Episode 3

Single European Sky Implementation support through Validation

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EXECUTIVE SUMMARY

This document provides a refined description of the SESAR concept of operations regarding the en-route phase in managed airspace (Conflict Management in En-Route High & Medium/Low Density Operations – E6). The document is part of a set of Detailed Operational Description (DOD) documents which refine and clarify the high level SESAR ConOps concept description in order to support the Episode 3 validation activities, which have the objective of developing a better understanding of the SESAR Concept. It targets the 2020 horizon – i.e. considering up to and including ATM Service Level 3.

The business or mission trajectory of an airspace user of any kind represents their intention to operate in a desired way. In the SESAR concept air traffic service providers and airports will facilitate the execution of these trajectories and will ensure that this service is delivered in a safe and cost effective way within the infrastructural and environmental constraints.

Trajectory-based operations, represented by the Reference Business Trajectory (RBT), form the basis of the concept. A degree of pre-deconfliction of traffic flows, improved conflict management enabled by improved trajectory prediction and automation support will result in a reduction of controller task load per flight and fewer last-minute tactical interventions during flight execution. These are the principles, among others, on which SESAR will deliver greater airspace capacity than today.

It addresses the following system improvements:

- Safety: maintain or reduce operators’ task load by improving their situational awareness, minimising last-minute tactical and supporting routine. It is supported through enhanced tools - e.g. conflict/interaction detection and conflict resolution, and automation e.g. transfer, communication or data management, using shared and accurate data provide in order to keep operators’ task load and complexity perception at a manageable level;
- Flight efficiency: aircraft fly their individual optimum profiles to the maximum extent possible through the RBT;
- Capacity: both ground operators and flight crew are supported by advanced automation capabilities that enable efficient and timely tactical intervention when required and ensure that clearances have a longer valid duration.
- Flexibility: users decide how to face disruptions and unexpected constraints on resources - e.g. late airspace segregation requests, weather or crisis situations.

Automation support associated with relevant air and ground capabilities - i.e. Capability Levels, together with new ground and airborne separation modes will be used to enable the system to provide the necessary capacity. In managed airspace a separation service will always be provided but the role of the separator may be delegated to the flight crew through the use of ASAS applications.

The aim of this document is to describe the SESAR concept related to the en-route execution phase in sufficient detail to support the prototyping and evaluation activities of Episode 3. This document has been reviewed and updated to its final form by the addition of the results of the relevant validation activities. It may be considered as an input document to the SESAR Joint Undertaking (SJU) WPB and the associated operational threads WPs.

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1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

This document provides a refined description of the SESAR concept of operations regarding the en-route phase in managed airspace. Referred as “Conflict Management in En-Route High & Medium/Low Density Operations – E6”, this document is part of a set of Detailed Operational Description (DOD) documents which refine and clarify the high level SESAR ConOps concept description in order to support the Episode 3 exercises, which have the objective of developing a better understanding of the SESAR Concept. This set of DODs can be considered as step 0.2 of E-OCVM [1] - i.e. the description of the ATM Operational Concept(s). The DOD document structure and content is derived from the one of the OSED (Operational Service and Environment Definition) described by the ED-78A guidelines [2]. According to the ED-78A: “*the OSED identifies the Air Traffic Services supported by data communications and their intended operational environment and includes the operational performances expectations, functions and selected technologies of the related CNS/ATM system*”. The structure of the DOD has been defined considering the level of details that can be provided at this stage – i.e. the nature and maturity of the concept areas being developed.

The current version of this DOD has been reviewed and updated to its final form by the addition of the results of the relevant validation activities, namely WP4.4 En-Route Consolidated Assessment report [33] and WP4.3.1 En-Route Expert Group final report [34]. It may be considered as an input document to the SJU WPB and the associated operational threads WPs.

The complete detailed description of the mode of operations is composed of 10 documents according to the main phases defined by SESAR – i.e. Long Term Planning phase, Medium/Short Term Planning and Execution Phase (the complete set of documents is available from the Episode 3 portal home page [3]):

- The General DOD (G DOD) [4];
- The Long Term Network Planning DOD (L DOD) [5];
- The Collaborative Airport Planning DOD (M1 DOD) [6];
- The Medium & Short Term Network Planning DOD (M2 DOD) [7];
- The Runway Management DOD (E1 DOD) [8];
- The Apron & Taxiways Management DOD (E2/3 DOD) [9];
- The Network Management in the Execution Phase DOD (E4 DOD) [10];
- The Conflict Management in Arrival & Departure High & Medium/Low Density Operations DOD (E5 DOD) [11];
- The Conflict Management in En-Route High & Medium/Low Density operations DOD (E6 DOD), this document;
- The Episode 3 Lexicon (Glossary of Terms and Definitions) [13].

The operational enhancements described in this document are related to the execution and management of the Business/Mission Trajectory foreseen for High and Medium/Low complexity En-route operations.

The document addresses the environment expected in 2020 and the operations that will be incorporated in the end state system - i.e. transition elements are not taken into account. In other words, the operations described below are related to ATM Service Level 0 to ATM Service Level 3.

The figure below gives an overview of the scope of the document within the SESAR vision.

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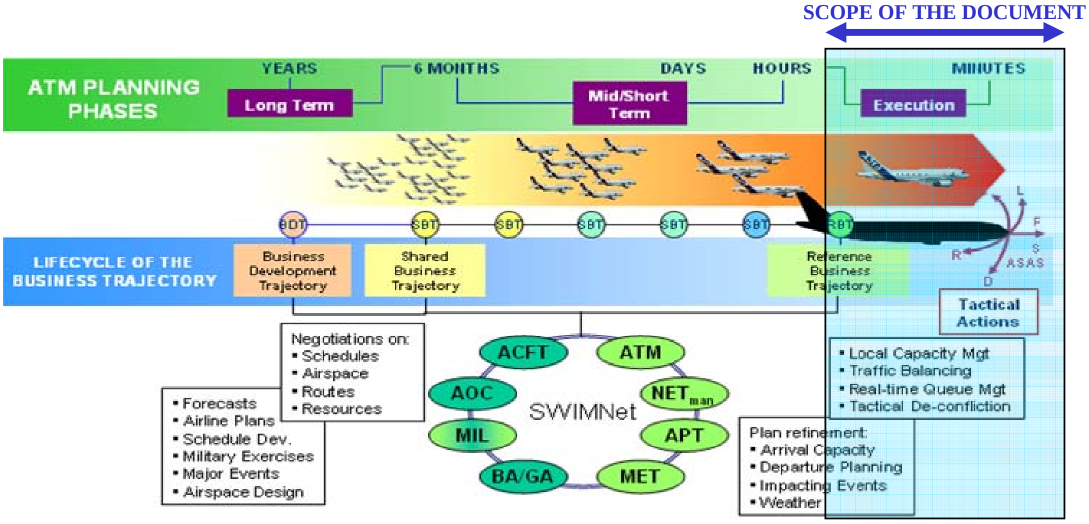

Figure 1: Scope of the document within the SESAR vision (SESAR ConOps)

The SESAR target concept of operations is a trajectory-based concept. All partners in the ATM network share trajectory information in real time to the extent required, from the earliest trajectory development phase through operations and post-operation activities. ATM planning, collaborative decision making processes and tactical operations are always based on the latest trajectory data. A trajectory integrating ATM and airport constraints is elaborated and agreed for each flight, resulting in the trajectory that a user agrees to fly and the ANSPs and Airports agree to facilitate.

For the en-route phase of flight the major impact of SESAR will be the use of 4-D trajectories, new separation modes and the results of complexity management and collaborative planning (refer to M2 DOD [7] and E4 DOD [10].

The key aspects of improved ATM in 2020 are:

- The aircraft's ability to fly precise 3-D routes whilst taking into account one or more target times – i.e. Controlled Time of Arrival (CTA) and Controlled Time of Over-fly (CTO), with high precision using on-board automation and Required Time of Arrival (RTA) techniques;
- Data link communications in a SWIM environment, in which the aircraft is now considered as a node of the network, enabling improved air/ground data exchanges and the availability/sharing of trajectory information from the onboard avionics;
- Controller support tools exploiting the aircraft capabilities that also support conflict detection and resolution.

1.2 Intended Audience

The intended audience includes:

- Episode 3 partners;
- The SESAR community.

1.3 Document Structure

The structure of the document is as follows:

- §2 of this document provides an overview of the functions addressed in this document;

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- §3 provides a description of how today's operation will be changed with the implementation of the concept area under analysis;
- §4 gives a description of the future operating principles. It details the benefits, the constraints, the human factors aspects, the enablers, the actors and the operating methods;
- §5 gives environment constraints of interest to the DOD, a general document provides this information at the global level;
- §6 lists roles and responsibilities applicable to this concept area;
- Annex A provides the list of the various scenarios relevant to this document;
- Annex B provides the summary of the Use Cases defined in this document;
- Annex C contains the traceability table of the SESAR Operational Improvement (OI) steps addressed by this document.

1.4 BACKGROUND

The Episode 3 project, also called "Single European Sky Implementation Support Through Validation", was signed on 18th April 2007 between the European Community and EUROCONTROL under the contract N° TREN/07/FP6AE/S07.70057/037106. The European Community has agreed to grant a financial contribution to this project equivalent to about 50% of the cost of the project.

The project is carried out by a consortium composed of EUROCONTROL, Entidad Publica Empresarial Aeropuertos Espanõles y Navegacion Aérea (AENA); AIRBUS France SAS (Airbus); DFS Deutsche Flugsicherung GmbH (DFS); NATS (EN Route) Public Limited Company (NERL); Deutsches Zentrum für Luft und Raumfahrt e.V.(DLR); Stichting Nationaal Lucht en Ruimtevaartlaboratorium (NLR); The Ministère des Transports, de l'Equipement, du Tourisme et de la Mer de la République Française represented by the Direction des Services de la Navigation Aérienne (DSNA); ENAV S.p.A. (ENAV); Ingenieria y Economia del Transporte S.A (INECO) ISA Software Ltd(ISA); Ingeneria de Sistemas para la Defensa de Espana S.A (Isdefe); Luftfartsverket (LFV); Sistemi Innovativi per il Controllo del Traffico Aereo (SICTA); THALES Avionics SA (THAV); THALES AIR SYSTEMS S.A (TR6); Queen's University of Belfast (QUB); The Air Traffic Management Bureau of the General Administration of Civil Aviation of China (ATMB); The Center of Aviation Safety Technology of General Administration of Civil Aviation of China (CAST); Austro Control (ACG); Luchtverkeersleiding Nederland (LVNL). This consortium works under the co-ordination of EUROCONTROL.

With a view to supporting SESAR Development Phase activities whilst ensuring preparation for partners' SESAR JU activities, Episode 3 focuses on:

- Detailing key concept elements in SESAR;
- Initial operability through focussed prototyping exercises and performance assessment of those key concepts;
- Initial supporting technical needs impact assessment;
- Analysis of the available tools and gaps for SESAR concept validation; and
- Reporting on the validation methodology used in assessing the concept.

The main SESAR inputs to this work are:

- The SESAR Concept of Operations (ConOps): T222 [22];
- The description of scenarios developed: T223 [23] & [24];

- The list of Operational Improvements allowing transition to the final concept: T224 [26];
- The definition of the implementation packages: T333 [26] & [27];
- The list of performance assessments exercises to be carried out to validate that the concept delivers the required level of performance: T232 [28];
- The ATM performance framework, the list of Key Performance Indicators, and an initial set of performance targets: T212 [29].

The objective of detailing the operational concept [22] is achieved through the development of the DODs. These documents are available for the SESAR development phase and are produced through the System Consistency work package (WP 2) of Episode 3. The life cycle of the DOD documents is defined through three main steps:

- Initial DODs provided as the first inputs to the Episode 3 project;
- Interim DODs containing first refinement and consolidation from Episode 3 partners aligned to the prototyping/evaluation work, provided by mid-project duration;
- Final DODs updated by the findings and reports produced by the prototyping/evaluation activities, provided at the end of the project.

1.5 Glossary of Terms

The Episode 3 Lexicon contains lists of agreed acronyms and definitions [13].

To complement the existing definition of RBT and to provide clarification on the use of the terms “update” and “revision” the following definitions are proposed for inclusion in the Lexicon:

- RBT update: whenever the RBT exceeds the ‘ deltas’ of the TMR, an update of the RBT will automatically be initiated by the ground system:
- RBT revision: whenever there is a mutually agreed change to the RBT, the RBT will be revised and will replace the previously agreed RBT.

Note: Throughout this document references to SBT and RBT also mean the military context of Shared Mission Trajectory (SMT) and Reference Mission Trajectory (RMT) which have not generally been referred to in the interests of clarity. A more detailed view of SMT/RMT provided by EUROCONTROL Directorate of Civil/Military ATM Coordination (D-CMAC) may be found in the EUROCONTROL SJU Early Project[1] 2 deliverable “Understanding Trajectory Management V2.01”.[31]

[1] SJU Early Projects are a series of projects which provide extra clarification on some key issues (e.g. what is SDM?) and will expedite the work of the SJU WPs on start-up.

2 OPERATING CONCEPT-CONTEXT AND SCOPE

2.1 EN-ROUTE TRAJECTORY BASED OPERATIONS

The trajectory-based approach applies three important characteristics of trajectories while also enhancing their significance and effects as a result of much improved data quality [22]:

- The Business/Mission Trajectory, expressing the specific needs of Airspace Users:

  "*The trajectories represent the business/mission intentions of the airspace users. By safeguarding the integrity of the trajectories and minimising changes the concept ensures the best outcome for all users. Airlines, business, General Aviation and the military all have 'business' or 'mission' intentions, even if the terminology is different and their specific trajectories have different characteristics. The trajectory is always associated with all the other data needed to describe the flight. If the trajectory is based on cruise climb, this will be facilitated*" [2].

Through a collaborative layered planning system and prior to agreeing to facilitate a requested trajectory Network Management assesses the impact of the additional flight on the overall traffic situation, ensuring that the proposed flight is within the capacity limitations of the System and where an imbalance is identified proposes solutions whereby the flight can be best accommodated, e.g. issues a TTOT, for which the user determines how best to meet, if necessary, in coordination with the Network Manager using NOPLA services. This collaborative process results in minimising the increase of complexity through the optimum use of ATM assets

- Trajectory Ownership:

  "*The airspace user owns the Business/Mission Trajectory, thus in normal circumstances the users have primary responsibility over their operation. In circumstances where ATM constraints (including those arising from infra-structural and environmental restrictions/regulations), need to be applied the resolution that achieves the best business/mission outcome within these constraints is left to the individual user. Typically constraints will be generated/released and taken into account by various ATM partners through CDM processes. The owners' prerogatives do not affect ATC or Pilot tactical decision processes (for example separation provision, weather avoidance etc)*."

- 4D trajectories:

  "*The business/mission trajectories will be described as well as executed with the required precision in all 4 dimensions. The trajectories will be shared and updated from the source(s) best suited to the prevailing operational circumstances and capabilities and the sources include the aircraft systems, flight operational control systems and ANSP trajectory predictors. The ability to generate trajectories in the ATM system from flight plan data will be retained for those flights that are unable to comply with SESAR trajectory management requirements.*"[3]

SESAR concepts will require new air and ground capabilities and automation. SESAR summarises these requirements as a series of capability levels, thus ATM Service Levels from 0[4] to 5.

[2] The flights will be facilitated as long as agreed, within their flight envelope and de-conflicted.

[3] It is also the case when the air/ground communication is degraded.

[4] Systems referred to as ATM Service Level 0 will still be accommodated but with fewer service options.

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

Each of the service level groups is associated with a set of capabilities for the various stakeholders that will appear in a broadly similar timeframe. The main capabilities required by the key SESAR target date of 2020 are allocated to Capability Level 3 and Capability Level 4 post 2020 up to 2025. More advanced capabilities for the high-end capacity target of the SESAR Concept – i.e. 2025 and beyond, are described as Capability Level 5 and are out of the scope of this document.

With regard to aircraft capability levels, the SESAR ConOps states [22]:

"*While the future ATM system is designed to take full advantage of trajectory management and the advanced aircraft navigational capabilities it will retain the capability to manage ATM Capability Level 0 aircraft and aircraft whose capabilities have become degraded: for this reason conventional surveillance and separation modes will be retained. In future, as other digital surveillance systems are developed, civil ATM will not require primary radar*[5].

