations.

The scope for En-Route operations is from top of climb to the first phase of top of descent. However, it was noted that the definition of En-Route "from Top climb – Top descent" implies that all the flights are going to be within ECAC area. En-Route controllers manage also the last phase of top of climb and the first phase of top of descent. The exact volume of this phase that it is managed by the En-Route controllers will be adapted dynamically in SESAR 2020.

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[5] I.e. the decision as to whether user-preferred or predefined routes are deployed will be based on spatial, as well as temporal, considerations.

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4.2.2.2 The ATM Service (TMA)

The Barrier Model for current and SESAR operations is not completely clear because it provoke a lot of discussion during the Expert Group. It was emphasized that it is not intended to be a precise model – but a way of visualizing the SESAR Concept at a high (service) level.

There is some unresolved concern about the title "Trajectory De-confliction".

4.2.2.3 ATM System Design

The ATM System Design contains a Functional Model and a Logical Model. The latest version of the SDD was amended for errors and omissions (also incorporated in the latest version of the ARR/DEP SDD) that were identified in an earlier draft version.

About the thread analysis of the Logical Model operation it is concluded that:

- It is essential that the *Thread Analysis* process includes a strong operational input;
- Even apparently simple transactions can be quite complex in system terms, in the SESAR environment;
- The *Thread Analysis* process is efficient and effective in revealing deficiencies in the Logical Design.

4.3 WP4.3.2

4.3.1 Objectives, Description and Methodology of the Exercise

The WP4.3.2 exercise studied the possibility of a workload reduction by adjusting the departure time of aircraft, which can enable a traffic increase with a sufficient safety factor.

The objectives of this exercise are to:

- Propose and study an algorithm to execute ATFM slot allocation, when 4D flight plans are provided;
- Evaluate the workload reduction that can be obtained according to the time dispersion allowed for takeoffs.

The methodology to carry out the exercise was based on fast-time simulations.

The final report provides complete information of the exercise [11].

4.3.2 Assumptions and expectations consolidated with the experts

Experts considered that the exercise is too theoretical to have a direct application in an operations context. However, they considered that the exercise is a first step towards the use of strategic complexity reduction measures in the ATM.

4.3.3 Feedback on DODs from WP4.3.2

The following text summaries the main conclusions extracted from the minutes of the Expert Group meeting held on the 15th and 16th July in Madrid, [14]. The conclusions extracted from WP4.3.2 to give feedback to DODs are divided into the categories that the experts suggested during the expert group and are shown in the following text.

- Trajectory Management: The RBT revision, the RBT update and application of TMR have an impact on ground delays and on the TTA.

  The RBT revision takes place when there is a mutually agreed change to the RBT between air and ground. RBT will be revised and will replace the previously agreed

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RBT. When controllers carry out de-confliction or complexity reduction to maintain the traffic without conflict, they can generate an RBT revision. This RBT revision may generate ground delays.

A TTA is a planning time into a capacity constrained airport that books a place within the arrival queue if within the AMAN horizon. From the TTA the departure time is back calculated. If the strategic complexity reduction affects this departure time, the TTA may be lost and a new TTA will have to be issued. This can generate a ground delay. For non ECAC aircraft the time constraint will be an arrival slot that will work in the same way as TTA for ECAC aircraft.

- Complexity Reduction: The exercise can be used as a first step for a complexity tool because it has an impact on complexity reduction management when it is used as a tool to delay aircraft in the En-Route phase. So, it helps to reduce the En-Route workload.

  This tool could only be used to solve tactical conflicts because complexity reduction only works in this horizon.

- Airport: It is necessary to minimise the time between start up and take off to assure that the take-off sequence is maintained correctly and, consequently, the runway throughput is also maintained. This produces an impact on departure queue management and on the airport operations (including turn around, taxi and runway management). Which could be the way to solve this?

  Apart from this, it is necessary to know whether a delay in a take-off time can block a gate or an arriving aircraft because, if it is, the exercise will have an impact on arrival queue management.

- Actors: Further investigation is needed about which actors could be involved in the exercise.

  On the one hand, it is clear that the exercise has no impact on Executive Controllers and MSP roles, but on the other hand, the ATCOs will experience a reduction in their workload due to the exercise.

- Tools: The methodology presented in the exercise has to be completed by other methodologies to make its application possible in other situations and dimensions.

- Information: the methodology presented in the exercise has an impact on the data flows, therefore this impact affects SWIM especially as it is a data platform.

- Other:

  - HOT TOPIC: Define equity. There is a necessity of clearly defining equity, as different experts understand it in different ways.

