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 & complexity management Expert Group Report
Deliverable ID	D4.3.1.1.1-02
Version	2.00
Owner	
Raquel Garcia	ISDEFE
Contributing partners	
Note applicable	

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

- This page is intentionally blank -

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

DOCUMENT CONTROL

Approval

Role	Organisation	Name
Document owner	ISDEFE	Raquel Garcia
Technical approver	DFS	Ralph Leemuler
Quality approver	EUROCONTROL	Ludovic Legros
Project coordinator	EUROCONTROL	Philippe Leplae

Version history

Version	Date	Status	Author(s)	Justification - Could be a reference to a review form or a comment sheet
1.00	11/04/2008	Approved	Enrique Casado	Inclusion internal comments
2.00	06/08/2009	Approved	Raquel Garcia	Document approved by the EP3 consortium.

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

TABLE OF CONTENTS

EXECUTIVE SUMMARY 6

1. INTRODUCTION 7

1.1 PURPOSE OF THE DOCUMENT 7
1.2 INTENDED AUDIENCE 7
1.3 DOCUMENT STRUCTURE 7
1.4 BACKGROUND 7
1.5 GLOSSARY OF TERMS 9
1.6 REFERENCES AND APPLICABLE DOCUMENTS 9

2. EXERCISE SCOPE 11

2.1 STAKEHOLDERS 11
2.2 DESCRIPTION OF ATM CONCEPTS BEING ADDRESSED 11
2.3 ANALYSIS METHODOLOGY AND TOOLS APPLIED 12
2.3.1 Delphi Method 12
2.4 LINKS WITH OTHER VALIDATION EXERCISES 16

3. RESULTS AND DISCUSSIONS 16

3.1 COMPLEXITY MANAGEMENT 16
3.1.1 Definition & Description 17
3.1.2 Identification of Complex Situations 18
3.1.3 Roles and Functions 19
3.1.4 Complexity Managements vs. Separation Management 20
3.1.5 ATCo Workload 21
3.1.6 Solutions 24
3.1.7 Scenario and Use Cases 26
3.1.8 Automations 42
3.1.9 KPAs, OCEs, OIs 44
3.2 FULFILMENT OF THE EXERCISE OBJECTIVES 49
3.3 RISK ARISEN AND MITIGATION ACTIONS 50

4. CONCLUSIONS AND RECOMMENDATIONS 51

4.1 COMPLEXITY MANAGEMENT PROCEDURE 51
4.2 CONSIDERATION FOR THE VALIDATION EXERCISES 55
4.2.1 Gaming exercise 55
4.2.2 Fast time simulation exercise 55
4.2.3 Real time simulation exercise 55
4.3 EXPECTED PROFITS IN THE FUTURE ATM SYSTEM 55
4.4 RECOMMENDATIONS 56

ANNEX 1 – 1ST QUESTIONNAIRE 58

ANNEX 2 – 2ND QUESTIONNAIRE 72

ANNEX 3 – 3RD QUESTIONNAIRE 138

ANNEX 4 – 4TH QUESTIONNAIRE 151

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

LIST OF TABLES

Table 3-1 Impact of CM procedure in SESAR KPAs 45
Table 3-2 OCEs involved in the CM process 46
Table 3-3 Primary OI Steps regarding CM 48
Table 3-4 Secondary OI Steps regarding CM 49

LIST OF FIGURES

Figure 2-1 Delphi Method Procedure 13
Figure 3-1 Complexity Management Procedure 27
Figure 3-4 General Case Step 2 31
Figure 3-5 General Case Step 3 32
Figure 3-6 Use Case #1 Step 0 33
Figure 3-7 Use Case #1 Step 1 34
Figure 3-8 Use Case #1 Step 2 35
Figure 3-9 Use Case #1 Step 3 36
Figure 3-10 Use Case #2 Step 0 37
Figure 3-11 Use Case #2 Step 1 38
Figure 3-12 Use Case #2 Step 2 38
Figure 3-13 Use Case #3 Step 0 39
Figure 3-14 Use Case #3 Step 1 40
Figure 3-15 Use Case #3 Step 2 41
Figure 3-16 Use Case #1 Step 2 42
Figure 4-1Complexity Management Procedure description 53
Figure 4-2 Complexity Management Timeframe 54
Figure 4-3 Increase of Capacity due to Complexity Management application 56

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

EXECUTIVE SUMMARY

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.

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

1. INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

This document gathers the information and results of the En-route Complexity Management Expert Group. The main objective is to define the procedure in detail explaining the timeframe of applicability, the roles involved and their functions and a high level description of the use cases which could be appropriate for the procedure validation.

1.2 INTENDED AUDIENCE

The intended audience includes:

- E3 WP4 En-Route and Traffic Management:
  - EP3 WP 4.1 Leader;
  - EP3 WP 4.2.1 Leader, who is responsible for reviewing this document;
  - EP3 WP 4.3.1.1.3 Leader;
  - EP3 WP 4.3.1.1.4 Leader;
  - EP3 WP 4.3.1.1.6 Leader.
- Expert Group Partners.

1.3 DOCUMENT STRUCTURE

This document structure is similar to the EP3 WP4.3.1.1.1 Exercise Plan [8]. Section 1 and Section 2, where the document purpose, structure and general background and supportive information is described and also the scope of the exercise, explaining the stakeholders, the objectives of the Expert Group (EG) and the methodology applied.

Section 3 gives the exercise results after extracting the most relevant information from the Experts. Section 4 presents the final conclusions and recommendations of the EG.

Finally the Annexes gather all information requested and exposed by the experts during the whole period. This information is the main source from where the final EG results have been extracted.

1.4 BACKGROUND

Episode 3 is in charge of beginning the validation of the operational concept expressed by SESAR Task 2.2 and consolidated in SESAR D3 [3]. Initial emphasis was given on obtaining a system level assessment of the concept's ability to deliver the defined performance benefits in the 2020 time horizon corresponding to ATM Capability Level 2/3 and the Operational Improvement Step IP 2.

The validation process as applied in Episode 3 was based on the E-OCVM [2], which describes an approach to ATM Concept validation. However, the E-OCVM has not been so

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

far applied to validation of a concept on the scale and complexity of SESAR. Such a system level validation assessment must be constructed from data derived from a wide range of different validation activities, integrating many different levels of system description, different operational segments and contexts and different planning horizons. The data will be collected through a variety of methods and tools and will vary in its quality and reliability.

The process of performing systematic validation and the integration of results must be actively planned and managed from the beginning of the whole validation activity. This validation management is coordinated by EP3 WP2.3, which is responsible for ensuring the effective application of the E-OCVM, the consolidation of the Episode 3 Validation Strategy, and establishing a Validation Framework, which allows the integration of the validation results and the construction of the necessary system level view.

Validation exercises should produce evidence (preferably measured) about the ability (some aspect) of the concept to deliver on (some aspect of) the performance targets. In order to be able to do Validation Exercises, there is a need for concept clarification, requirements development or elaboration activities in preparation for down line validation activities.

Clarification exercises are one of the tasks of the Expert Groups. The Expert Group exercises have taken place before any other validation exercise and generated input for some of these exercises. Their key outputs consisted of a better understanding of how the concept needs to operate to be evaluated and a consensus on best assumptions (to then be documented).

This Expert Group exercise is included in EP3 WP4.3.1, where the aim is at validating technologies, processes and procedures related to the en-route area of the execution phase. This work package was split into two cycles; during the first cycle the improvements were assessed in separate environments trying to evaluate individual improvements for Complexity Management and Separation Management without any mutual interaction. During the second cycle a common study was envisaged incorporating all the conclusions derived from the first cycle and considering the whole problem as an addition of complexity and separation together. In this second one all validation exercises considered scenarios addressing both situations to establish a common method to solve this kind of situations in a common way.

More specifically, this Expert Group exercise is included in EP3 WP4.3.1.1.1, En-route Complexity Management, the objective of which has been to explore en-route procedures for identifying and resolving complex situations, assessing the impact on the NOP (distortion of the RBT) and considering the capacity and efficiency of effects reducing complexity to a manageable level.

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

1.5 GLOSSARY OF TERMS

Term	Definition
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATCO	Air Traffic Controller
ATFM	Air Traffic Flow Management
ATFCM	Air Traffic Flow and Capacity Management
AOCC	Airline Operation Control Centre
CDM	Collaborative Decision Making
CM	Complexity Management
CONOPS	Concept of Operations
DAM	Dynamic Airspace Management
DOD	Detailed Operational Description
EG	Expert Group
E-OCVM	European Operational Concept Validation Methodology
ERC	EUROCONTROL Research Centre
FAB	Functional Airspace Block
IP	Implementation Phase
KPA	Key Performance Area
KPI	Key Performance Indicator
MTCD	Medium Term Conflict Detection
NOP	Network Operations Plan
OCE	Operational Concept Element
RBT	Reference Business Trajectory
RNM	Regional Network Manager
SESAR	Single European Sky ATM Research and Development Programme
SM	Separation Management
SNM	Subregional Network Manager
STCA	Short Term Conflict Alert
WP	Workpackage

1.6 REFERENCES AND APPLICABLE DOCUMENTS

Ref.	Document	Name	Applicability
[1]	Draft	EP3-Cycle1-DOD-E4 Network Management in the Execution Phase	Applicable

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

[2]	E-OCVM V2.0	European Operational Concept Validation Methodology	Applicable
[3]	SESAR D3	DLM-0612-001-02-00a	Applicable
[4]	WP4 Validation Strategy	D42-01 WP4 Validation Strategy-V02	Applicable
[5]	WP2.4.2 Description of Responsibilities	DLT-0612-242_00_09-Roles and Responsibilities	Applicable
[6]	n/a	Linstone, Harold A; Turoff, Murray The Delphi Method: Techniques and Applications, Ed. Linstone & Turoff (1975)	Applicable
[7]	E3 DOW v2.8	Episode 3 Annex 1 – Description of work	Applicable
[8]	E3-WP4-D4.3.1.1.1-01-PLN-V1.00-enroute-exp-group	WP 43111 Expert Group Exercise Plan	Applicable
[9]	SESAR DLT-0612-222-02-00	Task 2.2.2/D3 Concept of Operations	Applicable
[10]	n/A	Wickens, C.D. Engineering Psychology and Human Performance, Ed. Harper Collins, New York, 1992.	referenced

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

2. EXERCISE SCOPE

This Section describes general aspects related to the Expert Group such as the stakeholders related to this exercise, the new ATM concepts which are the subjects under study during the Expert Group and the methodology applied for steering it.

2.1 STAKEHOLDERS

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

The main external stakeholder groups in air transport industry involved in the Complexity Management process are described in SESAR description of roles and responsibilities [5].

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:
  - EP3 WP4.3.1.1.3 Gaming Exercise on En-route Complexity Management (ISDEFE);
  - EP3 WP4.3.1.1.4 Fast Time Simulation on a One Day Network Operations Plan (NOP) (ERC);
  - EP3 WP4.3.1.1.6 Generic Real-Time Simulation on Impact of the NOP at En-route Sector (ERC).

Diverse representatives of the air transport industry are involved in the preparation and conduction of this Expert Group as presented in the exercise plan,[8]. This ensures a realistic operational feedback and evaluation of the results.

2.2 DESCRIPTION OF ATM CONCEPTS BEING ADDRESSED

As defined in SESAR ConOps F3.2.1 [9], Complexity Management is seen as a process that is applied to simplify the ATM situation so that Separation Provision can be efficiently applied by human intervention.

Complexity management 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 time transition from operations without route structures to periods when routes structures are essential to assure the required capacity with safety;

- 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.

Traffic Complexity Management also includes the objective to free controller mental resources by minimising the level of risks perceived by the controllers.

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

2.3 ANALYSIS METHODOLOGY AND TOOLS APPLIED

For the conduction of this Expert Group the Delphi Method, presented in the document The Delphi Method: Techniques and Applications [6], was identified as an appropriate technique. 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.

2.3.1 Delphi Method

Delphi method has a number of beneficial features. First of all, it stimulates the synergy of the group discussion, enabling to take better results out of the group expertise areas than the same of simple gathering of contributions from every single expert separately. Moreover, controlled feedback in this iterative process is a positive way of taking advantage of the group heterogeneity, since very different participants are taking part in the group. This guarantees equity, which means that all opinions count the same. Another key feature is anonymity, which makes participants express their opinions without fearing to initiate a discussion or being judged, and allows them to clarify any doubt. Results are given in a statistical form.

As stated in the Exercise Plan [8], four cycles of questions – answers were established. During these four phases an iterative process composed of the following steps was performed:

- Questionnaire distribution to Experts;
- Answers/comments gathering;
- Answers/comments integration;
- Summary Report distribution.

Next diagram summarises the general process defined at the beginning of the Expert Group. Finally due to schedule constraints it has not been possible to follow exactly the same procedure. The step ‘Request Expert for Explanation in Detail’, planned to get a higher level of consensus, was not performed because there was no enough time to send a personalized questionnaire to those experts whose answers are very different to others’. The solution found was to include additional questions in next questionnaires trying to asses deeply the new inputs not only by the expert who raised the subject but also by all groups of experts. These modifications enabled to maintain the established schedule obtaining information with the appropriate detail and getting the expected level of consensus.

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

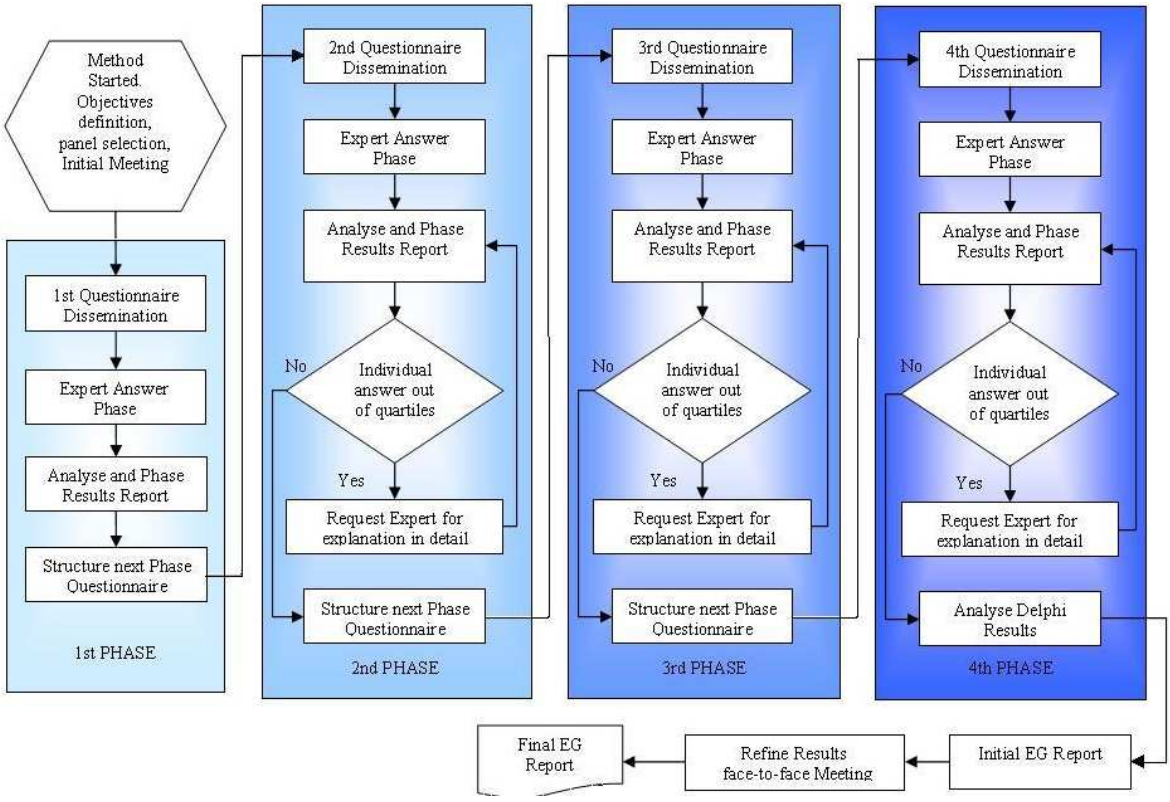

Figure 2-1 Delphi Method Procedure

2.3.1.1 Initial meeting

The 1st phase began with the selection of expert panel, see Exercise Plan Section 6.1 [8], and the definition of the EG Objectives. An introductory meeting was held with the next intentions:

- explanation of the Delphi methodology to the Experts;
- introduction of main topics about CM within SESAR;
- definition of the high level structure about subjects under study. The main topics to be treated during the expert group were split into five elements:
  - Assessing the Problem.

    Definition of complexity, how to measure it in general terms, how to get complexity awareness in advance, who is involved in the process and what the most relevant events of the Complexity Management procedure are.
  - ATCo workload.

    Description of relationship between Complexity Management and ATCo workload. Complex situations have a strong impact on the ATCo workload, therefore it is very important to control the complexity of traffic that should be managed by a single controller. Complexity Management entails the surveillance of complexity avoiding controller overloads.
  - Solutions.

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

Description of actions that should be carried out to solve a complex situation once it has been identified, with the target of minimising the impact on the ATCO workload.

- o Automation.

  Definition of high level requirements of automated tools supporting the whole process from the identification of a complex situation, the selection of appropriate solutions and final monitoring.

- o KPAs, OCEs and OIs.

  Evaluation of impact of the CM procedure from the SESAR point of view, assessing its influence in the KPAs and identification of the OCEs and OIs which will facilitate the CM procedure implementation.

- Description of the whole process focusing on how to answer the questionnaires and which the key dates were.

This introductory meeting was considered as kick-off of the exercise.

2.3.1.2 Phase 1

The main purpose of this 1st Phase of questionnaires was to provide to the panel with an overall vision of Complexity Management. Experts were encouraged to review the applicable documentation and to refresh their knowledge about Complexity Awareness, ATCo workload and Complexity Management. This purpose was accomplished and considering the responses to the first questionnaire, it can be concluded that experts made enough effort to train themselves and to refine their answers.

The answers from the experts gave a feedback to support the structure of the next questionnaires. The information gathered improved the definition of the procedure, the boundaries of Complexity Management and also showed important details and controversial issues.

2.3.1.3 Phase 2

With the conclusions of the first Questionnaire, the second Questionnaire was developed. The goal of this second one was to deeper analyse the information exposed by the experts, clarifying some areas or unclear response and detailing the Complexity Management procedure deeper.

To answer this second Questionnaire, the summary of responses related to the first was distributed to experts as initial information to be read prior to the completion of the questionnaire.

This second Questionnaire was focused on detailing some open subjects and on prioritizing the experts' opinion. To perform the task a quantitative evaluation was requested to the experts (test-type questions) of most of elements gathered with the responses of the first Questionnaire. All data coming from this quantitative evaluation was analyzed using the next factors:

- Average, referring to the arithmetical mean;
- Mode, value that has the largest number of observations;
- Quartiles, any of the three values which divide the sorted data set into four equal parts (25th, 50th & 75th percentiles).

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

For these quantitative questions, a prioritized list was built only considering those answers with an average higher than 7, 0.

For those answers which were not quantitative, the summary of experts' responses was handled in the same way as it was made in the previous questionnaire.

2.3.1.4 Phase 3

As performed in the previous phase the conclusions of the second Questionnaire were the starting point for developing the third Questionnaire. The goal of this third one was to clarify the possible operational scenarios and the Operational Improvements related to Complexity Management.

In this phase there was a need to create a new section to clarify all details about operational and validations scenarios and the definition of appropriate use cases. Then the third questionnaire included a new topic defined as Scenarios to be added to the five topics established at the beginning of the expert group (see Section 2.3.1.1).

With all information gathered during previous phases it was considered that topics 'Assessing the Problem' and 'ATCo workload' were almost clear and just an open question about pending issues not identified yet was risen. For the generation of the fourth Questionnaire both topics were considered closed yet pending on the final agreement during the last meeting.

The quantitative and qualitative answers were handled in the same way and applying the same criteria as performed in the previous questionnaire.

2.3.1.5 Phase 4

The goal of this 4th Phase was to get the final conclusions about some pending issues coming from the previous questionnaire and to generate a preliminary set of conclusions prior to the final face-to-face meeting.

Due to the fact that all answers showed a high level of consensus and 'KPAs, OCEs and OIs' topic was considered closed after the answers to third Questionnaire, then it was decided to focus the last questionnaire on getting more details about scenarios, use cases and automation tools.

2.3.1.6 Face-to-face meeting

The preliminary conclusions of the EG were presented to the Experts. The whole summary including the 4 Phases answers described what complexity Management is, its interaction and influences on ATCo workload, a top level description of the procedures and roles involved in it.

During the meeting Experts requested to define the list of functions related to Complexity Management (CM) that should be performed by the involved roles, prior to its inclusion in the Final Report.

In addition, the list of OI Steps was restructured according not to the targets of detecting or solving complex situations but according to whether they are necessary to implement the whole process or just to support and improve them.

The CM scenarios and proposed solutions to them were considered as appropriate by the Experts.

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

2.3.1.7 Final Expert Group meeting

The final expert group meeting was used to present to the experts this expert group final report, a summary of the information discussed all along the exercise and the conclusions agreed in the group.

In the meeting the objectives fulfilled and the risks that took place during the development of the exercise were also presented and agreed.

2.4 LINKS WITH OTHER VALIDATION EXERCISES

All activities of this EG are included in EP3 WP4.3.1 which has the objective of carrying out all validation exercises in the en-route area along two cycles of exercises. This comprises expert workshops, gaming sessions and fast time and real time simulations.

During Cycle 1 there is only one Expert Group exercise addressing complexity issues in EP3 WP4.3.1. Conclusions and outputs will be used by later exercise in this work package in order to get knowledge and first indications about the potential of these complexity management methods. Figure 2-1 summarises the global structure for this EP3 WP4.3.1 and the relationships among all tasks.

The Expert Group provides direct input for the following exercises within EP3 WP4.3.1:

- Gaming Exercise on Complexity Management (EP3 WP4.3.1.1.3 ISDEFE);
- Fast Time Simulation (FTS) on a One Day Network Operations Plan (EP3 WP4.3.1.1.4 EUROCONTROL).

Moreover, the outputs will be used in other Episode 3 work packages outside EP3 WP4.3.1:

- Operational Concept Refinement (EP3 WP 4.2.2 NATS);
- Results Analysis and Report (EP3 WP 4.3.2 DFS).

Additionally, EP3 WP4.3.1.1.6 Generic Real-Time Simulation on Impact of the NOP at En-route Sector (EUROCONTROL) is also being fed by the assumptions and clarifications produced by this Expert Group. The Expert Group is aware of the subsequent validation exercises needs and expectations.

3. RESULTS AND DISCUSSIONS

3.1 COMPLEXITY MANAGEMENT

After the finalisation of the whole process a clear and common understanding of the high level CM process from the early detection until the implementation and monitoring the solutions has been obtained.

Next section summarises the ideas risen and agreed during the EG, describing the CM procedure, its influences on ATCo workload, the description of the operational scenario and use cases, the possible solutions to be applied and the recommendations about automated tools that would support the procedure.

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

3.1.1 Definition & Description

The definition of the Complexity Management process is the first step to understand the situation and to go deeper proposing solutions.

Complexity Management (CM) is a process focused on managing overall ATC workload and primarily based on trajectory predictions using all information shared in the SWIM (RBTs, meteo information, NOP…) with the aim of maximizing the network capacity.

However, CM is also influenced by other secondary factors that should be considered along the process:

- Airspace configuration, based on the volumes, sector and families of sectors established to handle with the traffic;
- Aircraft density, number of aircraft included in a sector;
- Weather forecast;
- Traffic mix;
- Available airspace capacity;
- Available facility resources (ATC, Airport, Navigation, Communication, etc).

The CM implementation process will provide the benefits to the global ATM system, but it is important to define the airspace configuration previously considering the CM procedure will be applied when necessary. Without an appropriate airspace configuration this procedure is useless. When the circumstances are those which ensure the procedure efficiency, the expected benefits directly provided are:

- Simplify the ATM situation so that Separation Provision can be efficiently applied by human intervention;
- Remain the ATCo workload within reasonable limits in all situations;
- Maximise the network capacity;
- Keep tactical interventions per each individual aircraft (or cumulative set of flights), specially sequencing and conflict resolution, below a reference level.

Additionally to these topics some other indirect benefits have been highlighted by the experts:

- Optimise the ATC team resource management;
- Distribute workload throughout a predefined portion of airspace in which ATC is provided using dynamic airspace management, dynamic flow management and extensive pre-defined scenarios.

The CM process should trigger the next actions prior to the arrival of the aircraft in the subject airspace, removing or reducing the predicted complexity below the defined threshold:

- Dynamic Airspace Management;
- RBTs modifications;

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

- Demand & Capacity Balance Solutions or De-complexion Solutions;
- Structured airspace with fixed routes;
- Dynamic Constraint Management.

Problems detected by the CM process will be solved by adjusting traffic plans and control arrangements during the pre-tactical phase previous to any ATCo intervention.

When applying CM, the solution chosen requires finding a balance for all players. That supports the need of a simulation or 'what-if' tool helping the Complexity Manager when a de-complexion solution was necessary knowing its impact in advance.

3.1.2 Identification of Complex Situations

Measuring complexity is a difficult task, but it is a need in order to predict complex situations that may lead to extremely high workloads. The complexity predictions must be done with sufficient time to apply arrangements to decrease the ATCo workloads to admissible levels.

The following list shows the complexity variables the expert group has considered as the most important to identify complex situations:

- number and type of potential predictable conflicts based on actual flight parameters (speed, 4D contract, clearances…) and RBT known data;
- aircraft density considering the number of simultaneous flight movements in relation to the size of a certain volume of airspace;
- weather Parameters;
- Time pressure, considering the routine tasks performed by the ATCo and their time consuming.
- uncertainty of data, mainly in the prediction trajectories process;
- Overall demand.

These variables should be controlled to identify complex situations in advance. There are some different international initiatives, such as iFLY, trying to establish an analytical model for complexity awareness including most of these parameters.

It is important to understand that the indicators are not independent, so the complexity growth is nonlinear with the number of involved complexity variables.

A relevant point is the accuracy of data. Some conflict situations detected in advance do not become real conflicts due to the uncertainty of the data used for the calculation. CM should identify high probability complex situations and turning them into low probability situations. It is assumed the prediction accuracy will be considerably higher when SESAR is fully implemented (2020) than today due to SWIM, CDM, AMAN, etc. Nevertheless some indicated conflicts will not happen as predicted at a certain point in time as today. In that time the 4D contract trajectories will be monitored continuously, so the prediction will be more accurate with a decreasing look ahead time.

The Complexity Manager has to constantly monitor these variables, reviewing the traffic situation (both current and pending) to identify changes in advance and act accordingly.