Conventional ATC modes are also applicable to ATM Capability Level 1 aircraft taking advantage of capabilities such as RNP and constraint management to reduce the need for tactical interventions."

Flights will be managed in a manner similar than today, but supported by a number of ground/airborne automated tools, e.g. NOPLA services. Furthermore, extensive data-sharing allowed by the SWIM infrastructure will ensure a common view and the use of the most accurate and up-to-date information from both air and ground perspectives, by using the Trajectory Management Requirements mechanism (refer to G DOD [4] section 5.2.5.1 and ATM Process Model [14] for details and definition).

The execution phase for a given flight is initiated at the agreement of the Reference Business Trajectory (RBT) which represents the gate to gate 4D trajectory agreed between all involved actors - i.e. airspace user, airports and ANSPs. The objective of the en-route operations is to facilitate as closely as possible the execution of RBTs, which are reflecting the user preferred trajectories, with due regard to flight safety - i.e. provide separation and conflict management.

The RBT should not be considered as a clearance[6] as such which is conflict free, thus the pilot following successive conflict-free ATC clearances will manage the progress of the flight. These clearances, which may include either open7 or closed loop manoeuvres issued by Air Traffic Controllers, will define the conflict free cleared segment(s) of the Authorised RBT (refer to [4] section 5.2.5.2).

During flight execution, clearances will be issued to authorise the next segment(s) of the RBT to be flown. Thus the RBT will be decomposed into various portions and segments for which different states may apply during the life of the flight. It should be noted however, that any RBT revisions proposed by the ground (e.g. a time constraint such as CTO/CTA) must be within the agreed performance envelope of the flight. It should be noted that throughout this document revisions to the RBT are assumed to be by data link unless otherwise stated.

Flight crew and controllers tasks will be supported in the following ways:

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[5] This is the case for en route systems now. Before it is applied in a low level or TMA environment, the necessary safety case identifying the replacement technology and procedures will be completed.

[6] Within the ICAO context, the RBT represents the Filed Flight Plan (FPL). As such the flight is cleared to its destination following its flight plan route. However this clearance does not ensure separation from other traffic. Also should the flight deviate from its flight plan route then the original clearance is invalidated and a new clearance is issued for the revised route portion. Separation is thus provided on a tactical basis which in the RBT context means the cleared segment of the trajectory.

[7] Open loop clearances should reduce, through the ability to control traffic using fewer clearances but with a longer duration. These clearances are more likely to be closed loop clearances.

- Enhanced monitoring, conflict detection and resolution fed by the shared airborne predictions and ground-based trajectory predictor;
- Separation provision aided by enhanced aircraft capabilities including precise vertical navigation (V-NAV), time constraints and initial ASAS applications;
- FDPS to manage traffic and support Capability Level 0 aircraft and aircraft whose capabilities have become degraded.

The en-route ATM service will be required to provide queue management mainly in support of arrival queuing.

The design and development of the ATM process model identified that the new areas to be defined are at the boundaries and interactions between en-route ATC and network management. This includes the roles and processes associated with short-term Demand and Capacity Balancing (DCB) and with dynamic DCB (dDCB) processes. The ATM process model has been used to scope the Episode 3 DODs.

En-route operations are considered to encompass the flight segments between the Top of Climb and Top of Descent events. However, from an airspace perspective there is overlap of departure and arrival TMAs with en-route airspace, especially arrival and E-TMAs. There will be, therefore, some en-route controller functions which may be carried out in TMA airspace. At the same time in support of the ATM processes described hereafter, several generic concept components will be implemented to support these processes: the use of free routing between TMAs, and the transfer of areas of responsibilities between ATSUs. This document deals with en-route operations; a separate DOD will describe Arrival/Departure operations [11].

The lowest level of decomposition of the ATM Processes to be covered by the en-route DOD is shown in Table 1: ATM Model low level processes addressed. A full description of each ATM process in the table and its further decomposition can be found in Chapter 4 Proposed Operating Principles. For ease of reference, each process description is cross-referenced to its appropriate section in Chapter 4.

Code[8]	ATM Process	Description	SESAR ConOps References
A3.3.3	De-conflict & Separate Traffic in En-Route Airspace	This process describes the provision of separation of the traffic to detect potential conflicts and provide the optimal resolution thanks to the separation mode. (refer to §4.1.4.1)	F.2.3.3, F.2.4, F.2.4.1, F.4, F.4.3, F.6, F.6.3, F.6.3.3, F.6.3.4
A3.3.3.1	Detect & Solve Conflict in Managed En-Route Airspace	This process includes both; control of the flights in order to detect possible conflicts and the activities needed to provide a conflict solution for a detected conflict, including the appropriate separation mode. (refer to §4.1.4.1.1)	F.6.3.4, F.2.3.3, F.4, F.4.3, F.6, F.6.3, F.6.3.3
A3.3.3.2	Implement Separation in Managed En-Route Airspace	This process includes the activities needed to provide separation for the flights in the en-route area according to the separation mode provided to the flight. (refer to §4.1.4.1.2)	F.2.4, F.2.4.1, F.4, F.6, F.6.3, F.6.3.3

[8] This refers to the code associated with the process in the ATM Process Model SADT diagrams.

Code[8]	ATM Process	Description	SESAR ConOps References
A3.4.1	Apply Safety Nets in the En-Route Airspace	Airborne (ACAS) and ground (STCA, MSAW, APW) systems tuned to operate efficiently in the SESAR operational environment. (refer to §4.2.3.1)	F.7

Table 1: ATM Model low level processes addressed

2.2 ATM PROCESSES DESCRIBED IN THE DOCUMENT

The ATM Process Model [14] has been developed as part of the Episode 3 definition phase. It is intended to capture the whole ATM process. It is to be aligned with the SESAR concept and provides a mechanism for scoping the DODs.

The execution phase is related to the safe and efficient facilitation of the RBTs within managed airspace by ensuring the provision of separation and also the avoidance of collisions. This is described in the Manage Execution Phase of the Process Model (Figure 2).

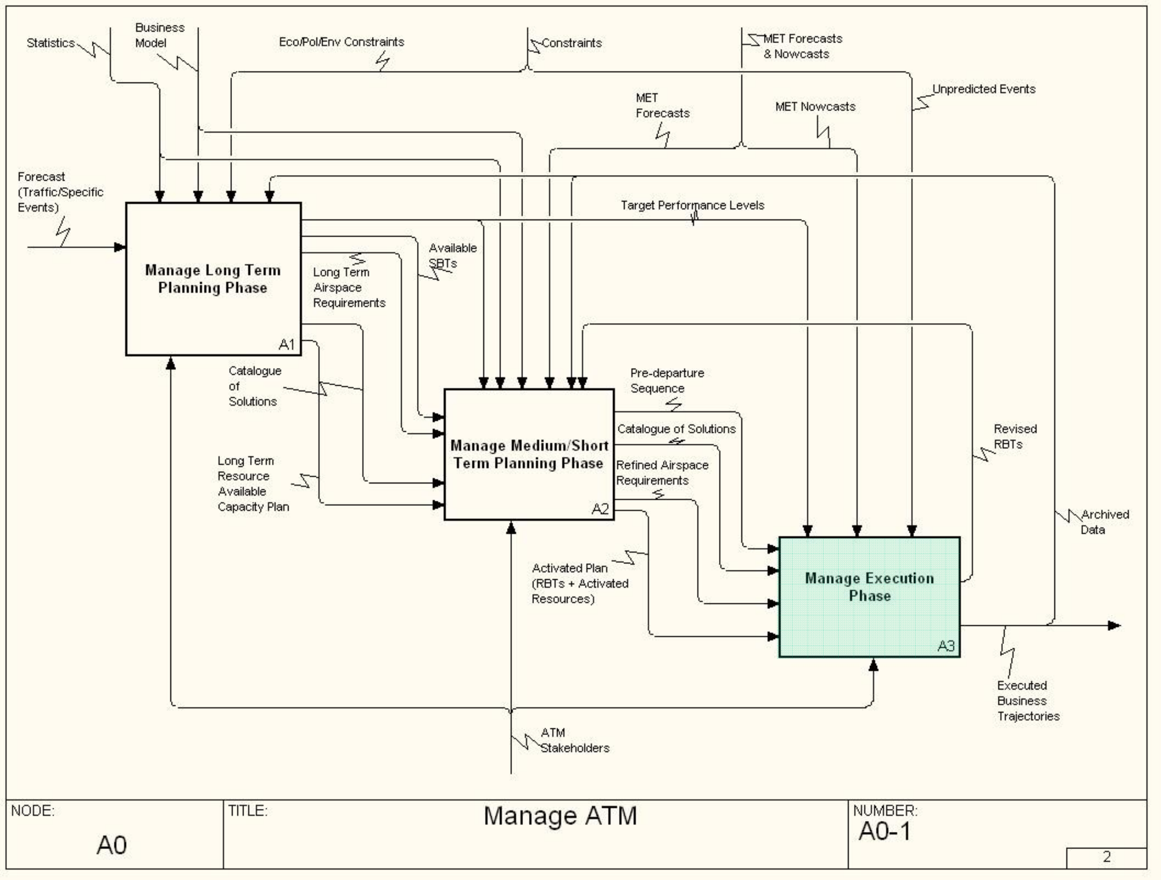

Figure 2: ATM Model Phase Level diagram

There are two major activities defined in the model (Figure 3) which are described by this document, but only from an en-route perspective:

- De-Conflict and Separate Traffic

This process aims at providing de-confliction and separation between traffic in en-route airspace

Traffic Separation involves various types of clearance of the RBT – e.g. PTC-2D, according to the separation mode (refer to Table 2).[9]

Actions to solve these near-term, i.e. tactical, conflicts should generally result in a closed loop trajectory change from the original RBT but at the same time respecting the integrity of the RBT, i.e. time constraints, and this should represent standard operating procedures in the SESAR environment. However, this does not preclude the use of a tactical open loop instruction[10] when circumstances dictate. Where an open loop instruction is issued, either a RBT revision is made or the controller will plan a return to the next way point associated with original RBT depending on the coarseness of the instruction[11]. In both cases if this instruction induces that a constraint is no longer achievable, the direct consequence will be a revision of the RBT (refer to General DOD [4] section 5.2.5.2 for more details). Even if the RBT is not constrained in time, a RBT revision may ensure in order to meet a vertical or horizontal route change. [1]

- Apply Safety Nets

  This process will allow the Sector Controller to be supported with the appropriate tools – e.g. ground-based STCA systems, in order to be able to carry out the appropriate actions in addition to the airborne safety net ACAS.

[9] When determining how to deconflict trajectories with different capabilities it is assumed that lesser equipped aircraft will be moved in favour of better equipped, otherwise the incentive to equip could be negated. (WP4 EG gaming exercise Madrid June 2009)

[10] A tactical open loop instruction may degrade the predictability of the 4D trajectory in the FMS.

[11] Other than emergency situations (e.g. “descend immediately”) when an open-lop instruction is issued by a controller, at least the ground system must show how the loop will be closed.

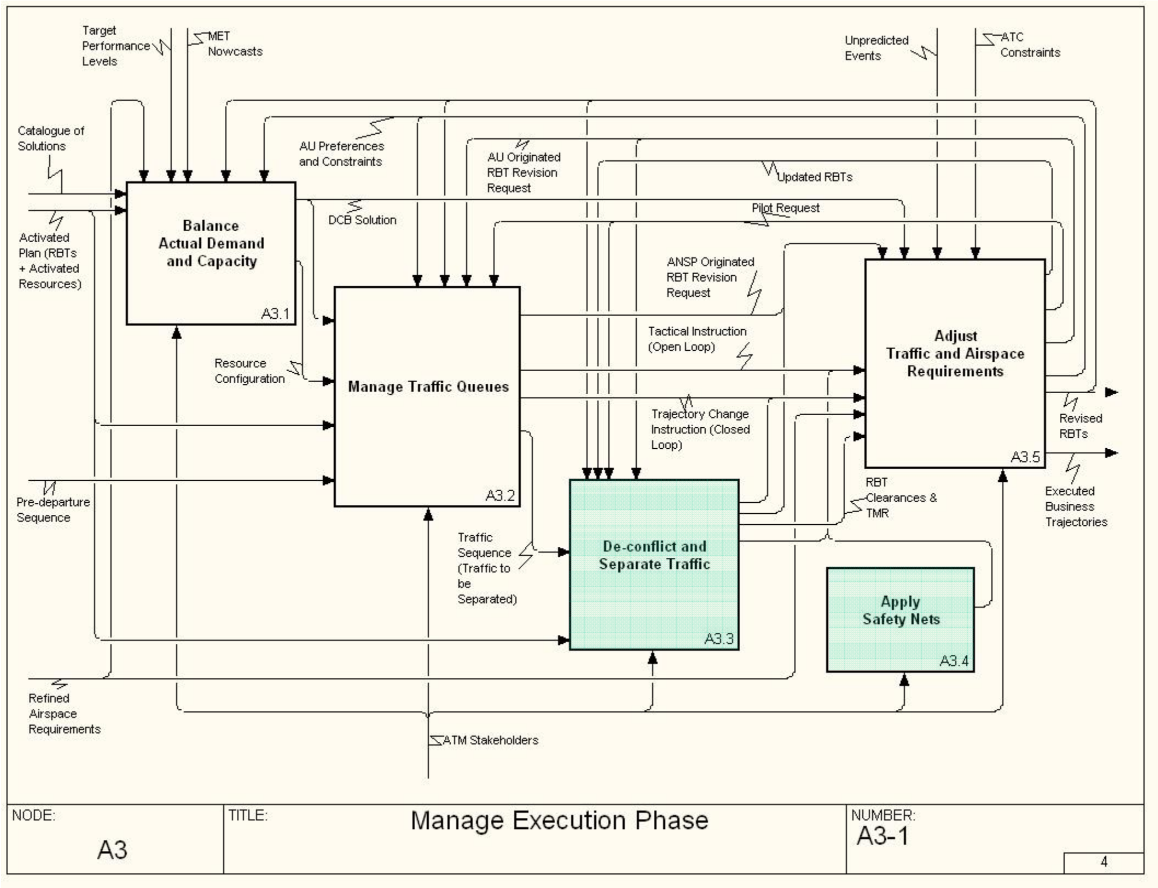

Figure 3: High Level Processes addressed from the Execution Phase

2.3 SESAR Concept Addressed in the Document

The DOD work is mapped onto the SESAR ConOps [22] and Operational Improvements [26].

SESAR ConOps [22] section F1.1 states:

"*The Business/Mission trajectories express the intentions of the airspace user and the trajectory is developed with a view to achieving the best possible outcome for the flight concerned. Any intervention with this trajectory can reduce the prospects of achieving the desired outcome: even unsolicited 'directs' can result in unwanted distortions. While it is recognised that for separation provision reasons it is usually impractical to have an operation with no intervention at all, it is important that all tactical interventions are considered at the trajectory level and not only at the immediate aircraft level. A tactical intervention that is focused only on the aircraft without taking account of the wider impact on the trajectories concerned may result in distortions of the trajectory which can be avoided if a broader view is taken. This broader view is enabled by the SESAR information sharing environment. In this way, if several options are available for implementing an unavoidable intervention, the one with the least impact on the overall trajectory, as well as all other trajectories concerned, can be identified and used on a systematic basis.*"

Trajectory-based operations form the basis of the SESAR Concept. The availability of shared trajectories leads to the concept of a collaboratively layered planning environment where all ATM partners will have access to the same increasingly refined information. As a consequence, the SESAR Concept claims to support a degree of pre de-confliction of traffic flows – e.g. structured routes in high complexity airspace, resulting in fewer tactical interventions during flight execution.

For the en-route phase of flight the major impact of SESAR will be the use of 4-D trajectories, new separation modes and the results of complexity management and collaborative planning (refer to M2 DOD [7] & E4 DOD [10]) to support Conflict Management and Separation. The availability of aircraft intent data from the aircraft will enhance ground-based trajectory prediction and reduce uncertainty calculation. Accordingly, conflict management support tools will be able to predict conflicts with sufficient accuracy and look-ahead time to allow the controller to negotiate any revisions to the RBT, but do not negate pilot/controller tactical interventions (see below). Furthermore, conflict resolution is further enhanced through the introduction of new Separation Modes using trajectory-based operations and ASAS applications in various severities of complexity have been defined as shown in Table 2.