  - No conflicts are solved with ground delays. Ground delays are used to reduce the complexity of the airspace and to achieve a more accurate entrance time into the En-Route phase; it provides controllers with a means of better management and control of the airspace.

  - OPEN ISSUE: the point of view of the airlines about ground delays is that they prefer a ground delay if after that they can achieve their objective at the exact time they had planned. Will this be promoted in SESAR?

4.4 WP4.3.3

4.4.1 Objectives, Description and Methodology of the Exercise

The WP4.3.3 gaming is based on role-based games that are used to explore the different options available in the SESAR concept of operations; especially investigating, assessing and

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exploring the implications of the statements made in EP3 WP4.3.1 Expert Group. So, there is a deep relationship between WP4.3.1 and WP4.3.3, in both directions. WP4.3.3 gives also feedback to the questionnaires of WP4.3.1.

The main objectives achieved were to:

- Investigate, assess and explore the implications of the EP3 WP4.3.1 Expert Group;
- Assess the feasibility of the En-Route complex operations and procedures at applicable times of the day and in applicable airspace;
- Validate the related negotiation processes;
- Explore the use of serious gaming techniques to analyse and describe new operational concepts;
- Reach a high-level of interaction between all the participants involved in the games in order to obtain all the possible points of view for the same topic and develop a useful discussion.

The methodology used to carry out this task is the role-based games used as a technique that promotes non-routine thinking. In this way, it provides an additional insight to the findings of the EP3 WP4.3.1 Expert Group results.

The final report provides complete information of the exercise [13].

4.4.2 Assumptions and expectations consolidated with the experts

Process Simulator (PROMAS) is a fast time simulation tool that simulates processes. Process simulations are useful at revealing hidden incoherencies arising from the relation between each actor involved and their responsibilities. The tool was used to assess dynamic DCB measures and Business Trajectory Management against simulated traffic samples. PROMAS offers qualitative and quantitative information, which will be scrutinised by analysts and operational experts.

The main actors studied with PROMAS have been the Multi-Sector Planner (MSP) and Executive Controller. Related to the MSP role, there are two statements that need the Experts' feedback.

The first one is about the number of sectors that the MSP area covers. An approximation has been made on this issue: the number of sectors will be no less than two and no more than six. The problem about this issue is that it is an approximation and it is not possible to decide on an exact number of sectors because it depends on the specific circumstances, the sector size, the conflict detection tool horizon, the complexity, the type of sectors and the traffic volume.

The second statement is about MSP and if an individual planning controller will be needed in the future in a MSP area. There are different opinions about this issue; on the one hand, there is the opinion that it is not necessary to have a planning controller in a MSP area because many control positions can cause more complexity procedures. On the other hand, there is the opinion that it is necessary because it is considered that the workload of the MSP looking at flows and overall system harmony in four sectors would be high enough without the added responsibility of coordinating individual trajectory changes and entry/exit conditions. Consider: if we assume a loading of even 30 flights per hour and four sectors, we would make him/her responsible for the entry conditions of 120 flights per hour and this it is not a logical assimilable workload for a person even with automation. So, it is necessary to divide the tasks depending upon the situation between MSP and Planning Controller.

It was not possible to reach a consensus because different opinions were pointed out and not all of them were accepted by the experts.

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4.4.3 Feedback on DODs from WP4.3.3

The following text summaries the main conclusions extracted from the minutes of the Expert Group meeting held on 3rd and 4th September in Langen, [15].

The main conclusions extracted from WP4.3.3 to refine the DOD are about the CDM process and the Catalogue of Solutions.

Regarding the CDM process, the horizon of the CDM for knowing when it has to take place and in which time-frame it does not happen should be defined. It is also important to know who is involved in each type of negotiation. WP4.3.3 has investigated this issue when related to the En-Route execution phase, but more information is needed. The main conclusions extracted about the CDM process are that CDM processes can be performed in two phases; the first one would include AU, and would be centred on reaching a general agreement between all the actors, the second one would be internal to the ANSPs and flight crew and would fine tune the active resources and RBTs.

The Catalogue of Solutions contains a compilation of pre-defined solutions that controllers should apply in certain circumstances. These circumstances may need other solutions not included in the Catalogue of Solutions. These solutions could be proposed by pilots and agreed by controllers. In this case, the solution would be performed in the same way as a catalogue solution. Some unplanned situations (airport closure, several weather conditions …) should not trigger an interactive CDM process; these cases are included in pre-defined solutions from the catalogue of solutions and are applied to resolve the complexities in the pre-defined way.

