SESAR Definition Phase

Deliverable 3

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The ATM Target Concept

DLM-0612-001-02-00

DELIVERABLE D3

V2.0

The ATM Target Concept

SESAR Ex Com
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We, Representatives of the Global Consortium Members within the SESAR Executive Committee, hereby approve the following D3 document for submission to the Purchaser ("EUROCONTROL") by the Project Directorate:

Document D3

Document No: DLM-0612-001-02-00 (accepted document)

Document Title: The ATM Target Concept

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Preface

The SESAR programme is the European Air Traffic Management (ATM) modernisation programme. It will combine technological, economic and regulatory aspects and will use the Single European Sky (SES) legislation to synchronise the plans and actions of the different stakeholders and federate resources for the development and implementation of the required improvements throughout Europe, in both airborne and ground systems.

The first phase of SESAR, the Definition Phase, is co-funded by EUROCONTROL and the European Commission under Trans European networks. The products of this Definition Phase will be the result of a 2-year study awarded to an industry wide consortium supplemented by EUROCONTROL's expertise. It will ultimately deliver a European ATM Master Plan covering the period up to 2020 and the accompanying Programme of Work for the first 6 years of the subsequent Development Phase.

The SESAR Definition Phase will produce 6 main Deliverables over the 2 years covering all aspects of the future European ATM System, including its supporting institutional framework. The scope of the 6 Deliverables (Dx) are:

- D1: Air Transport Framework – the current situation;
- D2: Air Transport Framework – the Performance Target;
- D3: Definition of the future ATM Target Concept;
- D4: Selection of the "Best" Deployment Scenario;
- D5: Production of the ATM Master Plan;
- D6: Work Programme for 2008-2013.

The SESAR Consortium has been selected to carry out the Definition Phase study, which for the first time in European ATM history has brought together the major stakeholders in European aviation to build the ATM Master Plan. The SESAR Consortium draws upon the expertise of the major organisations within the aviation industry. This includes Airspace Users, Air Navigation Service Providers (ANSPs), Airport Operators and the Supply Industry (European and non-European), plus a number of Associated Partners, including safety regulators, military organisations, staff associations (including pilots, controllers and engineers) and research centres who work together with the significant expertise of EUROCONTROL. This is considered to be a major achievement.

The third Deliverable, D3, has been produced in accordance with its Milestone Objective Plan (MOP) [Ref 1] and the inputs of the twenty-five Task deliverables (DLT) which are providing the substantiating information and which are identified within the SESAR Work Breakdown Structure. It has been subsequently approved and accepted by all Project Participants.

The SESAR Consortium members:

AEA (Association of European Airlines), ADP (Aéroports de Paris), AENA (Aeropuertos Espanoles y Navegacion Aérea), AIRBUS, Air France, Air Traffic Alliance E.I.G/G.I.E, Amsterdam Airport SCHIPHOL, Austro Control GmbH, BAA (British Airports Authority), BAE Systems, DFS Deutsche Flugsicherung GmbH, Deutsche Lufthansa AG, DSNA (Direction des Services de la Navigation Aérienne), EADS (European Aeronautic and Space Company), ENAV S.p.A. (Società Italiana per l'Assistenza al Volo), ERA (European Regions Airline Association), FRAPORT, IAOPA

(International Council of Aircraft Owner and Pilot Associations), IATA (International Air Transport Association), Iberia, INDRA Sistemas SA, KLM (KLM Royal Dutch Airlines), LFV (Luftfartsverket), LVNL (Luchtverkeer Nederland), Munich International Airport, NATS (National Air Traffic Services), Navegaçao Aérea de Portugal (NAV), SELEX Sistemi Integrati, THALES Air Systems S.A., THALES AVIONICS.

The SESAR Associated Partners:

ATC EUC (Air Traffic Controllers European Unions Coordination), Boeing, CAA UK (Civil Aviation Authority UK), ECA (European Cockpit Association), ELFAA (European Low Fare Airlines Association), ETF (European Transport Workers' Federation), EURAMID (European ATM Military Directors), IFATCA (International Federation of Air Traffic Controllers' Associations), IFATSEA (International Federation of Air Traffic Safety Electronics Association), Honeywell, Rockwell-Collins, Dassault (representing EBAA). Research Centres: AENA (Aeropuertos Espanoles y Navegacion Aérea), DFS Deutsche Flugsicherung GmbH, DLR (Deutsches Zentrum für Luft – und Raumfahrt), DSNA (Direction des Services de la Navigation Aérienne), INECO (Ingenieria y Economia del Transporte, S.A.), ISDEFE (Ingenieria de Sistemas para la Defensa de Espana), NLR (Stichting Nationaal Lucht- en Ruimtevaartlaboratorium), SICTA (Sistemi Innovativi per il Controllo del Traffico Aereo), SOFREAVIA (Société Française d'Etudes et de Réalisations d'Equipments Aéronautiques).

Executive Summary

SESAR Consortium agreement on the ATM Target Concept for implementation by 2020

As the European Air Traffic Management System is operating close to its limits, and is facing the challenge of continuously growing demand in air transport all categories of ATM stakeholders collaborate through the SESAR programme. As part of the work described in this D3 document the SESAR Consortium has produced and agreed the ATM Target Concept, i.e. its Concept of Operations (ConOps), its Architecture and supporting Technologies, associated human aspects, necessary institutional enablers and business aspects.

In the previous SESAR Milestone Deliverable document D2, the SESAR Consortium defined initial, indicative Performance Objectives and Targets for the European ATM Target System for 2020 and beyond so as to address the current shortcomings identified in D1. They have been further updated during the D3 Milestone activities. In continuation of this performance-based approach, the SESAR Consortium developed the ATM Target Concept, enabling the European ATM System with the objective of meeting these performance targets by 2020. To accommodate a 3-fold increase in capacity, the ATM Target Concept considers promising further developments that, subject to further R&D, will help achieving the longer-term performance objectives beyond 2020. It is based on a thorough and systematic survey and assessment of all known projects and ideas.

Global Interoperability is of major importance for the development of the ATM Target Concept. Compliance with the ICAO Operational Concept Document has been the objective from the outset and will be the basis for convergence with worldwide on-going initiatives (e.g. NextGen in the USA). As the ATM Target Concept is formed around the 4D Trajectory as the core of the System, a major requirement is to change the current ICAO Flight Plan into a 4D Trajectory with a common definition and exchange format.

The ATM Target Concept is not about one size/one solution fits all; it offers different concept features which can be tailored to the specific local needs to meet the local performance objectives and their evolution in the life time of SESAR. It addresses the needs of all Airspace Users operations.

The SESAR Consortium has achieved agreement on the 2020 ATM Target Concept. Work to date suggests that it is sufficiently promising to justify continuing the SESAR Definition Phase. Further validation and development of the ConOps will take place as part of the SESAR Development Phase.

The key features of the high performing ATM Target Concept in 2020

The ATM Target Concept follows a service-oriented approach based on a performance partnership amongst stakeholders.

The stakeholders agree that, in order to strengthen the air transport value chain, the Airspace Users' requirements need to be better accommodated. To this end, each single flight shall be executed as close as possible to the intention of its owner. This is the main driving principle for the ATM Target Concept, which is centred around the characteristic of the business trajectory (for military "mission trajectory") representing an Airspace User's intention with respect to a given flight. Air traffic management services necessary to execute this trajectory will ensure that it is carried out safely and cost efficiently within the infrastructural and environmental constraints.

Changes to the business trajectory must be kept to a minimum, altering it only for reasons of separation and/or safety or in case the Airspace Users' and ATM network goals (relating to capacity, environment and economic performance) are best met through maintenance of capacity and throughput rather than optimisation of an individual flight. In the case of unplanned disruptions the overall ATM network goals will take precedence over individual flight trajectories.

Changes will ideally be performed through a Collaborative Decision Making mechanism but without interfering with the pilots' and controllers' tactical decision processes required for separation provision, for safety or for improvement of the air traffic flow.

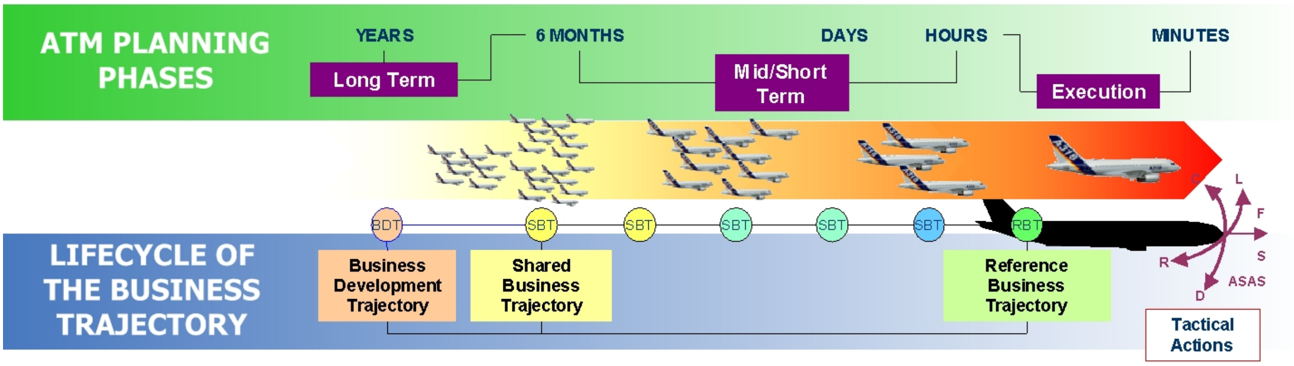

Figure 1: The Business Trajectory lifecycle

Business trajectories will be expressed in all 4 dimensions (position and time) and flown with much higher precision than today. Sharing access to accurately predicted, unique 4D trajectory information will reduce uncertainty and give all stakeholders a common reference, permitting collaboration across all organisational boundaries.

Fundamental to the entire ATM Target Concept is a 'net-centric' operation based on

- A powerful information handling network for sharing data;
- New air-air, ground-ground and air-ground data communications systems, and
- An increased reliance of airborne and ground based automated support tools.

The ATM ConOps for 2020

The ATM Concept of Operations for 2020 represents a paradigm shift from an airspace based environment to a trajectory-based environment.

- **Trajectory Management is introducing a new approach to airspace design and management;**

  Trajectory-based operations imply a new approach to airspace design and management to avoid, whenever possible, airspace becoming a constraint on the trajectories. Airspace User preferred routing, without pre-defined routes will be applicable everywhere, other than in some terminal areas and below a designated level in some areas. The only exception considered is a situation when sufficient capacity can only be provided through the use of structured routes, which at the same time shall decrease holding queues in the air and on the ground. However, such structured routes will only be activated when needed.

Integration of the needs of Military (operators and service providers) alongside civilian stakeholders will ensure the overall efficiency of the ATM network. Military needs regarding access to and flexible use of airspace, including the provision of sufficient airspace volumes to meet operational and training requirements, is safeguarded by the ConOps. No other segregation is considered required by the ATM Target Concept.

Only two categories of airspace will be defined and organised: managed airspace where a separation service will be provided but the role of the separator may in some cases be delegated to the pilot and unmanaged airspace where the separation task lies solely with the pilot.

- **Collaborative planning continuously reflected in the Network Operations Plan;**
  Collaborative layered planning undertaken at local, sub-regional and European level will balance capacity and demand taking into account constraints and diverse events. An efficient queue management will allow optimized access to constrained resources (mainly airports). The results of these processes will be permanently reflected in a continuously updated Network Operations Plan ensuring a degree of strategic de-conflicting whilst minimising holding and ground queues. In the event of a capacity shortfall, Airspace Users will be offered the possibility to determine a priority order between themselves for those flights affected by delays and to achieve their business objectives.

- **Integrated Airport operations contributing to capacity gains;**
  Airports will become an integral part of the ATM system due to the extension of trajectory management. Increased throughput and reduced environmental impact (through e.g. turnaround management, reduction of the impact of low visibility conditions, etc.) is envisaged. With improved Airport Resource Planning processes there will be greater coordination between the stakeholders and thereby improved use of available capacity to meet the increased demand.

- **New separation modes to allow for increased capacity;**
  New separation modes gradually being implemented over time, supported by controller and airborne tools, will use trajectory control and airborne separation systems to minimize potential conflicts and controllers' interventions.

- **System Wide Information Management – integrating all ATM business related data;**
  Underpinning the entire ATM system, and essential to its efficient operation, is a System Wide Information Management (SWIM) environment that includes aircraft as well as all ground facilities. It will support collaborative decision-making processes using efficient end-user applications to exploit the power of shared information.

- **Humans will be central in the future European ATM system as managers and decision-makers;**
  In the ATM Target Concept it is recognised that humans (with appropriate skills and competences, duly authorised) will constitute the core of the future European ATM System's

operations. However, to accommodate the expected traffic increase, an advanced level of automation support for the humans will be required. The basic principles of an automation strategy have been established and are clearly outlined within the SESAR Definition Phase activities. The nature of human roles and tasks within the future system will necessarily change. This will affect system design, staff selection, training (especially for unusual situations and degraded mode of operations), competence requirements and relevant regulations. Recruitment, training, staffing and competence implications have been evaluated and will be considered when the SESAR Development Phase has progressed sufficiently to support the change of the roles and responsibilities of all the actors within the ATM System up to a successful implementation of the ATM Target Concept.

<u>The ATM System architecture and technologies for 2020</u>

The ATM Target Concept has been designed to support Airspace Users' operations with different levels of ATM capability ranging from those available today up to those anticipated beyond 2020 allowing for a smooth transition. The ATM Target Concept will offer different levels of ATM services but should not use these capabilities to segregate access to airspace or airports.

The **ATM System architecture** is defined to support the 2020 ConOps, servicing aircraft with the flexibility and adaptability to adjust to changing traffic flows, performance requirements and different local conditions while capitalising on the current developments. Solutions have been proposed to implement SWIM (including the management of its security and its safety), which is a corner stone of the future European ATM System. The SWIM environment will shift the ATM architecture paradigm from message exchange to information publishing/using/contributing where the definition of the data and associated services are crucial.

It is recommended that, within the SESAR Development Phase, the architecture will be developed making use of an Enterprise Architecture methodology ensuring better alignment between the Information Technology systems and the Air Traffic Management business. It will based on a service oriented architecture, which will clearly distinguish between the ATM services that have to be provided, the underlying supporting services and the physical assets that will need to be deployed.

Technology enablers meeting the identified operational and architecture requirements in providing and distributing the information in time and to the right location with the required availability, continuity and integrity have been identified:

- The communication systems will increasingly use digital technology and protocols to a full integration of terrestrial and satellite networks towards a data network connecting all ATM sub-systems.
- The primary navigation system will be satellite based with a terrestrial fall back solution to mitigate against a potential full blackout of satellite navigation services.
- New surveillance systems e.g. ADS-B will increasingly provide improved 4D-trajectory information (position and time).

<u>Performance Analysis of the ATM Target Concept for 2020</u>

The performance assessment process in this SESAR Milestone Deliverable D3 has built on the basis of the Performance Framework and the initial Targets first introduced in D2, and has focused on the ATM Target Concept for 2020.

The preliminary assessment of the ATM Target Concept indicates that it has the potential to meet the capacity targets defined in D2 except in a few identified areas. Notably certain major congested hub airports and some high-density terminal airspace areas at major network nodes are seen as potential bottlenecks and will be severely constrained.

Consequently, additional capacity needs to come from new runways complemented by the greater use of regional and other uncongested airports (including military airports) to satisfy the demand.

Capacity will be provided with the required level of safety and security while minimizing the environmental impact. The assessment of the other performance areas shows positive contributions from the concept.

The achievement of the **capacity targets** will be supported by:

- 4D Trajectory Management;
- New separation modes;
- Wide availability of controller support tools;
- Collaborative planning and balancing of traffic demand and capacity;
- Reduction in trajectory uncertainty and
- Improved airport processes.

The major contribution to **safety performance improvement** will come from better planning, increased situational awareness and automated tools detecting all aircraft interactions at a far earlier stage than current methods allow. In order to show evidence of these expected safety benefits, the potential risk contributions need to be identified by continuous appropriate screening for any safety issues during the development and deployment of the ATM Target Concept and by developing appropriate safety assessment methodologies and procedures.

Security aspects of the ATM Target Concept have been analysed in respect of self-protection and collaborative security support. In order to show evidence of the expected security benefits, the potential risk contributions need to be identified by continuous appropriate screening for any security issues during the development and deployment of the ATM Target Concept and by developing appropriate security assessment methodologies and procedures.

Matching the societal expectation of a 10% CO_2 emission reduction per flight is considered as challenging. Nevertheless, the ATM Target Concept will **minimise the environmental impact** that can be attributed to ATM in terms of noise, local air quality, additional fuel burn and the related CO_2 emissions by optimizing the flight trajectories and lessening gaseous and particulate emissions on the surface by minimising holding and ground queues.

Cost Benefit Analysis/Cost Assessment – a main consideration within SESAR

A **preliminary cost assessment** has been performed which provides initial indications of the magnitude of the total costs associated with the R&D, implementation and operation of the ATM Target Concept for all stakeholders. This is considered to be a considerable achievement. It should be noted that this cost assessment has been based on a number of assumptions which will be further refined in the SESAR Milestone Deliverable D4 as well as during the SESAR Development Phase.

The SESAR Target Concept is likely to be affordable and economically viable to all stakeholders only under the following conditions: (on the benefits side) if the cost-effectiveness target is met and capacity and quality of service targets are met to their greatest extent, (on the cost side) if global interoperability (e.g. with NextGen) is achieved allowing significantly reduced forward fit costs. However, the results of Milestone 3 are not conclusive with regard to the questions of affordability and economic viability. A low benefit to cost ratio is currently expected, therefore the investment in the ATM Target Concept should be seen as long-term and strategic in nature which would justify the need for public funding for implementation.
Especially for General Aviation, the rate between costs and benefits is critical and requires further consideration. Also the distribution of costs and benefits for the military will need further study.

A major critical factor for the successful implementation of the SESAR ATM master plan is the full alignment of the implementation plans of all partners. In order to overcome the misalignment of ANSP investments until 2013 a contribution of public grants for impaired assets of ANSPs during the pre-implementation phase has been estimated. For the benefits of all stakeholders the set-up of special purpose financing structures to finance the investments necessary for the implementation of the SESAR ATM master plan is recommended.
The initial ATM Target Concept assessment results show that the direct cost of providing gate-to-gate ATM services, in an unconstrained traffic increase scenario, could reduce from €800 to an average of €450 (up to €600 for highly complex airspace) per flight when fully implemented. In order to fully achieve the initial cost-effectiveness target (€400 per flight) additional measures, external to the scope of the SESAR programme but within the framework of the Single European Sky (e.g. de-fragmentation of service provision), will be needed.

<u>Means for the implementation of the ATM Target Concept by 2020</u>

A main proposed characteristic of the way the 2020 ATM industry will conduct business is the existence of the ATM Performance Partnership (ATMPP). To be successful, the ATMPP must achieve genuine participation and buy-in from ALL stakeholder groups[1]. It must provide added value by producing coordinated and consistent positions to a level not achieved prior to the SESAR Definition Phase. The arrangements to achieve this will be particularly complex for those groups whose members are not corporatised (e.g. Military, General Aviation). Regulatory decisions, which must be enforceable (e.g. changes to mandatory aircraft equipage) will remain within the Institutional and Regulatory Framework, although it is anticipated that the improved discussion process enabled by the ATMPP, including full discussion with regulatory representatives, will permit preparation and development in a timelier manner. The ATMPP will coordinate stakeholder views as inputs to existing organisations or parts of organisations and, over a period of time the role of the ATMPP could establish itself with respect to these organisations.

At a pragmatic level, **there should be no outright legal showstoppers** at European Level to the ATM Target Concept. Variation between national laws in some areas may complicate specific issues

[1] Civil Airspace Users (both Commercial and General), Military, ANSPs, Airports, Supply Industry and Social Partners.

but not to the point where harmonisation is essential. However promising concepts such as the full implementation of self-separation will require major changes in European and global legislation to ensure the necessary technical and operational harmonisation.

For the environment regulations, the institutional arrangements should provide a pan-European environmental sustainability coordination mechanism/process to establish an inward facing pan-ATM guidance, performance monitoring and assessment role, together with a formal external liaison and advisory role with relevant industry, policy, legislative and regulatory bodies. In this respect, airports should be encouraged and offered guidance to produce a strategic business plan, of appropriate scope for their scale, and which is fully integrated with local land-use planning allowing planned growth (onus on planning authorities). In support of this, there should be adequate supervision of ATM relevant planning restrictions at national and international level (through EU working arrangements) to ensure that the implementation of the SESAR programme is not compromised.