Mode	ATM Service Level	Applies In Complexity	Use
Separation Modes			
Surveillance	0-5	L/M/H	The normal mode.
Procedural	0	L/M/H	
New ANSP Separation Modes			
2D-Precision Trajectory	2-5	L/M	The normal mode.
3D-Precision Trajectory	3-5	M/H	For high complexity operations.
Trajectory Control by Ground Based Speed Adjustments (TC-SA)	2-5	L/M/H	
4D-Precision Trajectory[12]	5	M/H	For very high complexity situations.
New Airborne Separation Modes			
Airborne Separation: ASAS	2-5	M/H	On ATC initiative.
Self-Separation: ASAS	5	L/M/H	

Table 2: En-route Separation Modes

The SESAR ConOps [22] states in Section D.2:

"*The SESAR target concept of operations is a trajectory-based concept. All partners in the ATM network will share trajectory information in real time to the extent required from the earliest trajectory development phase through operations and post-operation activities. ATM planning, collaborative decision making processes and tactical operations will always be based on the latest trajectory data. A trajectory integrating ATM and airport constraints is elaborated and agreed for each flight, resulting in the trajectory that a user agrees to fly and the ANSP and Airports agree to facilitate.*"[13]

"*The airspace user owns the Business/Mission Trajectory, thus in normal circumstances the users have primary responsibility over their operation. In circumstances where ATM constraints (including those arising from infrastructural and environmental restrictions/regulations) need to be applied, the resolution that achieves the best business/mission outcome within these constraints is left to the individual user. Typically constraints will be generated/released and taken into account by various ATM partners through CDM processes. The owners' prerogatives do not affect ATC or Pilot tactical decision processes (for example separation provision, weather avoidance etc).*"

"*The business/mission trajectories will be described as well as executed with the required precision in all 4 dimensions. The trajectories will be shared and updated from the source(s) best suited to the prevailing operational circumstances and capabilities and the sources include the aircraft systems, flight operational control systems and ANSP trajectory predictors. The ability to generate trajectories in the ATM system from flight plan data will be retained for those flights that are unable to comply with SESAR trajectory management requirements.*"

[12] 4D-PTC and Self-Separation are only mentioned here to present all the separation modes, but are not part of the capabilities of the targeted 2020 horizon described by this document.

[13] The available range of aircraft performance is described in the G DOD [4].

The SESAR concept aims to develop an environment where airspace is not a constraint on the trajectories. It states in the Executive summary "*User-preferred routing, without pre-defined routes, will be applicable everywhere except in those cases when sufficient capacity can only be provided by structured routes*".

The move to a full SESAR 2020 state will not be made in one-step. There will be a fleet mix of highly capable aircraft with current state-of-the-art aircraft, there may be an associated impact on route structure and airspace.

SESAR will still use sector-based operations, and route structures similar to those in use today may be deployed in order to deliver capacity in high density airspace (strategic deconfliction). Sector size may increase as a result of reduced tactical intervention and longer look-ahead time.

With Regard to Flexibility the SESAR ConOps states:

"*The operating philosophy underlying the SESAR operational concept is that the users will have the necessary freedom to change their business trajectories at any time prior to and even during execution, and the service providers (airports and ANSPs) will adjust their resource plans to facilitate those changes resulting in the minimum of delay or distortion to all trajectories. It is recognised, that late and significant changes to traffic flows may have implications on the performance of the system, and the needs of safety or network capacity will at times require constraints to be applied to individual trajectories. To achieve this goal, planning decisions will be made as late as possible relative to the time available to affect the outcome. Plans will also be constantly updated and refined to reflect the latest available data*."

The apparent contradiction between freedom to change and minimising delay/distortion is leading to an obligation to reach the best trade-off between Airspace User demand and ATM resources using transparent negotiation mechanisms incorporated in collaborative planning process. It also implies inclusion of constraints in the RBT, that are managed by the Airspace User, when required,

The RBT may include target times or constraints and in particular TTA[14] or CTA as appropriate. Most times indicated in the RBT are estimates, some may be target times – e.g. TTA, to facilitate the management of arrival planning and some of them may become constraints – e.g. CTO, to assist in queue management when appropriate - e.g. at arrival in an airspace volume management horizon.

It should be noted that:

- TTA and TTOs are ATM generated target times: in the case of a constraint to manage a queue for a constrained resource the TTO/A books an approximate place (space) in a queue.
- CTA and CTOs are ATM generated time constraints: a TTO/A may be replaced by a more precise CTO/CTA. In the case of a queue for an airport runway, this positions the aircraft in a sequence.

If a User wishes to impose a "constraint" on its BT/MT then this would be built into the SBT/SMT and be transparent to the ATM system. If this occurs in the execution phase, however, this would entail a User initiated proposal for a trajectory (RBT/RMT) renegotiation.

Constraints can be applied either to aircraft still on the ground or to already airborne a/c through dynamic DCB and can be defined in all 4 dimensions.

[14] The CONOPS description of TTA has been complemented in EP3 Lexicon [13] by the following; "An ATM computed arrival time[14]. It is not a constraint but a progressively refined planning time that is used to coordinate between arrival and departure management applications"..

2.3.1 Related SESAR Operational Improvements (OIs)

A table listing the SESAR Operational Improvements steps that are relevant to this DOD, and the associated processes, is provided in Annex C.

2.3.2 Related SESAR Performance Requirements

SESAR has defined several Key Performance Areas (KPAs) and Performance Requirements (objectives, indicators and targets) which are defining system wide effectiveness and thus, for most of them, affect the various components of the future 2020 ATM target system. The KPAs and performance requirements are shown here with the description of how the scope of en-route management addresses them (refer to [29] and [30]):

Key Performance Area (KPA)	Definition [30] and Description[15]
Safety	This KPA addresses the risk, the prevention and the occurrence and mitigation of air traffic accidents. The number of ATM induced accidents and serious or risk bearing incidents must not increase and, where possible, must decrease, as a result of the introduction of SESAR concepts. In order to maintain a constant accident rate, the overall safety level would have to increase by a factor of 3 in order to meet the safety objective for traffic levels in 2020. *The overall safety level should reach an improvement factor 3 in order to meet the safety objective [SAF1.OBJ1.IND1].*
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 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. *Security is not directly addressed by en-route operations, however improvements made will not degrade the current situation.*

[15] SESAR Performance Requirements (as defined by SESAR D2 [30]) are presented in this column; Performance definitions in black, performance targets in italics, along with the corresponding performance indicator ID in brackets.

Key Performance Area (KPA)	Definition [30] and Description[15]
Environmental Sustainability	This KPA addresses the role of ATM in the management and control of environmental impacts. The aims are to reduce adverse environmental impacts (average per flight); to ensure that air traffic related environmental considerations 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. *Yet to be determined. Cruise Climb at high-level en-route may be key in delivering key environmental benefits. Shorter path lengths and less holding from better predictability may decrease fuel consumption, with 4D trajectories based on optimum fuel usage, CDAs and optimum 2D routes.* *However, speed variations en-route may cause problems to be facilitated by ATM, potentially inducing extra conflict, extra routing and extra overtaking problems.*
Cost Effectiveness	This KPA addresses the cost of gate-to-gate ATM in relation to the volume of air traffic that is managed. Better planned, user driven trajectories and use of aircraft capabilities should provide cost-effectiveness. The cost of equipping resulting better adherence to plans and preferred business/mission trajectories in the en-route airspace. There may be some saving in more generic training and validation costs for ATCOs. *Halve the direct European gate-to-gate ATM costs through progressive reduction [CEF1.OBJ1.IND1].*
Capacity	This KPA addresses the ability of the ATM System to cope with air traffic demand (in number and distribution through time and space). Increased by reduced controller task load per flight. *The European ATM system will need to be able to handle 70% more flights per year than in 2005 [CAP3.OBJ1.IND1].* *The daily number of IFR flights that can be accommodated in Europe should be 49 000 flights [CAP3.OBJ1.IND3].*

Key Performance Area (KPA)	Definition [30] and Description[15]
Efficiency	This KPA addresses the actually flown 4D trajectories of aircraft in relationship to their Shared Business Trajectory. Better adherence to the BT due to more efficient ATM. *More than 95% of flights will have normal flight duration[16] [EFF1.OBJ2.IND1].* *The average flight duration extension of flights with extended flight duration[17] will not exceed 10 minutes [EFF1.OBJ2.IND2].* *Less than 5% of flights will suffer additional fuel consumption of more than 2.5% [EFF2.OBJ1.IND1].* *For flights suffering additional fuel consumption of more than 2.5%, the average additional fuel consumption will not exceed 5% [EFF2.OBJ1.IND2].*
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 Trajectory10 (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. Flexibility to modify operator preferences as well as more flexible approach to operational decision making are characteristics of the NOP as implemented by en-route ATC. Utilising, for example, dynamic processes, capacity headroom *At least 95% (European-wide annual average) of the (valid) requests for full RBT redefinition of scheduled and non-scheduled flights will be accommodated, albeit possibly with a time penalty [FLX1.OBJ2.IND1].* *At least 98% (European-wide annual average) of the VFR-IFR change requests will be accommodated without penalties [FLX2.OBJ2.IND1].*

[16] Normal flight duration is defined as actual block-to-block time less than 3 minutes longer than the block-to-block time of the SBT.

[17] Extended flight duration is defined as actual block-to-block time more than 3 minutes longer than the block-to-block time of the SBT.

Key Performance Area (KPA)	Definition [30] and Description[15]
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. Predictability is enhanced for all users based on common information sharing, using, for example, dynamic processes and capacity headroom. *The variability of flight duration (off-block to on-block) shall have a coefficient of variation of maximum 0.015[18] [PRD1.OBJ2.IND1].* *Reduce, at a regional level, diversion rates by 50% compared to 2010 baseline [PRD2.OBJ1.IND2].* *Reduce, at a regional level, total disruption delay by 50% compared to 2010 baseline [PRD2.OBJ1.IND3].* *Reduce, at a regional level, reactionary delay by 50% compared to 2010 baseline [PRD3.OBJ1.IND1].*
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: planning, development, deployment, operation and evaluation/improvement of the system. b) "Meeting the (sometimes conflicting) expectations of the community" implies that 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. *Fundamental to the concept is the participation of the user community in the decision making process through collaborative planning. The new concept includes trajectories pre-defined and owned by the airspace users. At a sector level the controllers perform separation functions taking account of user preferences.*
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 global 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. All aircraft with the minimum equipage requirements will be integrated into the En-route airspace. There will be no segregation, although there may be prioritisation for higher capability aircraft. *Provide a seamless service to the user at all times [IOP3.OBJ2.IND1].* *Operate on the basis of uniformity throughout Europe [IOP3.OBJ3.IND1].*

[18] This means that for a "100 minutes flight duration" more than 95% flights arrive on time.

Key Performance Area (KPA)	Definition [30] and Description[15]
Access & Equity	Access: This Focus Area covers the segregation issue: whether or not access rights to airspace and airports are solely based on the class of airspace user. In other words, is shared use by classes of airspace user allowed, and how much advance notice of this accessibility is provided? Equity: The scope covers the subject of equitable access, i.e. the prioritisation issue: under shared use conditions (i.e. access is possible), to what extent is access priority based on the equipage of airspace user. Dissatisfaction of airspace users regarding equitable treatment arises when there are no prioritisation rules, or the rules are not applied correctly. Access to specific en-route Airspace resources for airspace users should be provided in an equitable, transparent and more efficient manner. *This should be irrespective of variations in equipage above the minimum level required and enabled by the SESAR CDM/UDPP processes in the NOP*. [19]

Table 3: Key Performance Areas addressed

[19] Wp4.3.1 Expert group have raised the definition of Equity as a hot topic since different experts interpret its SESAR application in different ways. Since it affects other DODs the issue will be raised as a hot topic in the G-DOD.

3 CURRENT OPERATING METHOD AND MAIN CHANGES

Current operations are defined by the ICAO PANS-ATM (ICAO Document 4444 [18]). However individual national policy allows regional/national variations in the working methods to occur.

Current operations:

- ATC services as defined by ICAO have as their major objective to prevent collisions between aircraft while expediting and maintaining an orderly flow of traffic;
- En-route operations are related to the control of airborne aircraft inside a geographical portion of airspace, located in-between departure and arrival terminal areas, with respect to the objective defined by ICAO;
- A Sector is the cell of airspace in which services will be provided and is under the responsibility of one or more actors:
  - An Executive Controller, who separates and sequences flights located within his sector - i.e. his area of responsibility, and issues instructions and clearances to pilots to provide separation;
  - A Planning[20] Controller, who is checking trajectory of flights intending to enter the sector for potential separation risk, and coordinating entry and exit conditions leading to conflict-free trajectories.
- For IFR flights responsibility for separation is “ground-based” as, for managed airspace of class A to E, delegation to the pilot in command is rarely made;
- For VFR flights the flight crew is responsible for separation on a “see and be seen” basis;
- Delivery to the next sector is based on 3D points in certain environments and there is limited use of time-oriented downstream management with limited visibility of the airspace user schedule;
- The filed flight plan (FPL) contains the planned routing in three dimensions that the aircraft intends to follow (flight intent) plus time. Time is expressed as the estimated time of departure (EOBT) and a total elapsed time to destination. The FPL is owned by the Aircraft Operator.
- Pilots have the obligation to:
  - Ensure collision avoidance in the air and on the ground.
  - Guarantee safety of the aircraft and passengers during the flight/mission;
  - Execute the mission, as defined by the aircraft operator - e.g. operating manuals, airline instructions;
  - Comply with legislation and regulations applying to aeronautical traffic, national and international legislation, and operational rules in order to execute the mission;
  - Comply with all changes to the planned route as expressed through the issuance of clearances accepted by him and comply with all instructions issued unless the safety of the aircraft is jeopardised through compliance.

[20] Planning Controller: For this document only: when reference is made to the Actor “Planning Controller” it may also include the roles of the Multi-sector Planner or the Complexity Manager

Europe's current operational concept is ground-based. The implementation of Central Flow Management has managed declared airspace capacity and runway acceptance rates through delay and regulation restrictions. But there is a lack of integrated airport processes and procedures and insufficient dynamism in the system and therefore the system is unresponsive to real-time events. Currently, airspace users and ANSPs optimise their operations independently leading to system inefficiencies.

More recently, there have been ATM evolutions in terms of RVSM and the advent of Mode-S and an initial limited use of CPDLC to allowing more interactions with aircraft. Other than this there has been little in the way of a radical system change in order to meet the predicted shortfall in available capacity.

3.1 Aspects of today's operations that will remain

Many of today's practices remain. The SWIM environment and trajectory based operations allow the involvement of all actors based on known, common and agreed objectives – i.e. the RBT. The distribution of tasks can be shared to a greater extent between the controllers and the pilots.

Obviously, the legacy aircraft will be supported and even if the objective is to reduce the proportion of clearances issued by voice, voice communication will still be employed for the issuance of time critical clearances and instructions and at other times when voice is deemed as the most appropriate method.

Operations will still be defined by ICAO PANS-ATM and supplemented by national policy and it is anticipated that the following of today's practices will remain:

- ATC services as defined by ICAO will still have as their major objective the prevention of collisions between aircraft while expediting and maintaining an orderly flow of traffic;
- En-route operations will still be related to the control of airborne aircraft inside a defined volume of airspace, located in-between departure and arrival terminal areas, with respect to the objectives defined by ICAO;
- Responsibility for separation will be primarily "ground-based" however there will be initiatives that will eventually lead to the delegation of separation responsibilities.
- Within the ICAO context the RBT now represents the filed flight plan.
    - Pilots have the obligation to:
    - Ensure collision avoidance in the air and on the ground.
    - Guarantee safety of the aircraft and passengers during the flight;
    - Execute the flight, as defined by the aircraft operator - e.g. operating manuals, airline operating procedures;
    - Comply with legislation and regulations applying to aeronautical traffic, national and international legislation, and operational rules in order to execute the flight;
    - Comply with all changes to the planned route as expressed through the issuance of clearances accepted by him and comply with all instructions issued unless the safety of the aircraft is jeopardised through compliance.