4.5 WP4.3.4

4.5.1 Objectives, Description and Methodology of the Exercise

The WP4.3.4 exercise was performed to gather evidence about the 4D Trajectory Management benefits. The methodology used to assess these benefits included three prototyping sessions.

The main objectives of the exercise were to:

- Assess from the controller's perspective the operational feasibility and acceptability of the RBT concept;
- Assess from the controller's perspective the operational feasibility and acceptability of the introduction of En-Route CTA.

The final report provides complete information about the exercise [12].

4.5.2 Assumptions and expectations consolidated with the experts

To carry out the exercise of WP4.3.4, the leaders had to run different iterations to improve the tool. Feedback on the exercise from WP4.3.1 was given by presenting each one of these iterations to the Expert Group to gather their comments and suggestions about the assumptions used in each stage. In that way, the leaders of the WP4.3.4 exercise could make the changes needed and follow the development of the tool, being assured that their assumptions were supported.

The Expert Group thought that the assumptions of the exercise were correct. They also thought that the conclusions were appropriate and consistent with the results.

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4.5.3 Feedback on DODs from WP4.3.4

The following text summarizes the main conclusions extracted from the minutes of the Expert Group meeting held on 15th and 16th of July in Madrid, [14]

To obtain feedback on the DODs from WP4.3.4, there was a workshop where the experts gave their comments and opinions. The conclusions extracted from this workshop are divided into the same categories that the experts defined in the workshop and are shown in the following text.

- Flows: to obtain a good level of traffic management in high complexity areas during the execution phase, it is necessary that the DCB segregates the arrival and departure flows during the planning phase.

- Airspace management: to manage the flows mentioned above, it is necessary to perform an airspace/route redesign around the flows of the trajectories. Because of the fact that the airspace will be redesigned around the flows of the trajectories, the airspace won't be considered a segregated airspace; it will be considered a dynamic airspace.

- AMAN:

  OPEN ISSUE: The AMAN and Multiple AMAN impact on En-Route traffic needs further investigation. The changes in the trajectory execution to achieve the CTA/TTA/etc must be done before the TOD because that is when the aircraft has a wider manoeuvre capability than in continuous descent.

- Tools: all the present tools need improvement – e.g. Trajectory Editor (TED), Tactical Controller Tool (TCT), MTCD – an improvement on the feasibility of the MTCD and a change on its concept of use is especially needed. It will turn into an Executive Controller tool. Better tactical tools are also needed to obtain better management of the traffic.

- Changes in working methods: to facilitate the achievement of the aircraft's times indicated in the RBT, the Executive Controllers will have to give vertical instruction as a priority instruction.

- Standard: it is necessary to standardise the aircraft RTA handling.

- Information: the preferred trajectories are very useful for ATCOs because they decrease their subjective feeling of complexity and increase situational awareness. The information provided to ATCOs is also important, so it should be carefully defined so as not to overload them.

  Apart from this, it is noted that the need for cockpit information can introduce a time delay in ground-air communications.

- Other: two open issues were pointed out because they need further investigation:
  - The process of RBT revision;
  - The interaction with PTCs in order to alleviate the ATCOs separation tasks.

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5 CONCLUSIONS AND RECOMMENDATIONS

5.1 ON THE CONCEPT

The expert group agreed that the RBT is not a gate-to-gate clearance; it is an agreed trajectory designed to minimize bunching that can be subject to changes for tactical reasons.

In the SESAR 2020, no open loop instructions will be used, There will be no direct routings, as everybody will prefer to follow their RBT. There will be dynamic changes to the RBT that should have been agreed over a scenario during the planning phase. If possible these agreed scenarios will be applied. These pre-agreed scenarios will be part of a catalogue of solutions.

During the execution phase, the sub-regional manager deals with the optimisation of flows and resources in the area of responsibility, and is the main actor that performs CDM processes with users through the AOC. MSP/planning controllers deal with individual RBTs reducing complexity and minimizing conflicts. Executive controllers ensure separation, if not delegated, and facilitate the execution of the RBT. MSP/planning and executive controller contact flight crews when performing their activities. This is the general basis, exceptions may occur depending on the different situations

CDM. The expert group agreed with WP4.3.3 that in the En-Route execution phase, the use of CDM processes which include the user is not always effective and desirable. There are processes that although not tactical, should not trigger this CDM process, as they will be repeated several times during the normal operation. The time that the actor needs to dedicate to the CDM with the users could produce that the actors neglects the rest of his/her tasks.