Future developments of the ATM Target Concept should include clarification of the new roles and responsibilities in order that the legal implications and liability issues, as well as the **ATM safety responsibilities** and new interfaces between stakeholders may be assessed. It is recognised, that adequate change and transition management supports and contributes to aviation safety. The ATM Target Concept will require significant changes to technology, both on the ground and in the air, and this will need to be developed within a **clear safety regulatory** framework where safety responsibilities are unambiguously defined. A close civil-military interaction and the involvement of appropriate military expertise within this safety regulatory authority will be an essential requirement. Recommendations have been established to address these safety concerns during the SESAR Development Phase. Moreover, there is potentially a significant amount of European and worldwide regulations which will be subject to **change in the area of training and verification of competence for operational and technical staff**.

<u>Transition towards the implementation of ATM Target Concept has already started</u>

In order to consider the feasibility of the transition prior to Milestone 4 the contribution of on-going ECIP/LCIP or sub-regional initiatives to the ATM Target Concept has been assessed. It has been concluded that these initiatives are already establishing foundations for the ATM Target Concept such as Airspace organisation simplification and cooperative management, Layered planning and Network Operation Plan, SWIM and automation.

The implementation of the ATM Target Concept has already started delivering benefits in support of the performance objectives for 2013.

<u>SESAR – Next steps</u>

The 2020 ATM Target Concept is one of the main results of the SESAR Definition Phase. It provides the reference to support the decisions to build the SESAR Master Plan for the 2020 European ATM system. This ATM Target Concept with its identified issues will be further analysed and detailed during the SESAR Development Phase.

The next SESAR Milestone Deliverable D4 will be based on the agreed ATM Target Concept for 2020 and it will define the respective implementation packages for 2008-2020 in terms of timing and transition from today’s ATM system.

For optimal coordination of the SESAR Development Phase, the EC and EUROCONTROL have founded the SESAR Joint Undertaking (SJU), which starts its operations in 2007. In partnership with ATM industry members, the SJU will coordinate the necessary R&D activities to implement the SESAR ATM Master Plan (SESAR Milestone Deliverable D5) of which the ATM Target Concept will be the fundamental part.

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1 Introduction

An outline vision of the air transport industry in 2020 and beyond, how air traffic management (ATM) in Europe would be managed in the future and an initial set of performance targets for the future ATM Network were established in the SESAR milestone deliverable D2 entitled "Air Transport Framework – The Performance Target" [Ref.2]. These were based upon an analysis snapshot of the present situation described in the SESAR milestone deliverable D1 entitled "Air Transport Framework – The Current Situation" [Ref.3].

D1 recommended that:

- The future European ATM System must be able to cope with the expected growth in traffic;
- The design & management of the future European ATM System should be based upon:
    - A common framework which links the economic, commercial & operational values of its stakeholders and the establishment of explicit service relationships between them;
    - A comprehensive performance framework applied across the System as a whole;
    - The use of the notion of a "network plan";
    - The principles of asset management explicitly linking the strategic planning of new investments with the in-service support of operational systems;
- A simpler, more coherent framework of legislation and regulation, matched to ATM's business model, should be created;
- A single functional architecture should form the basis of the future European ATM System, with the airborne and ground-based systems being treated as one.

D2 subsequently laid the foundations upon which the future ATM Target Concept and its associated management regime should be built. The vision is the optimised management of the ATM Network encompassing all aspects of ATM, including airspace design, and upon which all stakeholders will focus their roles, responsibilities and activities.

It was envisaged that:

- Distinct business & regulatory management frameworks be created which work to a common performance framework based upon that developed by ICAO, and which have a "dynamic working relationship" between them to ensure the best outcome is achieved for the ATM industry as a whole;
- The ICAO global ATM operational concept [Ref.4] be used as the reference to develop the ATM system;
- The business management framework be consisting of the three main groups that, within the ATM Performance Partnership (ATMPP), are operators of the ATM Network.

Based on the analysis of the air transport value chain and needs, as well as the needs of society, performance objectives were defined and in many cases quantified for the 11 key performance areas (KPAs), which compose the performance framework; these are the initial set of targets to develop the ATM Target Concept.

In order to describe the often widely differing needs of the various Airspace Users in a coherent, consistent and balanced manner, the notion of a "Business Trajectory" (also referred to as a "Mission

Trajectory") was developed which enables each Airspace User to communicate and manage how it wishes to achieve the best sustainable outcome for each flight.

This SESAR Milestone Deliverable D3, entitled "The ATM Target Concept", builds upon the contents of D1 and D2 to propose an ATM Target Concept for 2020 and beyond, which is expected to meet the performance targets in a safe, affordable, sustainable and achievable manner.

The approach taken is that features of the ATM Target Concept can be deployed when they are needed to ensure the performance of the System in operation can meet the demands placed upon it. To illustrate this, and give confidence that the transition from today's situation to the ATM Target Concept will be feasible, the contribution of on-going initiatives which can be implemented up to around 2013 has been analysed.

Chapter 2 describes the future ATM Target Concept, the Concept of Operations, the associated human roles, the supporting architecture and recommended technologies

Chapter 3 analyses how the proposed future ATM Target Concept addresses the D2 performance requirements including an assessment of its cost-effectiveness and affordability

Chapter 4 describes the cost assessment and the funding & financing aspects for the future ATM Target Concept implementation.

Chapter 5 describes the enablers for the future ATM Target Concept implementation (ATM business framework, institutional & regulatory framework).

Chapter 6 analyses the contribution of on-going initiatives to the ATM Target Concept as a preview of the transition analysis to be performed until Milestone 4.

2 The ATM Target Concept

2.1 Introduction

2.1.1 Objective

The ATM vision for Europe is to have an affordable, seamless ATM Network enabling all categories of Airspace Users to conduct their operations with minimum restrictions and maximum flexibility, whilst meeting the agreed targets for safety, operational efficiency, cost effectiveness, environmental impact and meeting security and national defence requirements.

The European ATM Network of the future will be structured around the use of a performance-based, service-oriented operational concept. In support of the Network there will be a single European ATM System, which will provide a variety of ATM services to all types of Airspace Users to meet their respective needs. The expected demand and nature of the needs and expectations of the Airspace Users have been defined in detail in D2 [Ref.2], leading to the development of the performance targets to be met by the System [Ref.2] updated in the document "SESAR performance objectives and targets" [Ref.22].

The objective is that the ATM Network will not limit performance in the en-route and terminal manoeuvring phases of a flight, while maintaining the high level of safety. The D2 performance objectives and targets established for the airport capacity acknowledge that the already congested airports are considered to be unlikely to cope with the traffic demand growth. Nevertheless, the Network is expected to be able to readily satisfy the need for high performance ATM services as pressures within the air transport business build and lead to, for example, greater use of regional and other uncongested airports to satisfy the demand. As a consequence, the ATM services must be designed to have characteristics, which meet the specific needs of the various Airspace Users in order that each may achieve, to the greatest extent possible, the best outcome for each flight.

2.1.2 Current Limitations

D1 identified the limitations of today's situation [Ref.3]. The major ones are summarised as follows:

- European airspace is, in the main, organised around the use of fixed volumes and rigid route structures which are organised and managed in a fragmented manner. This results in aircraft being unable to fly their most efficient trajectory and creates unnecessary additional workload for air traffic control.
- Most aircraft operating today have the capability to fly with much greater precision in terms of position and time than is accommodated in the design of, and supported by, many of the systems in operational service to manage and control air traffic. This capability is currently not exploited.
- Throughout the processes, procedures and systems used by the stakeholders involved in planning, managing and executing flights today, decisions are often taken in isolation by

some on matters which have an impact on others. This leads to fragmentation and inefficient flight profiles. However, a large amount of information exists, within the stakeholders, which is currently not fully exploited.

- With the tools and procedures in use today the increase of capacity will be fundamentally limited and is reaching its limits.
- Today pilots have a limited situational awareness of the traffic, which can potentially affect them and this restricts them from taking a more pro-active role in the ATM process.
- Capacity at airports (due to e.g. their infrastructure, environmental and political constraints) together with the terminal airspace around them is primarily the limiting structural factor of overall capacity.

2.1.3 Organisation of the Chapter 2

The ATM Target Concept described in this chapter is composed of the:

- **Concept of Operation** (ConOps) to be used to define the entities, their actions and how they should operate collectively within the future ATM Network (described in chapter 2.2);
- Identification of the **human roles** necessary to support the ATM Target Concept with an analysis of the Human Factors and the recruitment, training, competence and staffing aspects of the ConOps (described in chapter 2.3);
- **Architecture** of the technical ATM System needed to structure and define the functions to be performed and the information to be exchanged between the entities which make up the System (described in chapter 2.4);
- Set of CNS **technologies** recommended to be used to implement the ATM Target Concept (described in chapter 2.5).

A structured approach has been applied to ensure that the ATM Target Concept is consistent and is addressing the D2 performance objectives and targets. The performance-based approach used to develop the concept is described in the chapter 2.2.1.1 and the traceability between the ConOps and the Performance objectives and targets has been developed as part of the performance assessment activities (see chapter 3.1).

A preliminary identification of the system-supported functions and of human roles has been performed based on the ConOps. This identification has been used as input to the human related activities, and to the architecture definition and CNS technology identification in order to ensure the consistency between the ConOps, the architecture and CNS technologies. This approach is shown and is supported by traceability matrixes ensuring that all elements of the ConOps were properly supported by architecture and CNS technologies. The details of this traceability can be found in the architecture and technology task deliverables (DLT 2.4.4/D3 [Ref.17] and DLT 2.5/D3 [Ref.18]).

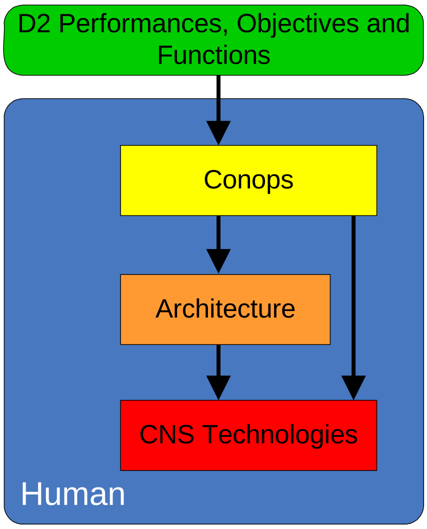


Figure 2: Top-Down design of the ATM Target Concept

2.2 Concept of Operations

2.2.1 Introduction

The Chapter 2.2 is a summary of a complex Concept of Operations (ConOps) that can therefore not be described in all aspects in this document. Therefore the ConOps defined by Task 2.2.2 deliverable (DLT 2.2.2/D3 [Ref.13]) shall be used as the primary reference for all future SESAR developments. The Task deliverable also includes statements of disagreement on specific aspects raised by individual stakeholders.

2.2.1.1 Concept of Operation Development Methodology

The development of the ConOps has been based on a thorough and systematic survey of all known existing ATM programmes, initiatives and R&D projects (e.g. ARDEP database). The potential benefits of each of them have been assessed with regard to the KPAs. The components of the ConOps address the performance objectives and targets and the operational vision developed by the SESAR Consortium with due regard to the evolving capabilities and requirements of the ATM service provision. Guided by the performance framework and the vision of the ATM, a coherent ConOps has been developed from the elements of the above survey.

The ConOps is compatible in all respects[2] with the ICAO Global Air Traffic Management Operational Concept as described in Doc 9854 AN458. The ConOps is a document that represents the concrete application of the global concept, adapted and interpreted for Europe with due regard to the need to be globally interoperable. Annex III outlines the relationship between the ICAO OCCs and the SESAR concept of operations.

2 except for the permanent separation delegation described differently in the SESAR ConOps. (See §2.2.4.2.4)

2.2.1.2 Scope of the Concept of Operations

The execution of an individual flight can be expressed in distinctive events from push back from the gate to the arrival at the gate, which includes taxiing, takeoff, climb, en-route, descent and taxiing to the gate. The scope of the ConOps is also considering the flight planning phases and post-flight activities (i.e. gate to gate).

The operational performance targets for an individual flight are expressed in gate-to-gate parameters. While this includes the runway, taxi way and gate assignment planning and operations, it doesn't include the turnaround ground handling process at the airport.
The performance of this process is a result of the collaboration process between Airspace Users and airport operators involving more partners such as ground handlers, catering and fuel suppliers and need to be coordinated with the ANSPs to ensure that the gate to gate performance can be met for connecting flights.

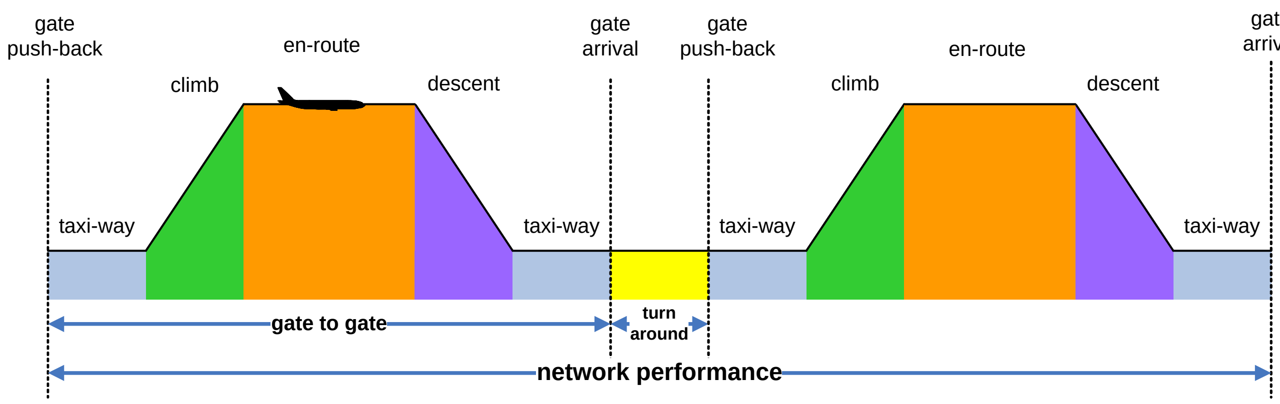


Figure 3: Network performance

2.2.1.3 Level of Maturity

The ConOps described in this document is the result of activities performed in a project definition study. This work has determined the potential solutions which are considered feasible to meet the performance targets. However, significantly more R&D work is required to prove that some aspects of the Concept can deliver the expected benefits and thus, reduce the level of uncertainty associated with them prior to them being considered as "fit for purpose" and ready for implementation. Nevertheless, it is considered that the level of detail reached in the work and the degree of assessment performed are sufficient to give guidance on what should be contained in the SESAR ATM Master Plan.

2.2.1.4 Structure of the Concept of Operations Chapter

The "Leading characteristics" chapter (Chapter 2.2.2) explains the main changes of the SESAR ConOps and their rationale.

The SESAR ConOps changes the approach to the ATM from an airspace based to a trajectory-based manner. The Business Trajectory, the backbone of the SESAR ConOps is introduced in the "Lifecycle of the Business Trajectory" chapter (Chapter 2.2.3).

The way ATM operations will be conducted and how they interact with the Business Trajectory is described in the "Facilitating the Business Trajectory" chapter (Chapter 2.2.4) in the following way:

- The "Building the Network Planning" chapter describes the management of the ATM network. To support this description, the following elements are explained in the following way:
  - the Airspace organisation and Management is described in Chapter 2.2.4.1.2,
  - the role of the ATM Network Management Function is described in Chapter 2.2.4.1.3
  - the Airport Planning is described in Chapter 2.2.4.1.4

  The "Development & Management of the Network Operation Plan" chapter (Chapter 2.2.4.1.5) describes how the Operations of the Network are planned, how Demand and Capacity are identified and the operations to ensure that they are balanced at the time of execution and their impact on the Business Trajectories.
- The "Execution of the Business Trajectory" chapter (Chapter 2.2.4.2) describes how individual flights will be executed after the Network Plan has been established.
  - The "Executing and managing the Business Trajectory" chapter (Chapter 2.2.4.2.1) describes how the flight is executed by the Airspace User and the ANSP and how the Business Trajectory is managed in synchronisation;
  - Operations in terminal areas and on and around airports are described in Chapter 2.2.4.2.2 and Chapter 2.2.4.2.3;
  - The way the conflicts are managed and the way the separation between individual flights is maintained is described in Chapter 2.2.4.2.4;
  - The SESAR approach to Collision Avoidance is described in Chapter 2.2.4.2.5.

2.2.2 Leading Characteristics

2.2.2.1 The Driver: Performance-based Approach to the ConOps

The performance-based approach is the main driver for the new ConOps. It should meet the performance targets and objectives defined and agreed by the SESAR consortium.
The ConOps is built on a service oriented performance partnership linking all the ATM stakeholders. The partners agree that, in order to create and increase value in the **ATM Value Chain** and bring a new equilibrium into it, the Users' business needs be accommodated to the greatest extent possible. To this end, each single flight should be executed as close as possible to the original intention of its owner. The ATM Target Concept should be driven by this main principle.

2.2.2.2 The Foundation: Trajectory-based Operations

The foundation of the ATM Target Concept is trajectory-based operations. A trajectory representing the business/mission intentions of the Airspace Users and 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 airport agree to facilitate. The trajectory-based operations ensure that the Airspace User flies its trajectory close to its intent in the most efficient way allowing to minimise its environmental impact. The concept has been designed to minimise the changes to trajectories and to achieve the best outcome for all users. In that respect, user preferred routing will apply without the need to adhere to a fixed route structure in low/medium density area.

The Airspace User owns the Business Trajectory and has primary responsibility over its operation. Where ATM constraints (including those arising from infrastructural and environmental restrictions/regulations) need to be applied, finding an alternative BT that achieves the best business/mission outcome within these constraints is left to the individual user and agreed through CDM process. The owners' prerogatives do not affect ATC or Pilot tactical decision processes. The business/mission trajectories will be described as well as executed with the required precision in all 4 dimensions.

2.2.2.3 The Key Enablers

2.2.2.3.1 All Partners Share the Same Trajectory and ATM Information

The sharing of information of the required quality and timeliness in a secure environment is an essential enabler to the ATM Target Concept. The scope extends to all information that is of potential interest to ATM including trajectories, surveillance data, aeronautical information of all types, meteorological data etc. In particular, all partners in the ATM network will share trajectory information in real time to the extent required from the 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 and most accurate trajectory data. The individual trajectories will be managed through the provision of a set of ATM services tailored to meet their specific needs, acknowledging that not all aircraft will (or will need to) be able to attain the same level of capability at the same time.

2.2.2.3.2 System Wide Information Management (SWIM)

A net-centric operation is proposed where the ATM network is considered as a series of nodes, including the aircraft, providing or consuming information. Aircraft operators with operational control centre facilities will share information via their applications while the individual user will be able to do the same via applications running on any suitable personal device. The support provided by the ATM network will in all cases be tailored to the needs of the user concerned.

2.2.2.3.3 Collaborative Decision Making (CDM)

Through CDM, decisions are made, supported by improved processes on the basis of common situational awareness and consequently a better understanding of the network effects on the decisions. This improves the general quality of the decisions, helping to more accurately achieve the desired results. The CDM principle although applied to each ATM business critical process, will not interfere with the ATC or Pilot tactical decision processes which need to be made at short notice.

2.2.2.3.4 Network Management

Collaborative layered planning, mediated by a network management function and based on CDM, has the goal of achieving an agreed and stable demand and capacity balancing. Planning is assisted by the Network Operations Plan (NOP). The aim of the NOP is to facilitate the processes needed to reach agreement on demand and capacity balancing. It works with a set of collaborative applications providing access to traffic demand, airspace and airport capacity and constraints and scenarios to assist in managing diverse events.

2.2.2.3.5 Airports as Integrated Partners

The trajectory management focus of the ATM Target Concept extends to include the airports to address the airport capacity issue which is the key challenge in the 2020 timeframe. Runway throughput must be optimised to achieve the airport capacity targets as defined in D2. This requires a spectrum of measures ranging from long-term infrastructure development, through realistic scheduling, demand and capacity balancing, queue management and runway throughput improvements. The impact of adverse weather conditions shall be minimised to allow for airport throughput to remain close to “normal”. During turnaround, milestones will track the progress of the turnaround process and the impact of events on later parts of the trajectory can be established at an early stage. Even with all these measures, the bulk of the required increase in airport capacity must come from greater use of secondary airports.

2.2.2.3.6 Airspace Capacity

The design of the airspace to match the trajectory-based management approach will be crucial in permitting the ATM System to provide the right services, at the right time and in the right places. Controller task-load per flight is a major factor in airspace capacity. The ATM Target Concept will increase capacity by reducing the controller workload per flight (decreasing routine tasks and the requirement for tactical intervention). In highly congested areas this will be achieved by deploying route structures that provide a greater degree of strategic deconfliction and procedures that capitalise on the greater accuracy of aircraft navigation. This applies in particular in high-density terminal areas to accommodate climbing and descending traffic flows. New separation modes supported by controller tools, utilising shared high precision trajectory data, will increase the valid duration of each clearance. Tools will also support task identification, clearance compliance and monitoring. Further reductions in controller workload per flight can be expected from air/ground data link communications and the delegation of some spacing and separation tasks to the pilot.