3.2 ASPECTS OF TODAY'S OPERATIONS THAT WILL CHANGE

The impacts[21] on the current operations are linked to the extensive sharing of data and a greater involvement of the Airspace User during the execution phase and the collaborative process as previously described in section 2.3:

- The SBT contains the validated 4D trajectory and is owned by the Airspace User and based on the User Preferred Trajectory (UPT) for most operations – i.e. medium and low complexity/density airspace. A route structure is still applied temporarily for high complexity/density operations (strategic deconfliction).
- The RBT contains the preferred route that the user wishes to follow after complying with any ATM constraints. This will be generally point to point, i.e. direct, in those volumes of airspace where a route structure is not established. Consequently, the Executive Controller will not offer a 'direct to' routing to a flight where opportunity exists unless specifically requested but will facilitate the agreed RBT as being the best service that can be provided. However, in the event of, for example, the early release of reserved airspace of which the user may wish to take opportunity, the Planning Controller will be aware of the user's preferences through the availability in the NOP of a catalogue of pre-defined scenarios.
- Queue management will be supported by sequencing tools -e.g. AMAN;
- Support to arrival queue from the en-route perspective is mainly linked to the compliance with the TTA/CTA that have been allocated to flights. This means that when actions have to be initiated both the controller and Flight Crew will need to take into account possible constraints/sequencing allocation in order to maintain/facilitate the Arrival Management process.
- En-route operations will not only be related and linked to a geographical reference but also to the extent of an involvement in a departure and/or arrival process - e.g. Arrival Manager Horizon.
- Except for areas in which a fixed route structure is necessitated by traffic volumes/patterns, the coordination point for an aircraft is no longer limited to designated 3D points but can occur at any agreed point on the sector boundary. Transfers between sectors will be automated and silent.
- The introduction of 4D trajectory management, including RBT, and aircraft already managed and sequenced in the en-route airspace induce a limitation of the use of tactical radar vectoring and intermediate level-offs;
- Advent of first ASAS applications initially enabling spacing tasks to be performed by the Flight Crew, ultimately leading towards the delegation of separation responsibilities.
- Linked to the definition of ATM Service Levels - i.e. Level-0 to Level-4, new separation modes will be introduced based on the aircraft capability. In addition the separation service provider may delegate the role of separator to the Flight Crew making use of ASAS applications according to the complexity of the airspace as previously described in section 2.3.
- In conjunction with the RBT management the emergence of comprehensive data-sharing through SWIM -e.g. data link - will limit the use of voice communications to time critical instructions and non-standard messages.
- Controller and Pilot will subscribe to the same goal of achieving the RBT.

[21] The description made hereafter is related to usual situation and does not apply to or be relevant for avoiding collision conditions.

- Integrated ATM system will subscribe to the goal of continuously delivering the NOP.
- Unmanaged VFR flights in managed airspace will not be permitted.[2] [22]

The evolutions mentioned here above are enabled by:

- New tasks;
- Introduction of new working positions such as a Multi-sector Planner and Complexity Manager;
- New and/or improved tools;
- New procedures and working methods;
- Closed loop clearances;
- Data link, ground and airborne automation.

It is expected that controller tools for conflict detection and resolution advice, complexity management tools and datalink capabilities will be more advanced and accurate allowing 4D trajectory management, CPDLC and surveillance to be supported through more stabilised and reliable tools. However, an increase in accuracy does not necessarily lead to an increase in controllability.

3.3 Aspects of today's operations that will disappear

Extensive use of open loop radar vectoring, as well as use of R/T for routine routing instructions or to make ATC aware of certain flight parameters, air-ground inconsistencies in the trajectory predictions, limited anticipation/planning, are expected to disappear..

[22] The issue of VFR flights in managed airspace where all flights and their intentions must be known has yet to be resolved.

4 PROPOSED OPERATING PRINCIPLES

4.1 EN-ROUTE SUPPORT TO DE-CONFLICT AND SEPARATE TRAFFIC (A3.3)

4.1.1 Scope and Objectives

The "De-conflict and Separate Traffic" process aims to provide separation and, when required, de-confliction between traffic on the Airport Surface, in Terminal Areas and in en-route airspace. However, as mentioned in section 2.2, this document will focus on en-route operations.

Traffic Separation involves the issuance of clearances which may lead to a RBT revision according to the separation mode - e.g. 2D PTC or 3D PTC (refer to G DOD [4] section 5.2.5 for more details); two Operational Improvement steps describe these new modes of separation, namely **[*CM-0603*]** and **[*CM-0604*]**. In accordance with the SESAR ConOps [22] conflict-free portions of the RBT will be successively cleared [3] [23] during the flight execution. The Trajectory Management Requirement (TMR) parameters are included in the clearance and thus uplinked if changes have been made. The CONOPS definition of the TMR is:

"TMR specify the requirement on the aircraft to share the updated trajectory in the event that the flight detects a 'delta' from previous predictions or on a cyclical basis.

The TMR:

- *Specify the lateral, vertical or time parameters that will trigger the update process.*
- *Specify the other event driven and periodic trajectory sharing requirements.*
- *Will specify the data content required.*
- *Will specify allowable tolerances of selected time/speed and altitude*

When time permits, actions to solve conflicts will result in a closed loop trajectory change from the original RBT to avoid the conflict. In situations that are time critical or in which the message set does not provide the appropriate instruction, a tactical open loop instruction will be used. If an open loop instruction is used, then appropriate monitoring will be performed and a final closed loop instruction issued. In both cases if the instruction results in a constraint not being met, the direct consequence will be a revised RBT (refer to G DOD [4] section 5.2.5.2).

4.1.2 Assumptions

A proportion of potential conflicts is managed in advance by measures such as Dynamic Demand Capacity Balancing and Complexity Management. Route structures may be deployed to ensure that the separation task may be conducted efficiently in high density areas. Dynamic allocation of routes may be used for de-confliction (refer to E4 DOD [10]).

The integration of multi-airport departures from a common TMA into en-route airspace and the time constraints that may need to be applied to resolve complexity, for example, are dealt with in E5 DOD [11].

Enhancement of the trajectory conformance and conflict detection tools, particularly regarding resolution advisories, may support the controller in order to decrease the task load.

[23] Successive clearance refers to the automated comparison of an aircraft's future RBT with those of all other flights to identify potential conflicts to the limit of the controller tools. It does not require the issuance of a clearance as such. Potential conflicts are identified and displayed to the Controller for evaluation and the issuance of clearances/instructions which may revise the RBT, if required

4.1.3 Expected Benefits Issues and Constraints

The expected benefits of the de-confliction and separation process are:

- Fewer losses of separation, allowing improvement of safety;
- Improvement of capacity through decrease of the controller task load supported by:
  - Improved presentation of traffic during peak loadings, provided through layered planning activities (medium/short/dynamic) that ensure 'just-in-time' imposition of ATC constraints - e.g. route structures;
  - Enhanced and new operating procedures – e.g. co-ordination, delegation of separation and spacing responsibility to the airborne side;
  - Automated tools - e.g. conflict detection and resolution, route conformance monitoring. These tools will benefit from the increase of data sharing and lead to fewer false alerts.
- Less vectoring as well as less ad-hoc conflict solutions contribute to improve the flight efficiency.

An expected limitation is the need to provide time constraints to improve the effectiveness of queue management procedures in the en-route phase in support of arrival operations. In circumstances where the arrival manager is dealing with multiple arrival streams, unique time constraints (CTA) may be allocated to individual flights. This process is dealt with in detail in DOD E4.

4.1.4 Overview of Operating Method

This activity is grouping all the activities associated with separation provision. Thus it has been broken down into three main sub-processes, namely:

- De-conflict & Separate Traffic at the Airport;
- De-conflict & Separate Traffic in Terminal Area;
- De-conflict & Separate Traffic in en-route Airspace.

Airport and Terminal Area operations are addressed in separate documents (refer to E1 DOD [8], E2/3 DOD [9] and E5 DOD [11]). However, it should be noted that the boundary between en-route and TMA airspace may not be a fixed dimension and that extended TMAs (E-TMA,) in which the TMA extends into en-route airspace, will exist to optimise traffic synchronisation and queue management as described in Operational improvement step [***TS-0305***].

All these activities are supported by a set of tools that will benefit from the sharing of all the information related to the trajectory and the intent of the aircraft allowing decrease of the task load for sector controllers and flight crew.

The tools available to the controller permit the trajectory to be validated as conflict free for the time horizon of the tool (e.g. 20 minutes[24] for MTCD in straight and level flight). Potential conflicts are therefore normally resolved through closed loop, agreed revisions to the RBT. Consequently tactical open loop radio instructions, (e.g. 5 minutes or less ahead of the aircraft's present position), are primarily issued as a result of unpredicted events such as an aircraft non-compliance with a clearance, in-flight emergencies and weather deviations.

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[24] Where times are quoted throughout the document they are for example purposes only unless otherwise stated.

4.1.4.1 De-conflict & Separate Traffic in En-Route Airspace (A3.3.3)

This process aims to provide de-confliction and separation between traffic in en-route airspace and is supported by OS 38 [15].

The activity has been decomposed into two sub-processes:

- Detect & Solve Conflict in Managed En-Route Airspace: perform continuous monitoring of the flights in order to evaluate potential conflicting situations. Once a conflict has been detected, evaluate the available solutions;
- Implement Separation in Managed En-Route Airspace: manage the safe and orderly progress of the flight and perform the relevant action including the separation mode to be applied through appropriate clearances and instructions.

The various activities described below have to be considered for anticipative procedures – i.e. not associated to imminent conflict. Procedures which have a short term time horizon (refer to section 4.2 on safety nets), have to be considered in the collision avoidance activities.

Separation provision ensures a safe traffic flow and includes the monitoring of traffic and tactical intervention for traffic under the controller's responsibility. It consists of tactical planning, tactical intervention and the transfer of separation assurance responsibility. The controller is provided with tools supporting conflict detection in the medium term, trajectory conformance monitoring and near-term tactical support. All separation tools support will take into account overall traffic optimisation goals and benefit from the massive data-sharing provided by SWIM (refer to G DOD [4] section 5.4).

In the en-route phase, the objective is to facilitate the RBT by the aircraft– i.e. "closed loop trajectory", and minimising flight path deviations. The RBT represents the agreed trajectory between all actors and rolling Demand and Capacity Balancing is ensuring that optimum sectorisation is provided, maximising available resources and minimising deviations from the RBT.

4.1.4.1.1 Detect & Solve Conflict in Managed En-Route Airspace (A3.3.3.1)

This process aims to detect conflicts in managed en-route airspace[25], monitor trajectory conformance and provide conflict resolution advisory(ies), possibly involving a change in the separation mode, taking into account the context and ATM capability level(s) of the aircraft involved.

The main drivers for the process are the following:

- Inputs[26]:
    - Activated Plan (RBTs + Activated Resources);
    - Traffic Sequence (Traffic to be separated).
- Constraints/Triggers:
    - Pilot Request;
    - AU Originated RBT Revision Request;
    - Updated RBTs;
    - Revised RBTs from upstream sectors[27].

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[25] The airspace may be either structured with pre-defined routes or free route [***AOM-0503***]

[26] Surveillance data are not mentioned explicitly, but are assumed to be an input of all the related surveillance processes.

[27] Proposals for trajectory change proposal to the flight crew are an automated process using data link [Operational Improvement step [***AUO-0303***].

- Human Actors:
  - o Executive Controller;
  - o Planner Controller;
  - o Flight Crew.
- Outputs;
  - o Detected Conflict + Advisories.

Monitoring of the trajectory is performed in order to either authorise[28] the next segment(s) of the RBT if the next portion is conflict-free or detect potential conflicting aircraft in the medium term horizon[29]. The RBT Clearance is not systematically defining a limit for the cleared trajectory. The clearance limit will be the arrival fix, as today, unless a new clearance limit has been specified. The successive authorisation of the RBT/RMT is described by Operational Improvement step **[*AUO-0302*].**

In the event of a trajectory drift - i.e. exit from the thresholds of the TMR, the aircraft shares the new predicted trajectory (refer to G DOD [4]). The update of the trajectory through TMRs is an automated process **[*IS-0305*].** This mechanism permits the sharing of the most accurate and up to date data for flight monitoring and conflict detection, without inducing potential overload of the SWIM network.

Trajectory data provided by the airborne avionics feed the ground trajectory predictor and thus improve the performance of conflict detection, intent and conformance tools.

Sharing of trajectory information will improve the performance of the tools to supporting the controller and the pilot in this activity[30]. At the same time the use of shared trajectory information will enable the coordination-free transfer of control **[*CM-0402*].**

Various tools are available to monitor the traffic, such as:

- Intent and conformance monitoring: ground trajectory predictor associated with the monitoring of the aircraft's progress against the trajectory to evaluate the potential drifts - e.g. Route Adherence Monitoring (see Operational Improvement step **[*CM-0203*])**;
- Medium Term Conflict Detection & Resolution (MTCD/R, CORA): monitoring the aircraft's progress against the trajectory, the detection of conflicting trajectories with associated alternative proposal(s) for conflict resolution (see Operational Improvement step **[*CM-0404*]**);
- Trajectory Control by Ground Based Speed Adjustments (TC-SA): coupled with conflict detection and resolution is the provision of separation between aircraft by generating conflict-free segment as described in Operational Improvement step ***[CM-0403].[CM-0403].*** This is achieved through automatic clearances that direct minor adjustments to the horizontal speed of the aircraft (refer to [19]) and are prepared for issue by the "Implement Separation" process.[4] [31]

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[28] The notion of authorising the RBT was developed after SESAR PD concluded to help describe the trajectory exchange process. It is important to note that the authorised portion of the RBT is not the same as the clearance issued by the controller to the pilot. See footnote 23

[29] Typical average order of magnitude is 20 minutes.

[30] However, surveillance data will also be taken into account in order to accommodate all the ATM capability level aircraft.

[31] ERASMUS [19] has not validated the benefits delivered by TC-SA ("….leads us to consider that the principle of modulating longitudinal velocity of aircraft (TC-SA) is facing serious difficulties in its implementation and to question its viability').

By considering the known traffic evolution and separation mode, the resolution of the conflict is proposed to, and managed by, the human operators. The controller and pilot are made aware of aircraft cluster(s) for which separation may be lost (a warning is raised) and resolution alternatives are proposed. Integrated resolution support shows context aircraft and allows conflict probing – e.g. what-if, in which alternative trajectories and separation modes are checked to ensure that they are free of conflicts for some look-ahead time.

Once the trajectory of a flight has been checked free of conflict, the controller is then able to authorise the next RBT segments and initiate the appropriate separation mode. If conflict resolution advisories are provided, the controller evaluates the conflict resolution proposed and initiates the most appropriate instruction including delegation of the separation responsibility.

The following Use Cases have been identified for Detect & Solve Conflict in Managed En-Route Airspace process:

Use Case	Description
Identification of Aircraft at ECAC Boundary	This use case describes how a Sector Controller uses the system to identify a flight that is about to enter the ECAC area.
Detect Conflict in Managed En-Route Airspace	The use case describes how a Sector Controller uses the system to detect a conflict or flight non-conformance in the en-route managed airspace.
Resolve Conflict in Managed En-Route Airspace	This use case describes how a Sector Controller interacts with the system to achieve the resolution of a conflict The system provides assistance to the Controller in this task.
Handle Pilot Requests in Managed En-Route Airspace	The use case describes how a Sector Controller uses the system to evaluate a request for revising the RBT initiated by the flight crew.

Table 4: Use Cases for Detect & Solve Conflict in Managed En-Route Airspace

4.1.4.1.2 Implement Separation in Managed En-Route Airspace (A3.3.3.2)

This process aims to implement the most appropriate separation solution in managed en-route airspace[32], according to the output of the “Detect and Solve Conflict” process.

The main drivers for the process are the following:

- Inputs:
  - Detected Conflict + Advisories;
  - Activated Plan (RBTs + Activated Resources);
  - Traffic Sequence (Traffic to be separated).
- Constraints/Triggers:
  - Updated RBTs;
  - Revised RBTs[33].