This does not mean that there will not be CDM processes with users in the execution phase. This means that the period where it is not feasible to perform CDM processes is not limited to tactical interventions.

The preference of the users will be taken into account through the use of a catalogue of solutions that contains the pre-agreed solutions to problems which are not planned but are likely to occur during the normal operation of the flight. This catalogue of solutions would have been agreed with the users during the planning phase. Controllers are not limited to the solutions in the catalogue.

AMAN. The En-Route management of the execution phase does not generate queues. The queues managed are generated by the Network operations and the AMAN.

Regarding the AMAN the expert group agreed with the Expert Group from WP5 that the short term DCB will smooth the traffic to congested destinations to achieve a low variability of planned arrivals preventing heavy bunching to airports. This smoothing goes beyond what the NOP alone can achieve.

The use of extended AMAN will facilitate the creation of an enhanced and more consistent arrival sequence increasing predictability and increasing the time available to the executive controller to facilitate the aircraft achieving the TTA issued by the AMAN.

Trajectory management. 4D trajectory management is defined as a situation where an aircraft is flying its RBT and can follow one or more time constraints in each route clearance with the required avionics performance, but is still not responsible for separation in managed airspace. Separation assurance is provided by the controller, applying the best suitable mode. Experts think that the use of 4D trajectory management will greatly improve Capacity, Efficiency and Predictability. The tools used have to be consistent in the sense of using the same data and should have knowledge of the aircraft performance capabilities to propose and assess RBT changes. The principle of operation in 4D trajectory management is that the best equipped aircraft will be favoured in constraining situations.

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Strategic complexity reduction using accurate 4D data will be a method of optimising the airspace reducing the complexity, number of possible conflicts and consolidating sectors. The use of 4D data for this aim can produce adverse effects in a mixed mode of operations.

During the transition between PTC-2D and the use of ASAS, the ground system in charge of the ATC (ATCO + tools) will be in charge of the consistency of the air situation with the transmission of the appropriate clearances.

Regarding actors some recommendation are found:

- MSP:
  - The MSP is an evolution of the planning controller that serves several executive controllers.
  - The responsibility of supervision of the MSP would cover the time between the sub-regional manager and the executive controller.
  - The main task of the MSP would be to propose changes to the individual RBTs trying to reduce the complexity and minimize conflicts within the sectors and facilitating the work of the executive controllers.
  - The role of the MSP as an evolution of the PC does not imply that the EC should be alone when performing her/his task, as this can produce a loss of situational awareness.
- Sub-regional Manager:
  - The sub-regional manager is responsible for all operations in an area or sub-region that includes several executive controllers.
  - The sub-regional manager responsibility starts in the medium-short term planning phase which for one specific area ends around 30 minutes before the designated executive controller performs his/her work.
  - His/her focus is the optimization of the flows and resources in the area of responsibility.
  - The sub-regional manager is also the point of contact and negotiation for the AU - i.e. the Airline Operational Centre - during the execution phase to perform the CDM processes.

The following text summarizes the main open issues that need further investigation and the main hot topics that need further discussion:

<u>OPEN ISSUES</u>

- Once an RBT is changed, new adjustments must be done with as a little deviation as possible from the last agreed RBT or from the initial RBT.
- Regarding Strategic complexity reduction using 4D PTC, the time horizon corresponding to “strategic” has to be defined.
- Air traffic measures to reduce complexity should only be applied if there is sufficient level of accuracy in the prediction of the trajectories (known a/c). The level of accuracy must be balanced against the necessity of applying the measures as soon as possible to promote their effectiveness.
- Extended AMAN points that need further investigation:
  - Single airports with overlapping individual AMANs;
  - Multiple airports with single AMAN;

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  - Single airports with individual AMAN overlapping multiple airports with single AMAN;
  - Multiple airports with single AMANs overlapping with the same type of clusters.
- Related to the airspace users' negotiation there can be a problem: will AOC allow the flight crew to negotiate with the controller? – e.g.: will a flight crew be able to negotiate a change in its TTA?