2.2.2.4 The ATM Target Concept is not "one size fits all"

The ATM Target Concept acknowledges the different nature of European users, airspace and airports. The concept offers different solutions for high density area, where route structures deployment will achieve the overall required capacity at the cost of some constraint on individual optimum trajectories, and for medium/low density area where the trajectories will be optimal allowing cost and environment efficient operations. Separation modes, queue management and airport operational improvements will be tailored to local performance needs.

However, the consistent implementation of the information sharing supported by SWIM together with the de-fragmentation of European ATM in the context of the SES is the prerequisite for all European ATM actors in order to achieve the European network performance.

2.2.3 Life Cycle of the Business Trajectory

This chapter describes the development of an individual business trajectory up to its execution.

Airlines, business, General Aviation and the military all have 'business' or 'mission' intentions, even if the terminology is different. Each and every flight operation has a specific purpose, business or mission aim, which is expressed in a Business (or Mission for the military) Trajectory. The business and mission trajectories are essentially the same in that both express the desired outcome for the User. However, it is important to realise that the military mission trajectory is more complex than a civil business trajectory. A military mission trajectory will usually consist of a transit to and from an airspace reservation with mission specific dimensions and characteristics. Outside of and inside of an airspace reservation a single trajectory could be used by multiple aircraft (e.g. formation flights, air refuelling) and a single airspace reservation could be approached and departed by individual aircraft or formation flights on different trajectories. These requirements and the different timelines of military mission trajectory lifecycles will be fully incorporated into the key enabler development.

The trajectory is always associated with all the data needed to describe the flight.

The lifecycle of the business trajectory starts with the development of a flight by the Airspace User and ends with post-flight activities after the aircraft has reached its final point of destination. The intention of the future ATM System is to enable this to happen with the minimum number of constraints. Trajectories will be expressed in all four (4D) dimensions and flown with high precision.

The Business/Mission Trajectory evolves out of a layered (CDM) planning process. The different development phases of the trajectory are the:

- Business Development Trajectory (BDT);
- Shared Business Trajectory (SBT);
- Reference Business Trajectory (RBT).

Figure 5 shows the business trajectory lifecycle process from its initiation to manage the flight throughout the time leading up to and on the day of operation and its execution.

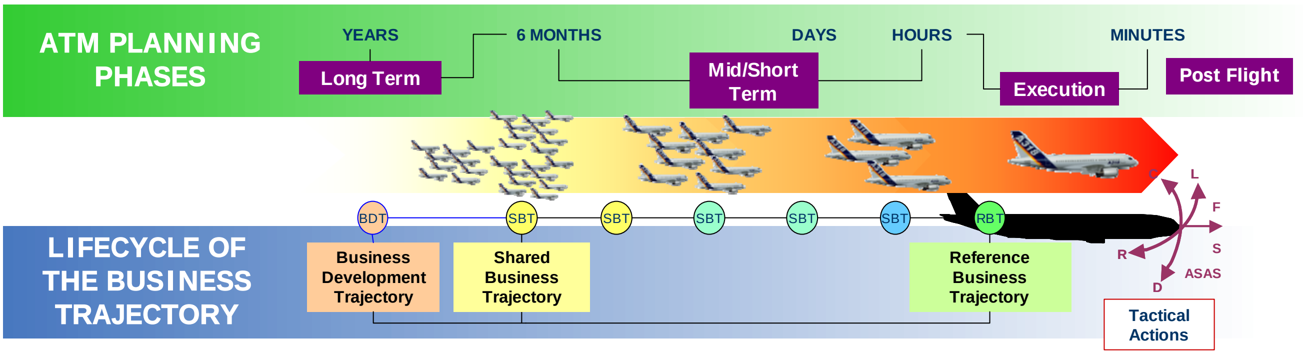


Figure 4: The Business Trajectory lifecycle

2.2.3.1 Business Development Trajectory

Depending on the nature of its operations an Airspace User may start a cycle of business planning several years before the day of operation with the aim of defining its schedule and associated resource and institutional requirements. The Airspace User develops a Business Development Trajectory (BDT) which is not shared outside the Airspace User organisation. The BDT goes through a number of iterations and it is constantly refined taking into account constraints arising from infrastructure and environmental considerations. Depending on the category of Airspace Users this process may be short or effectively non-existent.

2.2.3.2 Shared Business Trajectory

When the user has stabilised sufficiently the BDT, it will be made available as the Shared Business Trajectory (SBT) to the ATM System for planning purposes. Based on the aggregate information on the BTs the ANSP will consider the potential need to adjust airspace organisation to match the traffic flow and airports will adjust their planning for the needed capacity as much as possible. When increasingly more qualitative and quantitative information becomes available, the ANSP will plan the management of the airspace in terms of services required taking account of the traffic complexity and density. Coordination with the military and the airports will start to develop an initial operating schedule.

During this phase potential discrepancies between the SBT and network constraints might already be detected and the Airspace Users will be notified with the request to adjust their business trajectory. This process is iterative until the optimum result for the users is achieved taking due account of the need to ensure an optimum overall network performance.

2.2.3.3 Reference Business Trajectory

The iterative process of SBTs ultimately leads to a final trajectory just before flight execution: the Reference Business Trajectory (RBT), which the Airspace User agrees to fly and the ANSP and airport agrees to facilitate. The RBT becomes instantiated before the first ATC clearance is requested or issued but it does not constitute a clearance to proceed (see chapter 2.2.4.7 "execution of the business trajectory"). The RBT is the goal to be achieved and will be progressively authorised. The authorisation takes the form of a clearance by the ANSP or is a function of aircraft (crew/systems) depending on who is the designated separator.

Most times indicated in the RBT are estimates, however some may be target times to facilitate planning and some of them may be constraints to assist in particular in queue management when appropriate.

The RBT continues to evolve during flight execution in order to reflect all the applicable clearances and constraints and in accordance with the applicable trajectory change rules. There are 2 distinct processes to modify the RBT:

- **RBT automatic update** is triggered on specific events or when the Predicted Trajectory (PT – the trajectory continually computed/updated on-board in capable aircraft, which corresponds to what the aircraft is predicted to fly) differs from the RBT by more than predefined thresholds. The events and the thresholds are indicated in Trajectory Management Requirements (TMR). This process aims notably to improve the performance of automation support. Ground systems will support trajectory prediction and its updating for the aircrafts non capable to manage the automatic update of the RBT;
- **RBT revision** is triggered at air or ground initiative when constraints are to be changed (modified by ATC, or by flight crew if the RBT cannot be achieved by the aircraft).

In both cases of modifications, the new RBT becomes the new common reference that is analysed from a conflict management and network viewpoint by ANSP who will take the necessary actions in cases of adverse effects.

2.2.4 Facilitating the Business Trajectory

2.2.4.1 Building the Network Planning

2.2.4.1.1 Introduction

In parallel with the individual business trajectory development, a CDM planning process will be in place in which all stakeholders will share the necessary information to ensure the long and short-term stability and efficiency of the ATM system and that the necessary set of ATM services can be delivered on the day of operation.

This chapter will explain how airspace and airport resources are managed, the role of the ATM Network management function and gives a view of how the different partners interact to achieve stable network operations to optimize the accommodation of the business trajectory.

2.2.4.1.2 Airspace Organisation and Management

Airspace will be designated in 2 categories established and organised in a service-oriented approach:

- "Managed", where information on all traffic is shared and the ANSP is the pre-determined separator, but the role of the separator may be delegated to the flight crew with pre-defined rules;

- "Unmanaged", where the pre-determined separator is the Airspace User.

In managed airspace, particularly in the cruising level regime, user preferred routing will apply without the need to adhere to a fixed route structure. Route structures will however be available for operations that require such support. In either case the user will share a trajectory the execution of which is subject to an appropriate clearance. It is recognised that in especially congested airspace, the trade off between flight efficiency and capacity will require that a fixed route structure will be used to enable the required capacity. Fixed route procedures will be suspended when traffic density no longer requires their use. Where major hubs are close, the entire area below a certain level will be operated as an extended terminal area, with route structures eventually extending also into en-route airspace to manage the climbing and descending flows from and into the airports concerned. User preferred routings will also have to take into account the airspace volumes established for the operation of diverse (mainly military) aerial activities.

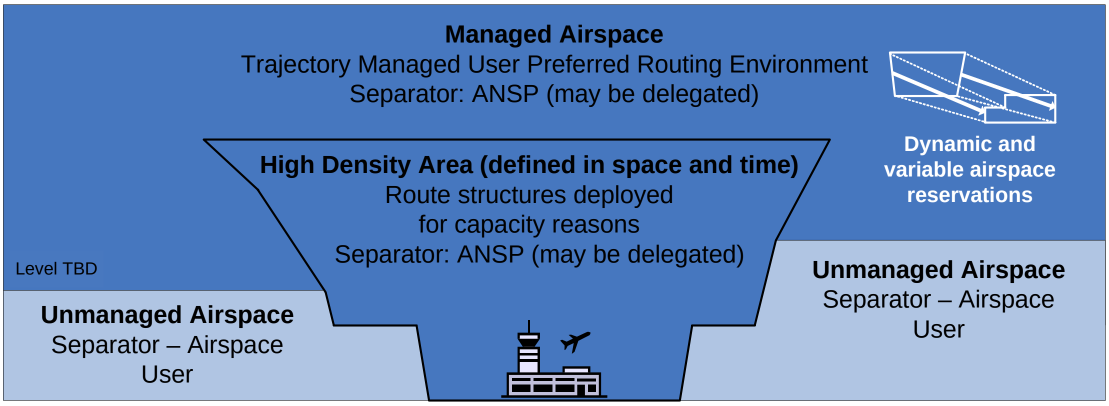


Figure 5: Airspace structure

In the ATM Target Concept airspace is used in a highly flexible manner. It will be treated as a single continuum, minimising the need for traffic segregation and allowing trajectory management with only a minimum of distortion due to the use of pre-determined airspace and/or route structures. Any specific Airspace Users' needs which impose operational constraints in both space and time (e.g. military, test flights) will be accommodated through segregation. The impact will however be minimised through more accurate planning, time management and level segmentation of the segregation, and procedures that can flexibly manage real-time changes to volumes and times and promptly return any unused segregated airspace to general use.

Organising and managing airspace in the future using Advanced Flexible Use of Airspace concepts (AFUA.) will play a vital role in improving civil-military cooperation and in increasing capacity for all Airspace Users. The AFUA regards airspace as a single entity that is available to all users. The aim will be to replace fixed airspace structures with volumes of airspace to be made available in a dynamic manner, including cross-border and multi-State arrangements, on the basis of the close cooperation between civil and military authorities. Embodied within the Network Management function will be an airspace reservation process to facilitate this, but such reservations should be temporary, created only when required and be tailored to meet the needs of specific missions.

The main assumptions upon which the above is based are as follows:

- Full application of agreed FUA concepts will be in place in all States by 2020 providing the basis for the next step of AFUA;
- Equal consideration will be given to meeting the needs of civil Airspace Users and military requirements;
- Protection of secure and sensitive military data will be assured;
- Agreed rules for certain priority procedures to enable military operations (e.g. national obligations and international commitments) to be fulfilled will be applied;
- States' sovereignty and responsibility for airspace will remain.

2.2.4.1.3 ATM Network Management Function

A Network Management function is foreseen to ensure the future ATM Network has an achievable operational performance which is subject to continuous planning and which remains stable and efficient, especially when confronted with unexpected changes. Network Management will work with all partners in a transparent and collaborative manner to ensure that this is achieved using a layered planning approach operating at a regional (i.e. throughout the whole applicability area), sub-regional and local levels.

It is considered that a sub-regional function will be best placed to determine the optimum planning and deployment of the resources needed to deliver the ATM services required by the Airspace Users in that sub-region. Working closely with military authorities, the sub-regional function will determine optimum airspace configurations and how to deal with any constraints which can best be resolved locally; all are aimed at delivering the required capacity and achieving the most efficient traffic flow throughout the sub-region.

The Regional Network Management function will act as the facilitator, arbitrator, synchroniser of sub-regional measures and ultimate decision maker to ensure effective solutions are reached which optimise the planning and operation of the Network as a whole. It will also ensure decisions are reached in a time commensurate with being able to deliver the agreed outcome.

Where sufficient capacity cannot be provided, Airspace Users will be included in CDM processes that adjust the demand to the available capacity.

2.2.4.1.4 Airport Planning

Two high-level operational processes are identified, aligned with the ATM planning process:

- Airport Resource Planning;
- Airport Resource and Capacity Plan Management.

Airport operations support co-operation between all stakeholders at appropriate decision-making stages whilst ensuring a seamless process over the entire planning spectrum, starting many years ahead down to the real-time. Besides these high-level operational processes, there is also a medium to long-term development process which focuses on future demand and capacity planning for airport expansion. This includes issues ranging from airport infrastructure and environmental aspects to landside capacity and regional planning. The focus of airports is equally divided between both the potential aircraft movement rate and also passenger throughput. It must be acknowledged that the airport planning cycle is generally longer than that of the airport users.

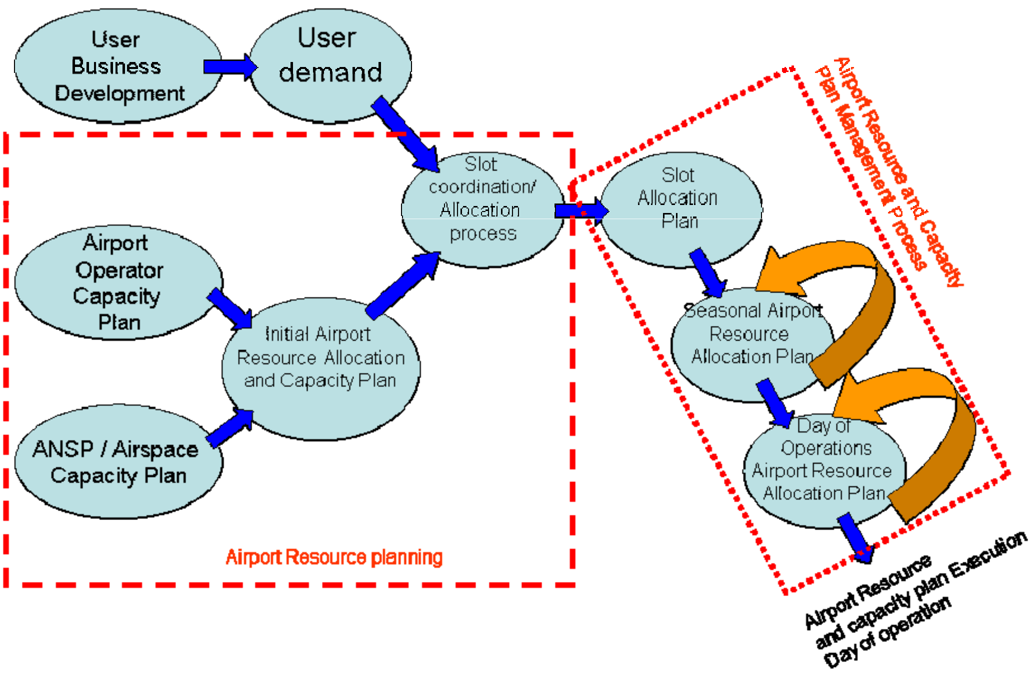


Figure 6: Airport High-Level Processes

2.2.4.1.4.1 Airport Resource Planning Process

Based on the Capacity figures of available resources, provided by the Airport Operator and the (local) ANSP, an initial Airport Resource Allocation and Capacity Plan is initiated. This plan contains:

- The availability of resources (for example maintenance scheme);
- A number of standard airport configuration schemes (incl. runways, taxiways, gates and terminal buildings/facilities);
- Capacity figures for each main process in each configuration taking account of external conditions like traffic mix, weather conditions, etc.

This initial plan will inform the Slot Coordination Process in which the traffic demand from the users is balanced against the airport and airspace capacity and constraints (if any). A seasonal airport operational plan will be established in a collaborative manner between the airport operator, ATC and Airspace Users, and iteratively maintained up to date. This operational plan will accommodate the appropriate level of on demand operations. Airports in close proximity may need to share resource-planning processes for the ATM part.

2.2.4.1.4.2 Airport Resource and Capacity Plan Management Process

Airport Resource and Capacity Plan Management is performed in the context of a robust planning process that is aligned to the maximum extent possible with the Development Phases of the business trajectories that feed the airport with accurate and reliable demand information. The evolution of the plan will be based on refined knowledge of the actual constraints on the day of operation and agreements between CDM partners. The demand forecast is based on:

- Airspace Users' intentions as specified by the intended schedule of operations and/or the Shared Business Trajectories;
- Airport information on landing time, constraints, turnaround time, airport capacity and taxiing time provided by the SWIM and supporting CDM processes.

The plan is consolidated through a balanced mapping of the BT demand on the various airport resources. If demand exceeds capacity the consequences are analysed and Airspace Users revise their Business Trajectories through a collaborative process.

Where unpredictable events create the need for short notice changes and/or refinement, a swift and efficient tactical response will be complemented by collaborative decision making within a previously agreed set of rules.

2.2.4.1.5 Development & Management of the Network Operation Plan

In parallel with all the phases of individual business trajectory planning, a CDM process is in place in which all stakeholders share the necessary information to ensure the long and short-term stability and efficiency of the ATM system and to ensure that the necessary set of ATM services can be delivered on the day of operation.

The key tool used to ensure a common view of the network situation will be the "Network Operations Plan" (NOP). The NOP is a dynamic rolling plan for continuous operations rather than a series of discrete daily plans which draws on the latest available information being shared in the system. The NOP works with a set of collaborative applications providing access to traffic demand, airspace and airport capacity and constraints, scenarios to assist in managing diverse events and simulation tools for scenario modelling. The aim of the NOP is to facilitate the processes needed to reach agreements on demand and capacity.

The NOP, in its initial phase, enables collaborative Demand and Capacity Balancing (DCB) through an integrated airspace/airport organisation and management in accordance with the nature of the traffic being handled. The NOP supports layered planning on local, sub-Regional and Regional level.

Long-term ATM planning starts with traffic growth forecasts including user business strategy development, and planned aircraft procurement. The required new assets can be considered as available resources for DCB only when their date of delivery becomes firm. Airspace Users will then declare their intentions through Shared Business Trajectories possibly including the requirement for airspace reservations. Network Management, working collaboratively with all partners will assess the resource situation with regard to potential demand. Network Management will facilitate dialogue and negotiation to resolve demand/capacity imbalances in a collaborative manner. Tools will be used to assess network efficiency. Capacity can be adjusted by the following means:

- The highly flexible airspace usage will ensure that the impact of diverse airspace activities on other operations is kept to the absolute minimum in both time and space, considering civil Airspace User needs and military requirements equally;
- Airspace organisation decisions and the choice of whether to deploy route structure to maximise capacity when deemed necessary;
- Any other resource management (staffing, airport resources etc.).

If after all possible measures have been taken, there is still an excess of demand, Network Management will work in close collaboration with individual Airspace Users, Airports and ANSPs to decide if the potential level of delay is acceptable or if and how the capacity shortfall will be managed.

It will be the responsibility of the Network Management function to initiate the User Driven Prioritisation Process (UDPP) when the agreed mismatch between capacity and demand threshold is reached. The Network Management function will propose an initial set of measures in line with precise rules agreed during the planning phase and made visible via the NOP.

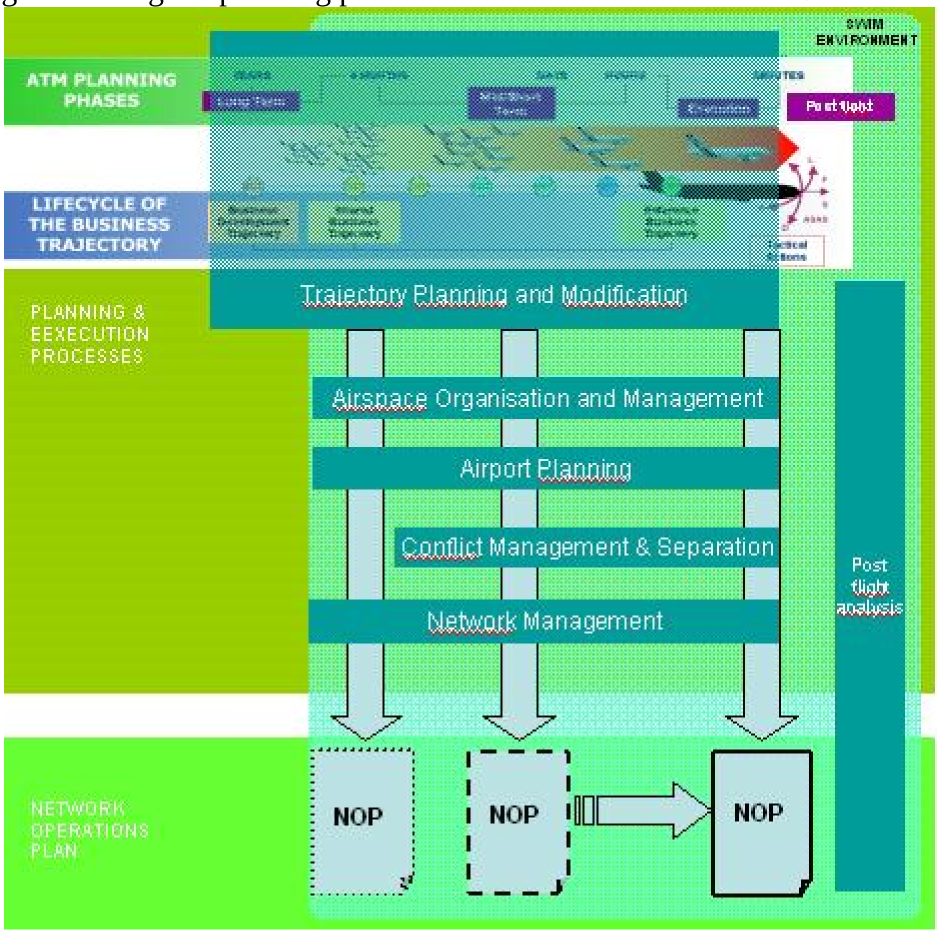


Figure 7: Development of the NOP.