[32] The airspace may be either structured with pre-defined routes or free route **[*AOM-0503*]**

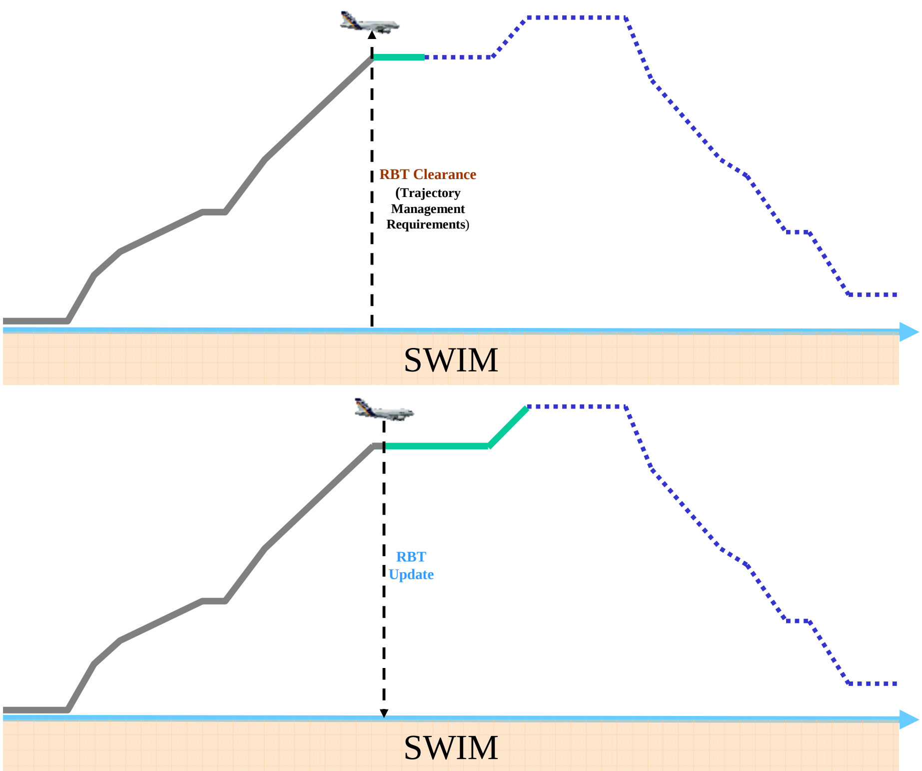
[33] Proposals for trajectory change proposal to the flight crew are an automated process using data link [Operational Improvement step **[*AUO-0303*]**].

- Human Actors:
    - Executive Controller;
    - Flight Crew.
- Outputs:
    - RBT Revision Request;
    - RBT Clearances & TMR;
    - Trajectory Change Instruction (Closed Loop);
    - Tactical Instruction (Open Loop).

The controller will authorise the next segment(s) of the current RBT (see **[*AUO-0302*]**). This will be sent to the flight crew a delta time before the aircraft reaches the end of the previously authorised segment (Figure 4). In the case of an automated clearance mechanism, the controller will be asked to validate and, if necessary, amend the clearance before it is sent. [5] [34]

Depending on the ATM capabilities of the aircraft and separation mode, the RBT clearance could be a:

- Conventional clearance;
- PTC-2D clearance (see **[*CM-0603*]**);
- PTC-3D clearance (see **[*CM-0604*])**;
- Trajectory Control by Ground Based Speed Adjustments (TC-SA) clearance [19].



[34] From an EP3 and ICAO perspective “authorisation” is synonymous with “clearance”. However, see footnote 23.

Figure 4: Authorise next portion of route

In managed airspace the predetermined separator is the ANSP. However the role of separator may be delegated in accordance with pre-defined rules, for example, the ad hoc delegation of separation to the flight deck as per Operational Improvement step **[*CM-0701*]**.

Depending on the available capabilities the separation mode is one of the following:

- Procedural;
- Surveillance;
- 2D Precision Trajectory (PTC-2D);
- 3D Precision Trajectory Clearance (PTC-3D);
- Trajectory Control by Ground Based Speed Adjustments;
- Airborne Separation (ASAS) when responsibility for separation has been delegated to the flight crew.

If a conflict is detected, resolution advisories may be proposed to the Executive Controller. These alternatives are evaluated and the selected solution is applied as described in Operational Improvement step **[*CM-0404*]**. The solution applied could include the use of ASAS applications.

If responsibility for separation has been delegated to the flight crew, an RBT revision corresponding to the selected airborne resolution trajectory is shared on the network. Otherwise, the associated Trajectory Change Instruction is sent by the controller, accepted by the Flight Crew and validated by the FMS which will then downlink the revised RBT to complete the verification/acceptance cycle [6] [35].

Due to unexpected events - e.g. thunderstorm, a modification of the trajectory may have to be made. This request can be initiated either by the flight crew or proposed by the controller.

When the request is originated by the flight crew, a Pilot Request triggers the "Detect and Solve Conflict" process[36] (Figure 5). The flight crew proposes a trajectory change - e.g. route and/or level change, due to weather hazard (e.g. convective weather), either the controller agrees and uplinks the clearance for the revised RBT, or the controller modifies the flight crew proposal - e.g. due to potential conflict, uplinks an instruction for a new change. In the case of an amended trajectory, the feasibility of the new proposal has to be agreed by the flight crew before onboard activation of the revised RBT.

[35] This process needs further elaboration to understand the ramifications of the flight crew unilaterally revising the RBT for separation purposes and, for example, the ground trajectory where the controller still has responsibility for separating the delegated aircraft from other flights.

[36] In this context a "Conflict" describes an aircraft versus hazard conflict.

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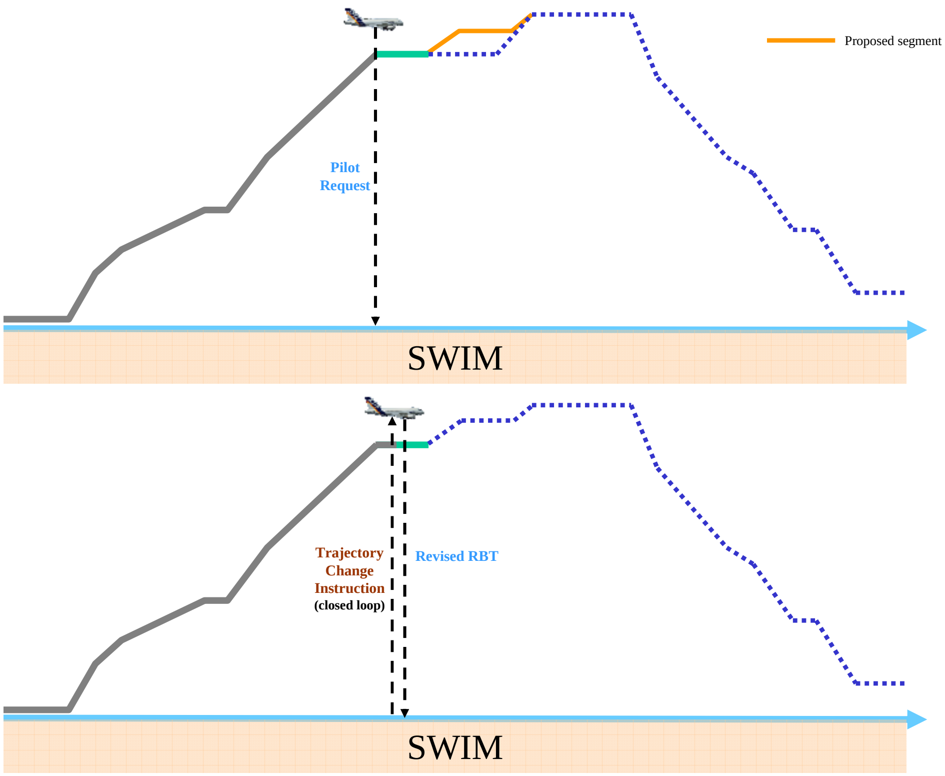

Figure 5: Airborne initiated revision of trajectory due to unpredicted event

When the revision process is initiated by the ground, depending on the time criticality either a RBT Revision request – i.e. look-ahead time sufficient for collaboration process, or a trajectory modification is initiated – e.g. Trajectory Change Instruction or RBT Clearance (Figure 6), . If a CDM process can be applied [7] [37], the controller proposes a trajectory change - e.g. route and/or level change, due, for instance to the detection of a potential conflict. Then the flight crew either agrees and downlinks the updated RBT[38] or modifies the controller proposal - e.g. for feasibility reason, and downlinks the new change. The amended trajectory is checked for conflicts, and if agreed by the controller, the clearance for the authorised portion of the revised RBT is uplinked (Figure 7).

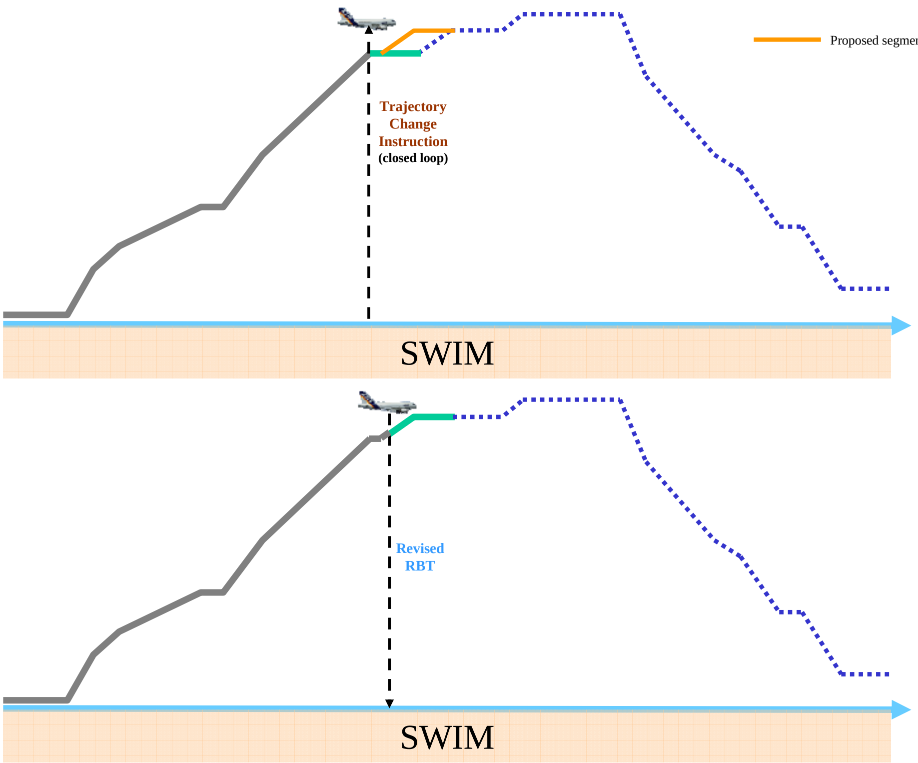

Figure 6: Ground initiated revision of trajectory due to potential conflict (no CDM)

[37] In a tactical situation it is proposed that RBT revisions be applied through flight crew/controller negotiation and not a CDM process. The time horizon in which a CDM process may be implemented needs further research.

[38] The update is mainly composed of the new predicted trajectory computed by the FMS.

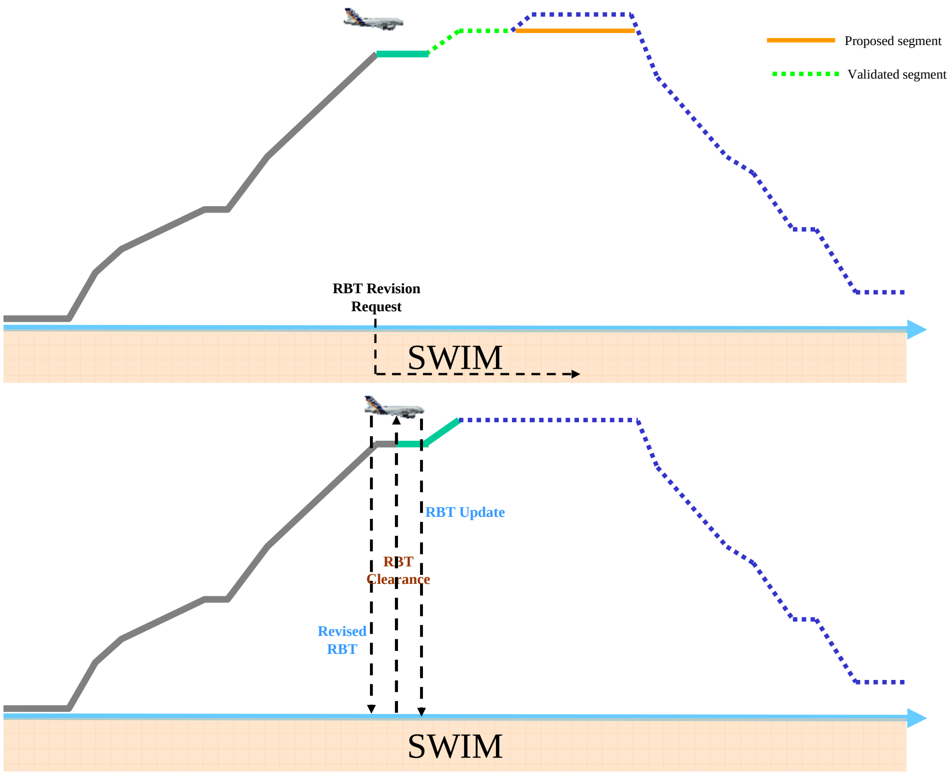

Figure 7: Ground initiated revision of trajectory due to unexpected event (CDM involved)

When the flight reaches the limit of the Area of Responsibility (AOR) a transfer of control occurs. However, the boundaries between AORs will be more flexible building on today's local agreements due to improved interoperability as described in OI step **[*SDM-0202*]**) Similarly, this flexibility will be enabled through the implementation of generic (non-geographical) controller validations **[*SDM-0203*].** The transfer of an aircraft from one control authority to the next involves a minimum of verbal or electronic dialogue and specific procedures will be restricted to non-standard situations. The receiving sector is notified through SWIM of the details of the aircraft about to be transferred and under what conditions the transfer will be made.

Whenever possible, traffic passes from the authority of one sector to the next in compliance with agreed silent handover procedures without the requirement for individual co-ordination. This is achieved through the sharing of trajectory information that will enable the coordination-free transfer of control as described in Operational improvement step **[*CM-0402*]**.

The following Use Cases have been identified for the process "Implement Separation in Managed En-Route Airspace":

Use Case	Description
Clear next portion of the RBT in Managed En-Route Airspace	The use case describes how the next portion of the trajectories is authorised by the Controller.

Use Case	Description
Implement "ground-based" Separation in Managed En-Route Airspace	The use case describes how a Controller uses the system to provide the pilot of the aircraft with separation, according to the current ground mode, in Managed en-route airspace: ▪ Surveillance; ▪ Procedural; ▪ 2D PTC; ▪ 3D PTC; ▪ TC-SA.
Implement ASAS applications in Managed En-Route Airspace	The use case describes how the flight crew and controller use the system during temporary delegation of responsibility for ensuring separation in Managed en-route airspace: Spacing; Separation.
Transfer of Control and/or Air/Ground Communications in Managed En-Route Airspace	This use case describes how flights are transferred between sectors.
Manage Traffic in En-Route Airspace with Respect to the AMAN Horizon	This use case describes how a Controller uses the system to handle the traffic involved in optimised sequencing from an arrival queue.
Perform Transfer of Responsibility from Managed En-Route Airspace into ECAC Managed Airspace	This use case describes how Sector Controllers interact with the System to achieve the transfer of a flight from outside managed airspace into the ECAC managed airspace. In normal circumstances the transfer is fully automated (silent transfer). The Controllers involved are informed of the progress of the transfer and may take control back from the automated process any time it is required, in particular to co-ordinate new transfer conditions (see separate use case). This transfer process is assisted by System-supported dialogue between controllers without need for verbal communication except under specified circumstances.
Handle Military Flight in Managed En-Route Airspace	Management of a typical military OAT IFR en-route flight, with or without trajectory amendment.

Table 5: Use Cases for Implement Separation in Managed En-Route Airspace

4.1.5 Enablers

The main Human, Procedural and System enablers to support provision of separation and de-confliction in the SESAR environment are:

- Collaborative infrastructure supported by SWIM allowing data sharing between airspace users and service providers - i.e. ATM systems, FOC, airport;
- Dissemination of the Network Operations Plan ;
- Collaborative delay and queuing management;
- Automated reporting of meteorological data, supported by datalink;
- Equipped aircraft with:
    - Data link applications - i.e. ADS-C, CPDLC, ADS-B/out and ADS-B/in;

- Multi-time constraints management – i.e. multiple RTA management linked to CTA and CTO (see Operational Improvement step **[*TS-0106*]**);
- 2D-RNP;
- Vertical navigational performance requirements and longitudinal constraint management enabling TMR;
- Airborne separation functions - i.e. ASAS separation;
- Conflict detection and resolution tools.