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

Mainly this task will be supported by an automated tool that warns when a complex situation is detected starting with the de-complexing process.

3.1.3 Roles and Functions

The CM process involves some of the SESAR roles as shown next. This list also defines the functions of each one regarding the CM process:

- Complexity Management
- Maximise network capacity within the airspace volume of responsibility;
- Maximise safety by providing the best use of controllers work force by reducing workload per airspace while maintaining high levels of productivity and safety;
- Monitor the levels of traffic complexity;
- Initiate CDM processes to find solutions to reduce complexity when needed;
  - Including initiate actions for sector splitting / merging or dynamic adjustments.
- Verify applicability of proposed solutions;
- Keep the workload reasonably distributed throughout airspace;
- Negotiate new RBT parameters and agreements;
- Initiate the RBT negotiation process;
- Coordinate with all roles involved in the CM process;
- Determine whether an alternative routing may be preferential to the overall traffic situation;
- In charge of resectorisation;
- Forecast traffic patterns.
- Civil / military Airspace Management
- Establish the structured airspace with fixed routes when required by the SNM.
- Disseminate the information to all users through the SWIM.
- Sub-Regional Network Management
  - Select the most appropriate de-complexion solution in close collaboration with the Complexity Manager;
  - Assure the provision of information on upcoming congestions;
  - Communicate with the RNM when a network effect assuming the most suitable solution is envisaged;

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

  - Checking the network impact and synchronisation;
  - Monitor the situation during the whole process and analyse the feedback.

- Regional Network Management
  - Decide, in close collaboration with the SNM and the Complexity Manager, the most appropriate solution when a network effect is envisaged;
  - Checking synchronisation.

- Airspace Users (AOCC) & Other Users - e.g. military, sport flying:
  - Negotiate and execute the new RBTs;
  - Be aware about changes and restrictions in the airspace structure.

- Multi-Sector planner (as an evolution of the planning controller)
  - Responsible for the process or resectorisation of airspace, optimise resources, when required by the SNM due to a detected complex situation that needs to be solved.

- Planning Controller
  - Near-tactical deconfliction of trajectories;
  - Balance the workload;
  - Entry & exit planning;
  - Assess how the impending flight fit within the demand pattern.

- Supervisor
  - Responsible of manpower planning and administrative resources;
  - Decide on restrictions coming from other areas of ATM.

3.1.4 Complexity Managements vs. Separation Management

Complexity Management and Separation Management are different procedures with different objectives but with a common element: conflicts. In order to avoid misunderstandings and overlappings a separation has been stated during the EG. Both of them are focused on safe traffic management avoiding collision risks and separation alerts. Mainly CM is basically a flow based process while SM is individual flight based. Besides they are also close related processes time differenced.

Separation management is a defined responsibility of the Executive ATCo, while Complexity Management is a DCB process where some other roles are involved at the same time. All CM actions and de-complexing solutions should be always assumed before the aircraft generating the complex situation goes into the defined sector. At this point in time, the ATCo takes the responsibility of the flight and no other people are able to take actions ensuring safe traffic but him/her. These actions are considered as Separation Management because the ATCo's

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

objective is to ensure the safety of flights by making sure that minimum separation criterion is never overcome.

Complexity Management:

- focuses on abstraction (including route structures, the required capacity with safety, the optimum sectorisation organisation, the efficiency of the separation provision service and the use of dynamic sector configurations);
- reduces the overall workload;
- Addresses both effort for SM and also effort to organise transfers, sectorisation etc.

Separation management:

- focuses on separation among aircraft (including radar separation, vertical separation etc);
- Is the primary ATC function. This is achieved via shared tactical control necessitating a co-ordination overhead;
- Ensures that the flight interacts safely with other flights in its immediate vicinity.

Although CM would solve a separation problem in advance if there were workload benefits, in general CM may be regarded as smoothing the tactical controllers SM work.

SM and CM are really established in a cohesive manner and are optimised in the interests of the overall ATC / ATM scheme, which include traffic synchronization (NOP compliance).

3.1.5 ATCo Workload

The main objective of the CM procedure is to maintain the ATCo workload under a predefined threshold, not only for one ATCo but also for all ATCos working on the same family of sectors.

When the Executive ATCo faces a complex situation, the workload perception is the leading factor as real time actions have to be taken. This section details the influence and relationship between complex situations and the ATCo workload.

Complexity is a contributory factor to ATCo workload but it is not the only one. There are other tasks related to workload such as monitoring the levels of radiotelephony. For an ATCo complexity has an impact on his/her workload, but the perceived workload is not only dependent on the number of aircraft he/she is required to control but also on the level of complexity experienced. The ATCo workload is mainly determined by three aspects:

- an intrinsic complexity related to the air traffic;
- a subjective component related to the controller itself (cognitive strategies and individual characteristics);
- Available supporting tools.

When dealing with a medium to high number of aircraft, a complex scenario is likely to increase the ATCo's workload quite significantly. In general, the higher the density in a sector is, the greater the potential complexity because there are more aircraft which could cause complex interactions or future conflict situations.

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

The main difference is that complex situations are detected measuring objective parameters and ATCo's workload includes subjective and mental parameters. The most relevant tasks that constitute the ATCo's workload are:

- conflict detection and resolution;
- real time or routine tasks;
- executive instructions to flights including level changes;
- co-ordination with other sectors;
- prioritisation of actions;
- monitor of changing conditions.

Measuring complexity means measuring ATCo's workload, which (to a large extent) should represent mental load. The list of factors having influence on ATCo mental workload:

- overall demand;
- radiotelephony frequencies requirements;
- weather;
- operations in adjacent airspace;
- time pressure, sequence of tasks to be performed in period of time;
- criticality of decisions;
- fatigue;
- sectors under control -number, shape, structure-;
- number and type of aircraft under control;
- complex operational scenario;
- level of standard operational procedures;
- level of supporting tools;
- information uncertainty;
- level of experience;
- level of training.

ATCo workload encompasses something else than mental load. There are 'mechanical' actions such as routine radiotelephony requirements and co-ordination sequences. These actions have an influence on the ATCo, producing time load, which is the number of activities to be performed, and physical load that shows the level of physical activity required by a

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

controller resulting from performing tasks which are interfaces with the physical environment (e.g. communications, data entry).

objective. There certainly are scenarios, which are not necessarily complex and therefore require a low level of mental workload but may entail a high level of physical activity such as radiotelephony activity - where there is a physical limit to workload. Then it is important to notice that not all situations producing high ATCo workload are complex situations.

It is quite difficult to calculate exact ATCo workload because of two main reasons:

- controller workload depends on more than complexity related issues alone (e.g. it depends on the experience and training of the controller);
- Predictions of future aircraft positions are subject to some inevitable uncertainty, as discussed below.

In the case that cognitive aspects of the ATCo response and workload perception could be clearly studied and defined, specific drivers would be considered, including complexity subjective perception parameters based on psychological studies of human reaction processes.

If it is known when a situation is considered as complex by the ATCo, instantaneous self assessment may be one of the better ways, but not the only one. The number of reported overloads is also an indicator, although this can also be influenced by external factors such as the satisfaction/morale of controllers.

The cognitive aspect is in the human factor scope and is possible to analyse and simulate it through techniques like the Wickens' model [10].

Among the indicators that can be used to measure the ATCo workload, the Experts have found the following as the principals:

- number of vertical movements;
- number of potential conflicts;
- interval between ATC instructions;
- number of commands (voice or data messages) sent per hour ;
- number of flights controlled by one controller per hour;
- number of flight level change instructions;
- average time for each possible action;
- number of co-ordination discussions with adjacent agencies;
- radiotelephony frequencies occupancy;
- number of heading instructions;

In addition, they have highlighted others parameters not directly related to the air traffic flow but having impact on the subjective component such as:

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

- time of working for every controller one day;
- controller alternating time.

As a conclusion, the workload of a controller is determined by three aspects: an intrinsic complexity related to the air traffic structure, a subjective component related to the controller itself (cognitive strategies and individual characteristics) and the available supporting tools. The subjective range cannot be measured, but can be taken into account during the calibration procedure of complexity measurement tools or can be considered during description of threshold values. The main point is that workload depends on local environments, procedures, methods and that is why approach CM air management can differ from the ATM environment. Measuring workload is quite complicated, but the objective is to have the capability to predict complexity in order to react so that it is possible to reduce the overall ATCo workload.

3.1.6 Solutions

After detecting a complex situation in advance, an action to maintain the situation under control avoiding ATCo overloads is needed to be taken.

The questions that should be answered by the Complexity Manager to select the most appropriate solution are:

- How much time is there until a complex situation becomes real?
- What severity is predicted?
- How can it be solved with a minimum impact?

There are many strategies to do that but a key issue should be modifying the minimum RBTs as possible, reducing workload under the predefined threshold. Assuming this statement the following list of applicable actions in Complexity Management situations is shown:

- Dynamic Sectorisation (including Sector Splitting);
- Dynamic Constraint Management;
- Enabling temporary use of airspace structures (fixed routes);
- Modifying RBTs (including route or level adjustments).

All actions and solutions applied to reduce complexity in a defined airspace could be considered as Demand & Capacity Balance Solution, but not all CM solutions are DCB solutions. Then the solutions used in Complexity Management processes are defined as De-complexing Solutions.

The characteristic that CM will follow to select the most suitable solution are listed next:

- ease to apply;
- effectiveness reducing complexity;
- minimum network effect;

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

- change a minimum number of RBT;
- Balance ATCo workload.

Prior to the implementation of the selected de-complexing solution it is necessary to evaluate its impact on the ATM System because it should not produce any adverse effect reducing complexity in an established airspace and increasing at the same time the global system complexity. This preliminary evaluation of possible alternatives should be provided by a 'What-if' tool.

Although general rules that seem to be appropriate to reduce complexity have been listed, the detailed development of a catalogue of de-complexing solutions will be ongoing under the responsibility of the Complexity Manager supported by the Subregional Network Manager. Anyway it is important to consider the support of other involved roles because it will be easy to implement a de-complexing solution if this has been designed in close collaboration among all roles.

New solutions will evolve with the experience gained applying the Complexity Management procedure. When developing these solutions the ATCo is an important source of information as they have the direct knowledge and understanding of the dynamics of the airspace and its interactions, and can provide the missing insight.

it could be made use of an adapted fast-time simulation tool in order to analyse the forecasted traffic/scenarios for complex situations. Current Management Position tools might be adapted to fulfil the same purpose.

Nowadays there are tools that can be used to stand the cornerstone of the future CM tools:

- trajectory calculation tools;
- medium term conflict detection tools;
- multi-Sector and in general medium / long term planning tools;
- fast-time simulation tools;
- sector capacity evaluation tools.

3.1.6.1 Dynamic Airspace Management

Most of the techniques and tools listed in the previous section are related to Dynamic Airspace Management, which is defined as the procedure where ATC sectors volumes and shapes are adapted in real-time to respond to dynamic changes in traffic patterns and/or short-term changes in users' intentions. Basically they include strategies such as Dynamic Sectorisation and Dynamic Constraint Management.

Dynamic Airspace Management offers additional options in situations where the usual structure and typical patterns do not work, in order to handle unpredictable changes in traffic demand (e.g. weather issues, system outages).

It is also a tool in order to distribute the ATCo workload throughout different sectors without big changes in traffic pattern.

DAM is a tool to maintain ATCo workload within the predefined boundaries. Dynamic Airspace Management could be used to alter the sector configurations in order to transfer

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

some of the traffic from the higher workload sectors to the adjacent lower workload sectors, thus spreading complexity and demand and maximising the utilisation of the airspace as a whole. However, it is also important to consider that DAM is related to the optimum use of the resources not only for complex situations.

All strategies included in DAM such those mentioned in Section 3.1.6, need an airspace configuration specifically designed to support them. This is a relevant issue because an appropriate design during the planning phase will let the implementation of this kind of solution to reduce complexity in the designated family of sectors. Otherwise the CM procedure and DAM will be inapplicable or at least inefficient.

3.1.7 Scenario and Use Cases

Previous sections have defined the most important elements to be considered in the CM procedure. Next step was to clearly define how roles and functions (see Section 3.1.3) interoperate along the process describing the high level mechanism from the detection of a complex situation until the monitoring of the solution implemented.

Theoretically in the planning phase the RNM and SNM configure the NOP in the way that the complexity foreseen in all sectors is under a predefined threshold and the likelihood of potential conflicts tends to zero. Due to an unexpected and/or sudden event, some flight plans have been subject to change and the involved aircraft are required to fly through a new airspace or through the same airspace but with a very different trajectory, producing a distortion in the NOP and likely generating an increase in complexity. Thanks to an Automated Support Tool for Traffic Load (Density) Management (OI Step CM-0101) this situation is clearly known some time in advance. Although the concerned airspace has enough capacity to accept this new traffic, the complexity level of some of its sectors will be very high and will overload the maximum ATCo Workload. Then a de-complexing action is needed to be taken.

The Complexity Manager detects this increase in complexity with the help of an Automated Support Tool for Traffic Complexity Assessment (OI Step CM-0103). The Complexity Manager has to analyse those trajectories that cause the main complexity problems and make a list of possible complexity reduction solutions. The Complexity Manager will be supported in this process by the SNM if detection happens with a long time span (around 2 hours early) or by the MSP if it is short (30 minutes early). These solutions can be extracted from the Catalogue of Dynamic De-Complexing solutions or can consist of changing only the most problematic RBTs. An automatic tool will support the Complexity Manager in order to predict the impact of the solutions through FTS or other ‘What if’ tools.

These tools for predicting the impact should use the information provided by the NOP and match it with the RBT changes, modifications of airspace configuration or airspace structure in order to simulate the expected situation. This way, the CM has the information about the possible impact of the solutions trying to find the most suitable de-complexing solution.

When the most appropriate solution is found, next step is to implement it. To do this the Complexity Manager will communicate the decision to nearest collaborators, SNM and MSP, and also share the information using the SWIM.

Finally the CM will monitor the solution implemented to get feedback for refining the solution and improve the Catalogue of de-complexing solutions.

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

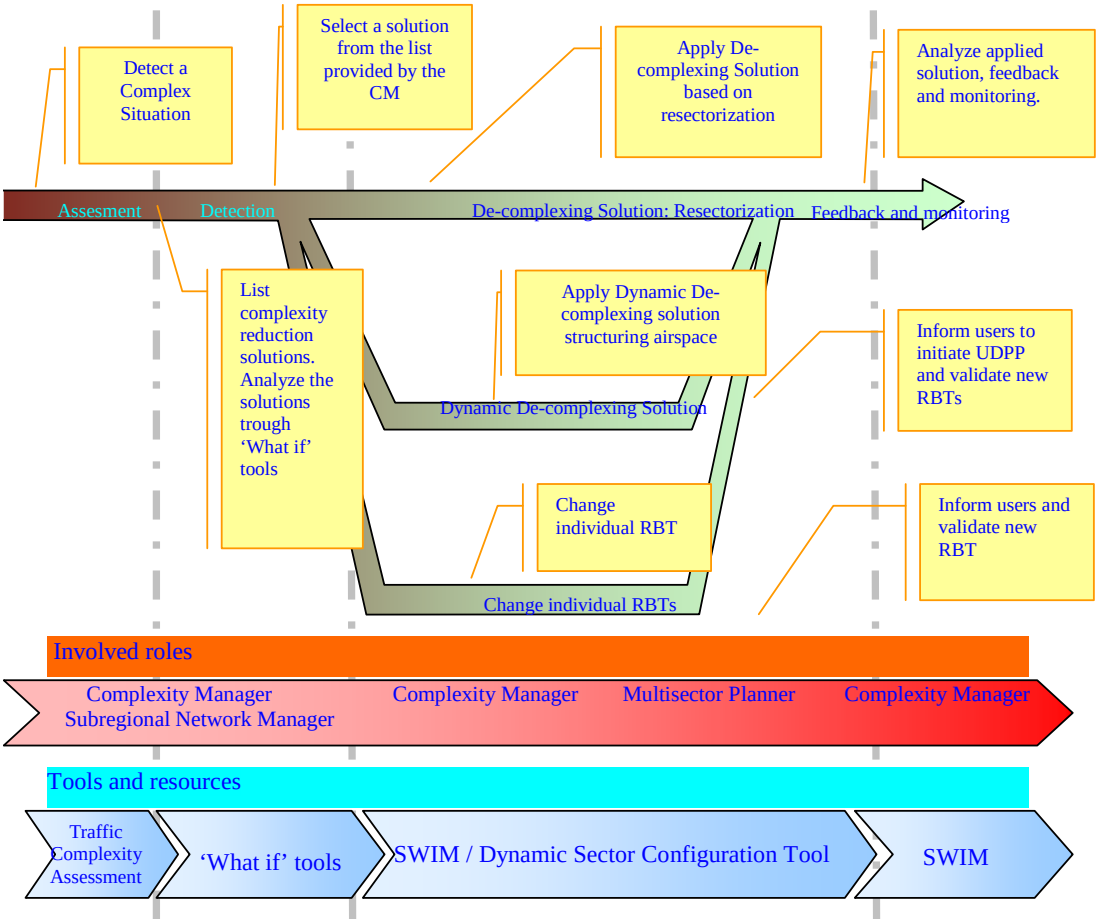

Figure 3-1 Complexity Management Procedure

3.1.7.1 Use Cases (Validation Scenarios)

From the point of view of the validation exercises a package of different Use Cases has been defined, explaining how the Complexity Management procedure works and the application of the appropriate solution for each complex situation.

In these Use Cases it has been supposed that there is an automated tool to evaluate the complexity in general terms, the complexity associated to the sector or family of sectors considered and the complexity inherent to each aircraft.

It is supposed the tool will be able to categorise the situation in detail, but at this stage a general scale to sort the situations has been used.

- Low complexity and potential conflicts foreseen are managed by the ATCo.

- Medium complexity, potential conflicts foreseen could cause an ATCo overload and a de-complexing solution could improve the situation. Due to the uncertainty of data the Complexity Manager should decide whether to take an action or not, considering the situation and the possible benefits.

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

- High complexity, potential conflicts foreseen are not managed by the ATCo without tactical intervention and a de-complexing solution has to be implemented.

3.1.7.1.1 Use Case #0

The CM procedure is a continuous process where the complexity is always being evaluated in the airspace considered. The automated tool analyses potential conflicts in advance identifying the severity of the complex situation. If a Low or Medium complex situation is detected the tool informs about it but no warning alert is raised.

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

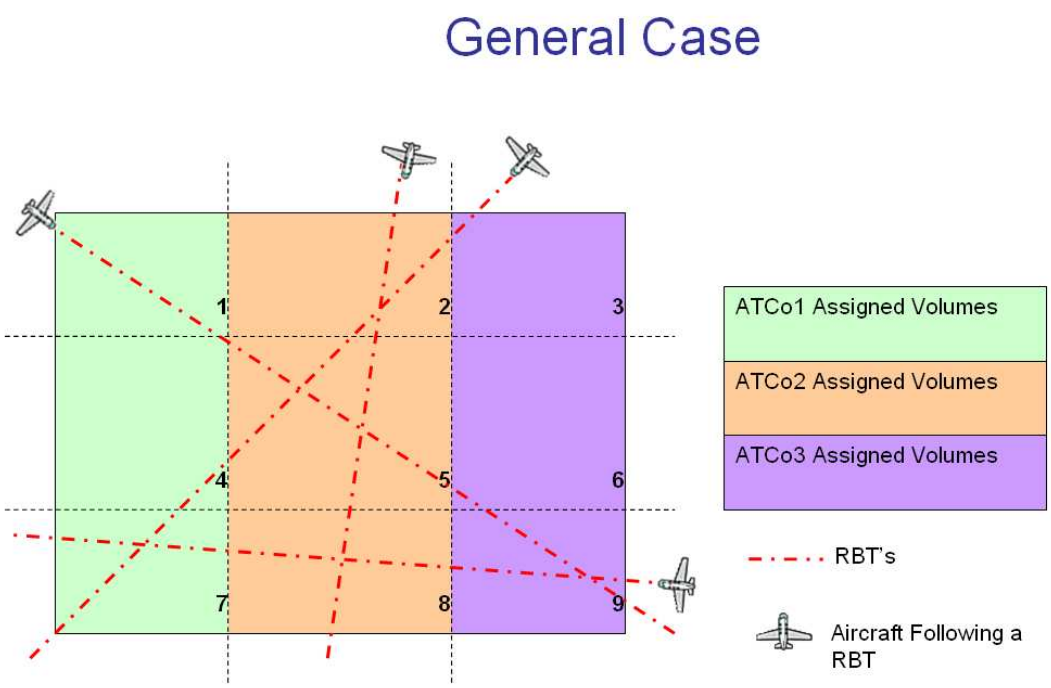

Figure 3-2 General Case Step 0

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

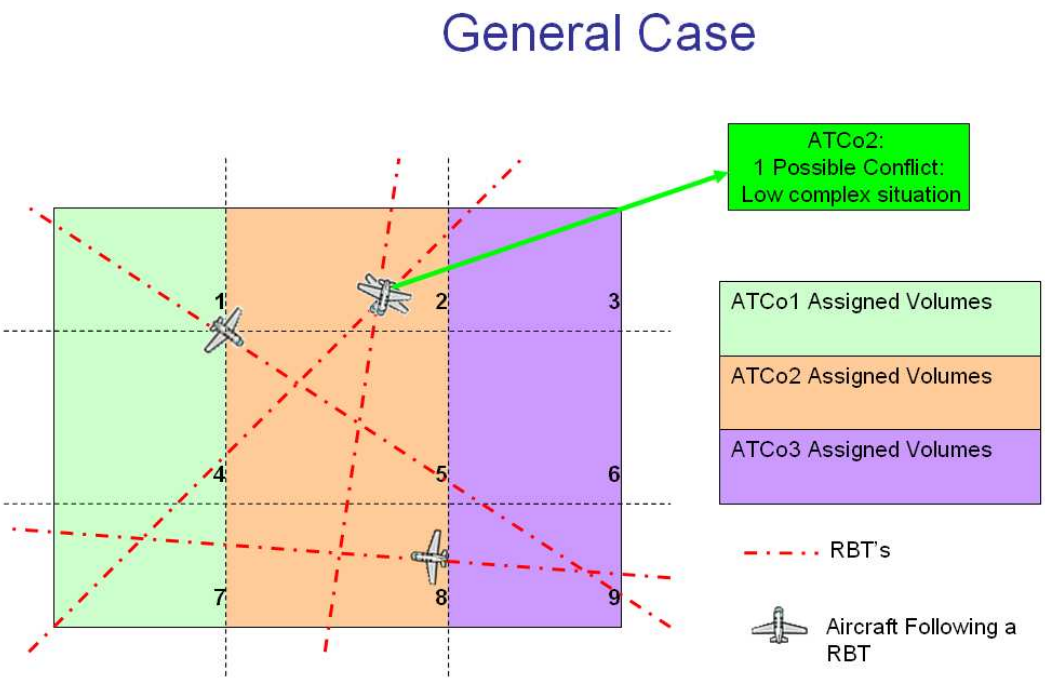

Figure 3-3 General Case Step 1

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

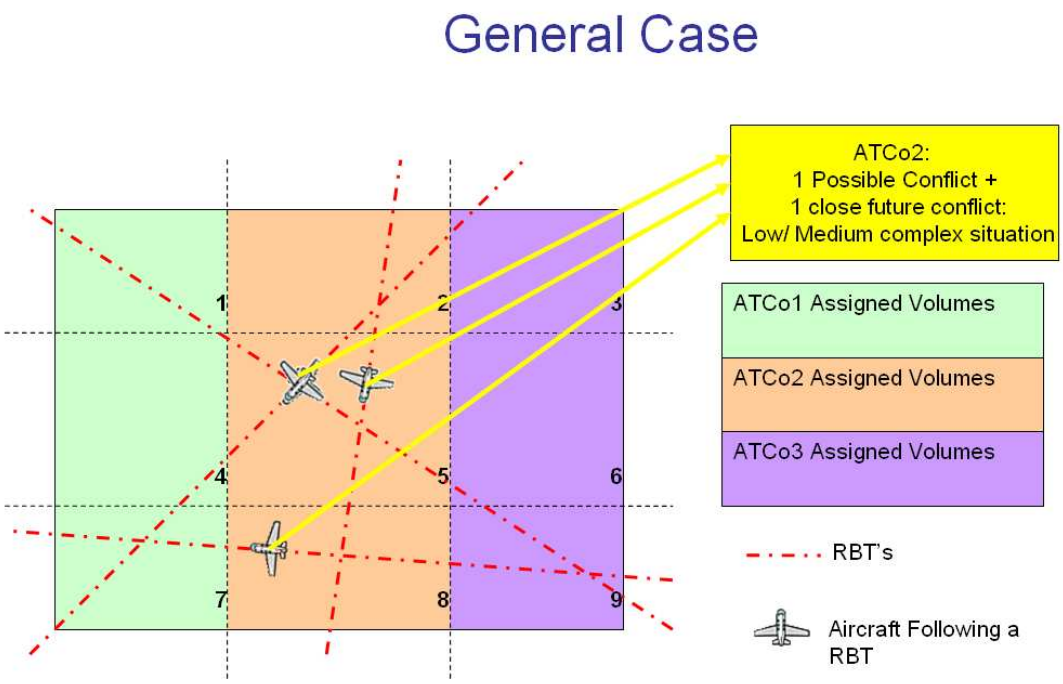

Figure 3-4 General Case Step 2

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

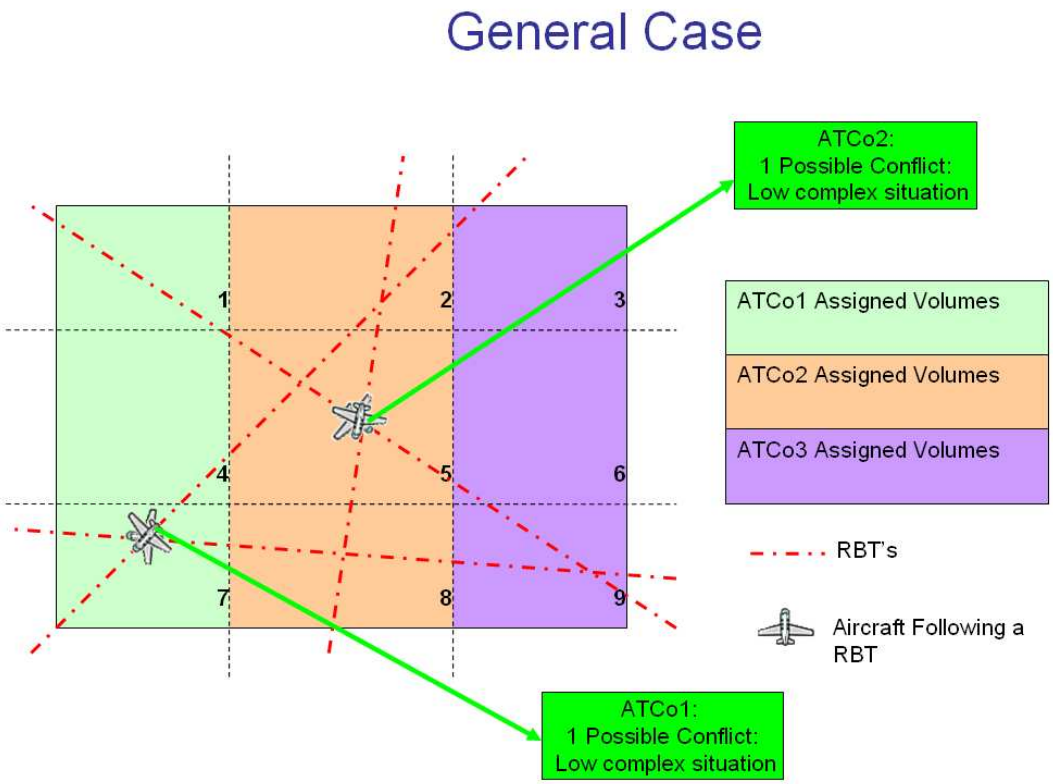

Figure 3-5 General Case Step 3

3.1.7.1.2 Use Case #1

The Automated Support Tool for Traffic Complexity Assessment detects a potential complex situation, which consists of three aircrafts heading 270º following similar 3D routes, obviously taking also more aircraft into consideration. Aircraft A and B have similar speeds but aircraft C flies faster than A and B. Moreover the RBT of aircraft C has some other potential conflicts with other aircraft in the airspace. These conflicts present individually only low complex situations for the ATCo but as they are expected to take place closely in time and distance a high complex situation will take place.