These measures will be the starting point for the process. They will serve as a common baseline enabling each partner to react to the situation on an individual basis to improve their own net return.

This process leaves room for Airspace Users to exchange ATM slots if they individually agree to do so, based on agreements and rules that are transparent to, and agreed by the other actors.

The process is permanently monitored by the Network Management Function in order to make sure that an acceptable solution is available in due time. In particular the Network Management function permanently monitors to see whether any adverse network wide effects develop and makes sure that all concerned parties are aware of them. The result of UDPP is a prioritised demand, which will provide input to queue management processes. If this fails to produce a satisfactory result, ANSP will be empowered to re-order errant individuals within the flows.

Queue management measures will be applied when necessary to optimise the utilisation of a constrained resource such as a runway and the results will be published via the NOP. Queue management will ensure fine-tuning of the trajectory of an individual aircraft into a stream that optimises the utilisation of a constrained resource within the overall efficiency of the whole network.

There will be no need to finalise a planned departure sequence until predicted departure times achieve the required level of accuracy taking into account the shared information on the progress of the airport turnaround in combination with information from the arrival sequence. The arrival management tools (AMAN) will build the arrival sequence, once the flight passes the sequencing horizon. In both cases, flexibility is considered the key to maximum use of capacity. Flights should be able to depart when they are ready to do so; subject only to any allocated target time at destination and constraints at departure airport, resulting in a target take-off time. This type of process maximises flexibility and capacity utilisation but still allows delays to be managed efficiently.

During the short-term planning and the execution phase, unexpected changes may occur that affect the capacity. Solutions will need to be found through the Network Management with the objective to put the network back into a stable situation as quickly as possible. These solutions will include any of the measures that can be practically implemented at that stage, based on draft plans that should be available to ensure that the impact of such events are kept to a minimum. The NOP will be updated as required.

After the execution of the flight, post flights analysis will be performed to measure the achieved performance with the objective to improve overall network performance.

2.2.4.2 Execution of the Business Trajectory

2.2.4.2.1 Executing and Managing the Business Trajectory

The ANSP will issue clearances and instructions to the Airspace User that either authorise successive segments of the RBT or cause the RBT to be revised. Similarly, the Airspace User will follow the authorised RBT and respect any applied constraints or will initiate an RBT revision. As part of the clearance process, all capable aircraft will receive Trajectory Management Requirements (TMR) for each flight.

Once the RBT is cleared by the ANSP and is being executed by the aircrew, the aircraft becomes the prime source of its 4D trajectory data (except for non capable aircraft where the prime source are ground Airspace User and/or ANSP systems). The RBT is subject to automatic and regular synchronisation through the RBT automatic update process. On-board systems will guide the aircraft along the cleared trajectory.

Requests to change the trajectory may come from the ground or air, for reasons which may include – separation provision, sequencing, weather, changing arrival constraints, etc. These are managed by the RBT revision process. The means for the ANSP to implement non-tactical changes is by the imposition, amendment or removal of constraints. The User will propose an RBT amendment that meets the changed constraints. The ANSP will accept the amendment if no additional problems are created by the change. For tactical changes the controller will issue instructions/clearances that may result in an RBT amendment. Otherwise, it is the controllers' role to make tactical changes by issuing instructions/clearances to resolve tactical conflicts, if the controller is the separator.

The Queue Management function supported by Arrival Manager (AMAN), Departure Manager (DMAN) and Surface Manager (SMAN, a function of the Advanced Surface Movement, Guidance and Control System: A-SMGCS) tools maintain a safe, orderly and efficient flow of traffic, both in the air and on the ground whilst providing the flexibility to ensure the maximum use of capacity. As increasingly accurate trajectory time data becomes available within the SWIM environment, Queue Management will fine-tune the position of individual aircraft into a stream and may assign a time constraint. Then the Airspace User will revise his RBT accordingly to achieve the constraint in the most fuel-efficient and environmentally acceptable way. This allows the system to respond rapidly to the changing situation and to optimise the utilisation of a constrained resource.

2.2.4.2.2 Terminal Operations

In high density traffic terminal areas (depending on the airport and/or the time), an efficient airspace organisation combined with advanced airborne and ground systems capabilities will be deployed to deliver the necessary capacity, maintain safe separation and minimise the environmental impact. The concept recognises that when traffic density is high the required capacity may only be achieved at the cost of some constraint on individual optimum trajectories.

Optimum spacing on the approach to optimise runway throughput will be achieved through controller actions or spacing instructions followed by the flight crew. Integrated Arrival and Departure Management sequencing tools (AMAN, DMAN) will assist the controllers and can be used in conjunction with airborne spacing capabilities.

High complexity terminal operations may feature separated departure and arrival routes, the vertical components of which may be defined by either:

- Level windows for crossing points (cones' with max/min levels) enabling aircraft to fly closer to optimum trajectories when traffic density allows, providing an optimum fuel efficient and environmental friendly approach profile;
- Aircraft being required to fly within 'tubes' when traffic density is highest to provide maximum runway throughput and minimising holding delays.

Low/medium density terminal area operation will be characterised by optimal profiles for all trajectories.

Multiple arrival routes that include curved route segments will converge through successive merging points for each runway. The number of merging points and proximity to the runway will depend on the distribution of traffic flows and environmental constraints. Ideally, the controlled times of arrival would be set at the runway threshold (to focus on the optimisation of runway throughput) but in reality a merging point further out is more likely to be practicable.

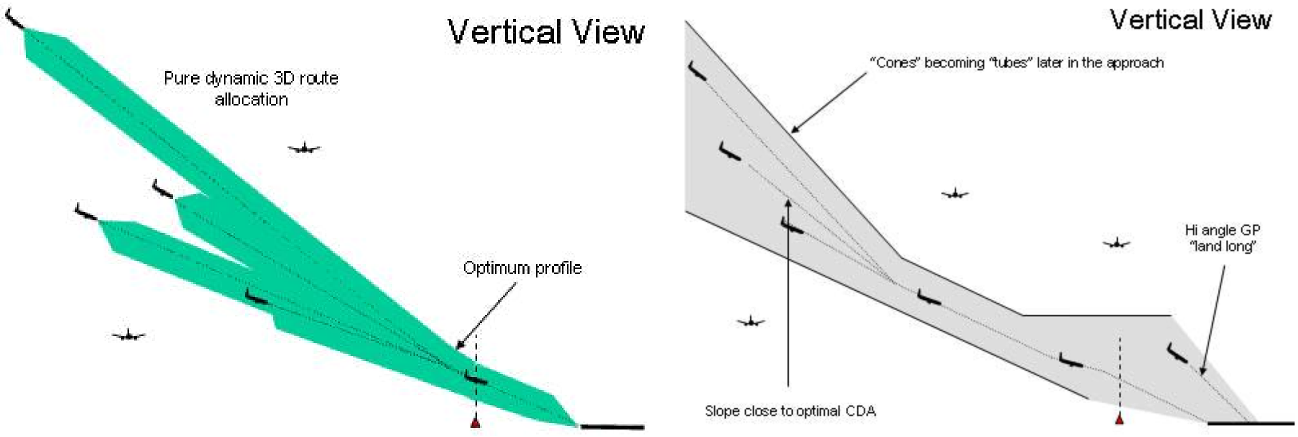


Figure 8: departure/arrival routes for high-complexity terminal operations with tubes (left) or cones (right)

2.2.4.2.3 Operations on and around Airports

Airports will be fully integrated into the ATM network, with particular emphasis being placed on turnaround management, runway throughput and improved environmental performance. The airport view of the ATM Target Concept is from the perspective of "en-route to en-route", managing the aircraft turnaround and flight operation as a single continuous event. The turnaround process links the flight and ground segments, and will include milestone monitoring, gate/stand management and apron management. Sharing turnaround information in a collaborative process will improve estimated times of subsequent events such as off-blocks and take-off.

Cluster of airports within the close vicinity of a large congested airport will require new harmonised ATM techniques and procedures serving the area concerned to assure maximum runway utilisation, flight efficiency and minimal flight path confliction.

The SMAN tool within A-SMGCS will determine the optimal surface movement plans involving the calculation and sequencing of movement events and optimising resource usage, while minimising the environmental impact. SMAN will collaborate with AMAN/DMAN to establish the arrival and departure sequence.

The provision of separation between aircraft and hazards on the airport will continue to be achieved through visual means. However, better situational awareness for the controller, aircrew and vehicle drivers including conflict detection and warning systems will enhance airports surface safety and will also create "room" for surface movement capacity expansion and improve throughput in low visibility conditions. A-SMGCS will provide enhanced information and decision support to controllers (enhanced ground surveillance information, runway incursion alerts and ground route planning information) whilst CDTI technology will provide aircrew and vehicle drivers with map, guidance and traffic information. Advanced, automated, systems may be considered such as “auto-brake” to make it impossible for an aircraft or vehicle to cross selected “stop bars”.

Various techniques and procedures will be in place to increase runway throughput and utilisation such as:

- Reducing dependency on wake vortex separation by the re-classification of aircraft into a wider range of wake vortex categories, dynamic pair-wise separations considering prevailing wind conditions and stability of the air mass, improved prediction and detection of wake vortex;
- Re-sequencing of the traffic flow to group similar categories of aircraft;
- Minimizing Runway occupancy time by runway and runway exits design improvements and improvement of the procedures to vacate at an agreed turn-off whether supported by systems or not;
- Accurate and more consistent final approach spacing achieved by time-based separation taking into consideration wake vortex by either controller tools or onboard tools like ASAS;
- Reducing departure spacing by better wake vortex management, runway design and improved terminal area capacity;
- Optimising runway configuration/mode of operation in case of multiple runways;
- Interlaced take-off and landing procedures (mixed mode operations);
- Increase runway utilization during Low Visibility Conditions (LVC) by mitigating the ILS signal disturbance issues and by tools to enhance ground controller and pilots' situation awareness in low visibility conditions;
- Improved weather forecasting;
- Redesign of runways and taxiways to avoid runway crossing.

The remotely provided aerodrome control service concept will allow to offer enhanced ATC services to places not normally eligible for ATC (e.g. rural or smaller airports) where determined feasible (and in particular where the site and techniques are proven to meet all appropriate safety requirements) and where/when this is cost-effective.

2.2.4.2.4 Conflict Management and Separation Modes: the 2020 Perspective and Beyond

The separator is defined as the agent responsible for separation provision and can be either the Airspace User (the pilot) or a separation service provider (the controller). In all cases the separator must be designated prior to the commencement of separation provision.

In managed airspace the pre-determined separator is the ANSP. However subject to the provision of a positive ATM system safety case self-separation will be permitted under agreed criteria. The role of separator may be delegated to the pilot following specific rules (e.g. approved aircraft equipment and pilot qualification) within specified limits (in time, distance or in respect to one or more aircraft). In unmanaged airspace, the pre-determined separator is the Airspace User.

Controller task load is one aspect of ATM capacity. To address this issue, 3 lines of action are included in the ATM Target Concept:

- Automation for the routine controller task load supported by better methods of data input and improved data management;
- Automation support to conflict/interaction detection, situation monitoring and conflict resolution;

- A significant reduction in the need for controller tactical intervention.
  - Reduction of the number of potential conflicts using a range of deconfliction methods;
  - Redistribution of the tactical intervention tasks to the pilots when appropriate through cooperative separation or self-separation.

The separation modes fall into three broad categories:

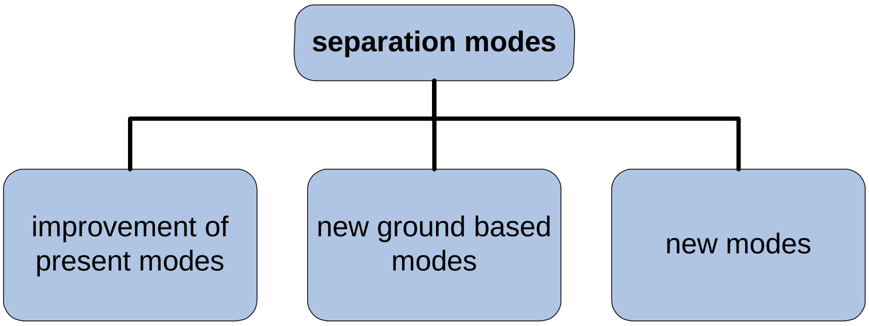


Figure 9: Separation modes

1. **Conventional modes** as used today, but with better data and better tools to improve trajectory and network efficiency.

2. New ground based modes, which will include **Precision Trajectory Clearances (PTC)** using the navigational performance of the aircraft, constraint management, and Controlled Times for queue management purposes. In each PTC, the aircraft will maintain its trajectory with the agreed containment, thus enabling 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. These clearances are of different types depending on the performance required in the 4 dimensions:

- 2D Routes (PTC-2D) with lateral containment, similar to current methods, and which may be fixed, temporary or user preferred routes depending on the airspace and operational environment;
- 3D Routes (PTC-3D) with lateral and vertical containment, applied dynamically to best match the aircraft's climb/descent performance and 'contain'[3] the vertical evolution of the trajectory;
- 4D Contracts (PTC-4DC) that prescribes the containment of the trajectory in all 4 dimensions for the period of the contract. The containment may be fixed, or flexible to take advantage of enhanced aircraft capabilities. A 4D contract will apply to a defined segment of the RBT (e.g. 20 minutes).

The 2D/3D/4D Precision Trajectory Clearance concepts rely on the de-confliction of flights to achieve capacity, flexibility and predictability with reduced controller intervention. The 2D/3D/4D Precision Trajectory Clearance concepts consist of the controller issuing a clearance to proceed on a

[3] In this context, the word "containment" implies ATM performance requirements, which have to be defined and agreed, it does not correspond to the EASA definition for aircraft certification – putting all safety requirements on the aircraft including abnormal situations should be avoided.

2D/3D/4D trajectory which is subject to agreement by the flight crew (for fly-ability reason). The clearance is ideally identical to the current RBT or may result in an RBT revision.

Trajectory control by speed adjustment: an automated deconfliction method, where automation support tools impose speed adjustments (horizontal and/or vertical) within a limited range and a medium term time horizon in order to tactically de-conflict traffic and reduce complexity and controller task load.

3. New airborne Separation modes using ASAS applications for:

- **Cooperative separation** in which the role of separator is temporarily delegated to the aircrew to assure separation with regard to other aircraft under specific circumstances;
- **Self-separation** in which the aircrew are the designated separator for a defined segment of a flight during which they shall assure separation from all other aircraft.

A cooperative separation or self-separation manoeuvre is to be considered as a temporary deviation versus the RBT to be renegotiated and resumed once the aircraft is conflict free. Self-separation relies on distributed tactical intervention to achieve the same goals.

It is the responsibility of the pilot in command to ensure that the flight can proceed safely when entering airspace where the Airspace User is the separator, when requesting self-separation or when accepting to carry out an ASAS manoeuvre.

The Business Trajectory must be negotiated with the ANSP by the Airspace User, when an aircraft enters an airspace where the separation service is provided by the ANSP or request a ground based separation service.

The benefits of these separation modes appear to be similar. One goal of the ASAS development path is to enable 'self-separation' in mixed mode operations. The intention is to allow self-separating flights and ANSP separated flights to operate in the same airspace provided that this can be proven to meet the target level of safety in addition to providing economic and capacity benefits.

In managed airspace, in medium or high-density area, not all the separation modes will be deployable by 2020.

The more advanced aircraft and ground systems capabilities required by 4D contract and/or ASAS self-separation are not expected to be available for the large majority of users in the 2020-2025 timeframe. Nevertheless, they are part of the feasibility study as best identified efficient ways to achieve the long-term performance target of a 3-fold capacity increase.

In low-density area, it is anticipated that self-separation will be introduced before 2020 on an opportunity basis in areas or flight segments where this is feasible and to gain experience as part of the validation process for broader implementation. All new separation modes will require further R&D validation.

2.2.4.2.5 Collision Avoidance

A global safety approach is needed to define the future collision avoidance systems, taking into account the new SESAR separation modes. The dual layer safety afforded by independent airborne and ground based safety nets, Airborne Collision Avoidance System (ACAS) and Short Term Conflict Alert (STCA) respectively, will continue to play a major role.

The SESAR programme will lead the way towards developing ACAS and STCA so that shared information could be used to coordinate warnings and resolution advisories. The aim will be to display these to both the pilot and controller as appropriate. Completely independent detection logics should be present in the different systems, using several independent information sources as well as any available shared sources (e.g. altitude from barometric and non-barometric sources, shared trajectories, etc.) but the calculation results are always shared. This does not imply that the two systems would negotiate the resolution manoeuvre.

2.2.4.3 Accommodating Different ATM Capability Levels

Throughout the ATM Target Concept techniques are described which are designed to achieve the performance requirements. These techniques depend on new capabilities and automation in the air and on the ground.

Different levels of ATM capabilities are defined to describe the on-going deployment of progressively more advanced ATM systems for aircraft, ground systems and airports. These capability levels provide a convenient means to link many of the operational concepts to an easily defined and supportable implementation timeframe as well as providing an understanding of some of the key dependencies within and between concepts.

In the first instance there is a need to define the main capabilities required by the year 2020. These will be based upon the requirements of the ATM Target Concept at that time and a realistic assessment of potential capabilities will be performed. Aircraft, ground ATM systems and airports that have these capabilities are referred to as **ATM Capability Level 3** (ATM-3)[4] and will exploit precise vertical navigation performance in addition to existing horizontal navigation capabilities and will support co-operative separation functions (ASAS Separation).

The ATM Target Concept also addresses the very advanced capabilities that potentially offer the means to achieve the performance requirements, in particular the very high-end capacity target through more precise longitudinal navigation performance and Self Separation functions (ASAS Self Separation). These capabilities have a much longer research and development cycle and/or a limited initial deployment. The timeframe for initial availability and progressive fleet equipage is 2025 and beyond depending on the specific capability. Aircraft, ground ATM systems and airports that have these capabilities are referred to as **ATM Capability Level 4** (ATM-4).

At the same time the ATM Target Concept recognises that for 2020 and beyond there will be the need to effectively utilise the capabilities of the existing systems even if delivered before the “SESAR 2020 capabilities” become available. Systems that do not meet at least the present commercial aircraft capabilities will still be accommodated but may have fewer service options.

[4] ATM capability levels 0, 1 and 2 have been introduced in the DLT 2.2.2/D3 [Ref.13]. The level 1 is the capabilities of existing systems and those that are delivered up to 2012/13 and largely have today’s capabilities. The level 2 is the capabilities of systems that are delivered and in-service from 2013 onwards with a range of new capabilities but which do not meet the full 2020 needs. The level 0 is assigned to systems that do not meet at least the ATM-1 capabilities.

It is recognized that some aircraft and some ground ATM systems will have a range of capabilities ahead of the times indicated. These capabilities will be utilized whenever possible.

2.3 Human Aspects

2.3.1 Introduction

The main findings[5] of the “human resource” and the “human’s roles” screening of the ATM Target Concept are summarised in the following chapters:

- **The results of a** Preliminary **Human Factor** Case, including the **automation** principles;
- **A description of Human Actors and Roles**, involved in the operational services;
- **Recruitment, Training, Competence and Staffing**, providing the essential guidelines to manage the transition from the Human Resource perspective.

2.3.2 Humans and Automation in the ATM Target Concept

Humans (with appropriate skills and competences and duly authorised) **will constitute the core of the future European ATM System’s operations**. However, to accommodate both the expected traffic increase and the reference performance framework an advanced level of **automation will be required**.