- Ground systems providing:
  - Data link applications supported by SWIM:
  - Trajectory uplinks[39];
  - Clearance to proceed[40];
  - Transfer of communications;
  - Traffic Information Service (TIS-B).
- Enhanced monitoring and resolution tools for the controller:
  - Medium Term Conflict Detection (MTCD);
  - Flight Path Monitoring Tool (FPM);
  - Trajectory prediction;
  - New and advanced tools – e.g. MTSA, Conflict Detection and Resolution tools, Tactical Controller Tools (TCT), Traffic Complexity Management (TCM) tools.

The en-route ASAS applications that are within the scope of the SESAR ConOps around 2020 are:

- Sequencing and Merging;
- Oceanic In-Trail Procedure;
- Crossing and Passing.

The definition of these applications and development of Operational Descriptions using ED-78A Methodology is a work in progress, primarily by the Requirements Focus Group (RFG).

The integration of ASAS applications into both SESAR and NextGen (refer to NextGen portal) is being addressed by the FAA/EUROCONTROL R&D Committee Action Plan 23 (AP23) via the development of a document that describes “The Operational Role of Airborne Surveillance in Separating Traffic” [41].

An overview of ASAS activity may be obtained via the ASAS portal [20].

A summary of these applications is included below.

4.1.5.1 Sequencing and merging operations (ASPA-S&M)

The objective is to redistribute tasks related to sequencing - e.g. in-trail following, and merging of traffic between the controllers and the flight crews. The controllers will utilise a

[39] Trajectory uplink includes all relevant information for RBT management – e.g. 4D segments, constraints.

[40] Including the Precision Trajectory Clearance parameters.

[41] The relevant work of Operational Descriptions for ASAS applications is being performed as a global activity and the Episode 3 DODs should refer to these activities.

new set of instructions allowing them, for example, to instruct the flight crews to establish and to maintain a given time or distance in trail from a designated aircraft. The flight crews will perform these new tasks using a suitable human machine interface. One anticipated benefit is increased capacity through better adherence to the ATC-requested spacing. The procedure is supported by Operational Improvement step **[*TS-0105*]**.

In-trail procedure in procedural airspace (ATSA-ITP)

This application permits a “climb-through” or “descend-through” manoeuvre to pass a “blocking” aircraft, using a distance-based longitudinal separation minimum with the blocking aircraft before the ITP manoeuvre begins[42]. This distance-based longitudinal separation minimum is less than the standard separation minimum applied in procedural airspace. The goal is to enable aircraft that desire flight level changes in oceanic and remote airspace to achieve these changes on a more frequent basis, thus improving flight efficiency and safety. Note that the procedure is designed so that there is no requirement to know the distance between the aircraft during the manoeuvre; the ITP tools could fail on the aircraft and the manoeuvre can still be completed. The procedure is supported by Operational Improvement step **[*CM-0701*]**. However it should be noted that notwithstanding the requirement not to know the distance between the aircraft, both air (ACAS) and ground safety nets (STCA) will need their algorithms tuned accordingly and this is described in Operational Improvement steps **[*CM-0804*]** and **[*CM-0805*]** respectively.

4.1.5.2 Enhanced crossing and passing operations (ASPA-C&P)

The objective is to provide the controller with a new set of procedures to solve conflicts directing, for example, the flight crews to cross or pass a designated traffic aircraft while maintaining a given spacing value. The flight crews will perform these new tasks using a human-machine interface. The main expected benefit is increased efficiency through the reorganisation and streamlining of tasks.

It should be noted that there have been negative initial results with regard to this application in that controllers are uncomfortable with the responsibility for separation within it. The Spacing (ASPA) application may well be dropped in favour of the applications in the Airborne Separation (ASEP) category described below.

4.1.5.3 Lateral crossing and passing (ASEP-LC&P)

The procedure allows an aircraft – i.e. the “clearance” aircraft, to cross or pass a “target” aircraft using ASAS. Responsibility for separation from the target aircraft is delegated to the flight crew of the clearance aircraft, although ATC remain responsible for separation of the clearance aircraft from all other aircraft. This responsibility is limited in time, space and scope for the duration of the Lateral Crossing procedure. Except in these limited specific circumstances where the flight crew takes responsibility for separation, ATC retains all other separation responsibility. The procedure is supported by Operational Improvement step **[*CM-0702*]**. As with ATSA-ITP air and ground safety nets will require to be retuned to take into consideration reduced passing minima **[*CM-0804*]** and **[*CM-0805*]**.

4.1.5.4 Vertical crossing and passing (ASEP-VC&P)

The ASEP-VC&P application will consist of scenarios such as Pass Above or Pass Below, in which an aircraft will be able to climb or descend two or more flight levels relative to a blocking aircraft such that during the vertical manoeuvre, the aircraft do not approach closer than some specified horizontal distance, until the vertical separation is recovered. There also

[42] In ASAS ITP the separation standards and the notion of who is the separator will be clearly defined for all the possible conditions in the procedure. ASAS is for others to define through standards. Any ASAS application will be part of the controller toolkit.

exist RVSM to non-RVSM transition scenarios which will support flight level transitions in the presence of opposing traffic when flying from RVSM to non-RVSM airspace.

4.1.6 Transition issues

None identified.

4.2 En-Route Support to Apply Safety Nets (A3.4)

4.2.1 Scope and Objectives

The Apply Safety Nets process allows both Controllers and Flight Crew to be informed with the actions of the ground-based systems - e.g. STCA, or the onboard systems - e.g. ACAS. Aircraft either airborne or on the ground, are thus able to monitor and carry out the appropriate actions - e.g. tactical instruction given to the Flight Crew by the Controller.

4.2.2 Assumptions

Safety Nets will operate independently of the SWIM Network and the prime recipients of the safety alerts will not rely upon a linkage with SWIM although the output from the safety nets and any RBT updates or revisions may be distributed via SWIM as well

Where coverage permits, Safety Nets will utilize surveillance/ADS data as the primary source of position information. Data linked position information may be used to enhance the accuracy of this information or extend the provision of safety net support into areas where no surveillance coverage exists (albeit with different parameters)

The use of the shared trajectory as the common view of flight intentions both in the air and on the ground will improve the reliability of STCA while reducing false alarm rates. STCA will be used as a safety net and not as a controller tool to manage separation.

The SESAR timeframe may see the introduction of Very Light Jets (VLJ) and UAVs which will operate in the higher levels of today’s jet traffic but at slower speeds. The logic built into the safety nets will permit these fleets to be operated in a mixed environment and the addition to complexity that the resultant blending incurs will be factored into the demand/capacity balance for the airspace before the associated SBT is validated

Expected Benefits, Issues and Constraints

In order to avoid common mode failures and keep safety critical system independent, safety nets are not sharing their input data. However, the expected benefits are linked to the sharing of the most accurate and up to date output data related to the processing information of the various safety nets:

- Improvement of detection and resolution advisories;
- Improvement of the awareness of both ground and air about the alarms, advisories or actions currently performed by the other party
- Decrease of false alarm rates and thus decrease of the controller task load.

However, some issues have to be resolved:

- Information sharing between air and ground safety nets should be taken into account carefully in order to apply the relevant filters allowing the right presentation of information to the human operators. Some information may be valuable for the enhancement of the tools processing but providing too much information to the operator may induce an increase of task load due to invalid triggers;

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- Collision avoidance is a critical situation both in terms of time and stress for the human operator; resolution advisories should be unambiguous and "unique" as there will be no time for evaluating alternatives.

Safety Nets are tuned to the environment in which they operate to ensure maximum efficacy in delivering their safety function. This ensures amongst other aspects the minimising of nuisance alerts.

A full evaluation of Safety Nets is a precursor for their deployment as mentioned by ASASA [21]:

"*It is a feature of ACAS II, which was well known prior to this work and which these studies have reinforced, that its performance is very sensitive to the characteristics of the airspace in which it is deployed. In particular the results of a study carried out in one airspace cannot be assumed to be applicable to an airspace with different characteristics.*"

The deployment, therefore cannot occur when the environment is not yet fully understood. In the evolution of ACAS there have been several updates with regard to the external changes, the arrival of RVSM flight levels and perceived effects - e.g. the introduction of the horizontal miss distance filter to reduce alerts from aircraft that would miss safely. Current TCAS provides advisory information in the vertical plane. The evolutions of ACAS may have to review this design paradigm – e.g. envisage horizontal resolution advisories.

4.2.3 Overview of Operating Method

This process encompasses the activities performed for aircraft still at the airport or in the air. It has been broken down into three sub-processes:

- Apply Safety Nets in the en-route Airspace;
- Apply Safety Nets in TMA;
- Apply Safety Nets at the Airport.

The following sub-section describes the en-route airspace activities. Safety nets at the Airport and in Arrival and Departure airspace are addressed in separate documents (refer to E1 DOD [8], E2/3 DOD [9] and E5 DOD [11]).

4.2.3.1 Apply Safety Nets in the En-Route Airspace (A3.4.1)

This process will allow the Controller to be informed of the actions of the onboard ACAS system or ground-based safety nets (i.e. Short Term Conflict Alert, Area Proximity Warning and Minimum Safe Altitude Warning), to be able to monitor and carry out the appropriate actions for ground-based safety nets - i.e. an open-loop tactical instruction given to the Flight Crew, in order to prevent collision with other aircraft or terrain. Correspondingly, the Controller should be aware of any actions taken by the Flight Crew for separation purposes as a result of an ACAS advisory. This will be enabled by Operational Improvement step **[*CM-0802*]**. At the same time it will be necessary to improve compatibility between airborne and ground safety nets (see **[*CM-0806*]**.

There is no discontinuity in the service provided by on-board safety net equipment while flying through different volumes of airspace - e.g. from an en-route to a TMA sector.

The main drivers for the process are the following:

- Inputs:
    - o None[43].
- Constraints/Triggers:

[43] The process is fed in by surveillance data.

  - None.
- Human Actors:
  - Flight Crew.
  - Sector Controller; (for situational awareness purposes)
- Outputs:
  - Tactical Instruction (Open Loop).

When separation provision and/or strategic de-conflicting have failed, the Apply Safety Nets in the en-route Airspace activity will take over with the support of airborne or ground-based safety nets. These tools are:

- Short Term Conflict Alert (STCA);
- Minimum Safe Altitude Warning (MSAW);
- Area Proximity Warning (APW);
- Airborne Collision Avoidance System (ACAS).

If the separation "failure" is detected by ground-based systems, the controller receives a warning that minimum separation, segregated airspace or terrain is predicted to be infringed. After evaluation of the possible alternatives to resolving the imminent conflict, the controller sends the relevant tactical instruction to the flight crew. This will lead to a deviation from the current RBT to prevent separation infringement.–Following resolution, the controller may then provide further instruction to resume its Agreed Trajectory.

If the separation assurance "failure" is detected by the aircraft, the airborne collision avoidance system provides a resolution advisory to the flight crew. The flight crew then follows the advisory – i.e. Tactical Instruction. This will lead to a deviation from the current RBT to prevent collision. The controller has been notified of the advisory. and is warned that the flight crew is reacting to a resolution advisory.-

The following Use Cases have been identified for Apply Safety Nets in En-Route Airspace process:

Use Case	Description
Ground-Based Safety Nets in Managed En-Route Airspace	The use case describes how a Controller is informed of the alarms of the safety net tools - i.e. STCA, APW, MSAW. The Controller monitors the system and carries out the actions needed to maintain separation.
ACAS avoids collision in Managed En-Route Airspace	The use case describes how a Controller is informed of the advisories of the ACAS system. The Controller monitors the system and carries out the actions needed to maintain separation with other traffic.

Table 6: Use Cases for Apply Safety Nets in the En-Route Airspace

4.2.4 Enablers

The main enablers that support collision avoidance in the SESAR environment are:

- Collaborative infrastructure supported by SWIM allowing data sharing;
- ATM Level 3 equipped aircraft - i.e. enhanced ACAS system;
- Ground systems providing enhance safety net applications:
  - STCA;
  - APW;

- MSAW.

4.2.5 Transition issues

None identified.

5 ENVIRONMENT DEFINITION

SESAR states that it will be able to include all capability levels within the concept. As with today's scenario no additional mandates are currently foreseen, except regarding safety-related issues. So fleet evolution is expected to be on the basis of identified benefit to airspace users.

5.1 AIRSPACE CHARACTERISTICS

European airspace is a single continuum with the only distinction being between Managed and Unmanaged airspace.

In Managed Airspace information on all traffic is shared and the predetermined separator is the separation provision service provider while in Unmanaged Airspace traffic may not share information and the predetermined separator is the airspace user. The role of separator in managed airspace may be delegated to the PIC, the separation provision being enabled by airborne separation and ASAS.

The trajectory management concept enables the dynamic adjustment of airspace characteristics to meet predicted demand with distortions to the business/mission trajectories kept to the absolute minimum. The co-ordination procedures established between the various units to reduce controller task load can often result in structural distortions to the trajectories. In the SESAR concept many of these procedures can be eliminated by the use of shared trajectories. The trajectory-based approach recognises that sufficient airspace volumes to meet military operational and training requirements will have to be provided and that military coordination and information sharing requirements will need to be accommodated.

With lower levels of tactical intervention, complexity management and longer look-ahead times for controller tools, it is likely that the future sectors will be larger than those in use today.

There may be increasing number of business jets, VLJs and UAVs, which may lead to increased complexity of the traffic.

There is pressure for aircraft trajectories to become more efficient and more environmentally friendly, e.g. through the use of Continuous Descent Arrivals (CDA). This will make the task of handling the traffic more complex. CDAs will affect the traffic in en-route airspace.

For further details refer to the General DOD [4].

5.2 TRAFFIC CHARACTERISTICS

Traffic will be characterised by the RBT resulting from the pre-departure CDM processes. Maximum levels of complexity and/or density will not be exceeded thanks to the pre-departure processes and subsequent dynamic DCB and Complexity Management in flight.

Within the scope of arrival management, aircraft may have a constraint - e.g. CTA included in their RBT. This will impact the en-route ATM task by reducing the en-route controller's scope for conflict management as controllers should ideally leave speed management to the flight crew in these circumstances. It may also introduce new tasks of issuing and updating CTA as well as dealing with situations where CTA cannot be respected.

For further details refer to the General DOD [4].

6 ROLES AND RESPONSIBILITIES

6.1 MAIN ROLES AND RESPONSIBILITIES

The ground-based actors involved in en-route operations either in the en-route Control Centre (ACC) or Airspace User's Operational Control Centre (AOC) are the:

- Executive Controller (EC);
- Multi-Sector Planner (MSP)/ Planning Controller (PC);
- Sub-Regional Network Manager;
- Airline Operational Control staff;
- Ground system.

An ACC sector organisation and staff deployment as follows:

- The Area of Responsibility (AoR) of the ACC will be divided into sectors (as today);
- Each sector will have an Executive Controller (EC) who will be able to communicate directly with the aircraft under his control via R/T and Air Ground datalink.

The **Executive Controller** responsibilities for separation and de-confliction will remain much the same as today. However, some new separation modes have been introduced (refer to Table 2) which will enable temporary delegation of the separation responsibility - i.e. separator role, with the flight crew. The impact of greater de-bunching of traffic and managing flows towards time goals has yet to be evaluated. In the SESAR environment the trajectory will be flown in a 4-D environment where the trajectory has been negotiated and is owned by the airspace user. Before the RBT is agreed potential interactions with other flights are taken into consideration. This agreement reduces but does not totally eliminate the potential for in-flight changes due to traffic. In high-density traffic environments, the use of speed assignments (TC-SA) to maintain the traffic flow without the risk of overtaking is one such occasion, however, the procedure has not yet been agreed amongst partners.[44]

The environment will favour the control via closed loop instructions[45]. The use of open-loop instructions such as headings will be infrequent and when issued, they will be quickly followed by a closed-loop instruction to retain the integrity of the RBT. Directs routings, when needed, e.g. proposed when speed variations cannot help the aircraft to meet time goals, will be planned and therefore closed-loop.

It is anticipated that improvement of the tools - e.g. MTCD or conformance monitoring, provided in order to enhance the situational awareness of the controller will supply better advisories and resolution alternatives leading to a decrease of the operator task load.

The EC will have a new mix of traffic to deal with:

- Flight on TTA;
- Flight on CTA/CTO;
- ATM Level 0 Traffic.