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

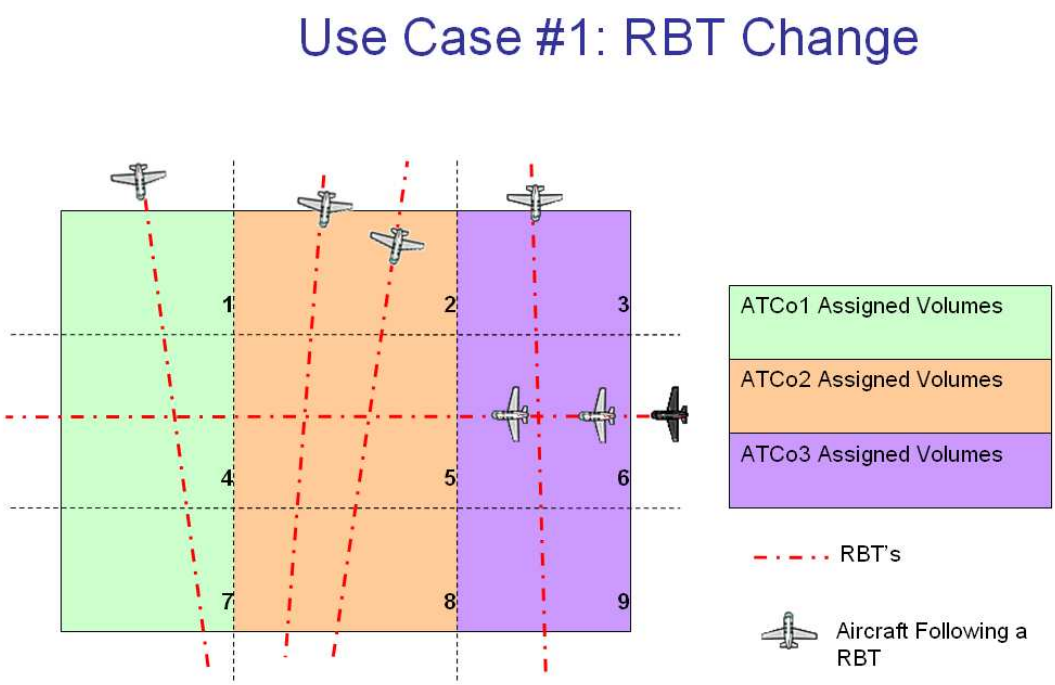

Figure 3-6 Use Case #1 Step 0

The Complexity Manager analyzes the situation with the help of the MSP and makes a list with possible solutions revising the catalogue of de-complexity solutions, selecting the most suitable solutions and simulating these solutions and other suitable “ad hoc” solutions (as individual RBT changes).

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

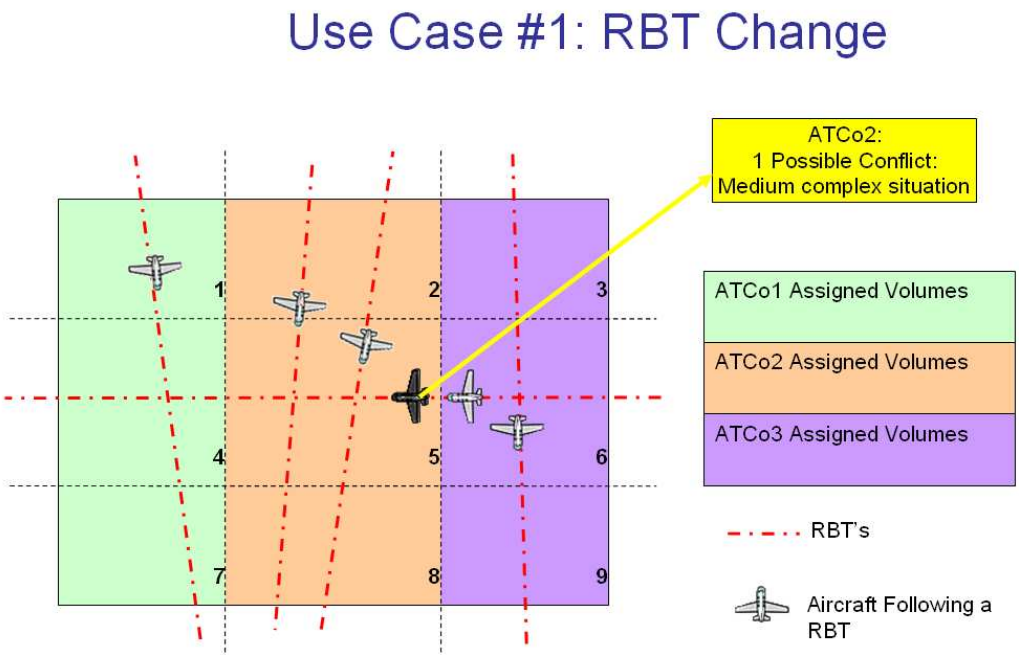

Figure 3-7 Use Case #1 Step 1

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

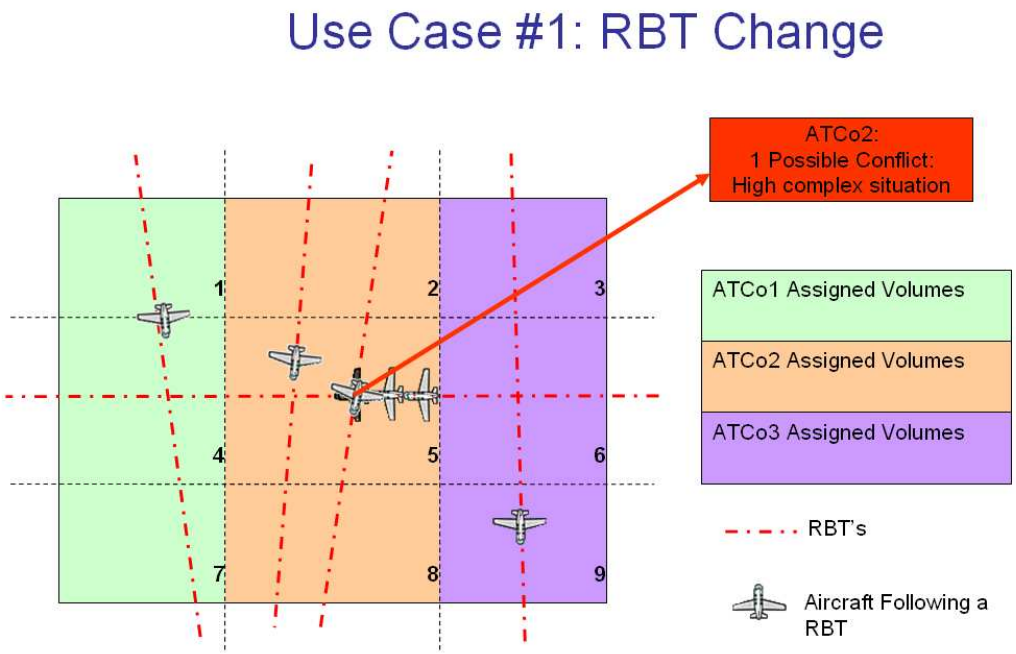

Figure 3-8 Use Case #1 Step 2

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

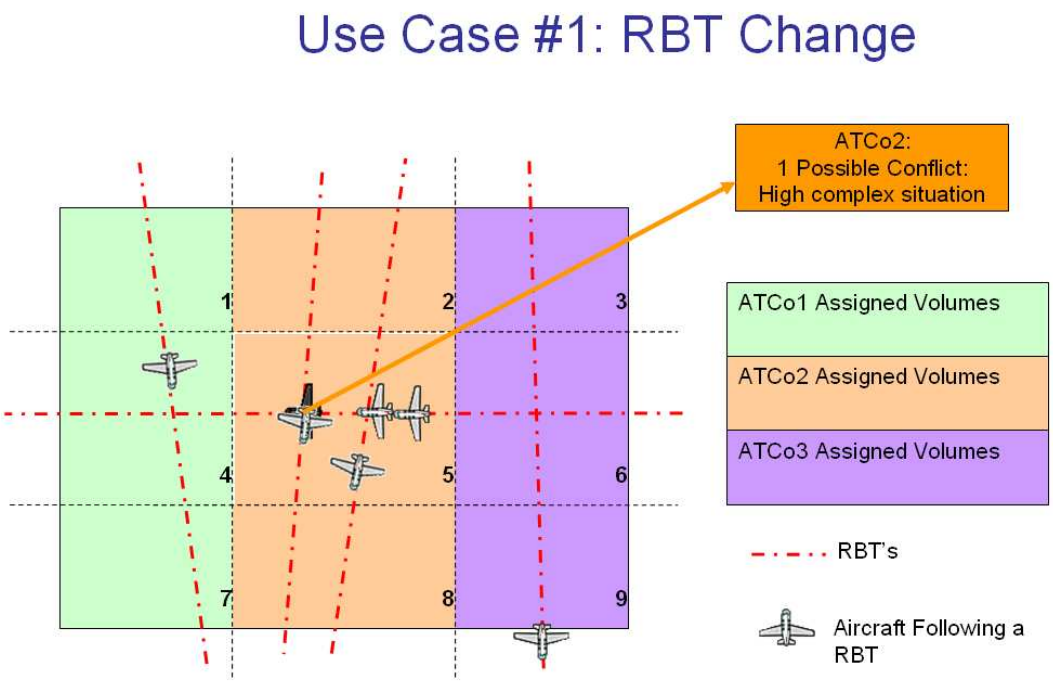

Figure 3-9 Use Case #1 Step 3

The solution selected is to modify aircraft C RBT changing its height to give higher clearance between the routes when this aircraft overtakes the others.

While the conflict situation is taking place the CM will have to monitor and analyze the solution to have a good feedback for supporting other future complex situations and to refine the catalogue of de-complexity solutions.

3.1.7.1.3 Use Case #2

The situation foreseen considers a particular en-route sector 45 minutes in advance. Due to a thunderstorm several volumes of the airspace have been closed and moreover a military airspace reservation demand due to missile testing activities is currently taking place closing other volumes of the airspace. The available volumes of the airspace have enough capacity for the traffic and thus RBTs have been modified to continue flowing through the same airspace.

The traffic mix consists of 12 aircrafts that have similar aircraft performance and are established in cruise. The route structure or predicted trajectories will not intersect and no potential conflicts are detected. However and due to the high number of simultaneous aircraft the Automated Support Tool for Traffic Complexity Assessment detects a complex situation.

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

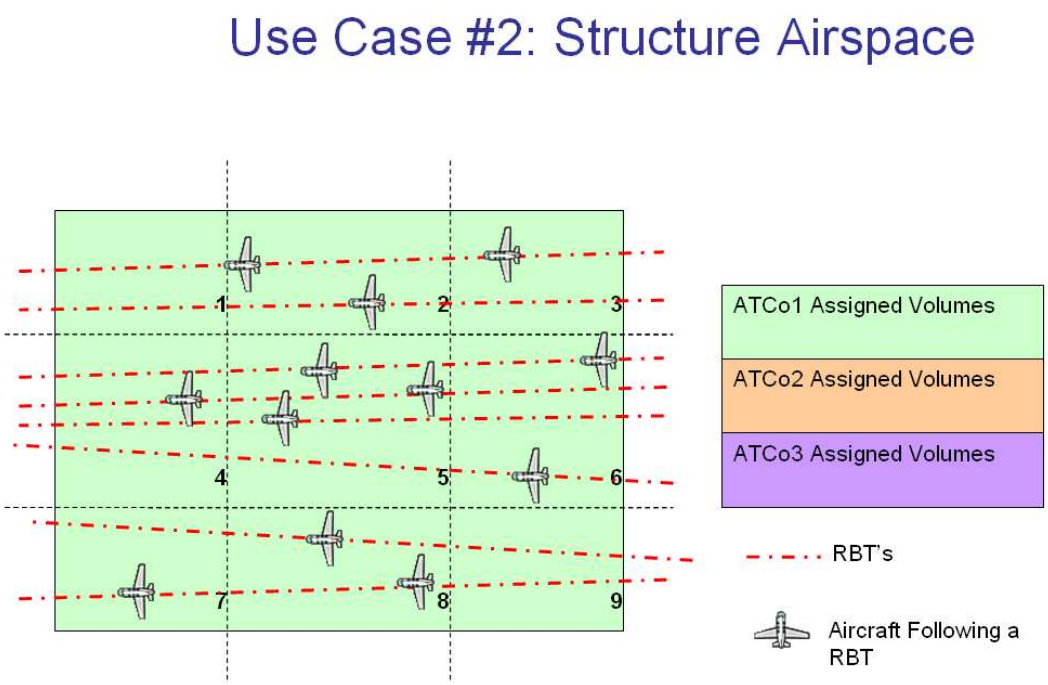

Figure 3-10 Use Case #2 Step 0

The Complexity Manager analyzes the situation with the help of the MSP and makes a list with possible solutions. They cannot consider any solution based on resectorization since the essential volume number 5 has to cope with a traffic that involves higher ATCo workload than its maximum one taking into account the current volume free-routing configuration and it is unable to divide. The solution is to apply a dynamic de-complexity solution based on structure the airspace into fix routes.

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

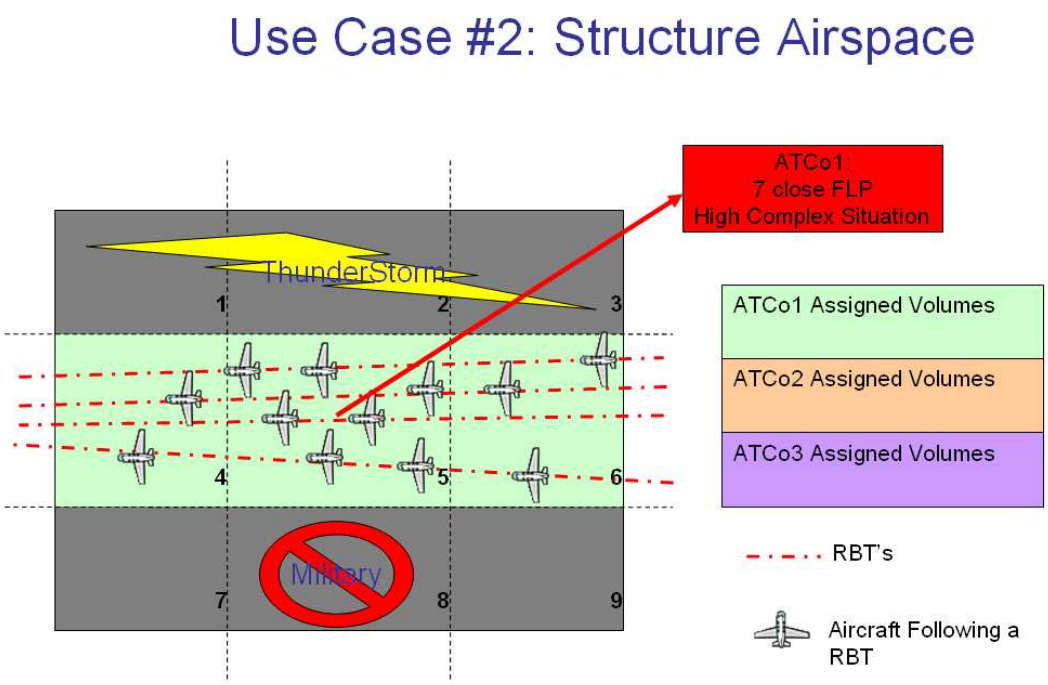

Figure 3-11 Use Case #2 Step 1

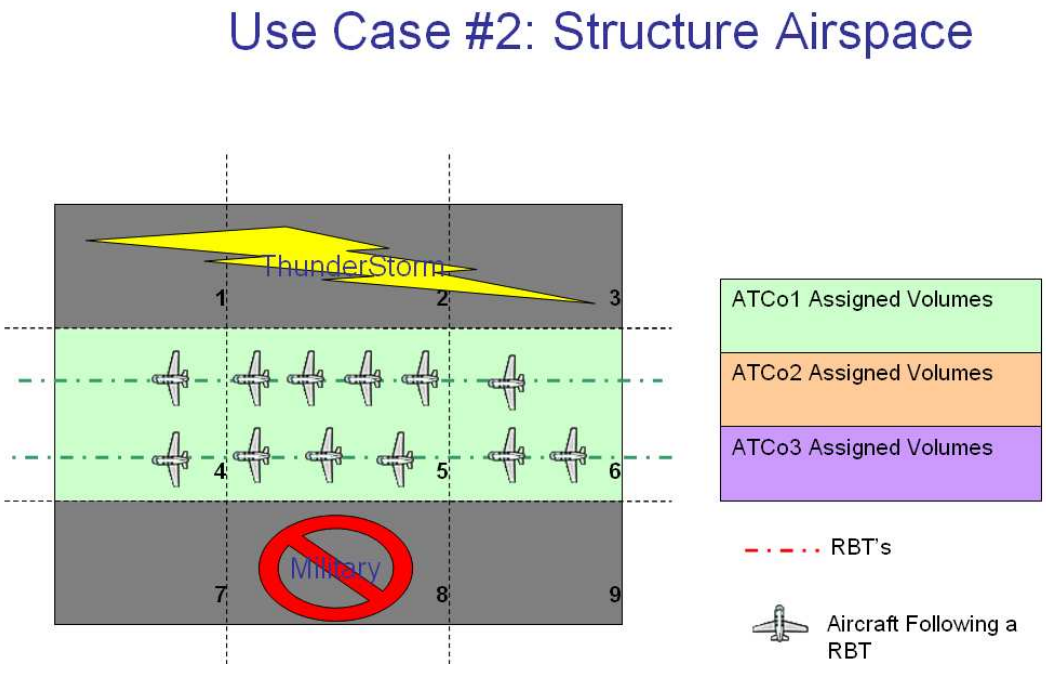

Figure 3-12 Use Case #2 Step 2

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

If there was enough time a UDPP (as described in DoD General Section 9.2.5) has to take place but in this case it will not be considered.

While the conflict situation is taking place the CM will have to monitor and analyze the solution to have a good feedback for supporting other future complex situations and to refine the catalogue of de-complexity solutions.

3.1.7.1.4 Use Case #3

A situation is foreseen in a particular en-route sector 25 minutes in advance with traffic mix with strong different aircraft performances. Moreover traffic is established in cruise together with traffic climbing and descending and RBTs are intersecting.

The Automated Support Tool for Traffic Complexity Assessment detects a complex situation since in the sector controlled by ATCo2 (volumes 2, 5 and 8) there will be two simultaneous potential conflicts and at the same time another flight plan.

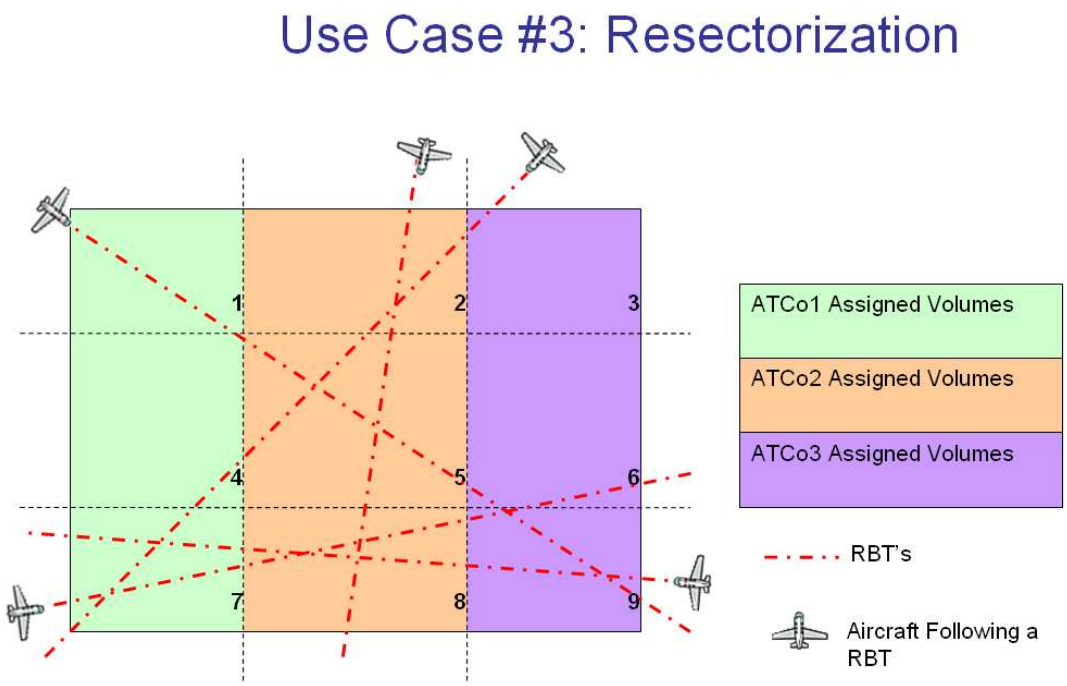

Figure 3-13 Use Case #3 Step 0

The Complexity Manager analyzes the situation with the help of the MSP and makes a list with possible solutions revising the catalogue of de-complexity solutions, selecting the most suitable solutions and simulating these solutions and other suitable “ad hoc” solutions (as individual changes of RBT).

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

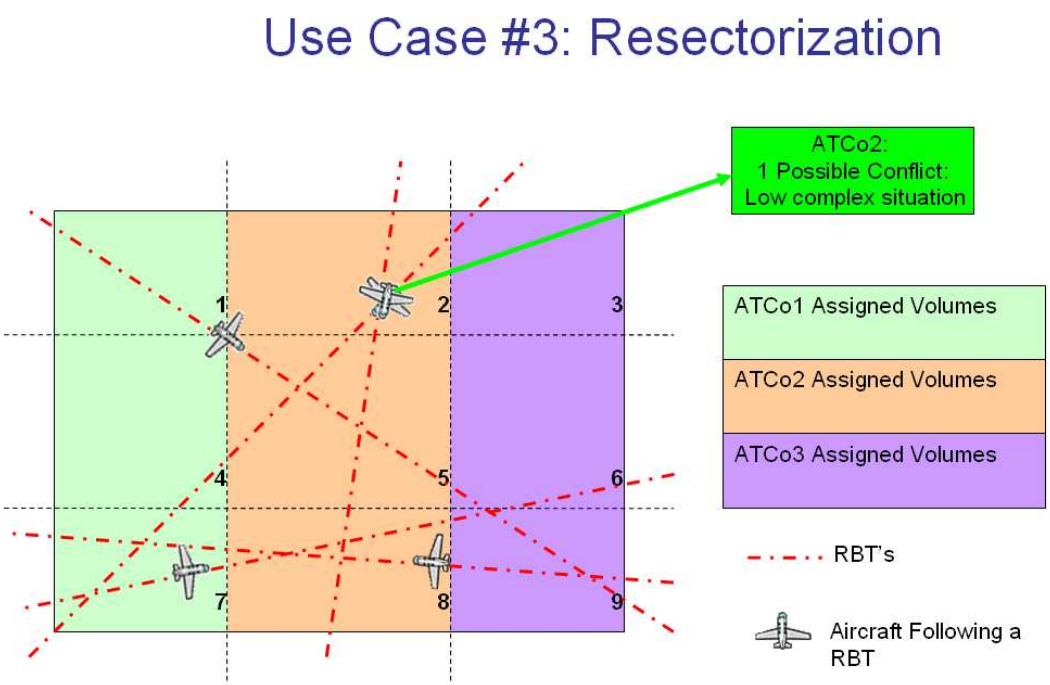

Figure 3-14 Use Case #3 Step 1

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

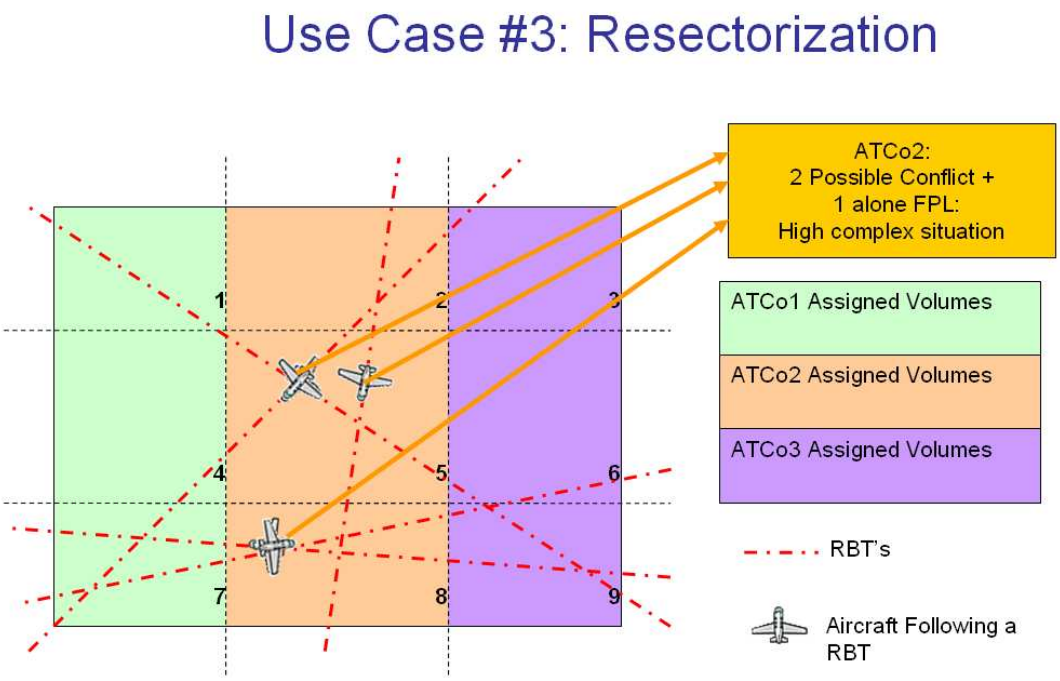

Figure 3-15 Use Case #3 Step 2

The de-complexing solution for this case would be to apply a DBC Solution, which consists of a resectorization of the volumes in order to balance the total workload. The sector controlled by ATCo2 will consist of volume 2 and 5 and volume 8 will be under control of ATCo3.