Benefiting fully from the net-centric, information-shared environment, automation will support seamless trajectory management, covering many aspects of ATM operations (e.g. supporting the dynamic NOP, Conflict Management applications, etc.).

The nature of **human roles and tasks within the future system will necessarily change**. This will affect **system design**, current **staff selection**, **training** (especially for unusual situations and degraded mode of operations)**, competence requirements and relevant regulations.**

A preliminary Human Factors Case analysis has been carried out, identifying a number of concerns to be addressed at the early stages of JU activities, including Human-centred simulations on the various operational scenarios envisaged by the ConOps, and to be solved well ahead of the implementation phase by adopting the following actions:

- **Drastic changes in procedures, human roles and responsibilities** are expected in the future and have to be well understood and justified. If responsibilities change, **possible associated changes in legal accountability (and liability)** will be clarified through appropriate analysis;
- One of the basic, reasonable assumptions in the ConOps is that careful, advanced planning will solve many of today’s ATM problems. However there is a risk of a **planning versus flexibility paradox,** as more planning is inserted into the system, less freedom is available to

[5] The complete results of “Human Resource” and “Roles and Responsibilities” screening activities can be found in the WP1.7 DLW D3 and T2.4.2 DLT D3 working documents.

deal with unexpected events. Adaptation of the concept, new procedures and/or automation support for human decision making will mitigate this risk;

- Several new layers of planning and separation methods, such as multi-sector planning and airborne separation are proposed and need to be linked to a specific actor. To avoid safety risks, it is necessary to define clear **divisions of roles/tasks/responsibilities** and relevant mechanisms for task delegation and authority sharing;
- The strategy of **automating routine tasks** to reduce controller workload, and thus improve capacity, will be validated. Automation does not replace people in systems; rather, it places the operator in a different, and in many cases, **more demanding role**;
- The impact of the wide implementation of **data communications** capabilities, the envisaged complexity of the traffic situation and the possible consequential increase of workload might exceed human capabilities to build and maintain **appropriate situation awareness.** The assumed improvements in safety, capacity and efficiency will therefore be subject to further, extensive, validation activities;
- To ensure the implementation of existing and future best practices and knowledge, Human Factors will become an integrated part of the safety regulatory framework;
- A top-down analysis to decide which ATM functions should be clustered together and be assigned to either human actors, automated systems or combinations of both will be conducted. This will allow sensible decisions on what to automate and to verify the envisaged improvements in the different Key Performance Areas ("**Function analysis**").

To ensure the alignment of automation with the vision on the human in the ATM Target Concept the following high-level **automation principles** will be adopted:

- Automate only to **improve overall system and human performance**, not just because the technology is available;
- Examine the **overall impact of automation** before implementation to avoid additional complexity, loss of appropriate situation awareness or increase of errors;
- Achieve balance between the efficiency created by automation and the human capability to recover from non-nominal and/or degraded modes of operations (**automation failure strategy**);
- **Place the human in command**. The human will be the automation manager and not the automation monitor. Automation will assist humans to carry out their tasks safely, efficiently and effectively. Furthermore, the delegation of authority to machine should be clearly defined in all operational situations;
- **Minimise the potential for errors**. Mainly by regulating workload and providing tools to help humans organise their work and make the right decisions;
- Automation will be **error resistant and error tolerant**;
- **Involve users** in all phases of system design to ensure, inter alias, benefits for overall system performance and to foster **trust and confidence** in the automation functions;

- Consider the respective **typical strengths and weaknesses** of humans and of technology when deciding what to automate.

2.3.3 Human Actors and Roles

The main roles and functions are derived from the ConOps and associated to the organisations of the stakeholders involved in the operational services.

The initial characterisation of the future roles described in this chapter will be further refined within the SESAR Development Phase in line with the service oriented approach.

The following definitions apply:

Actor: An actor is any entity that interacts with the ATM Network. It might be a human user, an organisation or a computer system. Actors are consumers or providers of services.

Role: A role is an office or a function (i.e. a set of related activities or tasks) assumed by an actor. More than one Role may be assigned to an actor.

In the following, the most important roles and associated actors are listed and the main expected changes for the corresponding stakeholder involved in the operational services: Airspace Users, Airport Operators and ANSP.

The expected changes in roles are colour-coded as follows:

No changes
Few changes
Big changes
New role

Airspace Users

Actor		Main Role(s)
Organisation/Unit	Individual	
Airlines, BA, GA, Military	Flight Crew, Pilot	• Conduct Flight according to RBT and applicable rules; • Modify RBT (if required); • Assure Separation (if Separator); • Avoid Collisions; • Optimize Queuing (achieving RTA).
Airline Operational Control (AOC) WingOps (WOC)	Staff Member	• Dispatch Flights; • Prioritise Flights (through UDPP); • Develop and Plan Trajectories; • Manage Flight Data; • Manage Environmental issues.
GA	Flight Crew, Pilot	• Plan and Submit Trajectories' data.
Airline, BA, Third Party	Airline Station Manager	• Manage Turnaround of aircraft.

Actor		Main Role(s)
Organisation/Unit	Individual	
Flight Schedule Department, WingOps (WOC)	Staff Member	• Develop Flight Programme; • Plan Missions.

Table 1: Airspace Users roles

Main evolution and expected changes for the long term:

- Reference Business Trajectories need to be reliably executed by the flight crew according to required navigational performance;
- Where separation responsibility is assumed by Flight Crew it has to be executed in accordance with pre-defined rules;
- "Ownership" of business trajectory implies enhanced responsibilities in creating, negotiating, adapting, maintaining and distributing the various types of business trajectories during planning and execution phases;
- For scheduled Airlines Operations (and for many Business Aviation Operations) the Airline Operations Centre will be the organisational unit being responsible for Trajectory Management on the day of operations;
- Military may be capable of mission trajectory management within their Operations Centres;
- For Airspace Users not capable of supporting full trajectory management, third parties (e.g. AOC of scheduled airlines, ANSPs or independent companies) will provide the necessary service support;
- The roles of humans in UAS operations shall be defined in the Development Phase.

Airport Operators

Actor		Main Role(s)
Organisation/Unit	Individual	
Airport Authority	Airport Duty Officer	• Manage Airport Safety; • Provide Alerting Service.
Apron Control Unit (where existing)	Apron Controller	• Assure Separation on Apron; • Avoid Collisions on Apron; • Optimize Queuing on Apron.
Airport Operations Centre (Civil Aerodrome) WingOps (Military Aerodrome)	Staff Member	• Set up Departure Queue; • Manage Airport Resources; • Manage Environmental issues; • Manage Flight Data.
Airport Ground Handling Unit Third Party	Ground Handling Agent	• Manage Turnaround of Aircraft

Table 2: Airport Operator roles

Main evolution and expected changes for the long term:

- Airport Operations Centre (APOC) is the central airport unit integrating the airport airside managing roles;
- New role of "Resource Management" provides Airport information (on capacity etc.) into the NOP during the planning phase and manages the resources during the day of operations;
- Enhanced role of "Environmental Management" aims to ensure environmental sustainability in collaboration with other stakeholders (Airspace Users, ANSP);
- CDM network with other stakeholders (Airspace Users, ANSP) needs to be further implemented;
- Wing Operations Centre is the focal point for all military aerodrome activities. Any implementation of new responsibilities or roles will need further consideration by the military authorities.

Air Navigation Service Providers

This chapter addresses Air Navigations Service Providers (ANSP), Aeronautical Information Service (AIS) providers, Network Management Service providers, CNS providers and others. These organisations will provide services related to the ICAO Operational Concept Components: Airspace Organization and Management, Network Management, Queue Management and Conflict Management.

The main actors and roles are:

Actor		Main Role(s)
Organisation/Unit	Individual	
ANSP/ATS Unit ACC, APP, TWR (Civ., Mil.)	Air Traffic Controller • Executive Controller; • Planning Controller; • Ground Controller; • Runway Controller.	• De-confliction of RBTs; • Authorise RBT; • Assure Separation (if Separator); • Avoid Collisions; • Optimize Queuing.
ANSP/ATS Unit ACC	Complexity Manager	• Assess Traffic/Airspace Complexity; • Optimise airspace organisation (sectorisation, route structure); • Modify RBT (if required).
ANSP/ATS Unit ACC, APP, TWR (Civ., Mil.)	ATS Supervisor	• Manage ATS Resources; • Provide Alerting Service; • Manage Environmental Issues.
ANSP/ATS Unit (Civ., Mil.)	ATSEP	• Provide Communication, Navigation, Surveillance and Information Services; • Provide Network Services.

Actor		Main Role(s)
Organisation/Unit	Individual	
MET Office (Civ., Mil.)	MET Data Manager	• Provide MET information; • Support Trajectory Development.
AIS Units (Civ., Mil.)	AI Data Manager	• Provide Aeronautical information; • Support Trajectory Development.
Various (ANSP and/or third party provider, Communication Service Provider, etc.)	SWIM Network Manager	• Provide NOP Access and Services; • Provide Network Timing Service; • Operate/Maintain SWIM infrastructure.
Various (ANSP and/or third party provider, Communication Service Provider, etc.)	SWIM Access Manager	• Ensure secure access to SWIM Network; • Monitor SWIM access and traffic.
National Airspace Policy Body	Airspace Designer	• Design Airspace for optimum operations; • Develop scenarios/simulations for efficient airspace use.
Airspace Management Cell (AMC, Civil-Military Unit)	Civil Airspace Manager Military Airspace Manager	• Co-ordinate airspace requirements; • Provide optimum airspace availability; • Publish airspace allocation.
Regional Network Management Unit	Regional Network Manager	• Match overall capacity to demand in Planning Phase; • Develop scenarios/simulations for efficient regional traffic flows; • Coordinate and maintain the NOP; • Coordinate the management of unexpected events; • Trigger and monitor UDPP; • Provide solution for continued demand and capacity imbalance.
Sub-regional Network Management Unit	Sub-regional Network Manager	• Match sub-regional capacity to demand in Planning Phase; • Develop scenarios/simulations for efficient sub-regional traffic flows; • Optimize traffic flow through CDM in the Execution Phase.

Table 3: Air Navigation Services Providers roles

Main evolution and expected changes for the long term:

- In managed airspace separation responsibility may be delegated from Air Traffic Controller to the Flight Crew in accordance with pre-defined rules;

- Departure and Arrival queues will be generated by queuing systems and will be optimized by Air Traffic Controllers and/or Flight Crew;
- Planning Controller will assume the role of pre-tactical de-confliction of trajectories by utilizing multi-sector planning tools to review RBTs;
- Complexity Manager will be responsible for keeping the complexity of the traffic to a level which is manageable by Air Traffic Controllers;
- New “Sub-regional Network Management Unit” will be established. This unit may be co-located with sub-regional AMC to achieve improved co-ordination with Airspace Management. Both regional and Sub-regional units will co-ordinate necessary changes to the NOP with Airspace Users, Airports and relevant ATS units;
- The “Sub-regional Network Manager” determines the optimum deployment of sub-regional resources to meet all Airspace User demand via CDM processes;
- Civil-Military Airspace Management Cells should be organised and managed at sub-regional level;
- The currently distinct CNS and ATM Service roles (ATSEP) may be merged as automation systems will be more integrated and focus in the future will be more on service delivery and less on individual equipment maintenance;
- New roles for System Wide Information Management (SWIM) address the SWIM network both in terms of institutional and information/communication technology aspects (SWIM Network Manager, SWIM Access Manager);
- SWIM Management actors will be required on different levels, either centrally or distributed (sub-regional, local) depending on the deployment of the SWIM network;
- Various organisations may provide SWIM and Ground/Air-Ground Network Services, e.g. Communications Service Providers, ANSP, third party providers.

2.3.4 Recruitment, Training, Competence and Staffing

During the implementation of the ATM Target Concept, there will be significant changes to the roles, responsibilities and supporting technologies affecting about 200,000 commercial pilots (ATPL and military), air traffic controllers, engineering and maintenance staff, and operation centres staff. Approximately a further 330,000 ATM staff will be less affected, but will require some additional training and a systematic management of social and legal implications. It should be noted that the GA pilots will also need to undertake a certain level of training which will affect around 200,000 GA pilots.

In addition, the interaction between systems, procedures, humans and their organisational environment in the provision of ATM performance will significantly change compared to the present situation.

From the perspective of recruitment, training, competence and staffing, the implementation of the ATM Target Concept should apply the following:

- The transition towards the ATM Target Concept should be managed in a **carefully designed sequence of implementation steps**. Only this approach will result in a resilient transition while building humans trust in system safety and efficiency;
- The SESAR development work should use appropriate **working arrangements combining operational, engineering and Human Factors expertise** during R&D activities to allow timely identification of any relevant activity in the area of recruitment, training, competence verification and staffing;
- Regulators and ANSPs, supported by international working arrangements, should continue their **harmonisation efforts in terms of training and competence verification of operational staff**. The key activities will be an enhancement of comparability of ATCO competence and the implementation of guidelines for the verification of competence of ATSEP. States lagging behind in implementation of established standards should be supported by appropriate bodies;
- Regulatory bodies should be given at least 4 years notice to adapt the relevant regulations and standards before having trained/certified staff available to operate mature new systems and/or procedures;
- Efficient pan European working structures will develop the required training standards and manage all competence related implications;
- Detailed conclusions on staffing needs cannot be derived yet. Presumably, the staffing needs for the four key groups of staff mentioned above will remain at least stable with pilot staffing varying with the fleet size of Airspace Users. Predicted **staffing needs** derived from proposed system and procedure changes should be continuously analysed **4-5 years before implementing** new working structures;
- The **manpower resources** required for:
  - Staff involvement in the development and implementation of future systems and/or procedures;
  - Provision of system upgrade training, training development and increasing requirements for continuation training;
  - Interdisciplinary training to address complex interactions between the ATM airborne and ground actors;
  - Effective participation structures for staff involvement;
  - Increased level of certification of ground operational systems and relevant involvement of Regulators;
  - Safe transition processes;

  will consume temporarily during the SESAR Deployment Phase several millions of working days in excess of the requirements to continue with day-to-day operations. To ensure safe operations at all times, these manpower needs will be calculated 2-3 years in advance. The **staff involvement** in the development activities is expected to be needed from **2009**

onwards. The **provision of training** for operational staff is estimated to consume about **2.4 Million working days**. Other, additional, staffing needs may result in support and administration units (e.g. an increased requirement for Environment specialists for training purposes);

- The ConOps will require only minor changes to the recruitment and selection profiles of ATM operators due to the requirement to maintain current skills/capabilities to manage non-nominal situations. However, there is a continuing trend of the required characteristics being exhibited by a smaller proportion of the general population. Thus employers must adopt a solid long-term manpower planning strategy to compete for such personnel;
- **Security requirements for staff** involved in data sharing and system management, with access to facilities, personnel, data, operational information or operational systems will play an increased role due to the wide data sharing processes; consequently this staff should be security vetted/cleared;
- The **development of a simulation infrastructure for training** should start at least **4 years before** a system element is expected to be implemented. This has to be considered in the activity planning of D4 and in the R&D planning of the SESAR JU.

Further regulatory recommendations are given in chapter 5.2.3.

2.4 Architecture

2.4.1 Introduction

The performance framework for the European ATM System and the resulting ConOps was analysed in the DLT 2.4.4/D3 [Ref.17] following the process described in Figure 10.

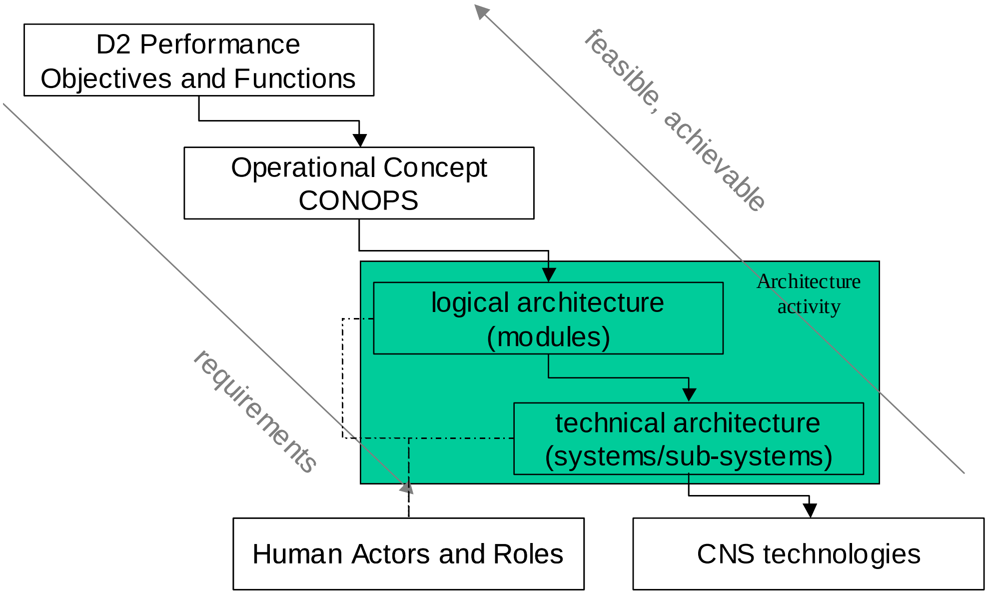


Figure 10: Architecture Process diagram

From the ConOps, System functions were identified and allocated to logical architecture modules (see Figure 11) representing functions and information to be managed by the ATM system.

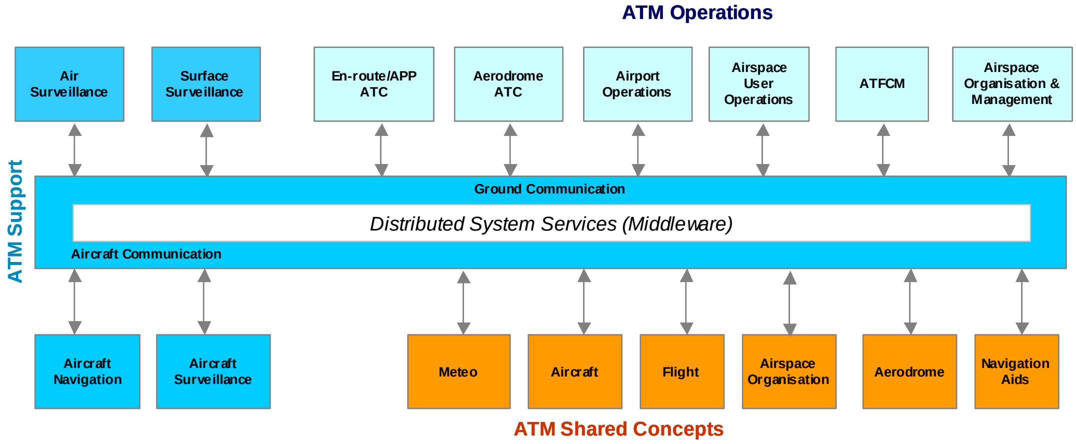


Figure 11: High level European ATM System 2020 logical architecture

Those modules were then allocated to technical systems and sub-systems that are the elementary components of the ATM technical architecture. Sub-systems were defined as a set of loosely coupled functions with clear dependencies and interactions; Systems were defined as the grouping of sub-systems within each ATM stakeholders' domains (see **Figure 12**).