<u>HOT TOPICS</u>

- Definitions needed for RBT update and RBT revision. No agreement was reached about the exact definition of the two items, but the general idea of the definition was agreed.
- Need for clarification between clearances and authorisation: If you are flying your RBT do you receive clearances or authorizations?
- How will the aircraft return to an RBT after an open loop? The confidence of the downstream portion of the RBT is not clear. After an open loop instruction the RBT will be suspended. The open loop instructions are limited to updates but not used in revisions. There are two kinds of open loops, those that the (ground) system will automatically close, and those that are a permanent open loop (e.g. permanent heading). The latter will not be used in the SESAR environment. No open loop instructions will be used in SESAR 2020.
- The degree of airspace users involvement in terms of impact on the SBT/RBT when a route structure area is activated – e.g. airspace users can decide if they want to delay the flight on the ground or if they want to enter to the high complexity area taking into account that MSP has the possibility of doing tactical changes in the RBT to accommodate and fine-tune all the flights and facilitate the task to the executive controllers of the transition areas.
- The feasibility and the nature of the CDM which includes AU during the execution phase itself has been questioned. Further research may be required regarding the effectiveness, or even desirability given the limited time window that might be available of this procedure.
- The RBT includes the arrival time and the flight level that the flight has to follow. In the flights that are not flying into an AMAN horizon, ETA and TTA will be the same in the sense that all actors involved work together to achieve it.
- Definition of TTA. It should be defined which are the time slots related to ETA (if any), TTA and CTA, and the consequences of not achieving them. It should also be defined when and how each one should be used.
- There is a need to define 'equity' clearly, as different experts understand it in different ways.
- In a mixed equipage environment, the expert group detected the need for a clear definition of the different responsibilities, and the possibility that airspace organisers and managers might establish zones where ATM capabilities match the same requirements to decrease complexity and controllers workload.

5.2 LESSONS LEARNT ON THE TECHNIQUE

The lessons learnt on the technique are here divided into those regarding the preparation of the EG, the execution of the EG, the debriefing of the EG and general things about the EG.

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General:

- The EG should have at least some representation from each group of stakeholders involved in the concept addressed. In this way, all the decisions taken will be acceptable for all the groups involved in the operational implementation of the concept addressed.
- When an EG is performed, the experts selected to take place in it should be operational experts and experts on the concept to be addressed. In the first session, in R+D, a training session about the new concept should be performed. This training should have two steps, first, to give a general overview of the concept, and second to give special training on the main items that will be addressed in the EG.
- A discussion room could be activated in a website – e.g.: the EP3 website – where everyone will give their opinions. The discussion room could be a fast way to know the experts' opinion but, to obtain a good feedback from it, it is necessary to have a person who maintains the discussion into the objectives, summarizes the different opinions and has control over the development of the discussion. As some experts could have the same opinion about an issue, it could be interesting to add two buttons for agreeing or disagreeing with the opinions already given.
- The combination of the expert group technique together with the gaming technique gives an added value to the results of each individual technique. The distribution of the meetings, taking place the EG and the gaming in consecutive days, is very useful and the feedback obtained for each technique is really high.
- **Characteristics of the management team:**
    - The average attendance in WP4.3.1 EG was about fourteen people. It is a big group with a deep background and which has participated in many projects. Sometimes was difficult to manage them, but the expertise of all the group provided different points of view about the issues addressed, and information about the results achieve in other projects. This provided higher value to the EG.
    - The leader of an EG needs high experience in managing people and technical knowledge about the concept to address. One person is not enough for keeping all the EG aspects up-to-date and for conducting the EG.
    - The meetings in the expert group should be conducted by a facilitator (or team) with experience in group dynamics, able to guide and stop discussions. This facilitator (or team) should also have some technical background to understand when and where a discussion is worth continuing, and which of the remarks must be recorded in the minutes.
- **Link of the exercises to the EG:**
    - The EG should be the backbone of the exercises of the related concepts. The exercises should present the initial, intermediate and final results to the EG, for obtaining the feedback of the EG.
    - The EG should collaborate in the definition of the first assumptions of the exercises, in the guidance of these exercises towards their objectives and in the definition of the priority of each activity included in each exercise.
    - The interactions between the exercise leaders and the EG are useful in the intermediate stages for verifying the work done or for correcting dubious steps in the development of the exercise.
    - The EG should use a meeting for the presentation of the final results of the exercises to globalize the results of all exercises and for giving the project a homogeneous view.

- o The support meetings should be prepared by the management team of the EG and the exercise leaders. In this way, things could be defined according to both interests. These things could be: the objectives of the meeting, the documentation experts should read, the questions that should be sent in advance and those that should be answered in the meeting, and the best suitable technique to answer the questions.