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

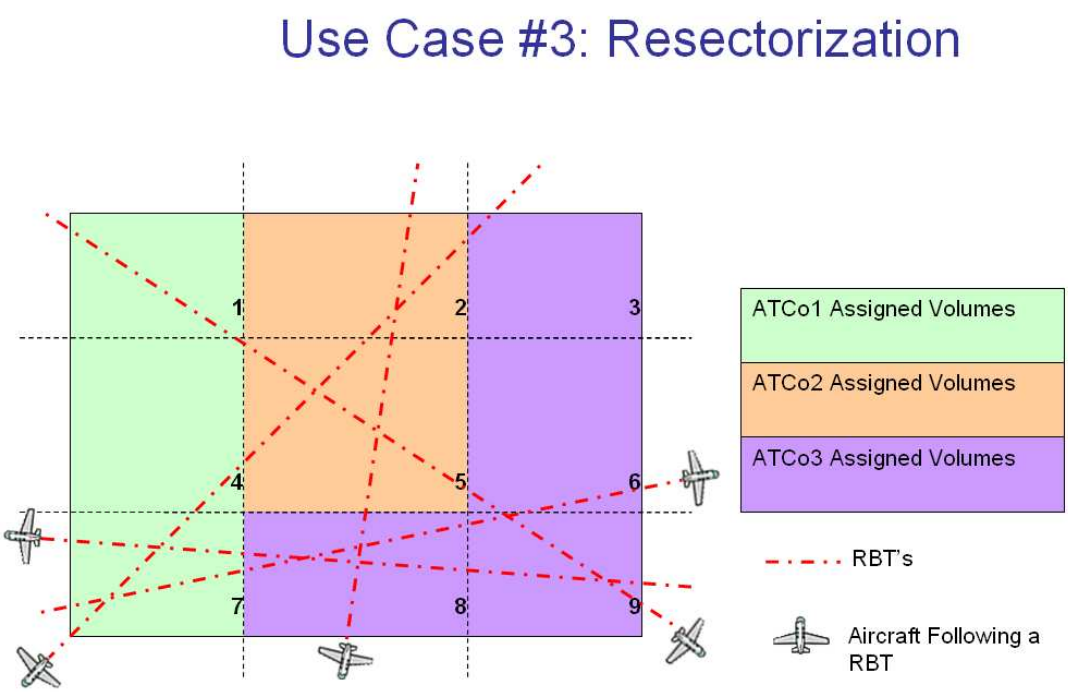

Figure 3-16 Use Case #1 Step 2

While the conflict situation is taking place the CM will have to monitor and analyze the solution to have a good feedback for supporting other future complex situations and to refine the catalogue of de-complexity solutions.

3.1.8 Automations

There are many assumptions made about the reliance on automation to provide detection and solutions but finally the global CM procedure will be a balance between automated and human activities. This means that there should be tools supporting the decision making process and also for the solution simulation and implementation. In general terms, the automated tools will have better prediction, will be capable of evaluating both planned and tentative (possible) solutions and will connect to both separation assistance tools and network planning tools.

Currently there are automation tools providing partially the needed features of the next generation tools and applications. The most important strengths that should be maintained in the next development are:

- current operations based on current automation tools are safe;
- reliability and robustness;
- correlation of tracks;
- uniform data format;
- high efficiency.

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

However, to reach the Complexity Management requirements it is necessary to fill the gaps that current automations have such as:

- predictability cannot be assured over large time frames due to the level of accuracy;
- sharing of information is not enough, also some selected solutions are not always visible to adjacent agencies;
- little collaborative decision making with airlines/airfields to reduce complexity problems in the network;
- system not widely integrated;
- current traffic management tools do not maximize the network capacity producing unused capacity in the system;
- level of aircraft-ground links.

The new automation tools will support the whole Complexity Management process, from the early detection of complex situations until the implementation of the selected de-complexing solution and also the final monitoring and feedback analysis. A preliminary list of high level requirements for the automation tools have elaborated by the Experts and it is shown below:

- Accuracy, predictability, reliability & robustness. These are general requirements for all automation tools but in this type should be considered more relevant;
- long prediction time span identifying potential complex situations well ahead;
- be part of SWIM in order to communicate data fastly and effortlessly, communicating solutions to other agencies so that the flight profile is not changed to disrupt the planned solution;
- assess complexity solutions in terms of the impact over the airspace as a whole, not just for an individual sector;
- indicate uncertainties in the predicted complexity or ATCo workload;
- simulate a range of solutions in both time, vertical and horizontal profile and compare the merits of each of these advising about the most appropriate for each situation;
- Simple to use and efficient.

3.1.8.1 ATCo Support tools

The Complexity Management procedure aims at reducing the ATCo workload below a threshold that ensures safe operations. Then ATCo support automations tools could also be improved facilitating the tasks performed by ATCos. This would produce a reduction in the ATCo workload led by these new or improved functionalities.

These tools implement the mechanisms to enable the medium-term detection of potential conflicts to the ATCos. Also they are adapted to local operational procedures and provide services like warning, alerting and STCA. The most relevant characteristics of these tools are that reduce co-ordination effort to a few mouse clicks SYSCO.

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

However there are many gaps that could help ATCos produce an increase of flight management capacity and a global positive effect. A general issue is the high level of fragmentation across Europe and low level of information sharing which avoid or reduce synergies between tools. From the ATCo point of view the voice commands load is too heavy then it would be very useful to have an automation superseding this kind of communication such as data link. Finally the level of accuracy produces the prediction capability strongly decreases when vertical movements are concerned (MTCD tool).

3.1.9 KPAs, OCEs, OIs

Experts have evaluated the impact of CM Procedure on the global system in a qualitative manner. Also they have identified the most important OCEs and OIs affecting this procedure.

3.1.9.1 Key Performance Areas

The following table shows the expected CM procedure impact on the SESAR KPAs. In general terms the impact is positive.

KPA	Definition	Impact on KPA	Impact intensity
Cost Effectiveness	This KPA addresses the cost of gate-to-gate ATM in relation to the volume of air traffic that is managed.	Positive	Medium Impact
Capacity	This KPA addresses the ability of the ATM system to cope with air traffic demand (in number and distribution through time and space). It relates to the throughput of that volume per unit of time, for a given safety level.	Positive	High Impact
Efficiency	This KPA addresses the actually flown 4D trajectories of aircraft in relationship to their Shared Business Trajectory.	Positive	High Impact
Flexibility	This KPA addresses the ability of the ATM system and airports to respond to “sudden” changes in demand and capacity: rapid changes in traffic patterns, last minute notifications or cancellations of flights, changes to the Reference Business Trajectory (pre-departure changes as well as in-flight changes, with or without diversion), late aircraft substitutions, sudden airport capacity changes, late airspace segregation requests, weather, crisis situations, etc.	Positive	High Impact
Predictability	This KPA addresses the ability of the ATM system to ensure a reliable and consistent level of 4D trajectory performance. In other words: across many flights, the ability to control the variability of the deviation between the actually flown 4D trajectories of aircraft in relationship to the Reference Business Trajectory.	Positive	Medium Impact
Safety	This KPA addresses the risk, the prevention and the occurrence and mitigation of air traffic accidents.	Positive	High Impact
Security	This KPA covers a subset of aviation security. It addresses the risk, the prevention, the occurrence and mitigation of unlawful interference with flight operations of civil aircraft and other critical performance aspects of the ATM system. This includes attempts to use aircraft as weapons and to degrade air transport services. Unlawful interference	N/A	N/A

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

KPA	Definition	Impact on KPA	Impact intensity
	can occur via direct interference with aircraft, or indirectly through interference with ATM service provision (e.g. via attacks compromising the integrity of ATM data or services). ATM security also includes the prevention of unauthorised access to and disclosure of ATM information.		
Environmental sustainability	Aviation has a diverse impact on the environment, but not all aspects can be influenced by the ATM system. This KPA addresses the role of ATM in the management and control of environmental impacts. The aims are to proportionately (per flight) reduce adverse environmental impacts; to ensure that air traffic related environmental constraints are respected; and, that as far as possible new environmentally driven non-optimal operations and constraints are avoided or optimised as far as possible. This focus on environment must take place within a wider “sustainability ” scope that takes account of socio-economic effects and the synergies and trade-offs between different sustainability impacts.	Not clear	N/A
Access and Equity	This KPA splits the management of airspace usage (and usage of other ATM resources such as airports and ATM services) into two distinct issues: access/segregation and equity/prioritization.	Not clear	N/A
Participation	At the level of overall ATM performance, the KPA “Participation by the ATM Community” covers quite a diversity of objectives and involvement levels. Participation by the ATM community can be considered in the following dimensions: a) Separate involvement issues and approaches apply for each of the ATM lifecycle phases. b) Participation and involvement should be explicitly pursued for each of the other Key Performance Areas. c) Involvement should be monitored and managed per segment of the ATM community.	Not clear	N/A
Interoperability	At the level of overall ATM performance, the main purpose of interoperability KPA is to facilitate homogeneous and non-discriminatory global and regional traffic flows. Applying standards and uniform principles, and ensuring the technical and operational interoperability of aircraft and ATM systems are to be seen as supporting (enabling) objectives for the above main objective.	Not clear	N/A

Table 3-1 Impact of CM procedure in SESAR KPAs

3.1.9.2 Operational Concepts Elements

At the beginning of the Expert Group the list of Operational Concept Elements was evaluated and those related directly to CM procedure were identified. This task was performed

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

considering that these elements are collected and detailed in SESAR ConOps [9], but the current satiation is that this list has been superseded by the Operational Improvements which were also evaluated during the expert group. Because this list is the most appropriate, here is only a brief summary of the main OCEs in the CM detection and reduction context is included.

OCE ID	OCE Definition	Description
003	Automated Decision Support	Controller Automation Support. Advanced automation support for controllers including conflict detection and resolution (strategic and tactical) conformance monitoring (CM) intent monitoring (IM) and complexity monitoring. In combination, these tools will detect almost all aircraft/ aircraft conflicts, aircraft penetrations of segregated airspace and potential task overloads with sufficient time to allow an orderly resolution. The tools also effectively monitor the ATM system for human error while enabling efficient and timely tactical intervention when required and ensure that clearances have a longer valid duration
004	Collaborative Decision Making	Collaborative planning. Throughput is improved by collaborative planning reflected in the NOP
005	Controller Task Load Reduction	3D/4D Precision Trajectories. 3D/4D precision trajectory clearance concepts enabled by advanced navigation capabilities Trajectory De-confliction. Precise management of trajectories supporting a high degree of strategic deconfliction in congested airspace (2D-RNP and 3D route structures)
010	Information Management	Advanced Communications Capability. Allows system-wide information sharing between pilots and controllers and between air and ground systems.

Table 3-2 OCEs involved in the CM process

3.1.9.3 Operational Improvements

As explained in the previous section, actually within SESAR framework the Operational Improvements are the relevant elements describing the technological research needed for the development of the concept. From the OI Steps v1.3, the Experts identified those related to the CM procedure.

The most relevant Operational Improvements Steps are those related to Automation. The identified OI Steps sorted according to its importance are:

- CM-0101: Automated Support for Traffic Load (Density) Management.

  Automated tools should provide support for managing traffic load per network node (e.g. sector, waypoint, route, route-segment, etc) according to declared capacities. It will be used to assure that ATCO's workload limits are not exceeded.

  Currently several tools need to be combined, or a new tool needs to be written so as to fulfil these requirements. Routine tasks need to be automated like identifying ac/initial call by data link e.g.

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

- CM-0102: Automated Support for Dynamic Sectorisation and Dynamic Constraint Management.

  This improvement relates to the dynamic management of airspace/route structure. Complexity in very busy airspace may be so high that it will not be possible to manage it with conventional ATC means; managing controllers' workload becomes crucial. One way of doing it is through this operational improvement:

  - Dynamic resizing and change of sector's shape and volume contributes to equal distribution of workload throughout sectors in one centre/FAB and it could be done only through automated systems which continuously evaluate traffic complexity in the future and propose optimum sectorisation solutions.

  - Present de-complextion is mainly based on static constraints which "defend" sectors from very complex situations, as the information on the trajectories (TP) certainty improves, it will be possible to remove this static system of constraints and replace it with dynamic constraint management supported by automation. This will provide possibilities for the users to fly as close as possible to their "business trajectories".

  The tool of nowadays can only resize and change of sector, in order to balance ATCO workload. Moreover this change is manual control at Supervisor Position, not automated by system.

  There are tools which automatically calculate a new sectorisation but results are totally adapted to the present traffic those tools have not reached a sufficient maturity level. FTS tools support in finding appropriate sectorisation and help balancing the load throughout the sector system.

- CM-0103: Automated Support for Traffic Complexity Assessment.

  Automated tools continuously monitoring and evaluating traffic complexity (in a certain airspace volume) according to predetermined scale (e.g. high-medium-low) facilitating information on upcoming congestions and allowing switching to the correspondent "airspace sub-category" and applicable operating procedures. It will be used to support decision making processes related to Airspace management (transition between airspace sub-categories).

  This automation should be based on Fast Time Simulations, calculating the complexity values in each sector and rising warnings when the established threshold had been overcome.

Besides to this evaluation all OI Steps were analysed and identified regarding their relationship with the CM procedure. Three different categorisation were found,

- primary OI Steps, directly involved in the process. Their development is essential to implement the required CM procedure with full capabilities;

- secondary OI Steps, which will support the procedure improving it in some functionalities. Without this improvements the CM procedure would be useful anyway but these add value to the CM performances;

- no related OI steps.

The list of primary Operational Improvement Steps needed for the development and implementation of the CM procedure is shown next.

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

Code	Title	Description
CM-0101	Automated Support for Traffic Load (Density) Management	Automated tools provide support for managing traffic load per network node (e.g. sector, waypoint, route, route-segment, etc) according to declared capacities.
CM-0102	Automated Support for Dynamic Sectorisation and Dynamic Constraint Management	This improvement relates to the dynamic management of airspace/route structure. The system provides support for decision making based on pre-defined sector sizing and constraint management in order to pre-deconflict traffic and optimise use of controller work force.
CM-0103	Automated Support for Traffic Complexity Assessment	Automated tools continuously monitor and evaluate traffic complexity (in a certain airspace volume) according to predetermined scale (e.g. high-medium-low) facilitating information on upcoming congestions and allowing to switch to the correspondent "airspace sub-category" and applicable operating procedures.
CM-0401	Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number	The use of shared trajectory (RBT/4DT) will increase the performance of conflict detection tools, reduce the number of false conflicts and reduce the controller workload.
CM-0403	Conflict Dilution by Upstream Action on Speed	The system - through use of better navigation accuracy, FMS performance and air/ground communication facilities - is able to 'dissolve' conflicts by minor adjustments of flight parameters (vertical/horizontal speed, rate of climb/descent) not directly perceivable by the controller and not conflicting with their own action and responsibility.
DCB-0203	Enhanced ASM/ATFCM Coordinated Process	Collaborative activities within the planning and execution phases between ASM and ATFCM to optimise the utilisation of the available capacity based on the continuous assessment of network impact of the expected airspace allocations. The collaborative activities also consist on the day of operations in making a better usage of the opportunities (increase of route availability) and in ensuring more airspace use flexibility to fully respond to ad-hoc military needs in accordance with defined time parameters (e.g. 3 hours before operations).
DCB-0205	Short Term ATFCM Measures	In order to close the gap between ATC and ATFCM, operational procedures are developed requiring dynamic coordination between more than one ACC, the AOs and the CFMU. The aim is to maximise the efficiency of the system using flow management techniques close to the real time operations.
AOM-0801	Flexible Sectorisation Management	Sector configuration management is improved as a function of airspace management (Network Operations Plan) to ensure balance between demand and capacity at European network level through more effective resource utilisation, improved flexibility in staff rostering, adaptation and synchronisation of opening schemes across centres, and more generally speaking through harmonisation of working practices.
AOM-0802	Modular Sectorisation Adapted to Variations in Traffic Flows	Airspace is apportioned to small elementary sectors or modules. Modules are grouped in control sectors according to grouping principles and pre-defined sectorisation scenarios adapted to the main traffic flows predicted for each day of operation. The appropriate sectorisation scenario is activated based on the assessment of the predicted traffic demand.
AOM-0803	Dynamically Shaped Sectors Unconstrained By Predetermined Boundaries	ATC sectors shape and volumes are adapted in real-time to respond to dynamic changes in traffic patterns and/or short term changes in users' intentions.

Table 3-3 Primary OI Steps regarding CM

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

The list of secondary Operational Improvement Steps which support the procedure improving the functionalities is listed next.

Code	Title	Description
CM-0202	Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace	The system assists the controller in conflict identification and planning tasks by providing automated early detection of potential conflicts; facilitating identification of flexible routing/conflict free trajectories; identifying aircraft constraining the resolution of a conflict or occupying a flight level requested by another aircraft.
CM-0204	ATFCM Scenarios	Pre-defined scenarios (incl. Modus Operandi) are established at strategical and/or pre-tactical levels taking into account partners' requirements (ATC, airports, military) for usage of the network in relation to ATC sector configuration, route and airspace availability, social events, etc.
AOM-0403	Short Term ATFCM Measures	The route network will evolve to fewer pre-defined routes with the exploitation of advanced navigation capabilities and generalisation of FABs not constrained by FIR boundaries, allowing for more direct routes and free routing. Route constraints are removed along with the development of 4DT based operations. However, it is assumed that some form of route network will be retained to cater for specific requirements (e.g. non capable aircraft, transition of medium complexity operations to/from TMA lower airspace, segregation between managed and unmanaged airspace, military flight planning, etc.).

Table 3-4 Secondary OI Steps regarding CM

3.2 FULFILMENT OF THE EXERCISE OBJECTIVES

As defined in the Exercise Plan [[8]] the objective of this EG is aimed at clearly define the Complexity Management procedure providing information on next elements - in the brackets the sections of this document where these goals are complimented -:

- the stages of the process including roles involved and roles and responsibilities for each one (see Sections 3.1.1, 3.1.2, 3.1.3 & 3.1.6);
- high level requirements for associated automated assistance tools for the identification, monitoring and resolution of complex situations (see Section 3.1.8);
- recommendations about new techniques and tools that will improve the ATCo workload in complex situations (see Section 3.1.5 & 3.1.8);
- operational scenarios (see Section 3.1.7);
- the KPAs affected by this procedure and the OI Steps that should be developed to support the Complexity Management procedure (see Section 3.1.9).

The defined objectives have been achieved successfully and the conclusions extracted from them reflect the expected results.

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

3.3 RISK ARISEN AND MITIGATION ACTIONS

The Exercise Plan described a potential risks that could impact on the quality and validity of the EG outputs or produce delays in the planned schedule. Next list only includes those risks which have had impact during the EG.

Risk 1:	Status of En-Route Execution Phase DODs		
Description:	This is the main document that details the procedure to be assessed by the Expert Group regarding En-route Complexity Management. The detailed operational description should not have gaps or inconsistencies, in other case the EG outputs will not be as precise and useful as could be expected otherwise.		
Occurrence:	☒ YES	☐ NO	
Level:	☐ Low	☒ Medium	☐ High
Mitigation Actions:	Ask experts about topics not completely detailed in the DODs.		
Result:	Details about unclear elements in the DODs were provided by the Experts within their responses.		

Risk 2:	Participants profile and experience exactly with required Experts Profiles.	
Description:	The Participants profiles and experience do not match exactly with required Experts Profiles.	
Occurrence:	☐ YES	☒ NO

Risk 3:	Delays with the questionnaire answers		
Description:	Experts should respond within the defined period, some delays will produce a big impact in schedule.		
Occurrence:	☒ YES	☐ NO	
Level:	☒ Low	☐ Medium	☐ High
Mitigation Actions:	Recover the delay speeding up the process gathering the answers and issuing the next questionnaire in a short period.		
Result:	Although some delays occurred with some questionnaires, the global process schedule was not modified.		

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

Risk 4:	Experts not having deep knowledge of SESAR Operational Concept	
Description:	N/A	
Occurrence:	☐ YES	☒ NO

Risk 5:	No final consensus	
Description:	Conclusions at the end of the Expert Group not fully supported by experts	
Occurrence:	☐ YES	☒ NO

Risk 6:	Experts not being able to assist meetings		
Description:	N/A		
Occurrence:	☒ YES	☐ NO	
Level:	☒ Low	☐ Medium	☐ High
Mitigation Actions:	Communicate the experts how important is their participations in the meetings to reach clear conclusions. Move the meeting if necessary.		
Result:	Due to incompatible agenda some Experts could not attend some meetings. In some cases other collaborators attended the meetings. Anyway the participations of Experts in the meeting was over 80%.		

4. CONCLUSIONS AND RECOMMENDATIONS

This section collects the summary of conclusions exposed during the EG, clarifying the high level procedure, the relevant aspects of the scenario and use cases defined, the expected benefits of applying this procedure and general recommendations and remarks about some important details of the CM procedure.

4.1 COMPLEXITY MANAGEMENT PROCEDURE

The procedure described by the Experts during the EG exercise is mainly focused on En-route Complexity Management at local level.

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. If this happens the application of CM

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

procedure will get the expected benefits not only to those sectors where it is applied but also to the whole system.

It is assumed that the beginning of the process uses a predefined NOP designed during the long-term planning phase considering the airspace configuration, the catalogue of DCB and de-complexing solutions and some kind of maintenance criteria. The level of complexity of this NOP is always under the defined threshold and only an unexpected situation will produce a distortion increasing the complexity.

The procedure is a continuous process structured in different elemental tasks:

- Complexity evaluation. Complexity is continuously calculated in the designated area usually by automated tools;

- Complexity detection. Due to a distortion in the NOP the complexity value could change and the threshold is exceeded. Then a warning message is communicated to the Complexity Manager;

- Catalogue of solutions. For the detected complex situation there will be a catalogue of possible solutions considering the particular conditions of each single case. Some solutions will be suitable to reduce complexity and some other not. An assistance tool will help to select the feasible alternatives;

- 'what-if' evaluation. To find the adequate solution, the list of all feasible solutions will be simulated trying to evaluate the expected impact for each one;

- Selection of solution. Considering the time to complex situation, the CM will select the most appropriate solution for those which have been simulated. Usually maximise the network capacity will be the criterion, but in some circumstances other criteria could be optimum under the Complexity Manager consideration;

- implementation. Once the solution has been selected, next step is to communicate this to those involved roles and share the information through the SWIM and implement it. Usually the Complexity Manager will be in close collaboration with the SRN and/or the MSP;

- monitoring. Final action is to get feedback analysing the real impact of the solution implemented. This will help to refine the catalogue of solutions, the evaluation process, the selection criteria and the implementation phase.

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

Next diagram represents the process graphically.

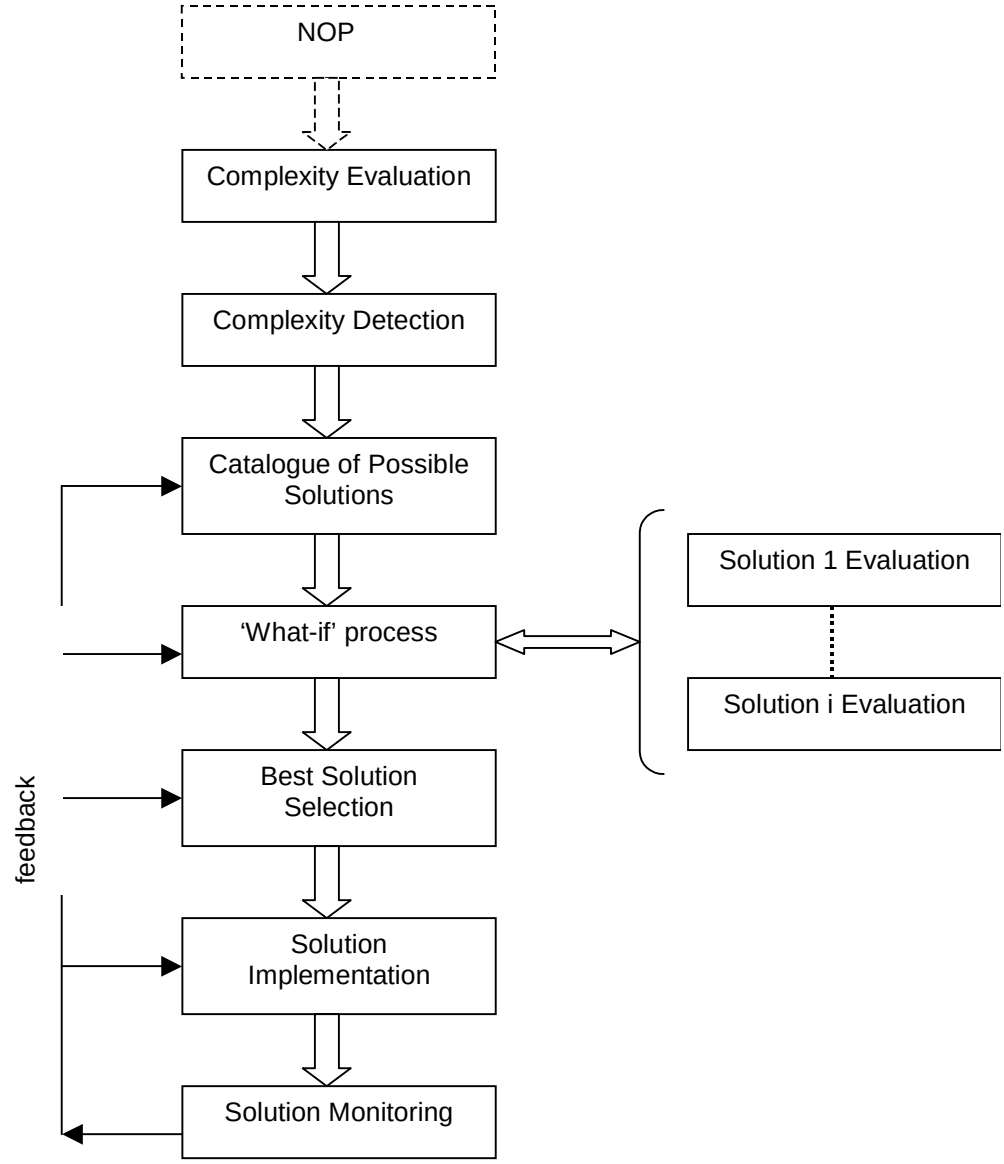

Figure 4-1Complexity Management Procedure description

After the high level definition of the CM procedure, next step is to know when it is applicable. To get an efficient procedure the described actions will be previously performed before the complex situation becomes real. The event that determines the limit is when the aircraft producing the complex situation goes into the sector or family of sectors considered. Considering this event the final of the CM chain, all actions assumed have to be implemented time in advance to ensure their effectiveness.