It may be necessary to distinguish aircraft involved in TC-SA separation or flying to a CTA/CTO – i.e. aircraft on RTA, from those that are not. Aircraft on an RTA should be left alone in terms of speed disturbance wherever possible.

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[44] ERASMUS has called the suitability of TC-SA into question. [7]

[45] Ability to control traffic using fewer but with a longer duration closed loop clearances.

The **Multi-Sector Planner (MSP)**, final evolution role of the Planning Controller, will be responsible for the planning of flights through a group of sectors. The MSP will be responsible for co-ordinating entry and exit conditions of each flight that penetrates the sector group with adjacent MSPs and for some degree of trajectory planning within the sector group. The MSP may have access to R/T and AGDL but would not normally communicate directly with aircraft. A Working MTCD is assumed with look-ahead time between 15 and 30 minutes[46], looking into other sectors and taking early action to solve problems. Above this there may be a Meta-sector planner who is the first MSP for the airspace in question. The tools that will be necessary for this role have not yet been defined.[47]

The **Sub-Regional Network Manager** is the Network interface actor to the en-route operations. This is the network actor with the most dynamic role in terms of traffic re-planning. A simple rule for determining the responsibility for changes in an aircraft trajectory is:

- If due to unexpected event, the modification involves a change in sector sequence - i.e. re-routing, then it is allocated to Network;
- If it does not it is allocated to ATC.

The **Airline Operational Control staffs in charge of operations during the execution phase are** responsible for the management of the flights associated with the airspace user he/she represents. Within the airspace user operations, organisation the AOC staff are the point of contact for all relevant CDM matters. When unexpected events occur, AOC staffs negotiate with the Sub-Regional Network Manager and with Planing controllers to try to achieve an RBT revision that is as close as possible to their objectives The AOC staff is also responsible for the communication with the flight crew of the associated impacts on the flight of such CDM/recovering decisions. The AOC staff is also responsible of the sharing - i.e. publishing, of the relevant data/modifications made in order to inform impacted counterpart of other stakeholders.

The air-based actors involved in en-route operations are:

- The flight crew;
- The airborne system.

The **Flight Crew/Pilot** is the ultimate actor responsible of the safe execution of the flight. However the role of the flight crew will evolve and more responsibilities are anticipated, mostly related to the extent of delegation of the role of separator to the flight crew. The flight crew is then responsible to operate the aircraft in accordance with the agreed trajectory - i.e. RBT, and the clearances - i.e. RBT clearances, or instructions - i.e. trajectory change instructions or tactical instructions, expressed by ATC.

The flight crew will be supported by advanced airborne systems providing automatic monitoring of the trajectory thanks to the constraints/containment parameters - i.e. TMR, conflict detection/resolution and separation manoeuvres.

The **Complexity Manager** assures that traffic complexity remains within the limits the controllers can cope with safely. This process supports an efficient provision of Separation Services in that it detects zones/volumes of high complexity and takes mitigation measures against overloads of Controllers.

The tasks of the Complexity Manager are to:

- Monitor the levels of complexity of traffic;

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[46] The look-ahead time and the interaction with airspace and sector size will have to be investigated.

[47] It is envisaged that the role of the MSP may involve that of complexity management as well as a “super planner” role. How the role is implemented in a multi sector planning area will be up to individual ANSPs. For example, some may wish the super planner role supporting conventional sector manning (PC plus EC), some may wish the role to supersede the sector PC and support multiple ECs etc.

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- Forecast traffic patterns;
- Assure the provision of information on upcoming congestion;
- Initiate CDM processes to find solutions to reduce complexity when needed;
- Verify applicability of proposed solutions of airspace users etc.

In general the complexity management role does not exist for military units.

The main interactions of the Complexity Manager are with Planning Controllers and Supervisor and with Sub-regional Network Manager, Airspace Users (AOCC), Airport Operations (APOC) and Airspace Manager. The tasks performed by this actor can also be subsumed by the MSP.

6.2 ACTORS' RESPONSIBILITIES IN THE ATM PROCESS MODEL

The following table summarizes the main actors and roles involved in en-route execution phase relating to the ATM processes:

Issue: SESAR WP 2.4.2 D3 (Actors Roles and Responsibilities) [25] states: "Complexity Management assures that traffic complexity remains within the limits the controllers can cope with safely. This process supports an efficient provision of Separation Services in that it detects zones/volumes of high complexity and takes mitigation measures against overloads of Controllers". Within this context the Complexity Manager (could also be seen as a role for the MSP) indeed could be a primary actor; needs further investigation to see whether this actor should be added.

Organisation/Unit	Individual Actor	Related Process(es)	Main Role(s) & Responsibilities
Air Navigation Service Provider/ En-Route (civil & military)	Planning Controller	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace A3.3.3.2 Implement Separation in Managed En-Route Airspace	The principal tasks of the Planning Controller are to check the planned trajectory of aircraft intending to enter the sector for potential separation risk, and to co-ordinate entry/exit conditions leading to conflict free trajectories. In the SESAR long term the role of the Planning Controller will evolve towards a multi-sector planning role in the en-route environment, which is supported by various tools like MTCD and CORA which - due to the more precisely predictable Business/Mission Trajectory - enable the planning of conflict free Business/Mission Trajectories through multiple sectors. Thus one planning will serve various Executive Controllers. Planning Controllers may also support the co-ordination of 4D solutions for/of AMAN/DMAN with adjacent centres. The Planning Controller provides services in en-route Units for both, civil and military units. The main interactions of the Planning Controller are with adjacent Planning Controllers and the appropriate Executive Controllers and also with the Complexity Managers within the domain of Air Traffic Control. The main roles of the Planning Controller are to: • Facilitate arrival queuing management; • De-confliction of RBTs.

Organisation/Unit	Individual Actor	Related Process(es)	Main Role(s) & Responsibilities
	Executive Controller	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace A3.3.3.2 Implement Separation in Managed En-Route Airspace A3.4.1 Apply Safety Nets in the En-Route Airspace	The principal tasks of the Executive Controller are to separate and to sequence known flights operating within his/her area of responsibility, and to issue instructions to pilots for conflict resolution. He/she is also responsible for the transfer of flights to the next appropriate Executive Controller and for co-ordination with the appropriate Planning Controller. In the SESAR long term the Executive Controller will still have to provide conventional ATC, but the task load per flight will decrease due to better pre-planning and de-confliction and automation support, e.g. datalink Services. The main focus of the controller's tasks will shift from active control to monitoring of Reference Business Trajectories. Under specific circumstances (e.g. for crossing and passing manoeuvres), separation responsibility may be delegated to flight crew of suitably equipped aircraft (airborne separation), but Executive Controller's monitoring of these flights will remain in such cases. Queue management tools will support the Executive Controller in the task of providing an optimum arrival sequence and solving conflicts in relevance with the CTAs. The main interactions of the Executive Controller are with adjacent Executive Controllers and appropriate Planning Controllers within the domain of Air Traffic Control and with the pilots – i.e. Flight Crew. The main roles of the Executive Controller are to: • Facilitate flight according to RBT and applicable rules – i.e. authorise the RBT; • Revise the RBT, if required; • De-confliction of RBTs; • Assure separation, if Separator; • Co-ordinate with the appropriate military and civilian controllers as required; • Avoid collisions.

Table 7: ANSP actors' roles and concerned processes

Organisation/Unit	Individual Actor	ATM process	Main Role(s) & Responsibilities
Airline, BA, GA, Military	Flight Crew/Pilot	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace A3.3.3.2 Implement Separation in Managed En-Route Airspace A3.4.1 Apply Safety Nets in the En-Route Airspace	The Flight Crew remains ultimately responsible for the safe and orderly operation of the flight in compliance with the ICAO Rules of the Air, other relevant ICAO and CAA/JAA provisions, and within airline standard operating procedures. It ensures that the aircraft operates in accordance with ATC clearances and the agreed Air-Ground Reference Business Trajectory (RBT). Responsibilities to assure airborne separation with regard to other aircraft may be delegated by ATC to the Flight Crew under specific circumstances. The Flight Crew will then be the separator using ASAS methods where safety or ATM system design does not require a separation provision service. The Flight Crew will be supported by the airborne system concerning automatic monitoring of trajectory management, automatic execution of spacing/S&M or separation/C&P, conflict detection and resolution and execution of the self separation manoeuvre. In commercial operations, the Flight Crew tends toward a system monitor and exception handling role. Main interactions of the Flight Crew are with the Airline Operations Control Centre within the domain of Airspace Users Operations and with Air Traffic Control. In summary, the main roles of the Flight Crew is to: • Conduct flight according to RBT and applicable rules; • Revise RBT, if required; • Assure separation, if Separator; • Avoid collisions; • Optimise queuing.

Table 8: Other actors' roles and concerned processes

7 REFERENCES AND APPLICABLE DOCUMENTS

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A ANNEX : Operational Scenarios

The ATC en-route part of the SESAR Concept relies on the use of closed-loop clearances and trajectory management using constraints.

The concept of SESAR 4-D trajectory management relies upon 4-D capable aircraft being able to negotiate trajectories with a system wide plan.

The controller during the ATC execution phase of the ATM system will have the same de-confliction and separation assurance responsibility as today. The use of ASAS would allow the delegation of some of these responsibilities to the pilot in command.

During the en-route phase, the en-route controller has to maintain, as far as possible, adherence to the 4D trajectory of the RBT and thus comply with a CTA/CTO or a renegotiated CTA/CTO.

The traffic arriving in the sector should be de-complexified and to some degree de-conflicted. The level of de-confliction is yet to be determined and there are bound to be variable levels of de-confliction depending on traffic demands and prevailing conditions within the ATM system – e.g. including weather.

Some examples of tactical environment experimental areas to explore are:

- Managing the consequences of a CTA becoming unattainable;
- Effect of reduced use of direct routing;
- Available strategies to achieve a CTA;
- Application and management of TMRs;
- Operations involving RBT through UPT, with or without pre-defined route included;
- Ground-based tools using FMS data.

The detailed description of those scenarios will be provided through individual files - i.e. one per identified scenario.

The following table summarises the scenarios that are specific to en-route operations.

This list will be refined to address the specific needs of en-route Management prototyping sessions and exercises.

Scenario[48]	Summary	Status
Executing delegated separation .	This scenario covers two ASAS Separation (ASEP) manoeuvres: ▪ Lateral Overtaking in en-route airspace; ▪ Vertical Crossing in en-route airspace. The technique is basically the same for crossing above, below or behind other traffic. In each case the Blue Jet aircraft (BJ123) is flying in En-route Managed Airspace; it is ATM-3 Capability Level equipped. The purpose of using ASEP techniques in en-route airspace is to enable a trajectory to be flown that is as close as possible to the optimum whilst also relieving the controller of separation provision and monitoring workload. The controller delegates responsibility to the PIC for a specific situation using an ASEP instruction. The controller remains responsible for providing applicable separation minima between all other aircraft and between all other aircraft and the aircraft involved in the ASAS Separation manoeuvre. The flight crew performs the ASEP manoeuvre applying appropriate airborne separation minima and wake vortex avoidance minima supported by onboard automation. The manoeuvre is complete and ASEP ends when the controller is able to re-assume separation responsibility under standard ground based separation minima.	**Not Planned within Episode 3**

[48] The following list of specific Scenarios is proposed by the Episode 3 team. This list will be refined to address the specific needs of En-Route operations.

Scenario[48]	Summary	Status
Responding to a new airspace exclusion .	Although airspace reservations are normally published in plenty of time to enable airspace users to take them into account in the planning of their trajectories, a new method, making maximum use of the possibilities of ASAS capable aircraft, is available for BJ123. When Blue Jet airways originally published their SBT, it was already known that at various points it passed through areas where military air activity was being planned. The military planners have also seen this (and all other SBTs) and had in fact scheduled the military activities to have the lowest possible impact on the trajectories. Obviously, eliminating all impact is impossible. However, they did see that BJ123 was ASAS-capable and that this flight was actually requesting self-separation in mixed mode for part of the trajectory. It was decided by the military planners that BJ123 would be allowed to keep its trajectory on the understanding that it would use its ASAS capability when it reached the affected area[49].	**Not Planned within Episode 3**

[49] This procedure is based on the extremely high reliability of the multiple communications channels BJ123 has. Should, nevertheless, a total communications failure occur, the procedures applicable for such situations (which still need to be investigated) would be activated and would also determine what the military flights would be allowed to do while BJ123 passed clear of the activity area.

Scenario[48]	Summary	Status
Flights in the Execution Phase in a 4D Environment	The year is 2020. All aircraft entering the en route airspace have Reference Business Trajectories (RBTs) (3D flight plan, initial and exit flight levels, and times which may be estimates, targets, or constraints.). Pilots are responsible for conforming to constraints in the RBT, and for revising the RBT if needed when there are no constraints. Controllers are responsible for facilitating the 4D trajectory. Once the aircraft enters the arrival manager (AMAN) advisory horizon (e.g. 200NM from destination airport), it may be tasked to achieve a Controlled Time of Arrival (CTA) at the Initial Approach Fix with a refined time window tolerance (±30s). Controllers use tools to plan conflict-free sector transits before the aircraft enter the concerned sectors and to monitor the evolution of the predicted conflicts within the sectors. Controllers issue instructions if needed to maintain separation, and in this case there is no re-negotiation of the RBT. There is no fixed route network in the airspace however there will be some structure for safety reasons and structure can be deployed from a catalogue of solutions in high density/complexity situations. Controllers may not expedite traffic (with direct-to instructions) nor issue open loop instructions (except for separation management) that may degrade the predictability of the 4D trajectory.	**Produced (OS-38)**
Negotiating a proposed ATC revision to the RBT .	A flight is progressing towards destination and has been issued with a CTA. At the arrival airport the wind is changing and a runway change is imminent. Precise meteorological forecasting combined with pre-defined operational processes assist in deciding on an optimum time for this change to occur. There will be a break between the last landing on the current active runway and the first landing on the new one; this requires that the inbound flow of traffic will have to be re-organised. The Airspace User is thus asked to provide a revised user-preferred route to the new runway.	**Not Planned within Episode 3**
Obtain a new TTA .	The departure airport has suffered a loss in capacity due to a runway closure. The arrival airport is operating at capacity. PINK Flight must obtain a revised TTA to fit around the available departure slot.	**Not Planned within Episode 3**

Table 9: Operational Scenarios identified for En-Route Operations in Managed Airspace

B ANNEX: Detailed Use Case

The following en-route Use Cases have been generated from the higher-level processes in the Process Model that have been described above. The Operational Concept and Overall ATM/CNS Target Architecture (refer to OATA portal) Use Cases have been taken into consideration and adapted when relevant and new Use Cases have been introduced.

The Use Cases will focus on the sector-level actors, but will address the interfaces with external actors and the operational impact of meeting time-based trajectory management requirements.

The detailed description of these Use Cases will be provided through individual files - i.e. one per identified Use Case[50].

Use Case	Status
Identification of Aircraft at ECAC Boundary	**Not planned within Episode 3**
Detect Conflict in Managed En-Route Airspace	**Not planned within Episode 3**
Resolve Conflict in Managed En-Route Airspace	**Not planned within Episode 3**
Handle Pilot Requests in Managed En-Route Airspace.	**Not planned within Episode 3**
Clear next portion of the RBT in Managed En-Route Airspace.	**Not planned within Episode 3**
Implement “ground based” Separation in Managed En-Route Airspace	**Not planned within Episode 3**
Implement ASAS applications in Managed En-Route Airspace	**Not planned within Episode 3**
Transfer of Control and/or Air/Ground Communications in Managed En-Route Airspace.	**Not planned within Episode 3**
Manage Traffic in En-Route with Respect to the AMAN Horizon	**Not planned within Episode 3**
Perform Transfer of Responsibility from Managed En-Route Airspace into ECAC Managed Airspace	**Not planned within Episode 3**
Handle Military Flight in Managed En-Route Airspace	**Not Planned within Episode 3**
Ground-Based Safety Nets in Managed En-Route Airspace	**Not Planned within Episode 3**
ACAS avoid collision in Managed En-Route Airspace	**Not Planned within Episode 3**

Table 10: Use Case summary

[50] Due to resource issues none of the identified Use Cases has yet been developed.