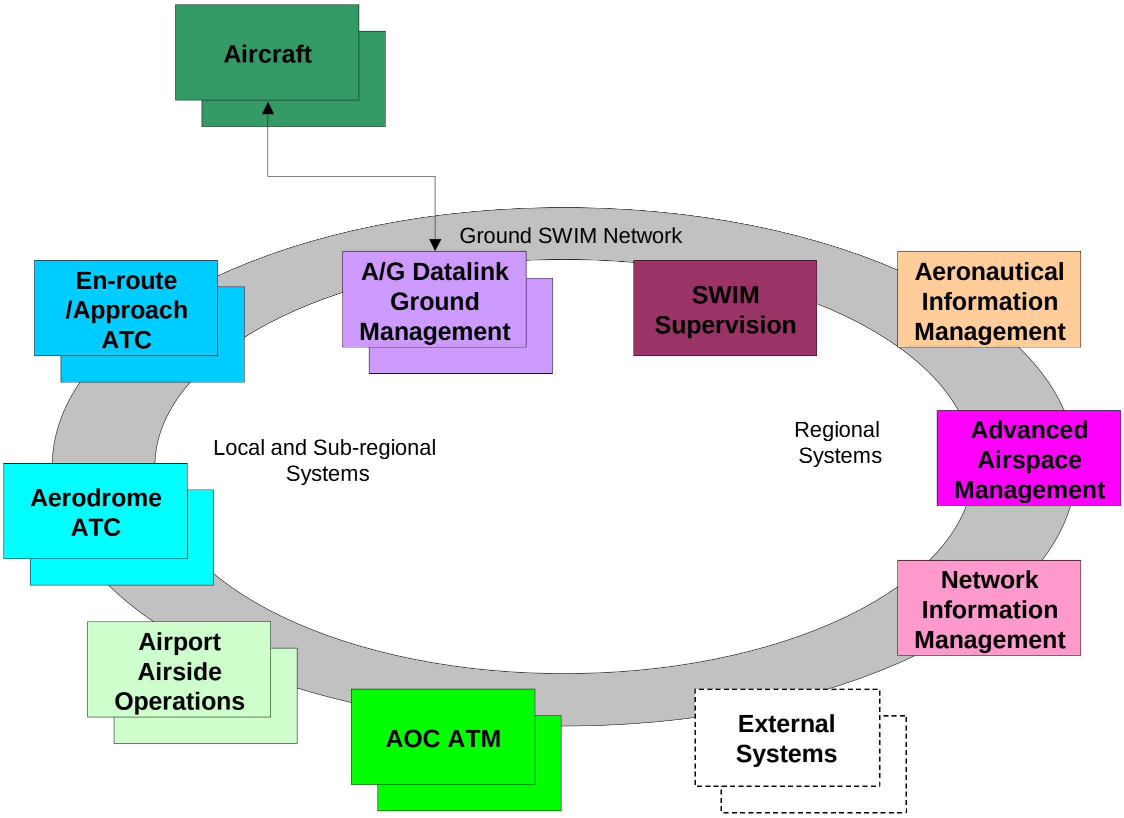


Figure 12. High-level European ATM System 2020 technical architecture

The individual ATM stakeholders have the responsibility to provide within their individual business domain, the identified ATM technical systems and sub-systems[6], in order to support the ConOps. Note, however, that some stakeholders will not need to implement all the sub-systems identified in the corresponding system. For example, low density/complexity airports may not need to implement departure management or surface movement management sub-systems; on-demand aircraft operators may not need the AOC ATM sub-systems.

Due to distribution over several geographic locations and the need for interaction between stakeholder technical systems, the importance of the information sharing was identified and conducted to the establishment of the SWIM principles, as further described in the chapter below.

The proposed architecture also supports the end-to-end provision of ATM services, thus enabling delivery of the expected network performances.

The architecture work has investigated and identified a number of principles and recommendations for the future architecture development within the SESAR Development Phase. Key among these is to make use of:

[6] The description is done through a list of Systems and their sub-systems providing the ATM services. The sub-systems addressed are recognised as core for the SESAR ConOps or where there is significant impact. The list is not intended to be exhaustive so that sub-systems that will not face significant change are not described. Systems which are required for simulation, training and test and development to support SESAR will have to be considered later, however are not considered within the scope of the Definition Phase.

- an Enterprise Architecture (EA)[7] framework which will ensure better alignment between the Information Technology systems and the Air Traffic Management business, and
- Service Oriented Architecture (SOA) techniques, which clearly distinguish the ATM services, that have to be provided, from the underlying supporting services and the physical assets that will need to be deployed. SOA techniques will provide the mechanism to organise and utilise distributed capabilities that may be under the control of different ownership domains. They define a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations.

A multi-domain approach is required to successfully implement the EA. Participants from each stakeholder group will collaborate in the necessary activities to ensure that all business needs and access to information are fairly addressed, from operational concept development up to the architecture design.

For the purpose of the SESAR Definition Phase, the architecture addresses the needs of the ConOps, fully exploiting the needed capabilities up to ATM capability level 3, and designed to evolve towards support of ATM capability level 4.

2.4.2 The Main Drivers for Change

The four main changes in the ATM Target Concept, which impact the European ATM System architecture for the long-term can be summarised as follows:

- SWIM: the ConOps requires a move from point-to-point message exchange to tailored sharing of information, in particular to facilitate the CDM processes;
- Business trajectory: it imposes the move from partial trajectories - produced and used independently - to a shared trajectory including the surface part. In addition, the trajectory is managed and shared during both the planning and the execution phase;
- Network Management: the required interaction between regional, sub-regional and local levels implies that Network Management functionalities are part of more stakeholder systems and may require tailored services according to the specific roles;
- ASAS: the concept calls for a number of ASAS applications, which introduce more ATM functionality to the airborne side. The aircraft is no longer just concerned with the management of its own trajectory but in addition may need to consider other aircraft trajectories. On the groundside the impact is mainly related to interfaces and management of the ASAS manoeuvres.

Whereas SWIM has impact on all ATM domains and is dealt with in a specific chapter below, the 3 other main changes are tackled in the analysis of the architecture evolutions (refer to chapter 2.4.5).

[7] An EA framework includes four different perspectives: business, information, information systems and technology/infrastructure.

2.4.3 Architecture serving the ConOps

The SESAR architecture has been developed to serve the ConOps. One of the main characteristics of the ConOps is the move to the business trajectory. This chapter illustrates in concrete terms, via an example scenario, how the architecture developed supports the use of the business trajectory during the execution of an individual flight from off block to on block. It shows how the actors and the identified sub-systems interact and describes all significant data exchanged. The other characteristics of the ConOps have been addressed in the same.

In the figure below, actors are illustrated as icons, while sub-systems are shown as coloured boxes – the colours indicate the system to which they belong (see Figure 13).

Both actors and sub-systems are identified in italic style within the directly following description text. The lines show the main flows of information required by the scenario(s) considered. These flows are numbered to have an easy cross-reference with the descriptive text that follows. The diagrams are deliberately kept quite simple, so you will find the main kinds of information identified in the architecture on the flows between actors and the sub-systems while the text often refers to more specific information items as described in the scenario, giving more detail.

The key system involved here is the aircraft system (shown in dark green) and its connection to SWIM.

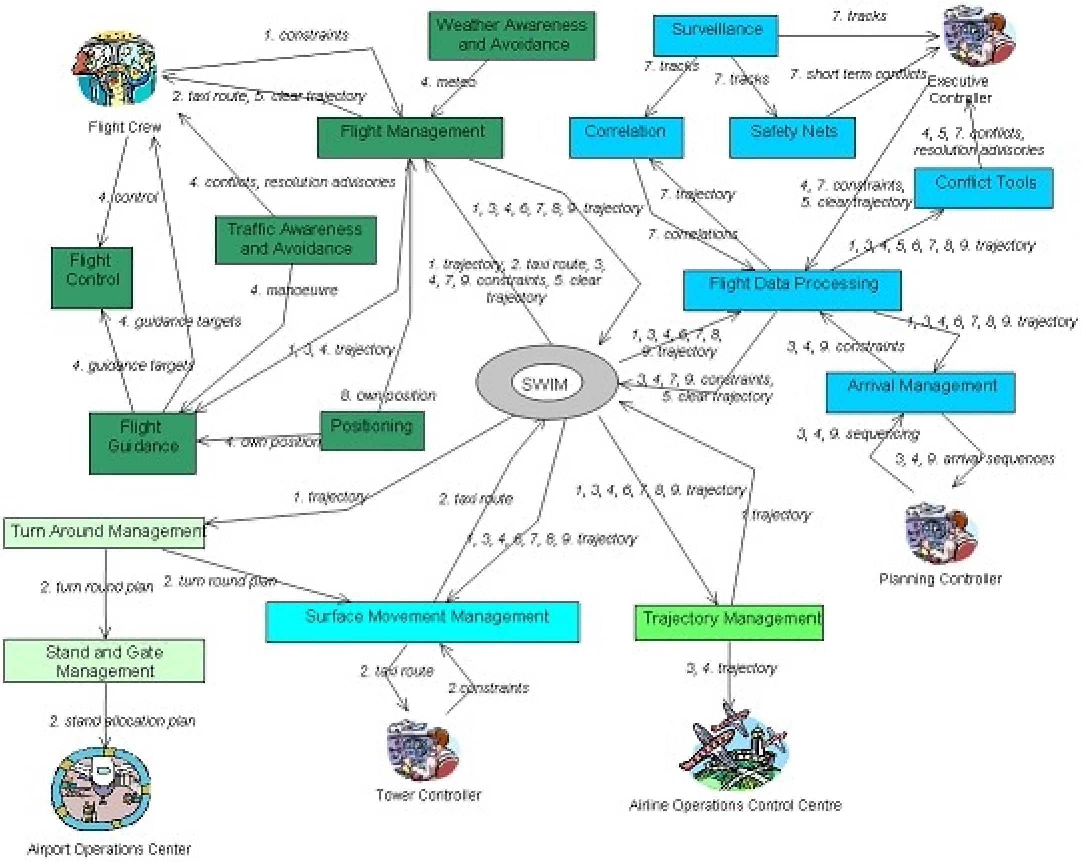


Figure 13: Execution phase

1. At the gate, the onboard *Flight Management* accesses the constituting elements of the reference trajectory agreed between all ground actors via *SWIM*. The trajectory activated in *Flight Management* is published via *SWIM* (where it is available to the ground-sub-systems) to give transparency and consistency between air and ground of the trajectory to be flown by the aircraft.

2. The taxi route and target take off time are updated by *Surface Movement Management* (part of Aerodrome ATC system) taking account of the turnaround plan provided by *Turn Around Management* sub-system (part of Airport Airside Operations system). Turnaround plan information is also provided to *Stand and Gate Management* (part of Airport Airside Operations system) to update the stand allocation plan. After push-back, the taxi route and the target take off time are published to *Flight Management* and displayed in the cockpit to help the flight crew to comply with the reference trajectory. In the same way, at arrival, the taxi route and the target gate are published by *Surface Movement Management*, made available to *Flight Management* and displayed in the cockpit.

3. After take off, the predicted trajectory and the estimates in the reference trajectory are updated by *Flight Management* (according to real take off time) and made available via SWIM to *Flight Data Processing*, *Trajectory Management*, *Surface Movement Management*. If the CTA is no longer feasible, a revised CTA is provided by *Arrival Management* on the basis of the airborne ETA, and the new reference trajectory activated onboard is published by *Flight Management* and is shared with the ground sub-systems.

4. During the climb and cruise phase, the aircraft automatically adjusts its speed to meet the CTA within a larger tolerance to be able to fly its economical profile (using *Positioning*, *Flight Guidance* and *Flight Control*).

Traffic Awareness and Avoidance detects any potential conflicts and issues manoeuvre orders to *Flight Guidance* in case of potential collisions with proximate traffic.

If the route or level is to be changed, the new preferred trajectory is published by *Flight Management* and used by *Arrival Management* and *Conflict Tools* to detect any new constraints which are then made available to *Flight Management*, and the revised trajectory activated onboard is published.

5. Part of the reference trajectory is cleared by the controlling unit (Executive Controller via *Flight Data Processing*), providing that the portion of the trajectory in its sector is conflict free. Effective separation is to be performed when required, through lateral, vertical or longitudinal changes (including ASAS mechanisms, where appropriate). Clearances are sent to the flight crew via *Flight Management*.

6. The predicted trajectory is published by *Flight Management* on ATC request for the ground systems to have access to the most accurate and up to date data.

7. If the predicted trajectory is not conflict free (*Conflict Tools* and *Safety Nets* help the controller to detect them), new constraints are made known to *Flight Management* and the new reference trajectory activated onboard is published (if feasible, otherwise, there will be a new air ground data link iteration).

8. From take off to landing, the current position and predicted trajectory are automatically published by *Flight Management*.

9. When entering the processing time horizon of *Arrival Management* , the aircraft *Flight Management* is requested to publish its near idle descent profile and ETA for adjustment by *Arrival Management* to better stream the traffic towards the airport according to the local situation. The

adjusted CTA is made known to *Flight Management* (as a constraint via *Flight Data Processing*) with a reduced tolerance to optimize the runway throughput. The trajectory integrating the new CTA and activated onboard is published by *Flight Management*.

2.4.4 SWIM Implementation

2.4.4.1 Introduction

SWIM is supported by a set of architectural elements (so-called SWIM architecture) allowing exchange of data and ATM services across the whole European ATM System. SWIM is based on the interconnection of various automation systems. The SWIM architecture aims at providing specific value added information management services: the SWIM services. They will:

- Support flexible and modular sharing of information, as opposed to closely coupled interfaces;
- Provide transparent access to ATM services likely to be geographically distributed;
- Ensure the overall consistency.

SWIM services will need to comply with potentially stringent Quality of Service (QoS) parameters, such as integrity, availability, latency, etc. The full impact of those QoS on the proposed architecture will require significant R&D activities. For instance, not all users will have permission to access all data within a domain because of operational, commercial or security reasons.

SWIM integrates Air-Ground and Ground-Ground data and ATM services exchange[8].

2.4.4.2 Information Domains

The information to be exchanged needs to be modelled explicitly, to allow a precise and concrete definition to be agreed. Previous work has already defined some data models and the associated services within specific domains (e.g. Aeronautical Information and Flight Information). The SWIM services will be organized around 6 data domains, as presented in **Figure 14**.

Dividing the problem into specific domains has the advantages of keeping the activities at manageable size, allowing requirements (e.g. performance or integrity) to be tailored to match the characteristics of the information. However this approach could lead to an inconsistent set of models since in practice the models are not completely independent. To address this problem an overall ATM Information Reference Model is required to define the semantics of all the ATM information to be shared. This model should form the master definition, subsets of which would be used in lower level models supporting interoperability for data-sharing domains.

[8] A/A data exchange is considered as being outside the scope of SWIM itself. Indeed, A/A exchanges (i.e. ADS-B) are inherently local between aircraft close to each other. In this sense, it is not system WIDE information management and as a consequence, does not require the same architecture principles.

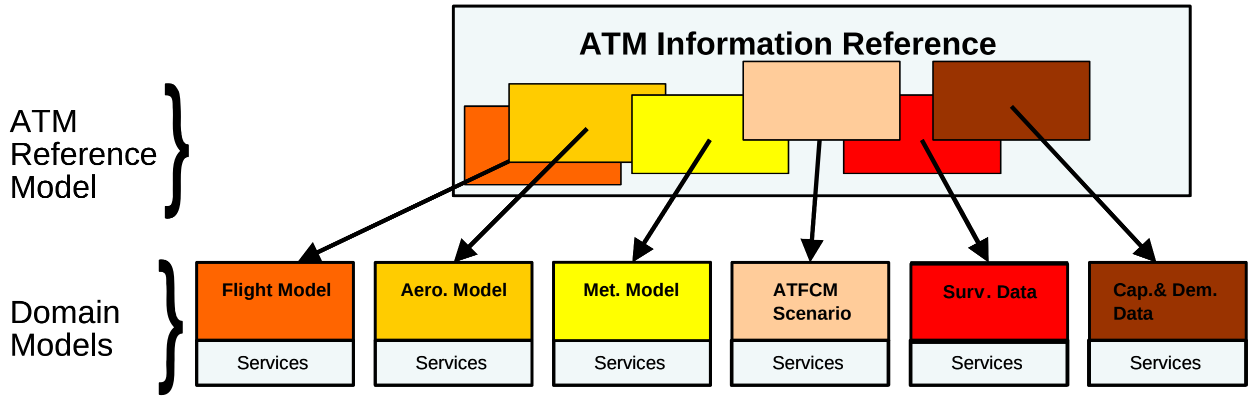


Figure 14: Interoperability Models

The ATM Information reference model should provide a neutral (i.e. no constraints on implementation) definition of the ATM information. It would contain well-known artefacts such as Aerodrome, ATS route, Airspace, Flight Procedure, as well as a common definition of fundamental concepts such as geometry and time. It would be a key asset in the ATM System design and would sit above a set of domain specific platform independent models, which may overlap with each other, without being incompatible. The overall reference model and existing models will need to be reconciled.

2.4.4.3 Systems playing Different Roles for each Data Domain

The Figure 15 illustrates an example of the interdependencies between the systems (and their sub-systems[9]) through SWIM for one data domain. It gives an indication of what could be the main flows of communication between ATM systems all using SWIM to interact between each other.

The diagrams identify which sub-systems are:

- **Users** [–] - those that are the expected/likely users of the Service provided information; they are shown in grey colour. They will get the updated information for which they have subscribed;
- **Publishers** [**P**] – those that are responsible for the Service of information provision for a certain information domain; they are shown in white with a symbol ‘P’;
- **Contributors** [–] - those that provide the contributor provisions to feed a main/focal point Publisher (where information originates in different/diverse stakeholders systems/sub-systems, these are the sub-systems in the local domains that provide these contributions); they are shown in white without the symbol ‘P’.

[9] The dotted lines around the boxes are used to represent sub-systems that are either not present in military context or have specificities that does not allow to use the same sub-system.

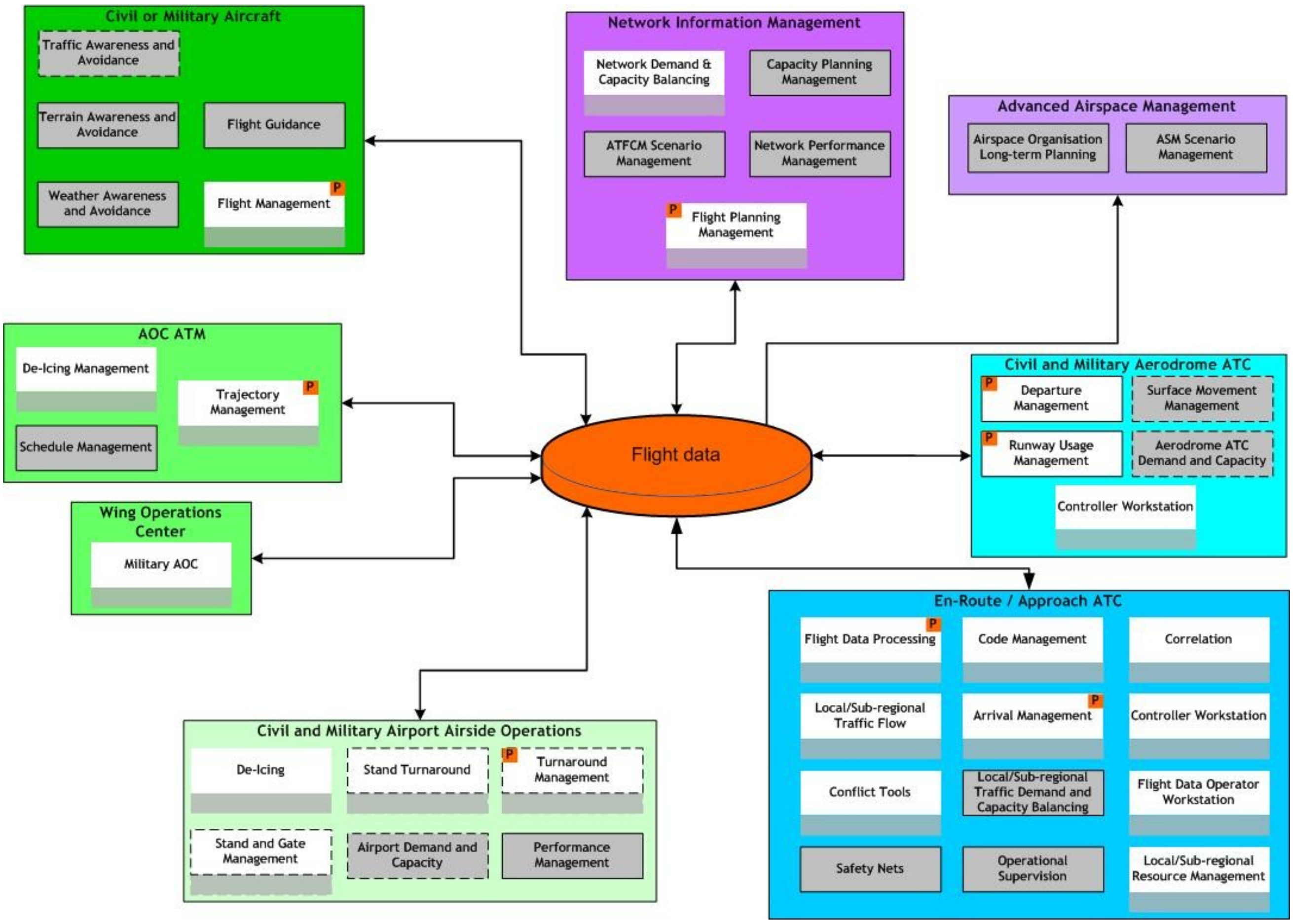


Figure 15: Interdependencies related to the shared flight data

2.4.4.4 Air-ground Information Management Principles

The architecture provides the means to manage the participation of the aircraft in SWIM (see Figure 16) taking into account in a transparent way the inherent constraint of the Air-ground Data link. This is done through the introduction of an A/G Data link Ground Management System. It offers the aircraft a single point of access[10] to the ground part of the SWIM architecture with filtering of the shared information that is needed by the aircraft[11] and at the gate to update onboard databases.

Benefits are expected through simplification of connectivity functions and gain on saving multiple connection infrastructures.

A high availability of the A/G Data link Ground Management System is essential, as a failure at sub-region level will jeopardize the primary data link communication with the aircraft in the sub-region.