Depending on how much time in advance the complex situation is detected, the solutions and roles will be different. If complexity awareness is produced 2h – 1h 30' in advance some general actions could be imposed but is unlikely to find the 'Individual RBT modification' solution as the most appropriated due to the high to medium data uncertainty. In this situation the Complexity Manager and the SNM will evaluate the situation considering all constraints.

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

Otherwise if detection comes up to 45' – 30' in advance, the data are more accurate and therefore the associated uncertainty decreases. This situation allows finding other solutions that should be implemented fast. Time constraints for these situations are very severe and should be considered for example when a resectorisation is considered because to be effective these actions should be taken 25' minutes in advance and at least the new sectorisation has to be maintained for 40'. If this is not considered ATCos will not have enough time to adapt themselves to the new situation and the solution will be useless and inefficient.

De-complexing actions will be taken as soon as the situation is detected. These solutions will not be always the same due to time constraints or other considerations, then the 'What-if' tool has a big influence along the process.

The next diagram explains the timeframe where the complexity management procedure is applicable and who is involved totally or partially in it.

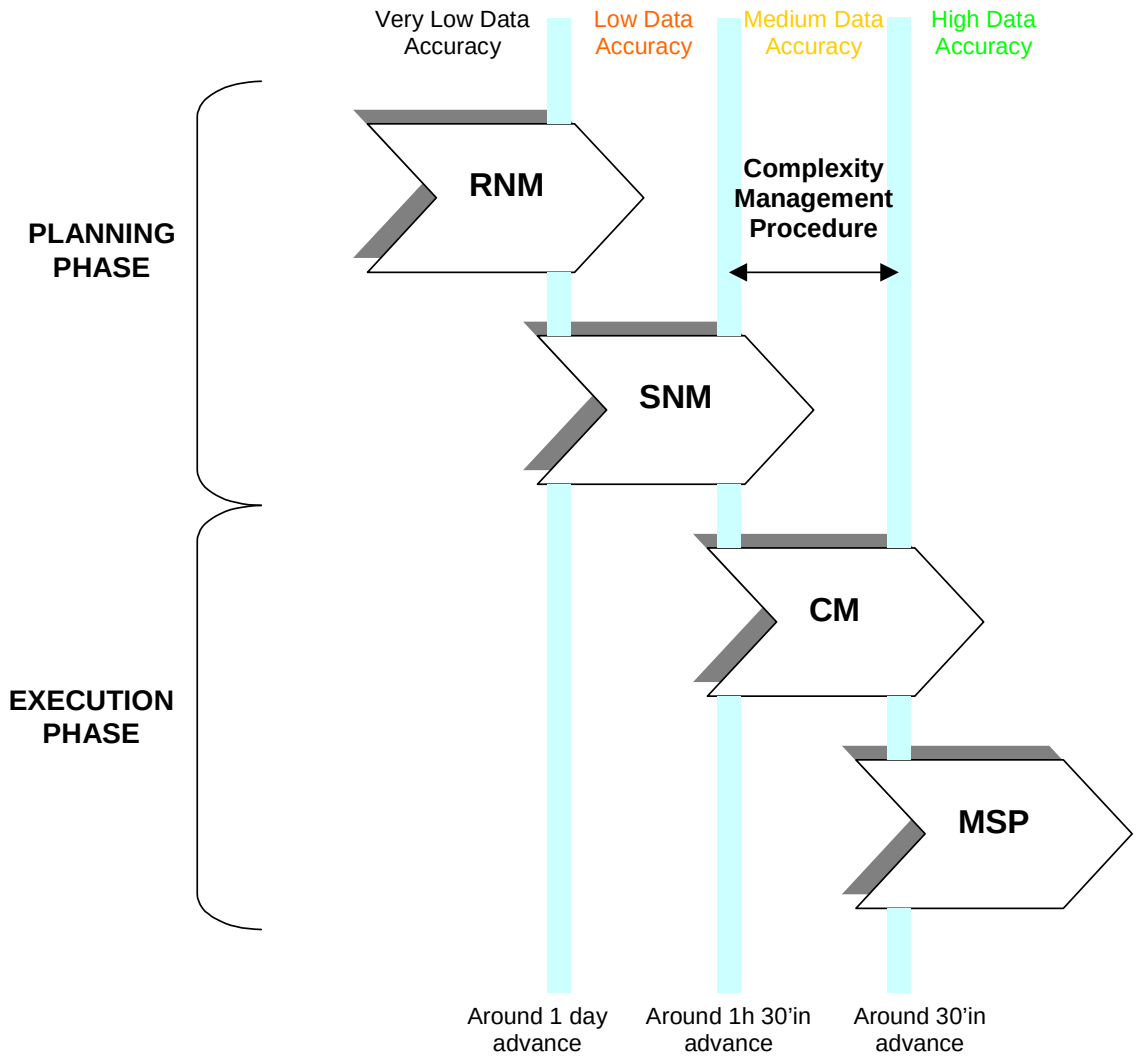

Figure 4-2 Complexity Management Timeframe

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

4.2 CONSIDERATION FOR THE VALIDATION EXERCISES

This EG has been focused on the high level description of the Complexity Management procedure which will be validated as part of the SESAR Operational Concept in subsequent validations exercises.

4.2.1 Gaming exercise

The Gaming Exercise followed a structured process to evaluate decisions related to CM operational staff, e.g. Complexity Manager, SNM and MSP.

Gaming exercises were essentially human in the loop activities, but they were suitable for concepts where the aim was at improving the decision making processes of the roles. The gaming exercise infrastructure therefore allowed a scenario to run in real-time (or even slow time) for the decision process. The technique was not appropriate for producing absolute performance figures and therefore required a baseline scenario to allow relative performance to be measured.

4.2.2 Fast time simulation exercise

The fast time modelling proposed has been used extensively in the validation of ATM concepts and use existing platforms (TAAM/RAMS) and bespoke models. Fast-time was used to obtain quantitative data of the CM procedure on KPAs. The most appropriate ones were those marked by the Experts in Section 3.1.9.1.

Fast time modelling produces relative rather than absolute performance so a baseline scenario needs to be defined.

4.2.3 Real time simulation exercise

As well as supporting the assessment of qualitative results to be obtained, RTS was also valuable in developing the proposed procedure and building common understanding of the changes envisaged.

Part of the exercise was focused on measuring the ATCo workload and the impact of the CM procedure. As in previous exercise types a baseline was needed to evaluate the expected improvements.

4.3 EXPECTED PROFITS IN THE FUTURE ATM SYSTEM

The most relevant expected effect of the application of the CM procedure was aimed at maximizing network capacity.

The network capacity, in general terms, was affected by two elements,

- Capacity of the airspace, considering the number of aircraft that are able to operate in this airspace safely. Free Route airspace configuration represents the highest capacity because the number of aircraft is bigger than Fixed Route airspace configuration;

- ATCo capacity. This factor represents the ability to manage aircraft by an ATCo in a defined configured airspace and it is directly associated to the ATCo workload (main

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

objective of the CM procedure). The bigger the number of aircraft the less the ATCo capacity.

These two factors have an opposite behaviour; Free Routes means high workload to the ATCo while Fixed Routes low. All possible situations are below these two behaviours represented in Figure 5.

CM procedure aims at reducing ATCo workload foreseeing a complex situation and at maintaining it below a defined threshold. Then ATCo could manage a higher number of aircraft in the same conditions producing an increase in the ATCo capacity and in general in the global system.

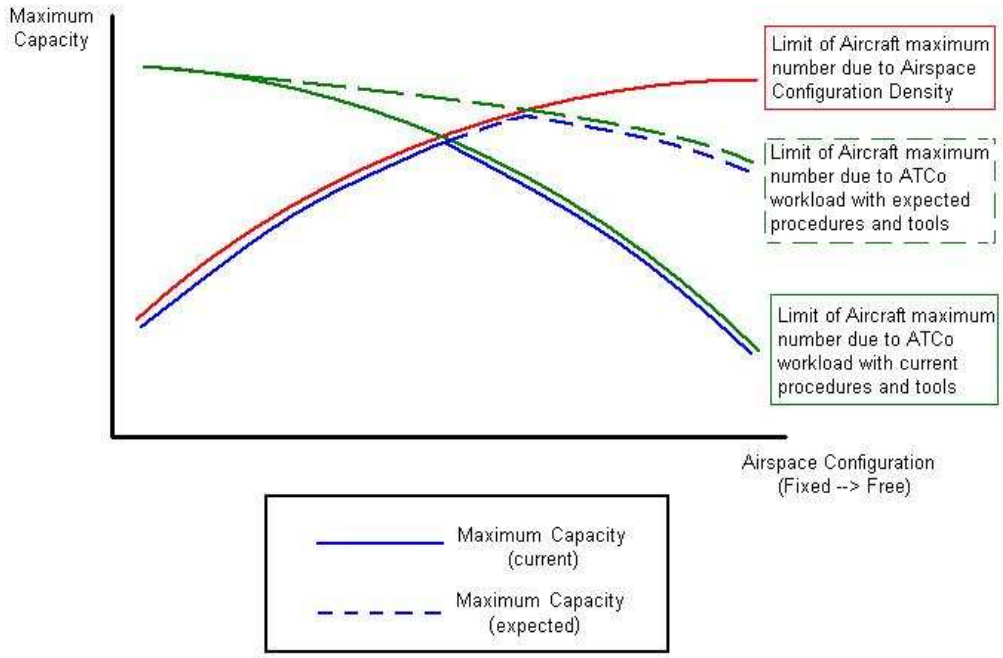

Figure 4-3 Increase of Capacity due to Complexity Management application

4.4 RECOMMENDATIONS

This Expert Group has defined the high level procedure regarding En-route Complexity Management. The detailed description of the procedure has been focused on:

- analysis of the prerequisites of airspace configuration needed to a proper application of the CM procedure, obtaining the highest benefits;

- interoperability among the most important roles, SNM, Complexity Manager and MSP, clearly defining their ranges of responsibility in the process and the flow of information among them and with other roles such as RNM or end users;

- extrapolate the procedure when possible to other areas such TMA, considering the specific characteristics of ATCo workload and the restrictive constraints in this case;

The applicability of the CM procedure will depend on the characteristics of the family of sectors where it is going to be applied. Local rules, geographical aspects and traffic patterns

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

have to be previously considered trying to implement a detailed procedure with the best outcome.

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

ANNEX 1 – 1ST QUESTIONNAIRE

Assessing the problem

Q1.1 What's Complexity Management?. Brief description.

CM is a process based on trajectory predictions that should:

- simplify the ATM situation so that Separation Provision can be efficiently applied by human intervention
- reduce complexity adjusting automatically the provision of separation
- optimise sectorisation
- remain within the limits the ATCo workload
- ensure a safely traffic management
- keep tactical interventions per aircraft (or cumulative set of flights), specially sequencing and conflict resolution, below a reference level
- maximise the network capacity

Predictions are based on the defined planned trajectories (RBTs), meteo information and flight plan information.

This process will trigger the next actions prior to the arrival of the aircraft in the subject airspace:

- Multi-Sector Planning
- RBTs modifications
- Demand & Capacity Balance solutions
- Structured airspace with fixed routes

Q1.2 How to identify a complex situation. CM drivers, how to measure them and trigger values that identify a situation as complex.

Although measuring complexity is very difficult a list of parameter to be controlled in order to detect these situations sufficiently before should contain:

- Airspace configuration
- Number of aircraft handled by a controller that require attention (e.g. unresponsive pilot)
- Time pressure
- Equipment failures

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

- Weak mastery of English language
- Equipment and Environment Distractions (e.g. Sound alarms)
- On the job training
- Look-ahead time
- Number of simultaneous flight movements in relation to the size of a certain volume of airspace
- Aircraft performance mix
- Flight phase/attitude
- Aircraft type
- Aircraft performances (speed, altitude, manoeuvring.....)
- Type of equipment
- Type of clearance
- Number of potential predictable conflicts based on actual flight parameters (speed, 4D contract, clearances…) and RBT known data.
- Aircraft density
- Weather Parameters
- Overall demand
- Predominant traffic orientation
- Traffic mix
- Operations in adjacent sectors / centres
- Bunching (geographical or temporal)
- Duration of flights in a certain volume of airspace.
- Type of predicted interactions/conflictions (AC climbing/descending/level flight)
- Time until the predicted interaction takes place as indicator for the inaccuracy of the prediction

There are no explicit values that identify the complex situation, at this moment.

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

Q1.3 Describe a Complex Situation considering the drivers presented in the answer to Q1.2

Scenario 1

- 3 a/c flying heading 179
- 2 (A & B) at odd levels,
- 1 (C) at even levels.
- The 3 a/c have similar speeds and are sequenced as A, B, C;
- a/c B & C fly faster than ordered; A is erratic.
- Neither A - B - C speak fluently English and there is a Collision Alert alarm bell in a Controller Working Position 2 desks away.

This example simply shows that complexity is not necessarily a geometrical issue, but that it also has a strong environmental component.

Scenario 2

Situation foreseen for a particular en-route sector 45 minutes in advance:

- Traffic mix with similar aircraft performance.
- All traffic established in cruise.
- Route structure or predicted trajectories no intersecting.
- No alerts of conflict detection.

In this case the situation could only be considered as complex depending on the number of simultaneous aircraft (typical values for most current en route sectors may vary from 10 to 15).

Scenario 3

Situation foreseen for a particular en-route sector 25 minutes in advance:

- Traffic mix with strong different aircraft performance.
- Traffic established in cruise together with traffic climbing and/or descending.
- Route structure or predicted trajectories intersecting.
- Several alerts of conflict detection.

This situation is highly unstable and may become complex from many different ways (number of simultaneous aircrafts, ratio of traffic climbing/descending, ratio of traffic using intersecting trajectories or number of conflict detection alerts).

Q1.4 Roles, roles and responsibilities involved along the whole process from complex situation identification to the application of a specific solution.

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

- Regional Network Manager
- Sub-Regional Network Manager
- AOC / ANSP
- Multi-Sector planner
- Executive/Tactical Controller
- Airspace Manager
- Complexity Manager
  - Monitor the levels of complexity of traffic
  - Forecast traffic patterns
  - Assure the provision of information on upcoming congestions
  - Initiate CDM processes to find solutions to reduce complexity when needed
  - Verify applicability of proposed solutions of airspace users etc.
  - Negotiation of new RBT parameters and agreements
  - Coordination with all roles involved in the CM process
- Planning Controller
  - Pre-tactical deconfliction of trajectories through multi sector planning tools
  - Assess how the impending flight fits within the demand pattern
- Supervisor
  - Adapting sector configuration.
  - Identify the presence of the impending flight within the system
- Airspace Users (AOCC)
- Airport Operations (APOC)
  - Enabling temporary use of airspace structures
- Airspace User Operations Manager
  - Modifying RBTs.
- Flight crew/pilot
  - Evaluation and acceptance of changes proposed to his RBTs through negotiation processes

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

- Flow Manager
  - Determine whether an alternative inbound routing may be preferential to the overall traffic situation

Q1.5 Define a timeline with the most important milestone from the Complex situation detection until the final resolution. In each milestone, roles, actions and responsibilities should be identified and defined clearly.

120 min. to 40 min before - As soon as a “high complexity” situation is detected by the system the Complexity Manager is warned and a set of mitigation options may be proposed. At this stage, the situation may not be known by others depending on the impact on traffic, especially in terms of time left.

Minutes after detection - Complexity Manager initiates a coordination process in order to assess the impact of mitigation actions in the network until a best (or bests) solution is chosen.

Minutes before complexity - Best solutions are proposed to controllers and coordinated with flight crews until a final decision is agreed and then put in place.

The most important milestone is the identification of what is likely to cause the complex situation.

Q1.6 Establish the timeframe needed to detect and solve efficiently any Complex situation. How much time is it required for the whole process?. The process is useful only if decisions are taken enough time before the situation becomes real. Establish the period during which the solutions should be applied.

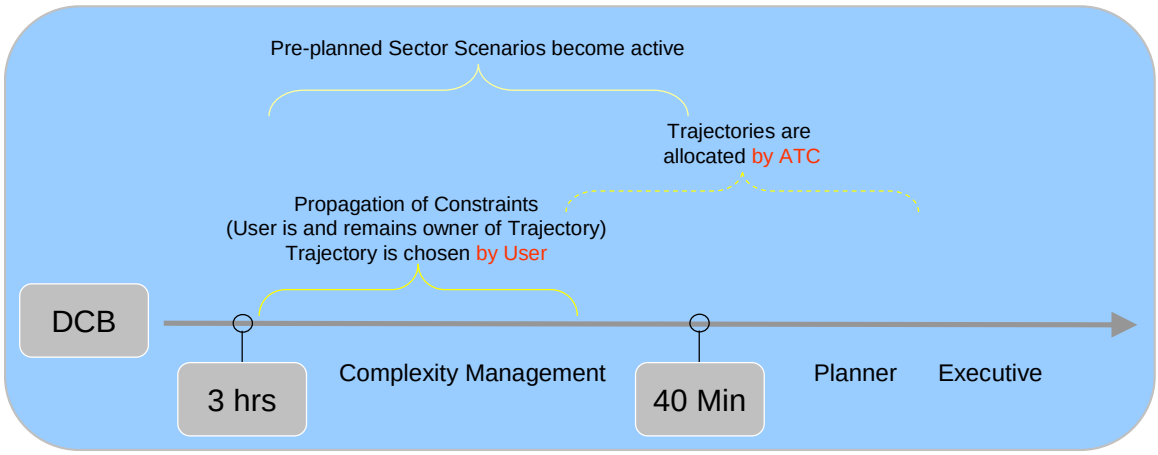

Figure 0-1 Complex situation timeframe

Complexity Management should be an event driven activity.

Anyway, the period of time in advance that a complex situation would be accurately determined, will mainly depend on uncertainty in trajectory prediction and local conditions (distance to/from main destinations/origins).

Probably this range will be between 2 hours and 20-15 minutes before entering the considered area. Time required to apply a particular solution will depend on both: local conditions and also the solution chosen.

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

Generally speaking, adapting sector configuration (whenever this is possible) will need a short time to be applied (10-15 minutes including CDM process and execution), modifications in RBTs are more difficult to quantify since it will depend on distance to fly (probably at least 40-50 minutes in advance will be necessary for the whole process), finally airspace management solutions probably will need a similar time period as RBT modification but, in some cases, the required CDM process may be a bit more complex and therefore time consuming.

Regarding the efficiency of complexity management decisions: since a complex situation is defined as a consequence of traffic circumstances that last beyond the time frame of tactical actions, it seems that they will be still useful even if apply some time after the situation had become complex.

The complex situation should be identified at least 30 to 40 minutes before entering compromised sector; solutions should be applied as soon as possible and finally should be reviewed up until the situation has passed.

Q1.7 Consider the boundaries between Complexity Management and Separation Management. Are they just time differenced?. What are the links and influences? Decision in one of them could impact in the other one? How?.

Separation management is a ATC aspect. Complexity management is a ATFM aspect.

Separation management focuses on separation between aircrafts, including radar separation, vertical separation etc, there are different subjects to decide and maintain separation, it towards concrete Topics.

Complexity Management focuses on abstraction, including route structures, the required capacity with safety, the optimum sectorisation organisation, the efficiency of the separation provision service and the use of dynamic sector configurations.

In addition, Complexity Management is about reducing the workload associated with the individual flight by changing some aspect of its operating environment. Separation management ensures that the flight interacts safely with other flights in its immediate vicinity.

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

ATCO Workload

Q2.1 Complexity Management is directly linked to ATCO mental workload. Describe this link and the relationship with the CM Drivers.

When the Executive Controller is faced with a complex situation, the workload perception is the leading factor as real time actions have to be taken.

Complexity is an contributory factor to ATCO mental workload. It is not the only factor, for example there are other tasks related to workload such as monitoring and levels of RT. For an ATCO whether complexity has an impact on workload is dependent on the number of aircraft he is required to control and the level of complexity experienced.

When there are a medium to high number of aircrafts, then it is quite possible for a complex scenario to increase an ATCO's mental workload quite significantly. In general, the higher the number of aircraft in a sector, the greater the potential for complexity as there are more aircraft which could cause complex interactions or other events.

The relationship between number of aircraft and ATCO's workload is direct and also between number of aircraft and Complexity.

Measuring complexity means measuring ATCO's work-or taskload which (to the greatest extend) should represent mental load.

Q2.2 Define the ATCO workload drivers if different to CM drivers.

Complexity Manager may use this geometrical complexity as enough information (and more objective) in order to detect high complexity scenarios and solutions.

In the case that cognitive aspects of the ATCO response and workload perception can be clearly studied and defined, specific drivers could be considered, including complexity subjective perception parameters, based on psychological studies of human reaction processes.

The main difference is that Complex situation are detected measuring objective parameters and ATCO's workload includes subjective and mental parameters.

The ATCO's workload drivers could be:

- Assessment of active traffic situation
- Determining safe separation of traffic
- Prioritisation of actions
- Executive instructions to flights
- Monitoring of changing conditions
- Determining onward co-ordination criteria
- Conflict detection and resolution
- RT

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

- Co-ordination
- Movements and level changes

Q2.3 Techniques to measure the ATCO workload. Define the maximum admissible level for this workload.

The list of parameters to be controlled would include:

- time of working for every controller one day
- Controller Alternating time
- number of flights control by one controller per hour
- number of sector boundary or fix one position
- number of command (Voice or Data message) send per hour
- volume of traffic flow per hour
- volume of ATC instructions per hour
- number of flights per hour
- interval between ATC instructions
- number of flights
- RTF occupancy
- number of level change instructions
- number of heading instructions
- number of co-ordination discussions with adjacent agencies
- number of vertical movements
- basic workload (routine tasks)

Solutions

Q3.1 How to solve a Complex situation? List the possible procedures that could be implemented and what impact is expected in this kind of situations.

- Sector re-configuration:

  This solution requires extra air traffic controllers, ATC positions and facilities. Different level of complexity need different sector reconfiguration. Requires acting on ATC resources management and might have an impact in the NOP.

- Reroute:

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

This solution requires flexible ATC routes, and may increase workload on other ATC unit.

- Reducing the anticipated flow in that high complexity airspace

- Enabling temporary use of airspace structures (fixed routes). Requires acting on airspace management and might have an impact on both: traffic demand and NOP.

- Modifying RBTs. Requires acting on airspace user operations management and also may have an impact on both: traffic demand and NOP.

- TMR reduction (tight parameters): gain of capacity, reduce uncertainty.

- 2D, 3D or 4D contracts, taking advantage of most capable a/c capabilities: Reduce uncertainty.

- Issue changes in Trajectories

- Reduce tactical complexity, separation management help.

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

Q3.2 How do you link CM with DCB Solutions?

DCB solutions are solutions to CM. But not all CM solutions are DCB solutions.

DCB solutions should be applied before complexity management and are intended to reduce the probability of reaching a complex situation.

Dynamic DCB Solutions are mostly predefined. These solutions or a refinement of DCB Solutions should be applied during the planning phase (e.g. adjustment of queue management measures).

Q3.3 List the available CM tools or techniques that are used to implement the solutions.

At the moment we do not have complexity management tools.

In the future there could be made use of an adapted fast-time simulation tool in order to analysis the forecasted traffic/scenarios for complex situations. Today's FMP tool might be adapted to fulfil the same purpose.

- Multi-Sector and in general medium / long term planning tools.
- Tools that increase and facilitate the acquisition of Situational Awareness (e.g. Improved HMIs)
- Dynamic 3D routes
- SMAN &A-SMGCS
- AMAN&DMAN
- CDM
- Aircraft performance data
- Aircraft performance model.
- Trajectory calculation tools.
- Sector capacity evaluation tools.
- Medium term conflict detection.
- Capability for quick simulation of solutions.

Q3.4 How do you think Dynamic Airspace Management can be used to reduce complexity?

Sector division makes controllers have a clear division of works, then an efficient sector modification could adapt to the changes in airspace, and make full use of controller resources.

DAM could be defined as the procedure where:

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

ATC sectors shape and volumes are adapted in real-time to respond to dynamic changes in traffic patterns and/or short term changes in users' intentions.

Dynamic Sectorisation offers additional options in situations where the usual structure and typical patterns do not work, in order to handle unpredictable changes in traffic demand (e.g. weather issues, system outages).

It is also a good tool in order to distribute the workload throughout different sectors without big changes in traffic pattern.

Dynamic Airspace Management could be used to alter the sector configurations to transfer some of the traffic from the high workload sector to the adjacent low workload sector, thus spreading complexity and demand and maximising the utilisation of the airspace as a whole.

Automation

Q4.1 Describe at least 3 strengths and 3 weaknesses for the current traffic management tools.