- **Delphi method:**
  - o The Delphi method enables experts that may not attend one session to reflect their opinions, fostering the continuity of the experts even when they are not able to perform all the journeys.
  - o The anonymity of the method was broken during the WP4.3.1 Expert Group as sometimes experts sent their answers to all the participants of the meeting. The performance of meetings decreased the effect of the desired effect of minimising the impact of influence from other experts.
  - o Some intermediate meetings in the Delphi method are necessary but dilute the desired effect of avoiding the possibility that one or more experts lead the opinions of the group.
  - o The positive effect of the Delphi method is lower when the number of issues to be covered is higher - i.e. trajectory management, strategic complexity reduction, ASAS, AMAN, military activity. It is recommended that, when using the Delphi method (or this variant), questionnaires are designed to explore only one theme.
  - o Questionnaires are useful to make the experts think about the issues that will be addressed before going to the meeting.

Preparation:

- To prepare for the EG, it could be interesting to use techniques that make it possible for all experts to express their opinions. The use of brainstorming in the workshops is useful as a way of presenting all the different ideas, but they should be contextualised correctly during the meeting for understanding the reasoning behind the idea.
- The agenda should be designed taking into account the objectives of each meeting. These objectives should be defined beforehand and, according to them, the agenda has to be distributed in the correct way – e.g.: time needed for each activity.-
- The composition and field of expertise of the participants greatly influences the expert group.
- The experts should read all the documentation before the meetings and give special attention to those points that are included in the agenda. The time needed to read this documentation must not be underestimated, as it may include several of the documents of the project together with documentation from other projects.
- The organizers of the EG should distribute the documentation and the agenda as soon as possible, at least 2 weeks before the meeting. In this way, experts could prepare in a better way the meeting and the related concepts.

Execution:

- When experts are not able to reach an agreement about a discussion, the discussion should be stopped by the management team. In this case, it is important to note that no agreement is reached and to compile all the points of view and the reasoning behind them.

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- The experts should respect the proposed agenda and take it as a reference for discussions that can be taken. It should not be possible to discuss an issue that is not on the agenda. As flexibility in the EG is important, if the new issue (not reflected in the agenda) is sufficiently important, it could be addressed when the discussion of the current issue is finished or at the end of the session. The issues in the agenda that could not be addressed should be identified for discussion at the next meeting or in the discussion room. If the new issue is not sufficiently important, it should be pointed for being discussed in the next meeting or in the discussion room
- It is very important to collect accurate information during the meeting. This information should be broken down by issues/concepts and by agree/no agreement reached. It is also necessary to collect the reasoning for agreeing (or not) an issue. Issues/concepts that need further investigation and hot topics that need further discussion should be identified. Before going to the next point in the agenda it is useful to summarize the previous point as a way of getting agreement from all the experts on the conclusion reached.
- The assistant who collects all this information must have knowledge of the concepts being addressed to ensure correct understanding of the concept situation.
- As a recommendation, the best way to avoid missing information during the meetings is to record the EG session.

Debriefing:

- The conclusions of the EG exercise should be dynamic. It is not a good idea to wait until the end of the EG exercise before presenting the results to the rest of the partners in the project. To avoid this, intermediate reports should be generated.
- It is important to generate high quality minutes after the meetings. These minutes should be consistent and should contain the information exchanged in the meeting. It is also important to note clearly the points that have been closed to inform to all experts about it and close discussions about that issue.
- The experts should read the minutes carefully and accept them, or not, in a short period of time. This time should be enough for obtaining the open issues from the previous meeting and for including them in the agenda of the following meeting.
- Coordination between the different expert groups of the project is essential because some conclusions or points of view can be contradictory in two different groups. To avoid this, experts can participate in more than one expert group, a coordination cell can coordinate contradictory points of view, and the management team of each expert group should know the work being performed by other expert groups. Another possibility is to establish intermediate meetings with the leaders of WP and sub-WP to discuss the common points.

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6.1 REFERENCES

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[8] **Episode 3** Support from WP4.3.1 to WP2.4.1, E3-WP4-I0134-WKP-V0.01, V0.01, 30/04/2009

[9] **Episode 3** Minutes 5th Expert Group meeting, E3-WP4-MOTH20090623-MIN-V0.01, V0.01, 22/07/2009

[10] **Episode 3** Briefing Note for En-Route Expert Group Safety Assessment Workshop, E3-WP4-MWKS20090623-WKP-V0.01, V0.01, 11/05/2009

[11] **Episode 3** Simulation Report on 4D Trajectory Management and Complexity Reduction, D4.3.2-02, V1.00, 03/09/2009

[12] **Episode 3** Consolidated Validation Prototyping Report on Queue, Trajectory and Separation Management, D4.3.4-02, V1.00, 22/09/2009

[13] **Episode 3** Gaming on Queue, Trajectory and Separation Management Report, D4.3.3-02, V0.04, 09/10/2009