[10] Although an initial trade-off showed that the preferred option could be to have one A/G Data link Ground Management System per sub-region, a study will have to be conducted (including CBA and Safety assessment) to refine this result.

[11] This filtering principle has been selected as the preferred option in a dedicated trade-off.

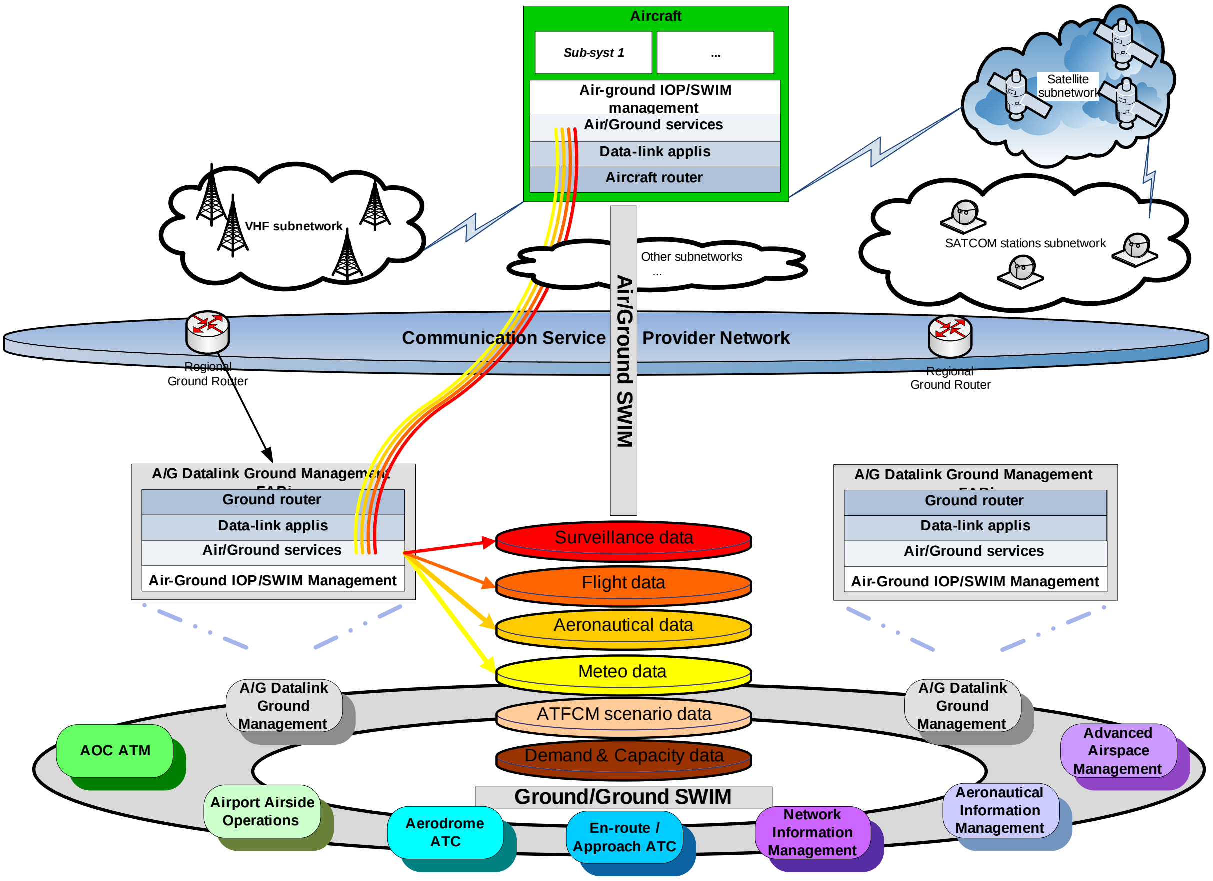


Figure 16: The aircraft participation in SWIM

2.4.4.5 Ground-Ground Information Management Principles

The technical systems of stakeholders participating in SWIM will have to fulfil what will be defined as the Interoperability (IOP) requirements. This capability will be provided thanks to a set of common and standard IOP services available to any stakeholder through Ground-Ground IOP/SWIM management. This IOP/SWIM management is not necessarily a dedicated sub-system in all cases but might be embedded in other sub-systems (e.g. FDP); it will be made of the two following layers:

- **The IOP middleware**: a set of standard IOP middleware services that will rely as much as possible on standard existing IT technologies;
- **The IOP application:** a dedicated software layer to interface the ATM-specific sub-systems to the IOP middleware. The IOP application offers high-level services to sub-systems that either will have to publish shared data under specific conditions or will subscribe to shared data updates.

Following the OSI standard principles, lower layers (i.e. physical to transport layers) will be provided through a **Pan-European Network (PEN) infrastructure** based on Internet protocols.

Systems and services not in the scope of the SESAR programme (some military systems, meteorological data suppliers, others) will also have the possibility to interact with the ATM European network infrastructure under the IOP rules and requirements for civil and military users.

The proposed SWIM architecture depicted in Figure 17 illustrates how remote sub-systems will interact using the SWIM environment (System B and C access some data and/or services from system A through their respective Ground-Ground Interoperability sub-systems). In more details, it shows the principles for the segregation between the operational applications (e.g. FDP, surface movement management) and the SWIM IOP layer. These principles support the flexibility to add or remove sub-systems.

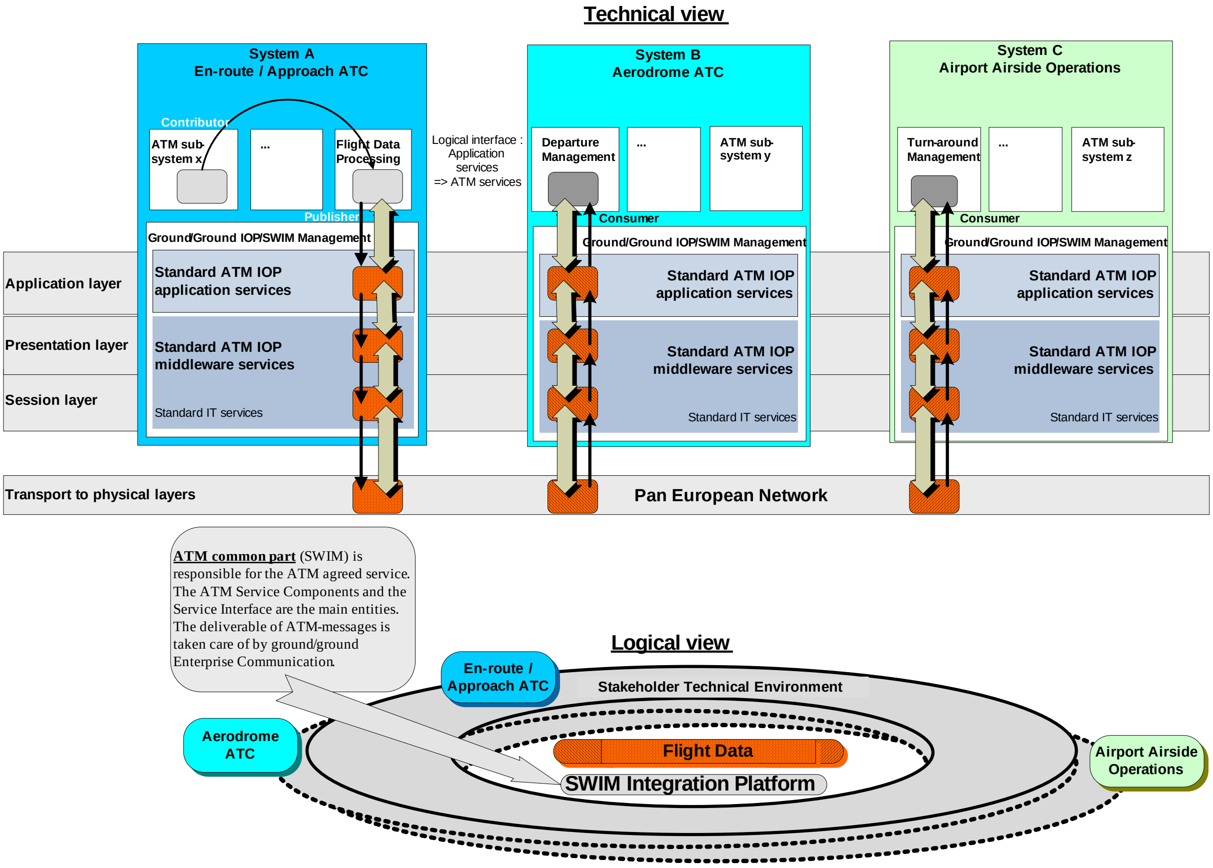


Figure 17: ATM Sub-systems interacting using SWIM infrastructure

For the long-term, it is expected that existing IT products deliver fully or at least partially the IOP middleware and application layers services. ATM specific services may have to be developed and added to the IT standards in order to get the full IOP services provision.

The SWIM infrastructure will be **supervised at different levels**. At the local level, the technical supervision will monitor and control the capabilities of the element of the system that constitutes the local contribution to SWIM. At the regional level, the SWIM supervision will provide the overall management (incl. guarantee that partnership principles are respected) and performance monitoring functionalities.

The description of interoperability services has focused on the provision or reception of shared information but it is expected that the SWIM infrastructure will also support any point-to-point exchanges and/or dialogues. The SWIM infrastructure will allow to set-up **virtual point-to-point connections** whereas the physical network will remain the same one as when the publish/subscribe pattern is used.

2.4.5 Overview of the ATM Systems and Sub-Systems

2.4.5.1 Introduction

This overview of ATM systems and sub-systems presents one feasible architectural breakdown of the overall European ATM System, which needs to be validated when a full Service Oriented Architecture has been developed in the SESAR Development Phase and which eventually needs to be complemented or adjusted in order to satisfy the Service view.

The ATM technical systems and sub-systems that ATM stakeholders will have to implement are identified. It includes the CNS and ATM technical sub-systems, which are likely to be distributed over several geographic locations. Depending on the air traffic density, complexity and user needs, some sub-systems may not be required at all stakeholder locations, whilst others may be mandatory in all provisions. For technical sub-systems to co-operate and share data in an effective way, **a common time reference mechanism** or process will have to be employed across the European ATM System.

Below a centralized level of provision, only a single level of individual stakeholder provision is currently identified. Whilst some sub-regional roles and responsibilities are recognised and encompass the geographic areas of responsibility of several ANSPs, no specific level or location is identified for their supporting technical systems. The current assumption is that they will be co-located at one of the related ANSP en-route ATC facilities for each sub-region. The functions that are supported by technical systems, which will need to be provided to enable the local provision/co-ordination of specific air traffic services– but not necessarily at the same location – are: -

- Airspace Organisation and Management;
- Network Management ;
- Queue Management;
- Aeronautical Information Management.

Environmental constraints will become increasingly important in the future. It will be strongly recommended to identify within each stakeholder's system – and not only airport airside operations -, dedicated provisions to manage environmental constraints and measure performances and influencing factors to make sure targets are met.

2.4.5.2 ATM Systems Description

In the following sub-chapters are given for each of the ATM systems described in the Figure 12, the main functional changes which will impact each of them to support the ConOps.

2.4.5.3 Airspace Users

2.4.5.3.1 Airspace User Operations Centre (AOC)

Figure 18 provides an abstract of Airspace Users sub-systems within the Airspace Users organisation, noting that users without an Operational centre[12] but willing to access to SWIM will need to contract an agent for provision of services and that Schedule Management is not needed for On-demand Operators.

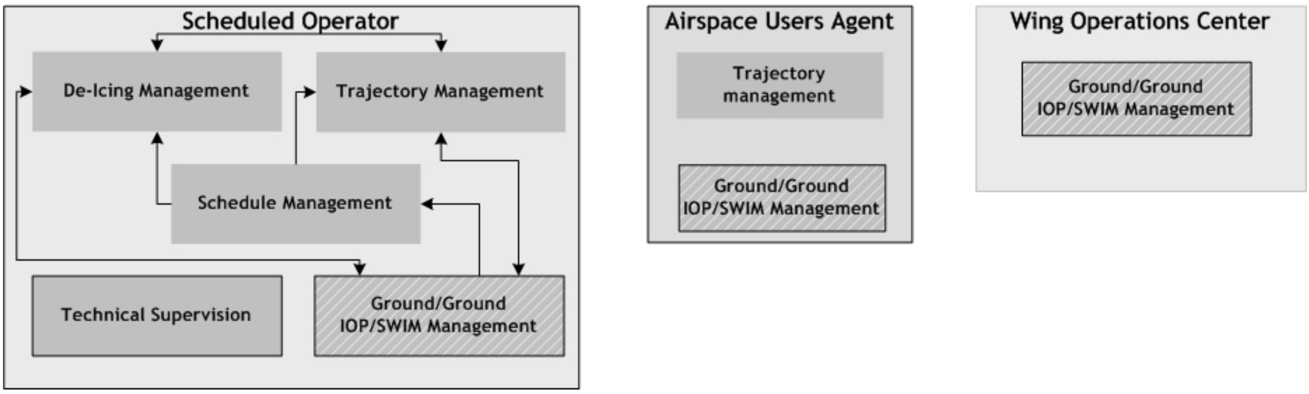


Figure 18: AOC simplified trajectory managements sub-system

The **De-icing Management**[13] is optional for scheduled operators, principally applicable in major hubs and not needed for On-demand operators. The main changes expected are:

- De-icing sequence will enter the AOC- Airport CDM;
- Connection to SWIM to optimise the overall network performance.

The **Trajectory Management** sub-system is the central Airspace User system publishing all relevant trajectory information. Its level of functionalities will be potentially reduced for on-demand Operators

To a large extent the functionalities already exist with the following main changes:

- Current AOC direct communication link with the aircraft for ATM purposes is foreseen to be replaced by SWIM;
- Shift from the management and publication of Flight Plan to 4D-trajectories;
- Ability to access up-to-date data (e.g. Meteo information, airspace availability) relevant to trajectories, as well as proposed scenarios from NIMS. This information (as well as airline commercial imperatives) will be taken into account in optimising the trajectories in all phases

[12] In some cases, e.g. on-demand operators, the access to SWIM services provided by the Operational Centre system could be implemented using very light and flexible solutions (mobile devices). This will need further studies.
[13] The same principles of intra-fleet optimization could be extended from De-icing only to other queue management processes (e.g. AMAN)

(planning and execution). This is foreseen to be the focal point of interface between the AOC system and the other ATM systems.

2.4.5.3.2 Aircraft

The Aircraft forms an integral part of the Airspace User Operations. They cover a variety of aircraft types from big commercial jets to Ultra light vehicles and unmanned aircraft systems (UAS) with different ATM capabilities.

The technical aircraft architecture, presented in Figure 19, identifies 3 main areas, each being composed by technical sub-systems, which can be specialized depending on the type of aircraft identified above:

- Communication: composed of Air-Ground Interoperability and Air-Air Information Exchange sub-systems;
- Navigation: composed of Flight Management, Flight Guidance, Positioning sub-systems;
- Surveillance: composed of Traffic, Terrain and Weather sub-systems.

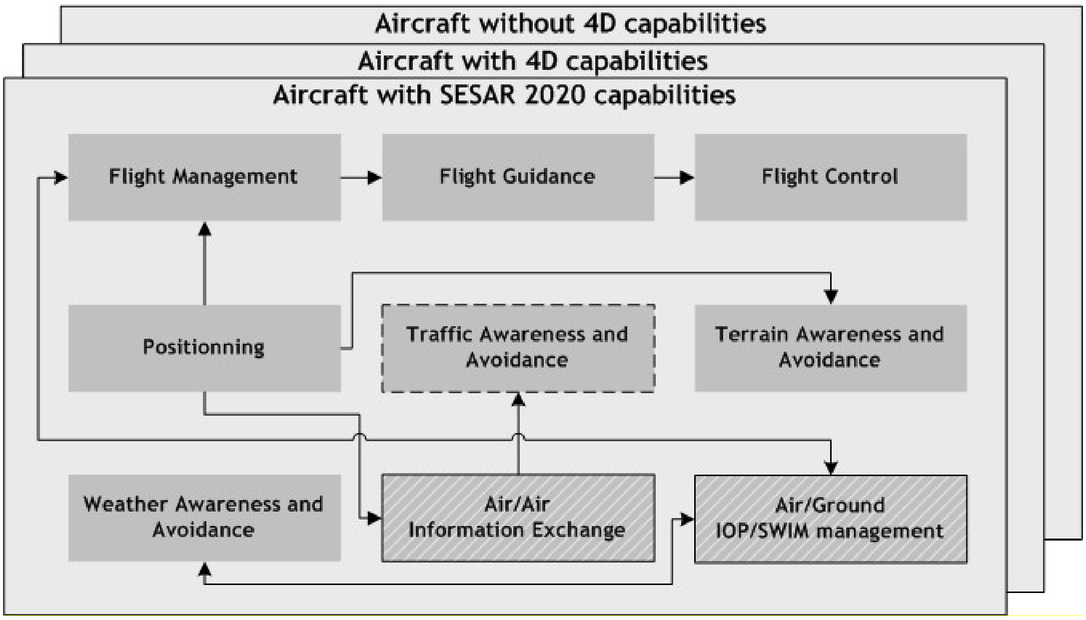


Figure 19: Aircraft main functional changes

The main expected functional changes in aircraft ATM capability from present to 2025 and beyond are:

- Development of new Flight Manager and Flight Guidance sub-systems, to support 4D trajectories and special approaches (curved, steep and offset optimised trajectories) to improve performance and reduce environmental impact. This will be done through the introduction of new functions such as automatic taxi and brake to vacate, improved 4D prediction algorithms using enriched meteorological modelling, TMR conformance monitoring, lateral containment with lower values, management of multiple time constraints, ASAS spacing manoeuvre (ATM-2), altitude containment along a segment of RBT and ASAS separation manoeuvre (ATM-3), longitudinal containment along a segment of RBT and ASAS self separation (ATM-4);

- Extensive usage of the aircraft navigation sub-systems for airport movement and position information transmitted to the ground by the communication sub-systems for planning and surveillance purposes. This encompasses taxi planning (ATM-2);
- Uplink of constraints and clearances (including those for taxiing) which mainly impacts the communication and navigation sub-systems, and of ASAS clearances, which impact all communication, navigation and surveillance sub-systems (ATM-2);
- Uplink and downlink of meteorological data, which impacts the communication and surveillance sub-systems (identification of significant meteorological events) as well as navigation sub-systems (wind and temperature data for construction of onboard reliable RBT predictions) (ATM-2);
- Direct air to air exchanges to support ATSAW, ASAS Spacing and Separation and ASAS Self Separation, which impact all communication, navigation and surveillance sub-systems.

Resulting changes in the technical sub-systems for commercial and military transport aircraft are:

- Development of a regional air-ground data link, based on “system to system” exchanges with human decision, instead of “human to human exchanges” with system activation (ATM-2):
    - New data link sub-systems for constraints uplink (including route & taxi clearance);
    - New data link sub-systems for RBT/PT downlink (including full 4D trajectory definition).
- Development of an air to air position/vector exchange to support ATSAW (ATM-2), ASAS Spacing (ATM-2), ASAS Separation (ATM-3) and RBT/PT exchange to support ASAS Self Separation (ATM-4)[14];
- Improvement of airborne surveillance sub-systems (CAT, CB, Wake Vortices, …) (ATM-2).

For combat aircraft, due to their specific nature, the communication sub-systems will mainly remain the same. Accommodation with the development of a new regional data link is an important topic. For navigation, it is highly improbable that combat aircraft will be equipped with a new flight manager sub-system. Accommodation will have to be found, as well as for usage of military GPS in managed airspace. This is also true for surveillance sub-systems (such as military radar which could render the same service as a traffic awareness sub-system for ATSAW).

It is expected that all UASs will comply with the trajectory data exchange requirements to the same level of integrity and accuracy as other aircraft operating in the same airspace.

For Business and General Aviation including Rotorcraft, the CNS architecture will be based on VHF voice, GNSS and Transponder Mode S. ADS-B is foreseen for surveillance and data information services.

[14] During a trade-off analysis, ADS-B in and out have been designated as the primary means for the Air Situation Awareness; a safety analysis shall be conducted to determine whether TIS-B shall be used as a complementary means.

2.4.5.4 Aerodromes

In addition to airport operation as described in Figure 20 and Figure 21, Aerodrome are involved in conflict management, queue management and network management processes.