Strengths

- Robustness
- Reliability
- Predictability
- A high degree of automation;
- Higher efficiency
- Uniform Dada Format
- Similar Operation procedure
- To be configured with advanced ATC automation system
- Current operations based on them are safe.
- To contain a large numbers of flight information;
- Flexibility of solutions as these are determined by an ATCO rather than by automated process
- Sufficient flexibility in the system to allow AOs to operate to their desired schedule and allow Airport ATC to integrate departures and arrivals and non-airways traffic
- Common base data between all agencies providing a common understanding of operational intentions.
- Allow some consideration of some of the elements of complexity such as predicted flight list, flight profiles to allow complexity management
- Measure of the level of confidence in the predicted data (i.e. are the flights airbourne or not)

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

- Tools are available across ANSP/ACCs.
- Correlation of tracks
- Agile flight plans management
- Configurable by the user

Weaknesses

- Lack of accuracy
- Short prediction time span
- Reactive rather than proactive
- Complex operation
- Interactive poor performance (regional information exchange)
- Intelligent level is not high enough
- Sharing of information is not enough
- Pilot autonomy weak
- Not enough ATM decision support tools
- Lack of confidence from airspace users
- Current traffic management tools produce “unused capacity” in the system
- Not integrated a uniform system widely
- Not compatible with all kinds of systems between areas
- Not implemented in a wide scope
- Accuracy and predictability cannot be assured over large time frames
- When implementing solutions you will inevitably change the traffic situation in adjacent airspace which will influence the workload and complexity in that airspace - thus there is a potential to create a more serious complexity issue elsewhere when solving a situation in your own airspace. Without some method of providing an overview and determining which is the 'overall' best solution the network as an entirety will not be optimised.
- Chosen solutions are not always visible to adjacent agencies thus they may take action that they believe supports the reduction in complexity or that meets customer demand, but that acts against the solution chosen by the subject sector.
- No comprehensive (and consistent) view of complexity and relation to workload.

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

- Little collaborative decision making with airlines/airfields to reduce complexity problems in the network.
- Very “rigid” tools to adapt new concepts
- Lack of aircraft-ground links

Q4.2 Current automation tools that help ATCO in their work and how they ease the day-to-day tasks. Describe at least) 3 strengths and 3 weaknesses

Strengths

- Robustness
- Reliability
- Predictability
- Information integrity
- Easy to use
- Obvious effects
- Flight Automation Delivery
- Electronic Flight Strip
- Safe
- Adapted to local operational procedures
- Contain a large numbers of flight information;
- Provide much services: warning, alerting, STCA
- Planning farther than the scope of one controller.
- More economic way of delaying AC
- Enable the medium-term detection of potential conflicts

Weaknesses

- Lack of accuracy
- Short prediction time span
- Reactive rather than proactive
- The prediction capability strongly decreases when vertical movements are concerned (MTCD tool)
- Complicated system, sometimes fussy to operate

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

- Not to compatible all kinds of systems between areas
- High level of fragmentation across Europe
- Low level of integration with other function of the ATM system
- Intelligent inadequate
- Controllers voice commands load too heavy
- Lack of information sharing

Q4.3 What top level requirements could be needed for the complexity management tools according to SESAR?

- Robustness
- Reliability
- Predictability
- Accuracy
- Long prediction time span,
- Proactive
- Adaptable to the different traffic conditions at the same time
- Able to balance the interests of all users
- Dynamic sector capacity evaluation
- ATCO workload assessment
- Complexity management mechanism and procedure
- Identify potential complex situations well ahead of them occurring
- More accurately model aircraft trajectories and to modify these as the flight profile changes
- Assess complexity solutions in terms of the impact over the airspace as a whole, not just for an individual sector
- Communicate solutions to other agencies so that the flight profile is not changed to disrupt the planned solution
- Look at a range of solutions in both time, vertical and horizontal profile and compare the merits of each of these.
- Be part of SWIM in order to communicate data fast and effortless.

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

ANNEX 2 – 2ND QUESTIONNAIRE

Assessing the problem

Q1.1.2 In the definition of CM, please consider this statement "process based on trajectory predictions". Is it only based on this? Are there other elements/data what CM is based on?

Complexity Management is about managing overall workload this is not just due to the trajectory but is also influenced by

- airspace configuration
- aircraft density
- weather forecast
- traffic mix
- time factors
- ATC language factors
- environmental factors
- available airspace capacity
- available facility resources (ATC, Airport, Navigation, Communication, etc)
- unexpected events (e.g. distress/emergency in blocking the runway)
- expected events (e.g. WorldCup)
- planned control measures e.g. sectorisation

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

Q1.1.3 Score (0-10) the next points according to CM definition.

1. Simplify the ATM situation so that Separation Provision can be efficiently applied by human intervention

Average	Mode	Quartiles		
		25%	50%	75%
8,5	10	8	9	10

2. Reduce complexity adjusting automatically the provision of separation

Average	Mode	Quartiles		
		25%	50%	75%
6,5	8	6	7	8

3. Optimise sectorisation

Average	Mode	Quartiles		
		25%	50%	75%
7,1	10	5	7	9

4. Remain within reasonable limits the ATCo workload

Average	Mode	Quartiles		
		25%	50%	75%
8,4	8; 10	7	9	10

5. Ensure a safe traffic management

Average	Mode	Quartiles		
		25%	50%	75%
8,5	10	8	9	10

6. Keep tactical interventions per aircraft (or cumulative set of flights), specially sequencing and conflict resolution, below a reference level

Average	Mode	Quartiles		
		25%	50%	75%
7,5	8	6	8	9

7. Maximise the network capacity

Average	Mode	Quartiles		
		25%	50%	75%
7,9	8	6	8	9

8. Interpret the current traffic plans and control arrangements

Average	Mode	Quartiles		
		25%	50%	75%
6,4	7	6	7	8

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

Additional points highlighted by the experts:

- optimise the ATC team resource management
- distributing workload throughout a predefined portion of airspace in which ATC is provided using dynamic airspace management, dynamic flow management and extensive pre-defined scenarios

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Simplify the ATM situation so that Separation Provision can be efficiently applied by human intervention
2. Ensure a safe traffic management
3. Remain within reasonable limits the ATCo workload
4. Maximise the network capacity
5. Keep tactical interventions per aircraft (or cumulative set of flights), specially sequencing and conflict resolution, below a reference level
6. Optimise sectorisation

Q1.1.4 "This process will trigger the next actions prior to the arrival of the aircraft in the subject airspace:

1. **Multi-Sector Planning**
2. **RBTs modifications**
3. **Demand & Capacity Balance solutions**
4. **Structured airspace with fixed routes"**

Do you agree on the statement?, If not, explain why.

Problems detected by the CM process will be resolved by adjusting traffic plans and control arrangements.

Q1.2.1 Score (0-10) the next points according to its applicability to detect a complex situation and to the level of complexity which they involve.

1. Airspace configuration

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,6	10	5	6	8

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

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,3	8	6	7	8

2. Number of aircraft handled by a controller that require attention (e.g. unresponsive pilot)

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,2	10	7	8	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
8,5	8	8	8	9

3. Time pressure

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,8	7; 10	7	7	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,9	10	7	7	10

4. Equipment failures

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,2	10	2	6	10

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

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
8,2	7; 10	7	8	10

5. Weak mastery of English language

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,1	7; 10	2	4	7

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
5,5	2; 6; 7; 8	4	6	7

6. Equipment and Environment Distractions (e.g. Sound alarms)

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,1	7	2	3	6

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
5,2	6	5	6	6

7. On the job training

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,8	5	4	5	5

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
5,6	5	5	5	6

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

8. Look-ahead time

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,6	8	4	7	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,7	8	5	7	8

9. Number of simultaneous flight movements in relation to the size of a certain volume of airspace

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,3	10	7	8	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
8,7	10	7	9	10

10. Aircraft performance mix

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,7	8; 10	7	8	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,5	8	7	8	9

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

11. Flight phase/attitude

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,3	7	4	6	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,8	3; 8; 10	4	7	9

12. Aircraft type

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,9	5	5	5	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,0	6	5	6	8

13. Aircraft performances (speed, altitude, manoeuvring.....)

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,0	9	5	8	9

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,3	7; 8; 9; 10	7	8	9

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

14. Type of equipment

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,4	3; 5; 8	3	5	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,1	5	5	5	8

15. Type of clearance

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,3	5	4	5	6

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,0	5; 7	5	6	7

16. Number of potential predictable conflicts based on actual flight parameters (speed, 4D contract, clearances…) and RBT known data.

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,1	7; 8; 10	7	8	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
8,1	8	7	8	9

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

17. Aircraft density

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,3	10	7	8	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
8,7	10	8	9	10

18. Weather Parameters

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,1	7; 9	7	8	9

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,9	8	7	8	9

19. Overall demand

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,0	7	6	7	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,4	7	5	7	7

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

20. Predominant traffic orientation

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,6	7	6	7	7

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,6	7	6	7	7

21. Traffic mix

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,7	7; 10	6	7	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,3	7	6	7	10

22. Operations in adjacent sectors / centres

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,7	7	5	7	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,1	8	6	7	8

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

23. Bunching (geographical or temporal)

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,9	7; 8	7	7	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
8,0	8	8	8	8

24. Duration of flights in a certain volume of airspace.

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,8	7	5	7	8

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
6,3	5; 8	5	7	8

25. Type of predicted interactions/conflictions (AC climbing/descending/level flight)

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,4	10	7	8	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
8,7	9; 10	8	9	10

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

26. Time until the predicted interaction takes place as indicator for the inaccuracy of the prediction

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,1	3; 8; 9; 10	6	8	9

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,9	8	7	8	9

27. Methods used for conflict resolution, coordination and monitoring traffic mix and ATCo workload

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,2	10	6	8	10

LEVEL OF COMPLEXITY				
Average	Mode	Quartiles		
		25%	50%	75%
7,5	7	6	7	8

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

- Detection:

1. Type of predicted interactions/conflictions (AC climbing/descending/level flight)
2. Number of simultaneous flight movements in relation to the size of a certain volume of airspace
3. Aircraft density
4. Number of potential predictable conflicts based on actual flight parameters (speed, 4D contract, clearances…) and RBT known data.
5. Weather Parameters
6. Number of aircraft handled by a controller that require attention (e.g. unresponsive pilot)

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

7. Time pressure

8. Aircraft performance mix

9. Methods used for conflict resolution, coordination and monitoring traffic mix and ATCo workload

10. Time until the predicted interaction takes place as indicator for the inaccuracy of the prediction

11. Aircraft performances (speed, altitude, manoeuvring.....)

12. Overall demand

- Level of complexity that involves:

1. Number of simultaneous flight movements in relation to the size of a certain volume of airspace

2. Type of predicted interactions/conflictions (AC climbing/descending/level flight)

3. Aircraft density

4. Number of aircraft handled by a controller that require attention (e.g. unresponsive pilot)

5. Equipment failures

6. Number of potential predictable conflicts based on actual flight parameters (speed, 4D contract, clearances…) and RBT known data.

7. Bunching (geographical or temporal)

8. Time until the predicted interaction takes place as indicator for the inaccuracy of the prediction

9. Time pressure

10. Weather Parameters

11. Aircraft performance mix

12. Methods used for conflict resolution, coordination and monitoring traffic mix and ATCo workload

13. Airspace configuration

14. Aircraft performances (speed, altitude, manoeuvring.....)

15. Traffic mix

16. Operations in adjacent sectors / centres

Q1.2.2 Do you think a combination of indicators has more influence on generating complexity than one single indicator individually?. This means, one indicator could generate less complexity if it was the only driver, but combined with others produces a

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

big impact in the system. Then, it would be not necessary to control this indicator but the whole package of indicators whose combination is critic.

The indicators are not independent. The complexity growth is nonlinear with the number of involved complexity factors/indicators.

Q1.3.1 Score quantitatively (0-10) and qualitatively (A-E) the next scenarios according to the next criteria:

A. Scenario 1

• 3 a/c flying heading 179

• 2 (A & B) at odd levels,

• 1 (C) at even levels.

• The 3 a/c have similar speeds and are sequenced as A, B, C;

• a/c B & C fly faster than ordered; A is erratic.

• Neither A - B - C speak fluently English and there is a Collision Alert alarm bell in a Controller Working Position 2 desks away.

This example simply shows that complexity is not necessarily a geometrical issue, but that it also has a strong environmental component.

Average	Mode	Quartiles		
		25%	50%	75%
5,5	5	4	5	8

B. Scenario 2

Situation foreseen for a particular en-route sector 45 minutes in advance:

• Traffic mix with similar aircraft performance.

• All traffic established in cruise.

• Route structure or predicted trajectories not intersecting.

• No alerts of conflict detection. In this case the situation could only be considered as complex depending on the number of simultaneous aircraft (typical values for most current en route sectors may vary from 10 to 15).

Average	Mode	Quartiles		
		25%	50%	75%
6,8	7	3	7	8

C. Scenario 3

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

Situation foreseen for a particular en-route sector 25 minutes in advance:

• Traffic mix with strong different aircraft performance.

• Traffic established in cruise together with traffic climbing and/or descending.

• Route structure or predicted trajectories intersecting.

• Several alerts of conflict detection.

This situation is highly unstable and may become complex from many different ways (number of simultaneous aircrafts, ratio of traffic climbing/descending, ratio of traffic using intersecting trajectories or number of conflict detection alerts).

Average	Mode	Quartiles		
		25%	50%	75%
8,5	10	8	9	10

D. Scenario 4

A situation in which several concurrent conflicts occur. For example a tactical controller that chose to consider conflicts 8 minutes ahead of now might be confronted:

• One conflict 30% of the time and this would be considered normal.

• 2 concurrent conflicts 5% of the time

• 3 conflicts 0.66% of the time

• 4 conflicts 0.02% of the time (based on studies relating to 32 aircraft in a sector 50% in climb on entry).

Decomplexing actions would aim to reduce the likelihood of multiple conflicts. Note: although conflicts undoubtedly contribute to complexity there are other concerns related to boundary and general monitoring activities: High density of a/c together with vertically evolving traffic. Peaks may happen when several flights are close to sector boundary and need controller attention for hand over and welcome. If traffic has a dispersion in speed capabilities and overtake happens within the sector, this increases complexity by the need of attention by the controller during long periods.

Average	Mode	Quartiles		
		25%	50%	75%
9,0	10	9	10	10

From the list of scenarios, the most appropriate according to experts' opinion have been those whose average is greater than 7,0. The scenarios 1 & 2 will not be study in detail in the next questionnaires.

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

For the experts the scenarios that describes a complex situation better is de Scenario 4. Scenario 3 should be also considered in the next questionnaires because its average suggests that experts consider it as appropriate.

Q1.4.1 Select the main function of the next roles and other functions:

1. Regional Network Manager

Main responsibilities: Coordination with all roles; Select those alternative that may be preferential to the overall traffic situation

Secondary responsibilities: Assure the provision of inform ation; Initiate CDM processes

Average	Mode	Quartiles		
		25%	50%	75%
8,0	8	8	8	9

2. Sub-Regional Network Manager

Main responsibilities: Monitor complexity level; Coordination with Complexity Manager;

Secondary responsibilities: Negotiation of new RBT; Initiate CDM processes

Average	Mode	Quartiles		
		25%	50%	75%
8,0	7	7	8	9

3. ANSP

Main responsibilities: Assure the provision of inform ation;

Secondary responsibilities:

Average	Mode	Quartiles		
		25%	50%	75%
6,7	8	5	8	8

4. Multi-Sector planner

Main responsibilities: Pre-tactical. Supported by multi sector planning tools; Coordination with all roles

Secondary responsibilities: Assess how flights fit in the demand pattern;

Average	Mode	Quartiles		
		25%	50%	75%
7,9	7	7	7	9

5. Planning Controller

Main responsibilities: Assess how flights fit in the demand pattern;

Secondary responsibilities: Coordination with all roles;

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

Average	Mode	Quartiles		
		25%	50%	75%
7,4	8	7	8	8

6. Executive/Tactical Controller

Main responsibilities: Provision of RBT clearances;

Secondary responsibilities: Modifying RBTs;

Average	Mode	Quartiles		
		25%	50%	75%
5,9	10	4	4	9

7. Civil / military Airspace Manager

Main responsibilities: Enabling the use of airspace structures;

Secondary responsibilities:

Average	Mode	Quartiles		
		25%	50%	75%
8,3	8; 9; 10	8	8	9

8. Complexity Manager

Main responsibilities: Monitor complexity level;

Secondary responsibilities: Initiate CDM processes; Verify applicability of proposed solutions; Negotiation of new RBT; Coordination with all roles

Average	Mode	Quartiles		
		25%	50%	75%
9,6	10	10	10	10

9. Supervisor

Main responsibilities: Split / Merge sector configuration;

Secondary responsibilities: Monitor complexity level;

Average	Mode	Quartiles		
		25%	50%	75%
7,3	10	7	9	10

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

10. Airspace Users (AOCC)

    Main responsibilities: Negotiation of new RBT;

    Secondary responsibilities:

Average	Mode	Quartiles		
		25%	50%	75%
7,9	7	7	7	8

11. Airport Operations (APOC)

    Main responsibilities: Assure the provision of information;

    Secondary responsibilities:

Average	Mode	Quartiles		
		25%	50%	75%
4,9	0; 6; 7	4	6	7

12. Airspace User Operations Manager

    Main responsibilities: Modifying RBTs;

    Secondary responsibilities: Negotiation of new RBT;

Average	Mode	Quartiles		
		25%	50%	75%
7,4	7; 8	7	8	8

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

13. Flight crew/pilot

Main responsibilities: Acceptance of changes proposed to his RBTs through negotiation processes;

Secondary responsibilities: Negotiation of new RBT;

Average	Mode	Quartiles		
		25%	50%	75%
6,7	3; 6; 7; 9	6	7	9

Possible Overlap with Complexity Manager (DCB Overlaps with Complexity Management).

Main responsibilities: Verify applicability of proposed solutions; Forecast traffic patterns

Secondary responsibilities: Select those alternatives that may be preferential to the overall traffic situation;

Average	Mode	Quartiles		
		25%	50%	75%
9,0	10	8	9	10

From the list of roles, the most appropriate according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

- Complexity Manager
- Flow Manager
- Civil / military Airspace Manager
- Sub-Regional Network Manager
- Regional Network Manager
- Multi-Sector planner
- Airspace Users (AOCC)
- Planning Controller
- Airspace User Operations Manager
- Supervisor

Q1.5.1 Complexity Management should be an event driven activity. Do you agree on this sentence? If not, explain why?

Checking for complex situations has to be conducted regularly. Conflict Management itself takes place at the event of an identified complex situation.

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

Q1.5.2 Could this process be split in different stages with the intervention of different role pending on the situation and the decision that should be taken?. Please enumerate the stages and roles involved in each one.

1. Complexity is regularly checked, preferably automated
2. Build-up of situational awareness
3. Identification of solutions.
4. Solution assessment
5. Decision phase. The complexity manger proposes solutions (e.g. negotiates/offers new trajectories)
6. Information stage - the complexity manager inform s relevant entities (preferably automated).
7. Solution implementation
8. Monitoring

Q1.6.1 Add comments, milestones and clarifications to establish the CM process in the appropriate timeline with its characteristic events

This chart not explain how many time need to CDM.

The period offered by the figure needs to be evaluated.

Time of detection is related to accuracy of traffic prediction so times should not be set in stone.

Q1.6.2 Adapting sector configuration will need a short time to be applied (10-15 minutes including CDM process). Do you agree on this statement?. How much time, at least, can a CDM process spend?

This depends on the level of automation.

CDM is a high level general concept; in this particular case it is meant to be just a negotiation between the Complexity Manager and the Supervisor of a particular ACC, which should be a quite quick process.

Application could be much quicker especially if all ATCo teams were co-located (Conventional splitting).

And in dynamic situation immediately (Mantas trials)

Q1.6.3 Detection it is not considered time consuming action making automatically by a computer application. Do you agree on this statement? If not, explain why?

Yes modern computers can easily simulate air traffic and investigate complexity.

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

Q1.7.1 Can be the entrance in the controlled volume of the airplanes which are considered to cause the complex situation, the event that differentiates both (CM and SM)?

Yes.

Q1.7.2 Are you agree with on the main issues that are explained that SM focuses on? If not, explain why.

Yes this is SM.

Q1.7.3 Does CM aim to reduce the workload per aircraft, per individual complex situation or per traffic sample? Explain why.

No, CM focuses on reducing the workload associated with the individual flight by changing some aspect of its operating environment.

There could be an optimisation in the sense workload per aircraft but as soon as a complex situation occurs safety needs to be ensured, and the workload does not matter any longer.

CM should aim to reduce the workload of the traffic sample. This is the same as reducing the average workload per aircraft.

No, CM aims to reduce the workload per controlled sector.

Per traffic sample. Overall Workload depends on a workload associated with a team of controllers working a family of sectors we need to trade expeditious conduct of flights, with controller numbers and capacity.

This optimisation is done with regard to traffic at the family of sectors level.

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

ATCO Workload

Q2.1.1 what are the factors that contribute to ATCo mental workload?

1. Overall demand,
2. RTF requirements
3. Weather
4. Operations in adjacent airspace
5. Monitoring and levels of RT
6. Time pressure
7. Criticality of decisions
8. Fatigue
9. Lack of situation awareness
10. The number of sectors under control
11. The shape/structure of the sectors
12. The number and type of aircrafts under control
13. Complex traffic circumstances
14. Complex operational scenario
15. Lack of standard operational procedures
16. Lack of supporting tools
17. Information uncertainty
18. Lack of experience
19. Lack of local training

Q2.1.2 Does workload encompass something else than mental load?

There are 'mechanical' actions such as routine RTF requirements and co-ordination sequences.

Time load (number of activities to be performed) and physical load. Physical workload refers to the level of physical activity required by a controller resulting from performing tasks which are interfaces with the physical environment (e.g. communications, data entry).

Q2.1.3 do you consider the relationship between ATCo workload and Complexity is direct? Are there any other factors participating?

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

Complexity definitely has a link to both (mental and physical workload) but this link is not bijectional. There are certainly scenarios which are not necessarily complex and therefore require a low level of mental workload but may entail a high level of physical activity such as RT activity - where there is a physical limit to workload.

Not all situations producing high ATCo workload are complex situations.

Q2.2.1 Complexity is not only referred to geometrical complexity. Is geometrical complexity enough to identify complex situations? If not, please identify other elements that should be considered.

Assuming geometrical is used in the interaction sense then we need to consider other factors such as controllers' ability and support tools available and weather. Could be handled as a sort of degree of difficulty post-multiplier to the geometrical calculation.

Different ATC unit has different level of ATS capability according to ATC facility and ATCo skills.

Time is a very important factor.

Q2.2.2 How can the cognitive aspect be measured? Is it important to determine if a situation is considered as complex by the ATCo?. Is it possible to ensure that controlling these values is useful to envisage complex situations?

It is human factors scope - Wicken's model

Instantaneous self assessment is one of the better ways. Number of reported overloads is also a good way, although this can also be influenced by external factors such as the satisfaction/morale of controllers.

Measuring workload is enough, no expected advantages in doing a physiological breakdown.

Q2.2.3 Is it possible to connect the CM objective parameters with the subjective and mental parameters?

Probably not to a great degree as the impact of subjective parameters is so variable/volatile.

Although this is done through validation experiments in the same way as the worth of other controller tools are established.

Q2.2.4 Score (0-10) the next indicators:

1. Assessment of active traffic situation

Average	Mode	Quartiles		
		25%	50%	75%
5,4	8	5	8	8

2. Determining safe separation of traffic

Average	Mode	Quartiles		
		25%	50%	75%
7,0	7	7	7	9

3. Prioritisation of actions

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

Average	Mode	Quartiles		
		25%	50%	75%
7,3	6	6	7	8

4. Executive instructions to flights

Average	Mode	Quartiles		
		25%	50%	75%
7,3	3; 8; 9; 10	6	8	9

5. Monitoring of changing conditions

Average	Mode	Quartiles		
		25%	50%	75%
7,1	7	7	7	9

6. Determining onward co-ordination criteria

Average	Mode	Quartiles		
		25%	50%	75%
6,2	7	4	7	7

7. Conflict detection and resolution

Average	Mode	Quartiles		
		25%	50%	75%
8,9	10	7	9	10

8. Real Time tasks

Average	Mode	Quartiles		
		25%	50%	75%
8,1	8; 9	8	8	9

9. Co-ordination

Average	Mode	Quartiles		
		25%	50%	75%
7,7	7	7	8	9

10. Movements and level changes

Average	Mode	Quartiles		
		25%	50%	75%
7,8	6	6	8	9

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Conflict detection and resolution

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

2. Real Time tasks
3. Movements and level changes
4. Co-ordination
5. Prioritisation of actions
6. Executive instructions to flights
7. Monitoring of changing conditions
8. Determining safe separation of traffic

Q2.3.1: Score (0-10) the next indicators:

1. Time of working for every controller one day

Average	Mode	Quartiles		
		25%	50%	75%
5,3	5	3	5	7

2. Controller Alternating time

Average	Mode	Quartiles		
		25%	50%	75%
6,2	8	4	7	8

3. Number of flights control by one controller per hour

Average	Mode	Quartiles		
		25%	50%	75%
7,8	10	6	8	9

4. Number of sector boundary or fix one position

Average	Mode	Quartiles		
		25%	50%	75%
6,3	5; 7; 8	5	7	8

5. Number of command (Voice or Data message) send per hour

Average	Mode	Quartiles		
		25%	50%	75%
8,2	10	7	9	10

6. Volume of traffic flow per hour

Average	Mode	Quartiles		
		25%	50%	75%
7,8	5; 7; 8; 9; 10	7	8	9

7. Volume of ATC instructions per hour

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

Average	Mode	Quartiles		
		25%	50%	75%
8,1	10	7	8	10

8. Number of flights per hour

Average	Mode	Quartiles		
		25%	50%	75%
7,9	8; 10	7	8	9

9. Interval between ATC instructions

Average	Mode	Quartiles		
		25%	50%	75%
8,3	8	8	8	8

10. Number of flights

Average	Mode	Quartiles		
		25%	50%	75%
7,4	8; 10	6	8	9

11. Real Time Frequencies occupancy

Average	Mode	Quartiles		
		25%	50%	75%
7,0	8	7	8	8

12. Number of level change instructions

Average	Mode	Quartiles		
		25%	50%	75%
7,7	8	7	8	8

13. Number of heading instructions

Average	Mode	Quartiles		
		25%	50%	75%
7,0	7	7	7	8

14. Number of co-ordination discussions with adjacent agencies

Average	Mode	Quartiles		
		25%	50%	75%
7,6	7	7	7	8

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

15. Number of vertical movements

Average	Mode	Quartiles		
		25%	50%	75%
9,0	10	8	10	10

16. Average time for each possible action.

Average	Mode	Quartiles		
		25%	50%	75%
7,7	7; 10	7	8	10

17. Basic workload (routine tasks)

Average	Mode	Quartiles		
		25%	50%	75%
7,3	5; 10	5	7	10

Additional points highlighted by the experts:

- Proximity of potential conflicts to sector boundary
- A measure of bunching
- variance in aircraft speed
- weather

The measurement of ATCo workload must be available from HF experts. Anyway it should be useful the information included the paper "*Cognitive complexity in air traffic control a literature review*" which could be found at

http://www.eurocontrol.int/eec/gallery/content/public/documents/EEC_notes/2004/EEC_note_2004_04.pdf

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Number of vertical movements
2. Interval between ATC instructions
3. Number of command (Voice or Data message) send per hour
4. Volume of ATC instructions per hour
5. Number of flights per hour
6. Number of flights control by one controller per hour
7. Volume of traffic flow per hour
8. Number of level change instructions

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

9. Average time for each possible action.
10. Number of co-ordination discussions with adjacent agencies
11. Number of flights
12. Basic workload (routine tasks)
13. Real Time Frequencies occupancy
14. Number of heading instructions

Solutions

Q3.1.1 Score (0-10) the next list of procedures:

1. Sector re-configuration. This solution requires extra air traffic controllers, ATC positions and facilities. Different levels of complexity need different sector reconfiguration. Requires acting on ATC resources management and might have an impact in the NOP."