[14] **Episode 3** Minutes 6th Expert Group meeting, E3-WP4-MWKS20090715-MIN-V0.03, V0.04, 07/10/2009

[15] **Episode 3** Minutes 7th Expert Group meeting, E3-WP4-3-4sept-expert_group-minutes, V0.01, 25/09/2009

[16] **Other** Multi Executive Sector Real-time simulation (CEATS SSRTS 4). CEATS research, development and simulation centre

[17] **Other** Analysis of Multi-Sector Planner Concepts in U.S Airspace. HAIL Report 2006-3442-01

[18] **Episode 3** Annex to D4.3.1-02 En-Route expert group report- questionnaires, D4.3.1-02a, V0.01, 30/09/2009

6.2 APPLICABLE DOCUMENTS

[19] **Episode 3** E3 Expert Group Report Template, E3-WP0-I0333-GUI-V1.00-eg-report-template, V1.00, 09/04/2009

[20] **Other** E-OCVM, V2.00, March 2005

[21] Episode 3 WP4 Validation Strategy, D4.2.1-01, V2.02, 05/03/2009

[22] Episode 3 SESAR DOD E6, Conflict Management in En-Route High & Medium/Low Density Operations Detailed Operational Description, D2.2-048

[23] Episode 3 SESAR DOD E4, Network Management in the Execution Phase Detailed Operational Description, D2.2-046

[24] Episode 3 OS-38, Flights in the Execution Phase in a 4D environment, part of Annex to SESAR DOD G - Operational Scenarii - D2.2-050

[25] Episode 3 WP4 En-Route Expert Group Plan, D4.3.1-01, V1.00, 07/01/2009

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

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

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1 Annex: List of Experts and planned meetings

Next table list the experts that attended the meetings or answered the questionnaires.

Name	Company	Name	Company
Patricia Ayllón	AENA	Roel Huurdeman	EUROCONTROL-MAS UAC
Antonio Obis	AENA	Christopher Adams	EUROCONTROL-MAS UAC
Javier Martínez	AENA	Víctor Bustos	INECO
Patrick Lelievre	AIRBUS	Xavier Ruiz	INECO
Yan Yonggang	ATMB	Jose Ignacio Nieto	INECO
Li Quan	ATMB	Laura Serrano	INECO
Bu Qiang	ATMB	Jose Manuel Rísquez	INECO
Yang Bo	ATMB	Ester Martin	INECO
Ralph Leemüller	DFS	Nicolás Suárez	ISDEFE
Eliana Haugg	DFS	Marta Fernández	ISDEFE
Ralf Kohrs	DLR	Amalia García	ISDEFE
Claude Chamayou	DSNA/DTI/MTC	Rocio Manjón	ISDEFE
Bernard Gayraud	DTI R&D	Raquel Garcia	ISDEFE
Serge Manas	DTI R&D	Inés Solano	ISDEFE
Cyril Allignol	DTI R&D	Claes Rundberg	LFV
Bill Booth	EUROCONTROL	Richard Powell	NATS
Frank Dowling	EUROCONTROL	Christopher Gerrard	NATS
Predrag Terzioski	EUROCONTROL	Bart Klein	NLR
Randall De Garis	EUROCONTROL	Joram G Verstraeten	NLR
Kevin Harvey	EUROCONTROL	Xavier Blanchon	THAV
Philippe Leplae	EUROCONTROL	Thierry Person	THAV
Ian Ramsay	EUROCONTROL	Xavier Jourdain	TR6

Meeting	Place	Host Partner	Date
1st EG - 1st Gaming	Madrid	Isdefe	15/16-10-08
2nd EG - 2nd Gaming	Langen	DFS	19/20-11-08
3rd EG - 3rd Gaming	Madrid	Isdefe	15/16-01-09
4th EG	Amsterdam	NLR	14/15-04-09
5th EG - 4th Gaming	Madrid	Isdefe	23/24-06-09
6th EG - 5th Gaming	Madrid	Isdefe	15/16-07-09
7th EG	Langen	DFS	03/04-09-09

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2 Annex: Separation Management Expert Group

This annex presents a summary of the Separation Management Expert Group led by DSNA before the suspension of the EP3 project.

The Expert group on Separation Management met twice in March and April 2008. The initial planning was to hold 3 workshops - one on Operational aspects of selected SESAR new separation modes, one on technical aspects derived from the operational scenarios described in the first workshop and the third one (cancelled) was intended to address validation activities with respect to the selected scenarios.

Each workshop gathered around 20 participants from all partners (DSNA, DFS, AENA, AIRBUS, ATMB, DLR, EEC, EHQ, E-MUAC, INECO, NATS, NLR, ISDEFE, TR6, and THAV).