C ANNEX: OI Steps Traceability Table

The following table captures the SESAR Operational Improvements (OIs/OI Steps) addressed by the en-route operations. Although most of the OI Steps should be IP2, some of them might be IP1 (if their implementation is still part of the target system context) or IP3 (if their implementation starts in 2020).

OI Step	Description	Rationale	Related ATM Model Processes
Airspace User Data to Improve Ground Tools Performance *[L01-05]*			
Automatic RBT Update through TMR ***[IS-0305]***	The event-based Trajectory Management Requirements (TMR) logic is specified by the ground systems on the basis of required time interval and delta of current PT versus previously downlinked PT. TMR parameters can be static/globally defined or dynamic/flight-specific. This process is transparent to ATCOs and pilots.	The objective is to improve ground trajectory prediction by use of airborne data while optimising the communication bandwidth. The improvement may be in several steps starting with fixed/pre-defined periodic downlink.	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace 4.1.4.1 A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2

OI Step	Description	Rationale	Related ATM Model Processes
Use of Free Routes/4D Trajectories[51] *[L02-06]*			
Use of Free Routing from Terminal Area Operations-exit to Terminal Area Operations-entry ***[AOM-0503]***	The free routing is implemented from exit from/ to entry into Terminal Area Operations.	Free routing will be permitted when and wherever traffic density permits. Fixed routes will only be deployed when necessary to provide the required capacity.	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace 4.1.4.1.1 A3.3.3.2 Implement Separation in Managed En-Route Airspace. 4.1.4.1.2
Increasing Flexibility of Airspace Configuration *[L02-09]*			
Transfer of area of responsibility for trajectory management ***[SDM-0202]***	Improved interoperability allows areas of responsibility to be transferred between ATSUs according to demand identified through the publication of the RBT.	Assessment of demand through the evaluation of the RBTs will allow a more dynamic allocation of resources. Current procedures where LoAs between adjacent ATSUs allow controllers to work outside of their own AoR are extended through improved interoperability to make the procedure more dynamic and flexible.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2
'Generic' (non-geographical) controller validations ***[SDM-0203]***	Advanced automation support allows controllers to hold more generic validations (e.g. validation according to airspace type and tool-set) rather than validations for specific (geographic) sectors.	Generic procedures and therefore generic validations will allow greater flexibility to match ANSP resources to predicted demand.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2

[51] The development of Business Trajectory independent of a specific route network will provide more efficient routing but the implementation will be progressive to take in account the need for the ground ATM system to adapt with new tools, methods and procedures. The end objective is to provide free routes where and whenever traffic density permits. Many steps are envisaged as far as lower level, role of intermediate points at ACC/FAB boundaries, place of climbing/descending flight phase are concerned. The benefits are expressed in terms of flight efficiency and environment. The potential negative impact on safety and capacity need to be counteract through better trajectory prediction, air-ground data-link and efficient automated tools.

OI Step	Description	Rationale	Related ATM Model Processes
Management / Revision of Reference Business Trajectory (RBT) *[L05-01]*			
Successive Authorisation of Reference Business/Mission Trajectory (RBT) Segments using Data link ***[AUO-0302]***	Controller's clearances are sent to the pilot by datalink for the successive segments of the Reference Business/Mission Trajectory (RBT) along the flight progress (this includes taxi route in case of surface operations). Pilot's requests to controller for start-up, push back, taxi, take-off clearances, etc. are also transmitted by datalink.	The SESAR concept of operations utilises digital data communication applications and services as the main means of communication even though there will remain circumstances in which clearances and instructions are issued by voice. In the shorter term, datalink will be used in non-time critical situations and may be applied instead of or in combination with voice communications.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2
Revision of Reference Business/Mission Trajectory (RBT) using Data link ***[AUO-0303]***	The pilot is automatically notified by datalink of trajectory change proposals (route including taxi route, altitude, time and associated performance requirements as needed) resulting from ATM constraints arising from, for example, ad hoc airspace restrictions or closing of a runway. ATM constraints may also be expressed in terms of requests such as RTA in support of AMAN operation or runway exit in support of BTV operation. On the other hand, the controller is notified by datalink of aircraft preferences in terms of STAR, ETA, ETA min/max, runway exit, etc.	This improvement may be in two steps starting with the uplink of simple flight specific constraints displayed on a dedicated cockpit screen as any datalink message. In a next stage, more complex constraints can be automatically generated by ground tools, including MTCD, AMAN and DMAN, and proposed to the controller for approval; on the cockpit side, the agreed constraints may be automatically loaded into the FMS, leading to a new trajectory computed and proposed to the flight crew.	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace 4.1.4.1.1 A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2

OI Step	Description	Rationale	Related ATM Model Processes
Moving to coordination-free environment *[L05-04]*			
Coordination-free Transfer of Control through use of Shared Trajectory ***[CM-0402]***	A single version of the current aircraft clearance and its RBT is simultaneously available at all sectors. The aircraft's current trajectory when down linked permits each receiving ATCO to identify any inconsistencies between the expected (as per flight plan) aircraft performance and its actual.	Common trajectory information equally available to all sectors permits the validation of proposed sector entry and initial trajectory and flight plan information: removing requirements to verify clearance and routing information on handoff between adjacent sectors. Coordination is required in non-nominal situations and when either time critical information or trajectory changes must be negotiated.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2
Introducing Ground based Automated Assistance to Controller[52] *[L06-01]*			
Automated Flight Conformance Monitoring ***[CM-0203]***	The system provides the controller with warnings if aircraft deviate from a clearance or plan, and reminders of instructions to be issued.	The objective of this automation is to assist the controller in maintaining situational awareness and relieving him from some routine tasks. Conformance monitoring is also essential for triggering trajectory re-calculation for the detection of potential conflicts.	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace 4.1.4.1.1 A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2

[52] The main objective is to reduce ATCO's task load so as to increase ATC capacity.

OI Step	Description	Rationale	Related ATM Model Processes
ATC Automation in the Context of En Route Operations[53] *[L06-02]*			
Conflict Dilution by Upstream Action on Speed ***[CM-0403]***	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.	The objective is to reduce the number of residual conflicts, thus increasing sector safety and productivity while maintaining controllers in the decision-making loop. This air-ground cooperative and human-centred ATC automation allows transition towards further automation while respecting the operator cognitive processes and taking account the fact that only part of aircraft will be equipped. See SESAR Conops TC-SA (Trajectory Control Through Ground Based Speed Adjustments).	A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace 4.1.4.1.1
Enhanced Tactical Conflict Detection/Resolution and Conformance & Intent Monitoring ***[CM-0404]***	Advanced automation support for controllers including conflict detection and resolution, conformance monitoring (CM), intent monitoring (INT) and complexity monitoring. In combination these tools 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.		A3.3.3.1 Detect & Solve Conflict in Managed En-Route Airspace 4.1.4.1.1 A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2

[53] The recommended transition path is based on a set of three applications that would apply across all phases from business planning to execution and would range from full automation (full delegation to the machine) to lower automation (the computer acting as an adviser to the controller). The concept integrates the mix of equipage (data-link, 4DT or not) and both conventional and PTC modes.

OI Step	Description	Rationale	Related ATM Model Processes
Arrival Traffic Synchronisation *[L07-01]*			
ASAS Sequencing and Merging as Contribution to Traffic Synchronization in TMA (ASPA-S&M) ***[TS-0105]***	The flight crew ensures a spacing from designated aircraft as stipulated in new controller instructions for aircraft spacing. The spacing could be in time or space. The controller remains responsible for providing separation between aircraft. The crew is assisted by ASAS and automation as necessary.	The flight crew ensures a spacing from designated aircraft as stipulated in new controller instructions for aircraft spacing. The spacing could be in time or space. The controller remains responsible for providing separation between aircraft. The crew is assisted by ASAS and automation as necessary.	Sequencing and merging operations (ASPA-S&M) 4.1.5.1
Multiple Controlled times of Over-fly (CTOs) through use of data link ***[TS-0106]***	The CTOs (Controlled Times of Over-fly) are ATM imposed time constraints set on successive defined merging points for queue management purposes. The CTOs are computed by the ground actors on the basis of the estimated times provided by the airspace user (airline operation centre or flight crew). They have to be met by the aircraft with the required performance.	The CTOs allow performing precise sequencing on intermediate merging points in en-route and thus supporting the TMA sequencing.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2
Arrival Management Extended to En-Route Airspace ***[TS-0305]***	The system integrates information from arrival management systems operating out to a certain distance (e.g. 200 NM) to provide an enhanced and more consistent arrival sequence. The system helps to reduce holding by using speed control to absorb some of the queuing time.	The objective is to prepare arrival sequence earlier in the En-route phase of the flight in order to maximise efficiency in TMA.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4

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OI Step	Description	Rationale	Related ATM Model Processes
Precision Trajectory Operations *[L08-02]*			
Precision Trajectory Clearances (PTC)-2D On User Preferred Trajectories ***[CM-0603]***	Vertical constraint and longitudinal separation is provided by ATC to complement the 2D route. This may be achieved through surveillance based separation and/or the dynamic application of constraints. New support tools and procedures and working methods have to be put in place.	The objective is to assure closed-loop clearances in order to reduce the need for tactical intervention, and favour to minimise open-loop headings.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2
Precision Trajectory Clearances (PTC)-3D On User Preferred Trajectories (Dynamically applied 3D Precision Trajectory Routes) ***[CM-0604]***	Longitudinal separation is provided by ATC to complement the 3D Precision Trajectory Routes. This may be achieved through surveillance based separation and/or the dynamic application of constraints. New support tools and procedures and working methods have to be put in place. This mode relies on aircraft capabilities enabling the vertical containment of the trajectory (3D tube).	Precision trajectory clearances take advantage of the capabilities offered by ATM Capability Level 1/2/3 aircraft in terms of navigational performance and constraint management. The goal is to enable controllers, supported by conflict prediction and resolution tools and conformance and intent monitoring, to manage a significant increase in traffic while keeping total task load at acceptable levels.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2
ASAS Spacing and ASAS Cooperative Separation *[L08-04]*			
Ad Hoc Delegation of Separation to Flight Deck - In Trail Procedure (ASEP-ITP) ***[CM-0701]***	The In-Trail Procedure - for use en-route in an oceanic environment - allows climbs and descents with temporarily reduced longitudinal separation minima. A limited transfer of separation responsibility between the controllers and aircrews is assumed (i.e. the duration of the ITP climb or descent). The flight crew has to monitor and maintain spacing to specific aircraft during the manoeuvre.	The benefits will be to discharge the controller, by delegation of tasks to the flight crew and to minimise the impact of conflict resolution on trajectory.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2

OI Step	Description	Rationale	Related ATM Model Processes
Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P) ***[CM-0702]***	The Crossing and Passing applications (incl. Lateral crossing and passing; Vertical crossing and passing) allow an aircraft to cross or pass a 'target' aircraft using ASAS.	The benefits will be to discharge the controller, by delegation of tasks to the flight crew and to minimise the impact of conflict resolution on trajectory.	A3.3.3.2 Implement Separation in Managed En-Route Airspace 4.1.4.1.2
Safety Nets Improvements (TMA, En Route) ***[L09-01]***			
ACAS Resolution Advisory Downlink ***[CM-0802]***	Controllers are automatically informed when ACAS (airborne collision avoidance system) generates an RA (resolution advisory). This improvement is intended to complement the voice report by the pilot.	The objective is to inform controllers of an RA event faster, more reliably and in a structured way, and hence increase controller's situational awareness in critical situations.	A3.4.1 Apply Safety Nets in the En-Route Airspace 4.2.3.1
Enhanced ACAS through Use of Autopilot or Flight Director ***[CM-0803]***	ACAS is combined with Auto Pilot (automatic control of aircraft) or Flight Director (display of commands to assist the flight crew in controlling the aircraft) in order to provide a vertical speed guidance using ACAS target. This would be an automatic manoeuvre if the autopilot is on (or a manual manoeuvre through flight director cues if autopilot is off). Monitoring is ensured through the display of the vertical speed indicator and at any moment the pilot can override the automatism.	The objective is to provide controllers with a reliable alerting system based upon all the surveillance information available.	A3.4.1 Apply Safety Nets in the En-Route Airspace 4.2.3.1
ACAS Adapted to New Separation Modes ***[CM-0804]***	The ACAS function is adapted to new separation modes, in particular if lower separation minima are considered.	In part as a result of the introduction of the delegation of the role of separator, aircraft may fly in close proximity to each other with geometries that would trigger ACAS as known today unless the system is made capable of recognising situations where such new separation modes are being applied.	A3.4.1 Apply Safety Nets in the En-Route Airspace 4.2.3.1

OI Step	Description	Rationale	Related ATM Model Processes
Short Term Conflict Alert Adapted to New Separation Modes ***[CM-0805]***	The STCA is adapted to new separation modes, in particular if lower separation minima are considered.	In part as a result of the introduction of the delegation of the role of separator, aircraft may fly in close proximity to each other with geometries that would trigger ACAS as known today unless the system is made capable of recognising situations where such new separation modes are being applied.	A3.4.1 Apply Safety Nets in the En-Route Airspace 4.2.3.1
Improved Compatibility between Ground and Airborne Safety Nets ***[CM-0806]***	ACAS and STCA are and need to stay independent at functional level. There is a need to have better procedures to avoid inconsistent collision detection and solution. Information sharing is to be considered cautiously, to avoid common mode of failure.	The aim is to ensure that in accordance with the predefined rules and the prevailing circumstances the pilot, the controller or both get a warning and resolution advisory in a way which preserves their common situational awareness.	A3.4.1 Apply Safety Nets in the En-Route Airspace 4.2.3.1

Table 11: Operational Improvements addressed

D ANNEX: Hot Topics

The following list identifies those areas of CONOPS definition where either, a consensus amongst partners is not yet reached or, where the concerned topic needs elevating to the SJU for resolution by WPB and/or the operational/technical threads WPs. To assist in identification of the concept detail under discussion, each topic is hyperlinked to the appropriate text in the document.

1. How will the aircraft return to the RBT after an open loop instruction? The confidence in the downstream portion of the RBT is not clear. After an open loop instruction the RBT will be held in abeyance until such times as the integrity of the RBT is restored or a revised RBT agreed. The open loop instructions are limited to updates, i.e. non-compliance with TMRs.

   Two kinds of open loops are envisaged: one that the ground system will automatically close after a defined time parameter, and another that is a permanent open loop (e.g. fixed heading.) This last one will not be used in SESAR environment, i.e. no open loop will be used

   The question remains, however, of how the aircraft systems will handle an open loop instruction. [Ref: 2.2 ATM Processes Described in the Document.

2. VFR rules within Managed Airspace still to be determined. [Ref: 3.2 Aspects of Today's Operations that will Change]

3. Will "successively cleared" imply a clearance limit with regard to the RBT meaning that the flight crew will need to receive and acknowledge a succession of clearances, or will it imply a seamless process only constrained by the horizon of the controller tools which is transparent to the flight crew? [Ref: 4.1.1 Scope and Objectives]

4. The efficacy of the TC-SA concept has come into question by ERASMUS project [19] and the WP4 Expert Group [34] The concept needs verification prior to inclusion in further SESAR planning. [Ref: 4.1.4.1.1 Detect and Resolve Conflict in Managed En-Route Airspace]. See also 8 below.

5. In ConOps terms does the authorised segment constitutes an ATC "clearance" that is legally compatible with the ICAO definition and global understanding? [Ref: 4.1.4.1.2 Implement Separation in Managed En-Route Airspace]

6. The process of how the Flight Crew unilaterally revise the RBT for self-separation purposes needs further investigation and elaboration. For example, what will be the impact on TMR and the ground version of the trajectory and controller tools? [Ref: 4.1.4.1.2 Implement Separation in Managed En-Route Airspace]

7. WP4 Expert Group [34] has questioned the feasibility and nature of CDM during the execution phase itself. Further research may be required regarding the effectiveness, or even desirability given the limited time window that might be available, of this procedure. [Ref: 4.1.4.1.2 Implement Separation in Managed En-Route Airspace]

8. WP4 EG [34] suggests that the Executive Controller must be informed regarding the automatic employment of speed control by the System. The mechanism for issuing such clearances has not yet been determined. ERASMUS [19] has called the suitability of the TC-SA concept into question. Should the concept be deleted entirely or flagged with a cautionary note is an issue that needs to be addressed. [Ref: 6.1 Main Roles and Responsibilities]. See also 4 above.

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