Average	Mode	Quartiles		
		25%	50%	75%
9,0	9	9	9	9

2. Reroute. This solution requires flexible ATC routes, and may increase workload on other ATC unit.

Average	Mode	Quartiles		
		25%	50%	75%
7,5	7	7	8	9

3. Reducing the anticipated flow in that high complexity airspace

Average	Mode	Quartiles		
		25%	50%	75%
8,1	9	6	8	9

4. Enabling temporary use of airspace structures (fixed routes). Requires acting on airspace management and might have an impact on both: traffic demand and NOP.

Average	Mode	Quartiles		
		25%	50%	75%
8,2	8	8	8	9

5. Modifying RBTs. Requires acting on airspace user operations management and also may have an impact on both: traffic demand and NOP.

Average	Mode	Quartiles		
		25%	50%	75%
8,2	8; 9	8	9	9

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

6. TMR reduction (tight parameters): gain of capacity, reduce uncertainty.

Average	Mode	Quartiles		
		25%	50%	75%
7,7	8; 9	7	8	9

7. 2D, 3D or 4D contracts, taking advantage of most capable a/c capabilities: Reduce uncertainty.

Average	Mode	Quartiles		
		25%	50%	75%
8,0	7; 9	7	8	9

8. Issue changes in Trajectories

Average	Mode	Quartiles		
		25%	50%	75%
6,3	6	6	6	8

9. Reduce tactical complexity, separation management help.

Average	Mode	Quartiles		
		25%	50%	75%
7,6	10	6	8	10

10. Route or level adjustment

Average	Mode	Quartiles		
		25%	50%	75%
8,2	9	7	9	9

11. Sector Splitting

Average	Mode	Quartiles		
		25%	50%	75%
7,1	10	5	7	10

12. Dynamic sectorisation

Average	Mode	Quartiles		
		25%	50%	75%
8,6	10	8	9	10

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Sector re-configuration.
2. Dynamic sectorisation
3. Enabling temporary use of airspace structures (fixed routes).

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

4. Route or level adjustment
5. Modifying RBTs
6. Reducing the anticipated flow in that high complexity airspace
7. 2D, 3D or 4D contracts
8. TMR reduction
9. Reduce tactical complexity
10. Reroute.
11. Sector Splitting

Q3.2.1 is it possible to ensure that DCB solutions applied will not produce an adverse effect on CM? How?

Proper planning should take into account this issue; e.g. a DCB solution should include the decomplexion measures.

Some mitigation could be provided through 'What if' scenarios on traffic management tools and simulations. Workload/complexity model.

Yes, if DCB optimisation techniques are aligned to CM optimisations (and CM are aligned to SM) same principles are applied.

Q3.2.2 Who is in charge of developing DCB solutions?

AOCs with the Regional Network Manager, Sub-Regional Network Manager and Complexity Manager.

Q3.2.3 Where will be the list of DCB solutions stored?

DCB solution should be shared throughout the NOP, all stakeholders can visit and applications When SWIM established.

Q3.2.4 Define the layers where CM could be applied.

Time dimensions:

- Planning stage (long-term, long-term and short-term)
- The implementation phase (short-term, real-time)

Different types of airspace:

- Low-density
- medium-density
- high-density

Q3.3.1 Score (0-10) the next CM tools or techniques:

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

1. Multi-Sector and in general medium / long term planning tools.

Average	Mode	Quartiles		
		25%	50%	75%
8,6	9	8	9	9

2. Tools that increase and facilitate the acquisition of Situational Awareness (e.g. Improved HMIs)

Average	Mode	Quartiles		
		25%	50%	75%
8,0	9	8	9	9

3. Dynamic 3D routes

Average	Mode	Quartiles		
		25%	50%	75%
7,2	6; 9; 10	6	7	9

4. A- SMAN & A-SMGCS

Average	Mode	Quartiles		
		25%	50%	75%
5,1	3	3	4	7

5. AMAN & DMAN

Average	Mode	Quartiles		
		25%	50%	75%
5,1	3	3	4	7

6. CDM

Average	Mode	Quartiles		
		25%	50%	75%
7,3	10	7	8	9

7. Aircraft performance data

Average	Mode	Quartiles		
		25%	50%	75%
5,2	5	4	5	5

8. Aircraft performance model.

Average	Mode	Quartiles		
		25%	50%	75%
5,1	5	3	5	5

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

9. Trajectory calculation tools.

Average	Mode	Quartiles		
		25%	50%	75%
8,7	10	7	8	10

10. Sector capacity evaluation tools.

Average	Mode	Quartiles		
		25%	50%	75%
7,5	9	6	7	9

11. Medium term conflict detection.

Average	Mode	Quartiles		
		25%	50%	75%
8,6	8	8	8	9

12. Capability for quick simulation of solutions.

Average	Mode	Quartiles		
		25%	50%	75%
7,6	9; 10	8	9	10

13. Route or level adjustment (or maybe speed)

Average	Mode	Quartiles		
		25%	50%	75%
5,9	7; 8	7	8	8

14. Sector Splitting

Average	Mode	Quartiles		
		25%	50%	75%
7,6	7; 8	7	8	9

15. Dynamic Sectorisation

Average	Mode	Quartiles		
		25%	50%	75%
8,2	8	8	8	10

16. In the future there could be made use of an adapted fast-time simulation tool in order to analysis the forecasted traffic/scenarios for complex situations.

Average	Mode	Quartiles		
		25%	50%	75%
8,6	10	8	9	10

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

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

1. Trajectory calculation tools.
2. Medium term conflict detection.
3. Multi-Sector and in general medium / long term planning tools.
4. fast-time simulation tool in order to analysis the forecasted traffic/scenarios
5. Dynamic Sectorisation
6. Tools that increase and facilitate the acquisition of Situational Awareness
7. Capability for quick simulation of solutions.
8. Sector Splitting
9. Sector capacity evaluation tools
10. CDM
11. Dynamic 3D routes

Q3.4.1 Who will be the responsible person that manages the process of changing sector and volumes?

Mainly the Supervisor with extensive coordination with Complexity Manager, because changes of airspace should be revised and issued by the supervisor, in the TMA and ACC as well.

The supervisor could assume the complexity manager role.

Q3.4.2 Is DAM a solution that could be applied for CM only?

No. DAM is related to the optimum use of the resources, not only for complex situations.

Q3.4.3 How will DAM improve unpredictable situations?

DAM will reduce complexity by distributing the demand to different roles, but it will not necessarily imply an increase in predictability

Q3.4.4 DAM is strong tool to reduce the workload, but sometime it would be useful to increase the workload in some sector if it is too low. CM could consider this situation not only decreasing complexity but also increasing when possible to increase efficiency, optimise resources and maintain the workload stable?

Correct, taking into account that complexity indicators limits are not overcome

Q3.4.5 Transferring complexity from high workload sector to the adjacent low workload sector, is it a way to reduce complexity in an area? Or complexity remains constant but managed in a different way?

A complex situation detected through an increase of indicators values, may be solved transferring workload to adjacent sectors, reducing values below trigger levels in all sectors, therefore reducing global complexity levels.

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

No, in general complexity is reduced, due to the non-linear nature of the complexity function. However, workload gain must overcome inertia of transfer effort.

Q3.4.6 Minimise workload or maintain under a threshold value?

Reduce workload to a threshold which guarantees safety, then optimise according to capacity and efficiency

Automation

Q4.1.1 Score (0-10) the next strengths of the current traffic management tools:

1. Robustness

Average	Mode	Quartiles		
		25%	50%	75%
7,1	7	7	8	8

2. Reliability

Average	Mode	Quartiles		
		25%	50%	75%
7,8	8	8	8	8

3. Predictability

Average	Mode	Quartiles		
		25%	50%	75%
5,8	8	4	7	8

4. *A high degree of automation*

Average	Mode	Quartiles		
		25%	50%	75%
6,3	7	5	7	8

5. Higher efficiency

Average	Mode	Quartiles		
		25%	50%	75%
7,1	7	5	7	8

6. Uniform data From at

Average	Mode	Quartiles		
		25%	50%	75%
7,8	7; 8; 9	7	8	9

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

7. Similar operation procedure

Average	Mode	Quartiles		
		25%	50%	75%
6,7	8	5	8	8

8. To be configured with advanced ATC automation system

Average	Mode	Quartiles		
		25%	50%	75%
6,6	8	5	8	8

9. Current operations based on them are safe

Average	Mode	Quartiles		
		25%	50%	75%
8,6	10	9	9	10

10. To contain a large number of flight information

Average	Mode	Quartiles		
		25%	50%	75%
6,6	10	9	10	10

11. Flexibility of solutions as these are determined by an ATCO rather than by an automated process

Average	Mode	Quartiles		
		25%	50%	75%
6,0	7	6	7	7

12. Sufficient flexibility in the system to allow AOC staff to operate to their desired schedule and allow Airport ATC to integrate departures and arrivals and non-airways traffic

Average	Mode	Quartiles		
		25%	50%	75%
6,5	7; 8	5	7	8

13. Common base data among all agencies providing a common understanding of operational intentions

Average	Mode	Quartiles		
		25%	50%	75%
6,6	5; 8	5	7	8

14. Allow some consideration of some of the elements of complexity such as predicted flight list, flight profiles to allow complexity management

Average	Mode	Quartiles

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

		25%	50%	75%
6,3	7; 8	7	8	8

15. Measure of the level of confidence in the predicted data (i.e. are the flights airborne or not)

Average	Mode	Quartiles		
		25%	50%	75%
6,3	8	5	6	8

16. Tools are available across ANSP/ACCs

Average	Mode	Quartiles		
		25%	50%	75%
5,7	2	2	6	8

17. Correlation of tracks

Average	Mode	Quartiles		
		25%	50%	75%
7,6	9	5	8	9

18. Agile flight plans management

Average	Mode	Quartiles		
		25%	50%	75%
6,8	7; 8; 9	6	7	8

19. Configurable by the user

Average	Mode	Quartiles		
		25%	50%	75%
5,4	8	4	6	8

20. Look at centre level

Average	Mode	Quartiles		
		25%	50%	75%
6,1	8	5	7	7

21. Anticipation

Average	Mode	Quartiles		
		25%	50%	75%
6,6	7	4	7	8

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

22. Identification of where and when actions are needed

Average	Mode	Quartiles		
		25%	50%	75%
6,5	7	7	7	7

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Current operations based on them are safe
2. Reliability
3. Correlation of tracks
4. Uniform data From at
5. Higher efficiency
6. Robustness

Q4.1.2 Score (0-10) the next weaknesses of the current traffic management tools:

1. Lack of accuracy

Average	Mode	Quartiles		
		25%	50%	75%
7,6	7	6	7	9

2. Short prediction time span

Average	Mode	Quartiles		
		25%	50%	75%
7,3	8	6	7	8

3. Reactive rather than proactive

Average	Mode	Quartiles		
		25%	50%	75%
6,4	7	5	7	7

4. Complex operation

Average	Mode	Quartiles		
		25%	50%	75%
5,5	6; 7; 8	6	7	7

5. Interactive poor performance (regional information exchange)

Average	Mode	Quartiles

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

		25%	50%	75%
6,5	5; 8	5	6	8

6. Intelligent level is not high enough

Average	Mode	Quartiles		
		25%	50%	75%
6,1	8	5	8	8

7. Sharing of information is not enough

Average	Mode	Quartiles		
		25%	50%	75%
7,8	10	8	8	10

8. Pilot autonomy weak

Average	Mode	Quartiles		
		25%	50%	75%
7,8	7; 10	7	7	9

9. Not enough ATM decision support tools

Average	Mode	Quartiles		
		25%	50%	75%
7,3	7	7	7	8

10. Lack of confidence from airspace users

Average	Mode	Quartiles		
		25%	50%	75%
5,3	7	4	5	7

11. Current traffic management tools produce "unused capacity" in the system

Average	Mode	Quartiles		
		25%	50%	75%
7,3	8	6	7	8

12. System not widely integrated

Average	Mode	Quartiles		
		25%	50%	75%
7,4	10	8	9	10

13. Not compatible with all kinds of systems among areas

Average	Mode	Quartiles		
		25%	50%	75%
6,3	3; 9	3	7	9

14. Not implemented in a wide scope

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

Average	Mode	Quartiles		
		25%	50%	75%
6,4	3; 9	3	7	9

15. Accuracy and predictability cannot be assured over large time frames

Average	Mode	Quartiles		
		25%	50%	75%
7,9	10	8	9	10

16. When implementing solutions you will inevitably change the traffic situation in adjacent airspace which will influence the workload and complexity in that airspace - thus there is a potential to create a more serious complexity issue elsewhere when solving a situation in your own airspace. Without some method of providing an overview and determining which is the 'overall' best solution the network as an entirety will not be optimised

Average	Mode	Quartiles		
		25%	50%	75%
7,8	8	7	8	8

17. Chosen solutions are not always visible to adjacent agencies thus they may take action that they believe supports the reduction in complexity or that meets customer demand, but that acts against the solution chosen by the subject sector.

Average	Mode	Quartiles		
		25%	50%	75%
7,3	8	7	8	8

18. No comprehensive (and consistent) view of complexity and relation to workload.

Average	Mode	Quartiles		
		25%	50%	75%
6,5	8	6	7	8

19. Little collaborative decision making with airlines/airfields to reduce complexity problems in the network

Average	Mode	Quartiles		
		25%	50%	75%
7,6	9	7	8	9

20. Very "rigid" tools to adapt new concepts

Average	Mode	Quartiles		
		25%	50%	75%
7,6	9	7	8	9

21. Lack of aircraft-ground links

Average	Mode	Quartiles

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

		25%	50%	75%
7,1	6; 8	6	7	8

22. Only problem detection, no solution proposed

Average	Mode	Quartiles		
		25%	50%	75%
6,0	6; 8	6	7	8

23. Poor complexity model (dynamic density)

Average	Mode	Quartiles		
		25%	50%	75%
5,5	8	3	7	8

24. Quality of the TC prediction for long look ahead times

Average	Mode	Quartiles		
		25%	50%	75%
7,0	7	7	7	8

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Accuracy and predictability cannot be assured over large time frames
2. Without some method of providing an overview and determining which is the 'overall' best solution the network as an entirety will not be optimised
3. Sharing of information is not enough
4. Pilot autonomy weak
5. Lack of accuracy
6. Very "rigid" tools to adapt new concepts
7. Little collaborative decision making with airlines/airfields to reduce complexity problems in the network
8. System not widely integrated
9. Chosen solutions are not always visible to adjacent agencies
10. Short prediction time span
11. Not enough ATM decision support tools
12. Current traffic management tools produce "unused capacity" in the system
13. Lack of aircraft-ground links
14. Quality of the TC prediction for long look ahead times

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

Q4.2.1 Score (0-10) the next strengths of the ATCo tools:

1. Robustness

Average	Mode	Quartiles		
		25%	50%	75%
6,3	7	7	7	8

2. Reliability

Average	Mode	Quartiles		
		25%	50%	75%
5,9	5; 8	5	6	8

3. Predictability

Average	Mode	Quartiles		
		25%	50%	75%
5,9	8	5	6	8

4. Information integrity

Average	Mode	Quartiles		
		25%	50%	75%
5,7	8	4	7	8

5. Easy to use

Average	Mode	Quartiles		
		25%	50%	75%
6,4	8; 9	5	6	8

6. Obvious effects

Average	Mode	Quartiles		
		25%	50%	75%
7,0	8	7	8	9

7. Flight Automation Delivery

Average	Mode	Quartiles		
		25%	50%	75%
7,1	8	7	8	9

8. Electronic Flight Strip

Average	Mode	Quartiles		
		25%	50%	75%

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

7,0	10	7	8	9

9. Safe

Average	Mode	Quartiles		
		25%	50%	75%
6,9	9	6	9	9

10. Adapted to local operational procedures

Average	Mode	Quartiles		
		25%	50%	75%
8,0	10	6	9	10

11. Contain a large number of flight information

Average	Mode	Quartiles		
		25%	50%	75%
6,4	7; 8	5	7	8

12. Provide much services: warning, alerting, STCA (Short Term Conflict Alert)

Average	Mode	Quartiles		
		25%	50%	75%
7,9	10	7	8	10

13. Planning farther than the scope of one controller

Average	Mode	Quartiles		
		25%	50%	75%
8,0	8	7	8	8

14. More economic way of delaying a/c

Average	Mode	Quartiles		
		25%	50%	75%
6,4	7	6	7	7

15. Enable the medium-term detection of potential conflicts

Average	Mode	Quartiles		
		25%	50%	75%
7,1	8	7	8	8

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

16. Prevent conflicts being overlooked, MTCD

Average	Mode	Quartiles		
		25%	50%	75%
6,7	6; 8	6	8	9

17. Reduce co-ordination effort to a few mouse clicks SYSCO

Average	Mode	Quartiles		
		25%	50%	75%
8,1	9	7	8	9

18. Assure plan conformity MONA

Average	Mode	Quartiles		
		25%	50%	75%
6,6	7; 8	6	7	8

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Reduce co-ordination effort to a few mouse clicks SYSCO
2. Adapted to local operational procedures
3. Planning farther than the scope of one controller
4. Provide much services: warning, alerting, STCA (Short Term Conflict Alert)
5. Flight Automation Delivery
6. Enable the medium-term detection of potential conflicts
7. Obvious effects
8. Electronic Flight Strip

Q4.2.2 Score (0-10) the next weaknesses of the ATCo tools:

1- Lack of accuracy

Average	Mode	Quartiles		
		25%	50%	75%
8,0	7	7	7	9

2- Short prediction time span

Average	Mode	Quartiles		
		25%	50%	75%
7,7	6; 7; 10	6	7	8

3- Reactive rather than proactive

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

Average	Mode	Quartiles		
		25%	50%	75%
6,4	7; 8	7	7	8

4- The prediction capability strongly decreases when vertical movements are concerned (MTCD tool)

Average	Mode	Quartiles		
		25%	50%	75%
8,0	8	8	8	8

5- Complicated system, sometimes fussy to operate

Average	Mode	Quartiles		
		25%	50%	75%
6,7	8	8	8	8

6- Not to compatible all kinds of systems among areas

Average	Mode	Quartiles		
		25%	50%	75%
7,4	8	8	8	8

7- High level of fragmentation across Europe

Average	Mode	Quartiles		
		25%	50%	75%
8,1	8; 10	7	8	9

8- Low level of integration with other function of the ATM system

Average	Mode	Quartiles		
		25%	50%	75%
7,6	8	7	8	8

9- Intelligent inadequate

Average	Mode	Quartiles		
		25%	50%	75%
8,2	7; 8	7	8	8

10- Controller’s voice commands load too heavy

Average	Mode	Quartiles		
		25%	50%	75%
7,8	8	8	8	9

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

11- Lack of information sharing

Average	Mode	Quartiles		
		25%	50%	75%
8,0	8	7	8	9

12- Controller acceptance

Average	Mode	Quartiles		
		25%	50%	75%
6,7	8	5	7	8

13- Imprecision of ETA for incoming aircraft

Average	Mode	Quartiles		
		25%	50%	75%
7,7	8	7	8	8

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Intelligent inadequate
2. High level of fragmentation across Europe
3. Lack of information sharing
4. Lack of accuracy
5. The prediction capability strongly decreases when vertical movements are concerned (MTCD tool)
6. Controllers voice commands load too heavy
7. Imprecision of ETA for incoming aircraft
8. Short prediction time span
9. Low level of integration with other function of the ATM system
10. Not to compatible all kinds of systems among areas

Q4.3.1 Score (0-10) the next requirements for the complexity management tools:

11. Robustness

Average	Mode	Quartiles		
		25%	50%	75%
7,9	7; 10	7	9	10

12. Reliability

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

Average	Mode	Quartiles		
		25%	50%	75%
8,9	10	7	9	10

13. Predictability

Average	Mode	Quartiles		
		25%	50%	75%
9,6	10	9	10	10

14. Accuracy

Average	Mode	Quartiles		
		25%	50%	75%
9,8	10	9	10	10

15. Long prediction time span

Average	Mode	Quartiles		
		25%	50%	75%
8,8	10	8	9	10

16. Proactive

Average	Mode	Quartiles		
		25%	50%	75%
8,3	8; 10	8	10	10

17. Adaptable to the different traffic conditions at the same time

Average	Mode	Quartiles		
		25%	50%	75%
7,4	8	8	8	9

18. Able to balance the interests of all users

Average	Mode	Quartiles		
		25%	50%	75%
7,4	8	8	8	9

19. Dynamic sector capacity evaluation

Average	Mode	Quartiles		
		25%	50%	75%
8,0	10	8	9	10

20. ATCO workload assessment

Average	Mode	Quartiles		
		25%	50%	75%
8,6	10	8	9	10

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

21. Complexity management mechanism and procedure

Average	Mode	Quartiles		
		25%	50%	75%
9,3	10	9	9	10

22. Identify potential complex situations well ahead of them occurring

Average	Mode	Quartiles		
		25%	50%	75%
9,5	10	9	10	10

23. More accurately model aircraft trajectories and to modify these as the flight profile changes

Average	Mode	Quartiles		
		25%	50%	75%
8,5	8	8	8	9

24. Assess complexity solutions in terms of the impact over the airspace as a whole, not just for an individual sector

Average	Mode	Quartiles		
		25%	50%	75%
8,1	7; 10	7	9	10

25. Communicate solutions to other agencies so that the flight profile is not changed to disrupt the planned solution

Average	Mode	Quartiles		
		25%	50%	75%
8,3	8	8	8	9

26. Look at a range of solutions in both time, vertical and horizontal profile and compare the merits of each of these

Average	Mode	Quartiles		
		25%	50%	75%
8,5	8	8	8	10

27. Be part of SWIM in order to communicate data fast and effortless

Average	Mode	Quartiles		
		25%	50%	75%
8,8	9	8	9	9

28. CM will refine the NOP and re-structured airspace region in order to ensure that the capacity goals, for its region of application, are met

Average	Mode	Quartiles		
		25%	50%	75%

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

87,4	8	7	8	9

29. CM will strike an equitable balance between ATC costs User Preferred Trajectories, and Queue Management (traffic sync) goals

Average	Mode	Quartiles		
		25%	50%	75%
7,5	8	7	8	8

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. Accuracy
2. Predictability
3. Identify potential complex situations well ahead of them occurring
4. Complexity management mechanism and procedure
5. Reliability
6. Long prediction time span
7. Be part of SWIM in order to communicate data fast and effortless
8. ATCO workload assessment
9. More accurately model aircraft trajectories and to modify these as the flight profile changes
10. Look at a range of solutions in both time, vertical and horizontal profile and compare the merits of each of these
11. Proactive
12. Communicate solutions to other agencies so that the flight profile is not changed to disrupt the planned solution
13. Assess complexity solutions in terms of the impact over the airspace as a whole, not just for an individual sector
14. Dynamic sector capacity evaluation
15. Robustness
16. CM will strike an equitable balance between ATC costs User Preferred Trajectories, and Queue Management (traffic sync) goals
17. Adaptable to the different traffic conditions at the same time
18. Able to balance the interests of all users

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

19. CM will refine the NOP and re-structured airspace region in order to ensure that the capacity goals, for its region of application, are met

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

Other topics

Q5.1.1 For next KPA, please indicate if CM impact is positive or negative:

1. Cost effectiveness

Average	Mode	Quartiles		
		25%	50%	75%
1,9	3	0	2	3

2. Capacity

Average	Mode	Quartiles		
		25%	50%	75%
4,4	5	4	5	5

3. Efficiency

Average	Mode	Quartiles		
		25%	50%	75%
4,0	5	3	4	5

4. Flexibility

Average	Mode	Quartiles		
		25%	50%	75%
4,0	5	3	4	5

5. Predictability

Average	Mode	Quartiles		
		25%	50%	75%
4,0	5	3	4	5

6. Safety

Average	Mode	Quartiles		
		25%	50%	75%
4,0	5	4	4	5

7. Environmental sustainability

Average	Mode	Quartiles		
		25%	50%	75%
1,1	0	0	1	2

From the list of KPAs, only it is going to be considered those whose average is far from 0, because this values identifies low impact of Complexity Management. With the values showed in these tables the expected I impact could be considered as positive in all cases although for Cost Effectiveness and Environmental Sustainability only slightly.

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

The KPA of Capacity is considered the most affected one with a great positive average. For the remaining KPAs (Efficiency, Flexibility, Predictability and safety) the expected impact is also positive and the values are very high considering the scale.