The main objective of the expert group on separation management was to provide guidance to partners performing simulations in cycle 1 and cycle 2

- AENA, INECO and DFS for WP 4.3.1.1.5: Fast-Time Simulation on 4D, RTA and ASAS (ASAS Applications and 4D-Contract Aircraft)
- EEC for WP 4.3.1.1.6: General Real-Time Simulation on Impact of the NOP at En-Route Sector.
- DSNA for 4.3.1.2.5: Real-Time Simulation on the evaluation of a consistent set of new procedures and tools for En-Route traffic dilution and de-confliction.

To start, the expert group ensured a common understanding of ATM capability levels in SESAR. It was then agreed to define the operational environments, then operational situations, including a discussion on the strategy and priorities in the application of the separation modes.

At the end of the first workshop, the refined scenarios were used to establish a series of items in preparation of the second workshop related to validation activities.

The second workshop in April 2008 succeeded in providing answers to partners for their validation exercises.

The third workshop was cancelled due to the EC stopping the project from April 08 to August 08.

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3 Annex: Complexity Management Expert Group

Next text is the Executive summary of the En-Route and complexity management Expert Group Report E3-WP4-D4.3.1.1.1-02-PLN-V2.00-enroute-exp-group-report. This Expert Group was part of WP4 En-Route execution phase expert groups and finalised their activities in April 2008.

Please refer to the report for further information.

This document describes the results of the Expert Group on En-Route Complexity Management focused on the definition of this procedure at local level. The Expert Group exercise is part of EP3 WP4.3.1, whose goal is to validate technologies, processes and procedures related to the En-Route area of the execution phase.

The internal stakeholders of the Expert Group exercise are the Gaming (GE), Real Time Simulation (RTS) and Fast Time Simulation (FTS) Exercises that complete the validation activities included EP3 WP4.3.1.

Main objectives reached during the Expert Group have been:

- High level definition of the Complexity Management procedure;
- Factors generating complex situations and their influence on ATCo workload;
- Roles and functions involved along the process;
- Operational scenario and use case descriptions;
- High level requirements for associated automated assistance tools;
- Recommendations about new techniques and tools that will improve the ATCo workload; and
- Impact on KPAs and relevant OI Steps needed to implement the process.

The Expert Group has defined Complexity Management as a process focused on managing overall ATCo workload and primarily based on trajectory predictions using all information shared in the SWIM (RBTs, meteo information, NOP…) with the aim of maximizing network capacity.

The efficiency of this procedure is based on the adequate design of the airspace configuration. The definition of elemental volumes, sectors and family of sectors should be performed thinking about the procedure that will support.

The procedure is a continuous process consisting of:

- Complexity evaluation and complex situation awareness;
- ‘What-if’ evaluation of solutions taken from the de-complexing solutions catalogue;
- Selection of the most appropriate solution for the identified complex situation;
- Implementation and monitoring of the implemented de-complexing solution.

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4 Annex: Questionnaires

Due to the length of the questionnaires and their answers, the complete information is available in the document Annex to D4.3.1-02 En-Route expert group report- questionnaires, [18]. An example is included in this annex.

In questions which answers can be yes or no, the associated percentage is related to the number of "Yes" obtained. NA means Non Agreement reached, this will happened if the percentage of answers is between 30 and 70.

Q2.11 En-Route queue management in the execution phase includes the management of queues to facilitated the delivery of traffic to airports without AMAN

Yes 80%

Q2.12 DCB arrival queues are planned by the Sub-regional Network Manager at the request and in coordination with the APOC staff (typical time horizon up to 2h)

NA 50%

Q2.13 DCB queue is a pre-sequence flight list over a constraint point

Yes 78%

Q2.14 Seamless coordination between TMA controllers and adjacent En-Route control authorities will be in place to facilitate the adjustments required to meet the assigned time constrains

Yes 89%

Q2.15 This coordination includes that MSP and EC will progressively integrate the arrival flows (previously defined by sub-regional manager and AMAN) using one or more merging points as part of the dynamic or predefined routes.

Yes 100%

Q2.16 In the execution phase this coordination will be performed mainly through:

The definition of the activated resources (merging points)	Yes 78%
The availability of the planned queues per merging point from Sub-regional manager and AMAN. The information in these queues includes the order and the TTA/CTA.	Yes 89%
Do you foresee any other type of coordination?	No
	There will be sector/sector coordination to initiate queue requirements further upstream and between complexity manager and AOC to prioritize intra-company flights where possible

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