Q5.2.1 Please score the impact of the OCEs at complexity DETECTION (0-Low, 10-High) and REDUCTION (0-Low, 10-High)

1. AFUA

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,1	5; 8	5	7	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,8	7; 10	8	8	10

2. ATC Teams and Validation

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,9	5	5	8	9

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,4	8	7	8	9

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

3. Transfer of Areas of Responsibility

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,6	5; 8	5	7	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,6	5; 8; 9	5	8	9

4. Remote Tower

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
2,9	0	0	3	5

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,4	0	0	3	6

5. Advanced aircraft Capabilities

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,0	8; 10	6	8	9

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,6	9	9	9	10

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

6. *AMAN-DMAN-Integration*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,9	3	3	7	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,4	3	3	7	9

7. *Controller Automation Support*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,8	10	8	10	10

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
9,2	10	9	9	10

8. *Safety Net*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,3	5; 7	5	6	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,2	0; 8; 9	1	7	8

9. *SMAN*

DETECTION

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

Average	Mode	Quartiles		
		25%	50%	75%
4,7	0	0	4	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,9	0	0	7	8

10. *ASMGCS*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,0	0	0	2	6

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,5	0	0	2	7

11. *Collaborative planning*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,4	10	6	8	10

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,8	10	8	9	10

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

12. *UDPP*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,9	5; 8; 10	8	9	10

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,6	10	5	8	9

13. *Trajectory De-confliction*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,2	10	7	8	9

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,6	10	9	9	10

14. *3D/4D Precision Trajectories*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,9	10	8	9	10

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,7	10	8	9	10

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

15. *4D-Contract*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,2	10	7	9	10

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,1	9; 10	8	9	10

16. *DCB*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,0	5; 6; 7; 10	5	6	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,3	10	7	8	10

17. *Environmental Management*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,3	0	0	3	5

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,1	0	0	1	5

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

18. *Tow*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
1,8	0	0	0	5

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
1,9	0	0	0	5

19. *Managed Departures*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
2,9	0	0	1	3

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,0	0	0	1	3

20. *Optimum arrival and departure routes and procedures to minimize the noise impact*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
1,9	0	0	0	3

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
2,2	0	0	0	3

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

21. *Improved WX-sustainability*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,9	0	0	5	6

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,3	0	0	4	8

22. *Disruptions & CDM*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,1	8	1	7	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,0	8	7	8	9

23. *WX*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,6	9	9	9	10

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,4	9	5	9	9

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

24. *ASAS*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,3	0; 7	3	4	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,1	9	5	8	9

25. *Controller Situational Awareness Tools*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,1	9	5	9	9

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,3	9	5	7	9

26. *Advanced Communications Capability*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,0	9	5	7	9

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,6	10	9	9	10

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

27. *Interoperability - Pursuing CNS/ATM*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,9	8	3	6	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,9	8	3	6	8

28. *Interoperability - Improved interoperability*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,2	8	4	7	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
7,1	8; 9	7	8	9

29. *Military enclosed in SWIM*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,4	8	5	7	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,8	8	5	7	8

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

30. *Airport Resource Management*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,1	0	0	1	5

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,8	0	0	1	5

31. *Wake Vortex Detection*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,2	0	0	1	4

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,3	0	0	1	5

32. *Runway Throughput*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,1	0	0	1	4

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,0	0	0	1	5

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

33. *Separation Delegation*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,9	7	5	7	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
8,1	10	8	9	10

34. *Optimal Trajectories*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,6	0; 5	2	5	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,9	0	0	2	8

35. *Airspace Classification*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,9	0	0	4	5

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,3	5; 7; 10	5	5	7

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

36. *Harmonised OAT Rules and Procedures*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,9	0; 8	0	5	8

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,9	8	5	7	8

37. *Performance Management*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,0	0; 5	5	5	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,0	0; 5	0	5	7

38. *No Segregation*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,0	0; 7	0	3	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,5	0	0	1	6

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

39. *Excess capacity*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,4	0; 7	0	7	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
6,4	7	5	7	7

40. *State Aircraft*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
2,8	0	0	0	5

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,8	0; 5	0	5	5

41. *Underutilised Airports*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,0	0	0	2	6

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,3	0; 5; 6	0	5	6

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

42. *Reduction of GND-Infrastructure*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,0	0	0	2	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
3,0	0	0	2	7

43. *Arrival Management*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,1	0; 7; 8	5	6	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,8	0; 8	0	6	8

44. *Departure Management*

DETECTION				
Average	Mode	Quartiles		
		25%	50%	75%
4,9	0; 7; 8	0	6	7

REDUCTION				
Average	Mode	Quartiles		
		25%	50%	75%
5,8	0; 8	5	6	8

From the list, the most important OCEs according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

- Detection:

1. Controller Automation Support

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

2. WX
3. 4D-Contract
4. 3D/4D Precision Trajectories
5. Collaborative planning
6. Trajectory De-confliction
7. Controller Situational Awareness Tools
8. Advanced aircraft Capabilities
9. DCB
10. Advanced Communications Capability

- Reduction:

1. Controller Automation Support
2. Collaborative planning
3. 3D/4D Precision Trajectories
4. Advanced Communications Capability
5. Advanced aircraft Capabilities
6. Trajectory De-confliction
7. DCB
8. 4D-Contract
9. Separation Delegation
10. Disruptions & CDM
11. AFUA
12. UDPP
13. Transfer of Areas of Responsibility
14. ATC Teams and Validation
15. ASAS
16. Interoperability - Improved interoperability

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

ANNEX 3 – 3RD QUESTIONNAIRE

Assessing the problem

Q1.1.1 Do you agree on the overall results presented in the 1st and 2nd phase reports about Complexity and CM?. If not, explain why?

In general the results can be supported. However there is a lot of assumptions made about the reliance on automation to provide detection and solution, and as the scenarios show there are complexity elements that cannot be predicted so this aspect needs further investigation and refinement. The end solution will be a balance between automated and human activities.

Q1.1.2 Have you considered any importance issue about these topics that have not been treated?

No, nothing missed.

Anyway whilst it may not be directly influencing complexity - there are a number of legal, procedural and professional issues associated with certain proposals (such as dynamic sectorisation) that have not been acknowledged. Additionally the airspace structure and environment needs to be made sufficiently simple for such 'exchange' of airspace to occur otherwise it becomes a complexity issue in itself.

Q1.1.3 Is there any issue appeared in the previous phases that you like to ask in detail or know other experts opinion about it?

It is necessary to be cautious in the way we apply CM. CM should ensure that whilst it reduces the complexity for ATCo, does not equally increase the complexity for other users (i.e. pilots and AOs)- The solution needs to find an elegant balance for all players.

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

ATCO Workload

Q2.1.1 Do you agree on the overall results presented in the 1st and 2nd phase reports about ATCo Workload and its links with CM?. If not, explain why?

Overall agreed.

There maybe a semantic issue with the word “complexity” perhaps we should be addressing workload management. Complexity should be regarded as our best machine guess at workload; it has to enable two key processes

1- Identification of overload possibility (regardless of whether “physical” or “mental”)

2- Assist workload balancing.

The distinction between ATCO workload indicators and Complexity indicators doesn’t seem particularly worthwhile. It might be argued that workload indicators also include factors that are not predictable, however, even these factors could be ascribed a background contribution based on their likelihood of occurrence.

Q2.1.2 Have you considered any important issue about these topics that have not been treated?

An important complexity issue is the spatial distribution of traffic in the sector. If the sector is large and there is a small volume of traffic concentrated at each end of the sector with nothing between, this will be more complex for the controller than having it all confined within a small space in the sector.

Q2.1.3 Is there any issue appeared in the previous phases that you like to ask in detail or know other experts opinion about it?

Measuring cognitive aspects. It is assumed this is in a simulated environment, otherwise the use of Instantaneous Self Assessment may introduce complexity elements in itself.

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

Solutions

Q3.1.1 Do you agree on the definition of Dynamic DCB Solution as the mix of the catalogue of DCB solutions from the planning phase with solutions based on constraining the airspace?

Overall agreed. However when developing DCB solutions the ATCo is an important source of information as they have the direct knowledge and understanding of the dynamics of the airspace and its interactions and can provide the missing insight.

In general we should talk of De-Complexing solutions rather than DCB solutions or simply "solutions".

Q3.1.2 Do you agree on this list of solutions?. If not, explain why?

The list of solutions appears to be comprehensive.

Q3.1.3 Do you think there is any possible solution missing?

No, but development of solutions will be organic and new solutions will evolve with development and experience.

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

Scenarios

Q4.1.1 for the defined Scenario, do you consider any modification of the scenario timeline considering the limits of complexity management and the en-route environment?

Which are the criteria for selecting one of the three available paths?

It should be recognised that if a situation is identified well in advance and a solution chosen then this is based on the environmental factors at that time. As the timeline progresses the environment may change which may require a review and reselection of any solution. The timeline needs to incorporate a review and re-assess cycle to encompass this

Q4.1.2 for the defined Scenario, is there any lack of information in the scenario?

Maybe the study should consider a 'low density / small volume' and a 'high density / large volume' case to show that the same principals apply across a wide spectrum of airspace configurations.

Specific time frames/ranges when different separation modes/complexity reduction -measures have to take place. This should be scope of a dedicated evaluation and not be based on an expert assessment.

Q4.1.3 For the defined Scenario, do you agree on the procedure followed to detect complexity, asset solution, apply solution, monitor and get feedback?

Yes.

The overall solution presented here is time consuming and could be streamlined - there are parts of the process (i.e. listing of possible complexity solutions) that seem to be well suited to automation.

The first box in diagram also produces complexity values. In addition it is needed some kind of box on the diagram that allows planner to create or amend proposed solutions and evaluate their effects (what-if)

Q4.2.1 for the Use Case #1, is there any role or responsibility missing or bad assigned?

The roles of the supervisor and of the complexity manager are not clearly stated. They seem to be able to do the same things in similar circumstances. E.g. it is not clear what a "low" or "medium" complexity airspace is.

Uncertainty about the responsibility of selecting a solution; maybe SNM “approves” the feasible solutions and the CM takes the decision.

Multi-Sector Planner is missing.

Q4.2.2 For the Use Case #1, what do you think about the complexity reduction solutions considered by the CM and applied by the SNM?

Proposed the solution with carries out the plan separately to have the different role to carry out is helpful to the mutual supervision, prevents wrongly in the internal circulation.

The second solution could be somewhat far fetched and inappropriate in light of the problem.

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

Q4.2.3 For the Use Case #1, do you have any additional comment about the use case?

There should be a time in advance. Because this case needs quickly resolved!

This does not appear to be a complexity issue - rather a basic separation and ATC issue - this is solved instantaneously by ATCo's ever day - the process described is far too long winded to provide any efficiency gains.

Q4.3.1 For the Use Case #2, is there any role or responsibility missing or bad assigned?

No.

Q4.3.2 For the Use Case #2, what do you think about the complexity reduction solutions considered by the CM and applied by the SNM?

This kind of solution requires high performance of navigation technique, such as RNAV and RNP, and high performance of surveillance ,such as ads-b. Maybe the ATC automation system target accuracy is required.

Q4.3.3 For the Use Case #2, do you have any additional comment about the use case?

No.

Q4.4.1 For the Use Case #3, is there any role or responsibility missing or bad assigned?

Not totally sure about the responsibility of selecting a solution; maybe SNM “approves” the feasible solutions and the CM takes the decision.

Q4.4.2 For the Use Case #3, what do you think about the complexity reduction solutions considered by the CM and applied by the SNM?

That is a good solution. But we should reduce route cross as much as possible, in order to reduce complexity.

Then we assign volume 8 to ATCo 3.The subsequently delivery procedure concerning ATCo 2 and ATCo 3 will accordingly change.

Although applying Dynamic DCB can reduce ATCo workload, it will not avoid the conflicts, so I think sometimes changing some aircraft RBTs will avoid some conflicts in this situation, maybe this will be more difficult than Dynamic DCB.

Solution 3 successfully reduces workload but needs enough space to solve the conflicts individually, as both controllers will either use solution 1 or 2 to solve the problems.

In this case no RBT is modified, so the users’ intentions are respected.

Q4.4.3 For the Use Case #3, do you have any additional comment about the use case?

No.

Q4.5.1 Do you consider any other important use case?. Describe it.

This should need to do some requirement research to ATCo. If there is some judgement criteria about how to select one solution from some solutions.

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

Automation

Q5.1.1 CM-0101: Automated Support for Traffic Load (Density) Management, is there any nowadays tool that can fit with the definition of this tool?, How does this tool fit with the former list of features?

1. Dynamic Sectorisation tool in development by Aena
2. There is no single tool that meets these requirements; however elements of the CFMU CHMI and NATS TLPD provide parts of the system requirements.
3. More ATC system can do it. Such as, THALES,RAYTHON which we use nowadays. That can make flight plan, setor map, fit point, en-route, etc. It can match SSR code with flight plan automatic operation.
4. Several tools need to be combined, or a new tool needs to be written so as to fulfil these requirements. Routine tasks need to be automated like identifying ac/initial call by data link e.g. So,ATCO's workload should be assured.

Q5.1.2 CM-0101: Automated Support for Traffic Load (Density) Management, could this tool be used to any additional function?

1. Probably. Need to check with Aena
2. No additional information
3. No, not all of ACC, APP, etc arrange this System, and that can not CDM with military about modify airspace configuration.
4. N/A

Q5.2.1 CM-0102: Automated Support for Dynamic Sectorisation and Dynamic Constraint Management, is there any nowadays tool that can fit with the definition of this tool?, How does this tool fit with the former list of features?

1. Dynamic Sectorisation tool in development by Aena
2. The tool of nowadays just can resizing and change of sector, in order to balance ATCO's workload. Moreover this change is manual control at Supervisor Position, not automated by system.
3. There are tools which automatically calculate a new sectorisation but results are totally adapted to the present traffic those tools have not reached a sufficient maturity level. FTS tools support in finding appropriate sectorisations and help balancing the load throughout the sector system.

Q5.2.2 CM-0102: Automated Support for Dynamic Sectorisation and Dynamic Constraint Management, could this tool be used to any additional function?

1. Probably. Need to check with Aena
2. No

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

3. No.

Q5.3.1 CM-0103: Automated Support for Traffic Complexity Assessment, is there any nowadays tool that can fit with the definition of this tool?, How does this tool fit with the former list of features?

FTS tools, namely AirTop could be adapted to fulfil this role.

Q5.2.2 CM-0103: Automated Support for Traffic Complexity Assessment, could this tool be used to any additional function?

FTS

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

Automation

Q6.1.1 Please score the impact of the OIs at complexity DETECTION (0-Low, 10-High):

1. DCB-0203. Enhanced ASM/ATFCM Coordinated Process

Average	Mode	Quartiles		
		25%	50%	50%
6,1	8	5	7,5	8

2. AOM-0403. Pre-defined ATS Routes Only When and Where Required

Average	Mode	Quartiles		
		25%	50%	50%
4,1	3	1,5	3,5	6,5

3. AOM-0801. Flexible Sectorisation Management

Average	Mode	Quartiles		
		25%	50%	50%
4,7	7	3	5,5	7

4. AOM-0802. Modular Sectorisation Adapted to Variations in Traffic Flows

Average	Mode	Quartiles		
		25%	50%	50%
4,4	6	1,5	6	6,75

5. AOM-0803. Dynamically Shaped Sectors Unconstrained By Predetermined Boundaries

Average	Mode	Quartiles		
		25%	50%	50%
4,4	7	1,5	4,5	7

6. CM-0102. Automated Support for Dynamic Sectorisation and Dynamic Constraint Management

Average	Mode	Quartiles		
		25%	50%	50%
6,0	7	5,25	7	8

7. SDM-0202. Transfer of area of responsibility for trajectory management

Average	Mode	Quartiles		
		25%	50%	50%
5,3	7	2,25	6,5	7

8. AUO-0102. User Driven Prioritisation Process (UDPP)

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

Average	Mode	Quartiles		
		25%	50%	50%
4,5	3	3	5	6

9. AUO-0201. Enhanced Flight Plan Filing Facilitation

Average	Mode	Quartiles		
		25%	50%	50%
5,7	7	3,75	7	7,75

10. DCB-0204. ATFCM Scenarios

Average	Mode	Quartiles		
		25%	50%	50%
5,5	5	3,5	5,5	8,75

11. DCB-0205. Short Term ATFCM Measures

Average	Mode	Quartiles		
		25%	50%	50%
5,1	5	3,5	5,5	7

12. DCB-0207. Management of Critical Events

Average	Mode	Quartiles		
		25%	50%	50%
5,3	8	2	6	8

13. CM-0101. Automated Support for Traffic Load (Density) Management

Average	Mode	Quartiles		
		25%	50%	50%
8,8	10	8	9	10

14. CM-0103. Automated Support for Traffic Complexity Assessment

Average	Mode	Quartiles		
		25%	50%	50%
9,6	10	10	10	10

15. CM-0202. Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace

Average	Mode	Quartiles		
		25%	50%	50%
9,3	10	9	9,5	10

16. CM-0401. Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number

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

Average	Mode	Quartiles		
		25%	50%	50%
8,5	10	8	9,5	10

17. CM-0403. Conflict Dilution by Upstream Action on Speed

Average	Mode	Quartiles		
		25%	50%	50%
7,0	10	5,25	7,5	8,75

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. CM-0103. Automated Support for Traffic Complexity Assessment
2. CM-0202. Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace
3. CM-0101. Automated Support for Traffic Load (Density) Management
4. CM-0401. Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number
5. CM-0403. Conflict Dilution by Upstream Action on Speed

Q6.1.2 Please score the impact of the OIs at complexity REDUCTION (0-Low, 10-High):

1. DCB-0203. Enhanced ASM/ATFCM Coordinated Process

Average	Mode	Quartiles		
		25%	50%	50%
7,4	8	8	8	8

2. AOM-0403. Pre-defined ATS Routes Only When and Where Required

Average	Mode	Quartiles		
		25%	50%	50%
7,2	8	7,25	8	8,75

3. AOM-0801. Flexible Sectorisation Management

Average	Mode	Quartiles		
		25%	50%	50%
8,2	10	8	9	10

4. AOM-0802. Modular Sectorisation Adapted to Variations in Traffic Flows

Average	Mode	Quartiles		
		25%	50%	50%

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

7,9	8	6,5	8	9,5

5. AOM-0803. Dynamically Shaped Sectors Unconstrained By Predetermined Boundaries

Average	Mode	Quartiles		
		25%	50%	50%
8,6	8	8	8,5	9,75

6. CM-0102. Automated Support for Dynamic Sectorisation and Dynamic Constraint Management

Average	Mode	Quartiles		
		25%	50%	50%
7,8	8	8	8,5	9,75

7. SDM-0202. Transfer of area of responsibility for trajectory management

Average	Mode	Quartiles		
		25%	50%	50%
6,3	6	5	6	7,75

8. AUO-0102. User Driven Prioritisation Process (UDPP)

Average	Mode	Quartiles		
		25%	50%	50%
6,8	5	5,25	7,5	8,75

9. AUO-0201. Enhanced Flight Plan Filing Facilitation

Average	Mode	Quartiles		
		25%	50%	50%
5,8	7	5	7	7

10. DCB-0204. ATFCM Scenarios

Average	Mode	Quartiles		
		25%	50%	50%
7,5	8	7	8	8

11. DCB-0205. Short Term ATFCM Measures

Average	Mode	Quartiles		
		25%	50%	50%
7,2	8	6	7,5	8

12. DCB-0207. Management of Critical Events

Average	Mode	Quartiles		
		25%	50%	50%
6,5	8	5,25	7,5	8,75

13. CM-0101. Automated Support for Traffic Load (Density) Management

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

Average	Mode	Quartiles		
		25%	50%	50%
8,4	10	8	8	10

14. CM-0103. Automated Support for Traffic Complexity Assessment

Average	Mode	Quartiles		
		25%	50%	50%
9,4	10	9,25	10	10

15. CM-0202. Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace

Average	Mode	Quartiles		
		25%	50%	50%
9,2	10	8,25	9,5	10

16. CM-0401. Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number

Average	Mode	Quartiles		
		25%	50%	50%
8,5	10	8	9,5	10

17. CM-0403. Conflict Dilution by Upstream Action on Speed

Average	Mode	Quartiles		
		25%	50%	50%
8,5	8	8	8	9,75

From the list, the most important topics according to experts' opinion have been those whose average is greater than 7,0. The next list is prioritized according to the consensus reached gathering all answers.

1. CM-0103. Automated Support for Traffic Complexity Assessment
2. CM-0202. Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace
3. AOM-0803. Dynamically Shaped Sectors Unconstrained By Predetermined Boundaries
4. CM-0401. Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number
5. CM-0403. Conflict Dilution by Upstream Action on Speed
6. CM-0101. Automated Support for Traffic Load (Density) Management
7. AOM-0801. Flexible Sectorisation Management
8. AOM-0802. Modular Sectorisation Adapted to Variations in Traffic Flows

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

9. CM-0102. Automated Support for Dynamic Sectorisation and Dynamic Constraint Management
10. DCB-0204. ATFCM Scenarios
11. DCB-0203. Enhanced ASM/ATFCM Coordinated Process
12. AOM-0403. Pre-defined ATS Routes Only When and Where Required
13. DCB-0205. Short Term ATFCM Measures

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

ANNEX 4 – 4TH QUESTIONNAIRE

Assessing the Problem

Q1.1.1 some conflict situations detecting in advance do not become real conflicts due to the uncertainty of the data used for the calculation. What do you think about this statement?

The problem is there is a probability of loss of separation, then CM should identify high probability situations and transforming them into low probability situations.

The uncertainty of the data should be considered in the prediction model.

The prediction accuracy will be considerably higher than today due to SWIM, CDM, etc. Nevertheless some indicated conflicts will not happen as predicted at a certain point in time. The trajectory will be monitored continuously, so the prediction will be more accurate with a decreasing look ahead time. 4D contract flights will be highly accurate even with a long look ahead time.

Also to this statement, some situations where no conflicts are detected in advance can become conflicts due to the uncertainty of the data used for the calculation.

Complexity Manager should constantly review the traffic situation (both current and pending) to identify changes and act accordingly. Any solution developed needs to include this continuous review and assess loop within its design and application.

Q1.1.2 The workload of a controller is determined by two aspects: an intrinsic complexity related to the air traffic structure, and a subjective component related to the controller itself (cognitive strategies and individual characteristics). The complex situation detection should be focused on complexity related to the air traffic structure. Do you agree on this statement??

The subjective range cannot be measured, but can be taken into account during the calibration procedure of complexity measurement tools or can be considered during description of threshold values.

Workload is also dependant on support tools available.

Agreed, however the personal attributes of the ATCo does not change the interaction of the aircrafts.

ATCO Workload

This area has been covered with the expected detail and the consensus reached by the exerts are very high in all the issued questionnaires related to Complexity Management on en-route environment.

There are no additional comments risen by the Experts in this 4th Questionnaire regarding this subjects.

Solutions

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

Q3.1.1 Is it a fact that structured airspace leads to more capacity and less workload in high traffic situations?, Is it expected that 4D contracts will lead to a more complex scenario than nowadays one?

Structured airspace leads to less capacity and less workload.

4D contracts sometimes maybe lead to a more complex scenario than nowadays one but apparent difficulties can be overcome with automation aids.

It is supposed that the accuracy of the FMS will be enough to maintain the level of safety without increasing the level of complexity.

If all the traffic in a certain area is 4D contract, probably it would not be more complex than the current situation.

Q3.1.2 Do you agree on the criteria listed to select the best complexity reduction solution? Is there any other criterion to be taken into account?

Yes, the criterion is comprehensive.

In addition, it should be included the Effectiveness of possible solutions as CM criteria.

Q3.1.3 Describe some basic guidelines that the CM should follow to select the most suitable complexity reduction solution.

The questions that should be answered by the Complexity Manager to select the appropriate solutions are:

- How much time until complex situation?
- What severity is predicted?
- How can it be solved with a minimum impact?

Scenarios

Q4.1.1 Do you think it is feasible in term of time, reviewing and reselecting the selected complexity reduction solution before its implementation?

This will depend on how far ahead the solution is selected. The farther ahead the solution is chosen the greater the opportunity for the environment to change and the solution becoming invalid or ineffective. It is needed a feedback and a review loop where sufficient time allows to validate its applicability. I would suggest a lead time of 10-15 minutes for this review, although this will vary depending on the airspace configuration etc.

There is a need for housekeeping or monitoring process that checks planned resolutions prior to their implementation.

There should be a unified process that evaluates complexity (and network effects) that serves a number of related CM needs:

- the general complexity monitoring activity applied to the planned traffic;
- the specific complexity monitoring activity applied to a selected but not yet implemented solution;

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

- the evaluation of candidate solutions whether manually or automatically generated.

Q4.1.2 Do you think it is possible to establish fixed timeframe in the Figure 1-1 of the scenario document sent with the 3rd questionnaire?. In case of yes, describe it.

No precise timeline possible. The effectiveness of CM depends on accuracy of complexity prediction, nature of complexity, ATM environment and applicable resolutions. It can vary from 2 hours before event (DCB like solutions) down to 20 minutes before event (refined solutions related to individual trajectories applied in a MSP environment).

It cannot be described in detail as long as there are not realised as prototype or tested in a simulation, or live trial. Because the time until the reduction solution can be used depends on the realisation of SWIM, CDM the accuracy of trajectory prediction and many more.

Q4.1.3 Do you think the role of CM and Supervisor can be carried out by the same role, independently of the level of complexity of the airspace? If not, explain why.

These roles can easily be combined, and may be combined and separate for the same piece of airspace depending on the overall demand, time of day etc. Ultimately the various 'roles' should be seen as functions rather than individual people, with these functions being assigned to the most appropriate person within the overall controlling and capacity management team at that specific moment. By recognising these attributes as functions rather than individual people the complexity reduction system will be commonly distributed across all ATSUs regardless of size and demand.

Q4.1.4 Do you think the SNM should only check the feasibility of the solution and then approve it?

Concerning complexity management, yes.

There could be an optional CM task that may be allocated to SMN (solution approval).

Q4.1.5 Do you think the role of MSP should be explicit or can be carried out by an automatic system that supports CM decisions?

A Multi-Sector Planner is a specific design solution. The ideal should be to produce a set of functions and activities that define complexity reduction then enable the various ATSUs to deliver these in the most appropriate and efficient manner in their own operation - which may or may not include the use of a Multi-Sector Planner.

The MSP is a role who may or may not be given CM responsibilities. He may or he may not exist in any particular ATM cell.

Q4.2.1 There is a fact that the change of RBT is nowadays carrying out by ATCo in a tactical environment. Do you consider that this solution can be carried out by the CM in a pre-tactical environment?

CM could take the decision of changing RBT in a pre-tactical phase, but changing RBT must be carried out by ATCo in tactical phase.

CM may determine RBT revision. ATCo may inform/instruct aircraft of revision - in a sense the tactical controller is fulfilling a CM task aimed at improving the workload of another (downstream) tactical controller.

Automation

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

Q5.1.1 CM-0101. Automated Support for Traffic Load (Density) Management: do you consider any other issue to deep into the concept of this tool from the point of view of your experience and expertise?

Need tools which:

1-Have better prediction;

2- Are capable of evaluating both planned and tentative (possible) situations;

3- Connect to both separation assistance tools and to network planning tools.

Q5.1.2 CM-0102: Automated Support for Dynamic Sectorisation and Dynamic Constraint Management: do you consider any other issue to deep into the concept of this tool from the point of view of your experience and expertise?

Need tools which:

1- have better prediction;

2- are capable of evaluating both planned and tentative (possible) situations;

3- connect to both separation assistance tools and to network planning tools.

Q5.2.1 CM-0103: Automated Support for Traffic Complexity Assessment: do you consider any other issue to deep into the concept of this tool from the point of view of your experience and expertise?

AirTop could only ever yield rough solutions.

Other topics

Q6.1.1 Have you considered any importance issue related to KPAs, OCEs or OI Steps that have not been treated yet?

No.

Q6.1.2 Do you agree on the list of final OI Steps selected? Do you think there is any OI Step missing?

CM-0403 seems to be too specific. If there is an OI dedicated to upstream action on speed then there should be corresponding OIs on profile etc. unless they can all be encompassed in a single OI in which case CM-0403 is superfluous.

If OI Steps list is prioritised then CM-102 needs to be much higher - up with CM-0103

AOM-0803 needs CM-0102

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

END OF DOCUMENT

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