High/medium density context

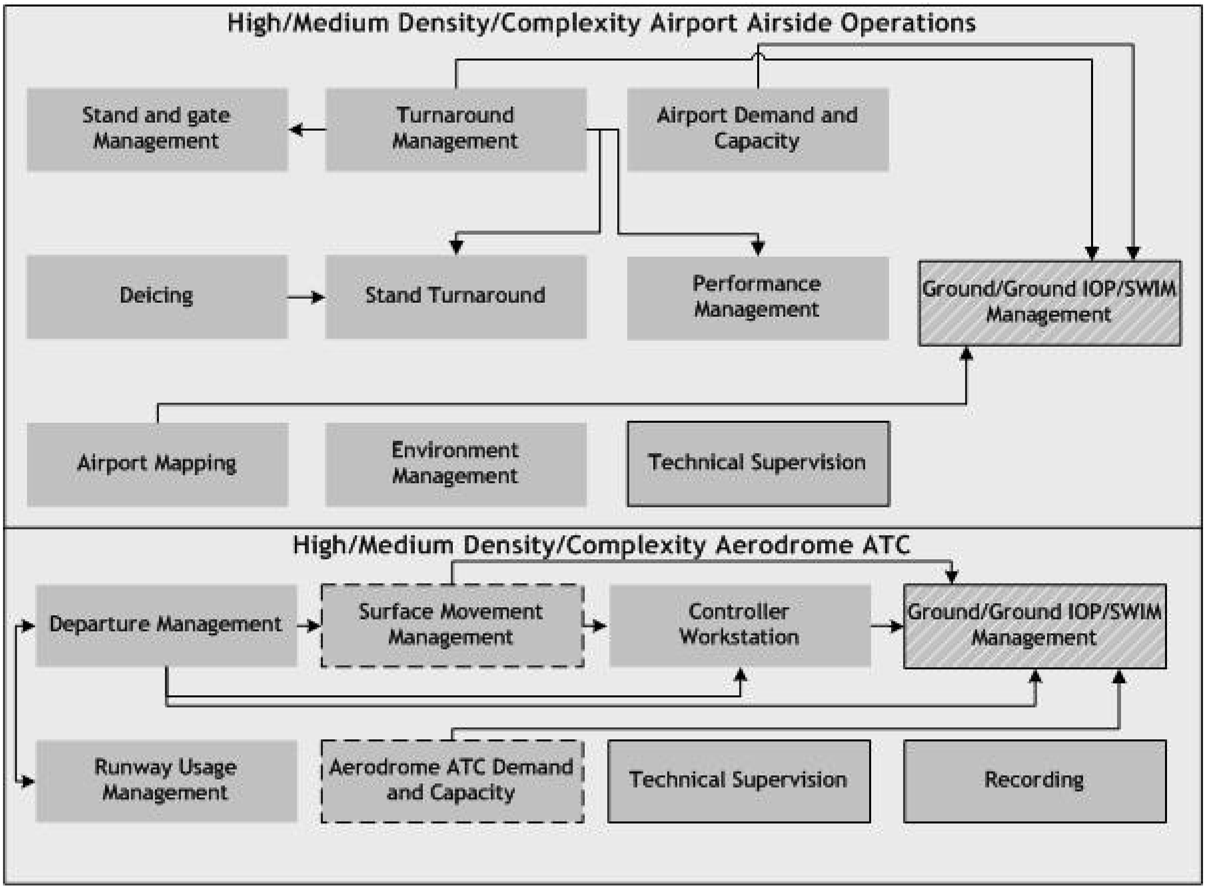


Figure 20: High/medium density Airport/Aerodrome ATC target architecture

All the sub-systems depicted in the figure above are considered as mandatory in an high density and complexity context. The sub-systems with a solid frame are delivering technical and communication services. The sub-systems with a dotted frame are sub-systems that are not present at military aerodrome.

Most of the airport airside sub-systems already exist today, but the target concept requires additional services to be provided as well as increased cooperation between the sub-systems. The main expected changes for the sub-systems of both Aerodrome ATC and Airport Airside Operations systems mainly concern the provision and access to a commonly shared data available through SWIM. This will show positive effects through queue management improvements in relation to both inbound and outbound flows to constraint runways.

It is recognized that services delivered by the Aerodrome ATC system may not necessarily need the assistance of functions usually delivered by an En-Route/Approach FDP sub-system. For example, coordination with vehicle movements or Follow Me/marshallers can be performed by using FDP services or by setting time stamps for airside processes (e.g. Start-up, Push-back, Taxi-Given, etc.). It is recommended that for high-density/complexity aerodrome ATC contexts, FDP services will be made available. However, they could be delivered through the Surface Management sub-system (and therefore there is no need here for a dedicated FDP sub-system). The FDP services might not be necessary for other Aerodrome ATC contexts or could be delivered through a remote access via terminals, to the relevant Approach ATC centre.

Some important services for the airport operations such as Fire Services, Meteo information management, Operational Supervision, Aeronautical Information Management are not depicted as they are not considered to be significantly impacted by the ATM Target Concept. The potential impacts however shall be studied in later R&D and implementation phases.

Low-density context

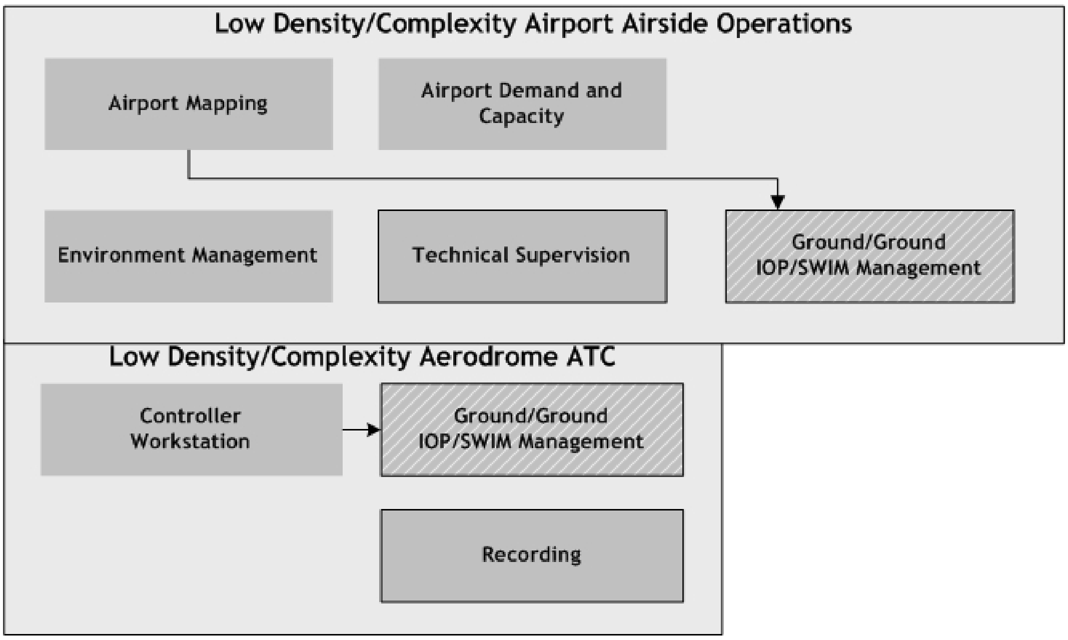


Figure 21: low density Airport/Aerodrome ATC target architecture

In a low density context similar services than the one available in high/medium density airport may be provided. The expectations is that most of those services will be provide either manually or through a remote access via terminal to the relevant organisation (either a larger airport or the relevant approach ATC centre) thus simplifying the local architecture.

2.4.5.5 Air Navigation Service Providers

2.4.5.5.1 En-Route and Approach ATC Centre

In addition to operating the sub-systems described in Figure 22 and Figure 23, En-Route and Approach ATC Centres are involved in regional network management processes.

2.4.5.5.1.1 High Density Context

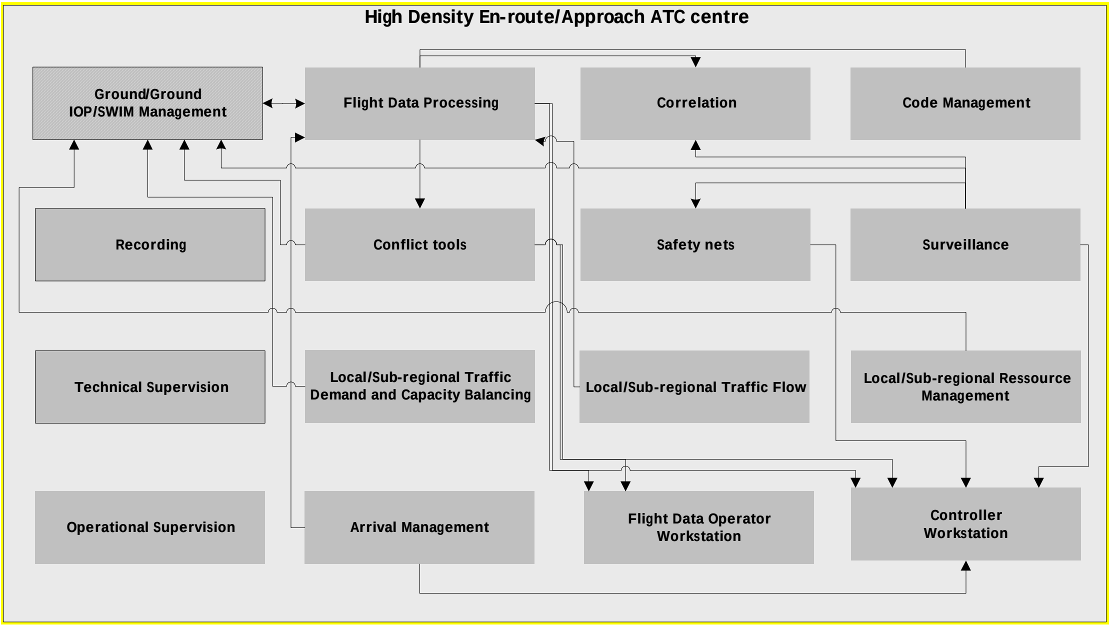


Figure 22: High-Density En-Route/Approach ATC Target Architecture

All the sub-systems depicted in the figure above are considered as mandatory in an high density and complexity context. The sub-systems with a solid frame are delivering technical and communication services.

The Flight Data Processing sub-system will have to manage and maintain different kinds of trajectories (SBT, RBT, PT, including those used for what-if purposes) using different sources of data and having the trajectory provided by the aircraft as the main input.

Information provided by the aircraft will allow enhancing significantly the planned trajectory prediction and the Quality of the services delivered today by Flight Data Processing, Surveillance, Arrival Management, Conflict tools and Safety Nets.

Support and management of ASAS applications will also be a major change to be supported by both Flight Data Processing and Controller Workstation.

The Conflict Tools sub-system will have to consider different kind of objects (such as flight, area, altitude) for advanced conflict detection and notification. Alternative conflict-free trajectories will be provided when certain events occur, including conflict resolution advisories.

The use and integration of Controller tools will be streamlined. Among them new tools in Approach airspaces will provide missing services today such as Arrival Management and mid-term conflict detection and resolution. A much closer coordination will take place between Arrival Management and in the Aerodrome ATC domain, Departure Management and Surface Management.

One En-Route Approach ATC centre per sub-region (FAB) will be elected to support the sub-regional coordination regarding Traffic Demand and Capacity Balancing, Traffic flow, and Resource management. It will arbitrate between local demand and capacity balancing received from the other En-Route and Approach ATC centres in the same sub-region and collaborate with the regional instances (NIMS, AAMS, and AIMS). These new sub-systems will participate actively whatever their level – local or sub-regional - to the network CDM processes.

A major global change will be the implementation of the Ground-Ground IOP/SWIM Management service either embedded in several sub-systems or in one single stand-alone sub-system providing to the rest of the sub-systems access to all necessary SWIM services.

2.4.5.5.1.2 Medium/Low Density Context

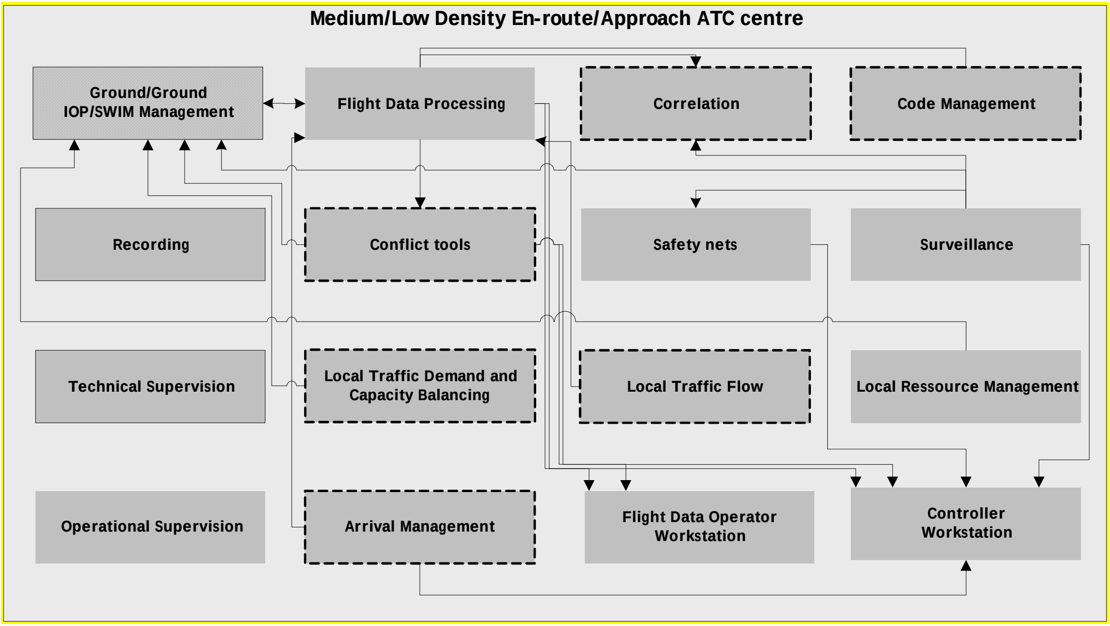


Figure 23: Medium/Low Density En-Route/Approach ATC Target Architecture

The difference with the High Density En-Route/Approach ATC centres is that most of the sub-systems – shown with a dotted frame in Figure 23- can be optional. Decision of whether sub-systems and their services shall be delivered depends mainly on the density of traffic they have to manage.

In a Medium/Low context, still a minimum set of ATM services has to be delivered thanks to Surveillance, Controller Workstation, Safety Nets and Flight Data Processing sub-systems. Technical Supervision will support the highest availability of these services as required by SESAR high safety level expectations.

Ground-Ground IOP/SWIM Management sub-system will support the high overall interoperability level expectation. Whatever their context, systems shall be able to access to SWIM services, to share the information as well as to provide the information they are responsible for.

2.4.5.5.2 ConOps Network Information Management System

The Network Information Management System (NIMS) is in charge of ensuring the support at the regional level of the collaborative processes with local/sub-regional (Airport, ACC, FAB) actors and all Airspace Users including military authorities: it supports the Network Management function in its “last resort broker” role by ensuring a stable and balanced network in all phases, from business Development Phase up to post-flight analysis phase. The NIMS relies on the 6 sub-systems shown in Figure 24, each one interoperating with mirror sub-systems at local/sub-regional level in the Airport and En-route and approach ATC domain.

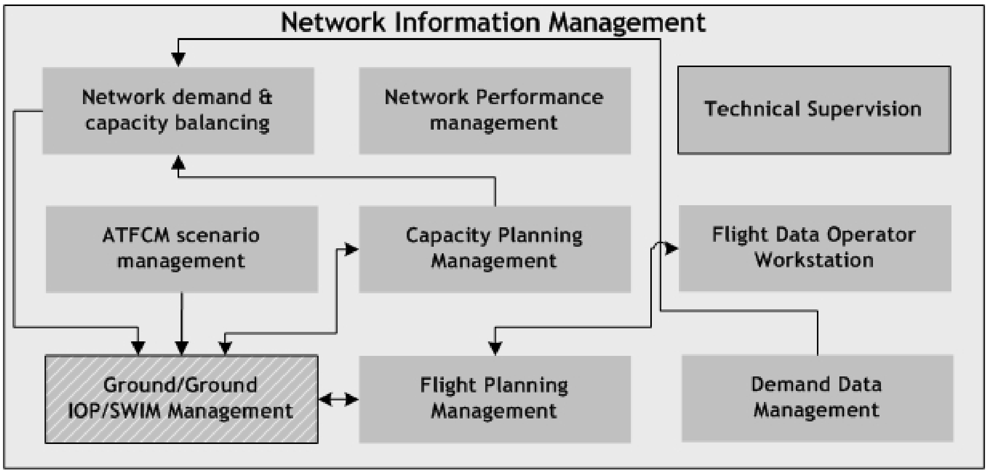


Figure 24: NIMS target architecture

- Capacity Planning Management: this sub-system supports the elaboration of capacity plans in a collaborative way (through CDM processes) with ACC, FAB, Airports and civil & military Airspace Users; based on an initial airspace design and traffic demand forecast, capacity plans are refined in close co-operation with AASM/Airspace Organisation Long-Term Planning;
- ATFCM Scenario Management: this sub-system supports the collaborative integration of airspace, demand and capacity data (through CDM processes) in order to mitigate the potential network capacity shortfalls and also to benefit from capacity opportunities; this sub-system supports elaboration of pre-defined scenarios in a collaborative way with local/sub-regional actors and AASM/Scenario Management;
- Network Demand & Capacity Balancing: this sub-system is used in the planning & execution phases. It supports the collaborative provision (through CDM processes) of a continuous demand & capacity balanced network situation (NOP); based on the User Demand Prioritisation Process it supports the evaluation of
  - Adaptations to existing pre-defined scenarios, and
  - Reactive ad-hoc scenarios, in close cooperation with AASM/Military activity planning.
- Demand Data Management: this sub-system supports ATFCM and ASM decision processes in managing civil and military demand (traffic and airspace usage) involving authentications

and authorizations to protect confidential and sensitive data. It provides demand forecast, traffic counts, flight samples according to parameters, ad-hoc reporting, etc.;

- Flight Planning Management: this sub-system supports the production, update and dissemination of flight plans (in the NOP) with routings that make optimal use of the available airspace while ensuring that all stakeholders have consistent information about the flights until they have been completed. It supports, in particular, the User Demand Prioritisation Process of the Airspace Users in refining their Shared Business Trajectories and agreeing the Reference Business Trajectories. In the long-term timeframe, it is expected that most Airspace Users will have their own capabilities to feed the NOP with business trajectories, taking into account the network constraints available as shared data through SWIM. Nevertheless, this Flight Planning Management sub-system will remain available at a regional level for civil & military Airspace Users that do not (want to) have their own local capabilities;
- Network Performance Management: this sub-system supports the continuous performance assessment of the network. The performance monitoring spans from the individual flight to the overall network operations; the outputs of this sub-system will not only enrich the inputs of the other sub-systems but also provide all actors and systems with measurement data to be used for continuous improvement.

2.4.5.5.3 Advanced Airspace Management System

The Advanced Airspace Management System as presented in Figure 33 supports the Airspace Organisation and Management.

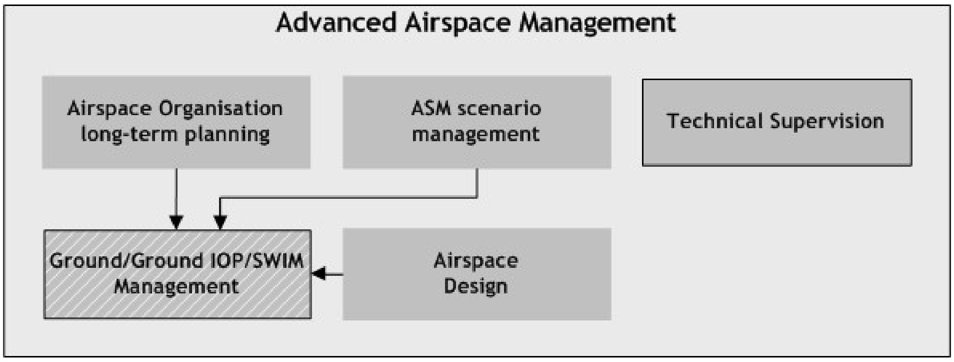


Figure 25: Advanced Airspace Management Target Architecture

The Advanced Airspace Management System aims at designing and organising an optimal airspace structure based on a shared and accurate, evolving demand. This system supports collaborative, dynamic & flexible airspace management processes. Pieces of airspace are no longer allocated in a permanent way for military activities, training and testing but are rather activated on an ad-hoc basis to meet specific flight requirements. They rely on highly collaborative processes, particularly with NIMS. It relies on the 3 following sub-systems:

1) Airspace Design: this sub-system supports the airspace and route design collaborative processes based on business needs and traffic forecast. The whole European airspace is

considered as a continuum with the exception of some designated areas such as danger areas (e.g. artillery ranges), environmentally and security sensitive areas. Managed airspaces are designed according to their level of complexity (High/Low/Medium) and based on NOP initial demand data (including traffic forecast). The Aeronautical Route Network and CDRs are designed based on area navigation technologies and the ground-based transmitter infrastructure is only used as a backup. The Airspace Design sub-system contributes to the airspace data in the NOP by providing an initial airspace structure, the elements of which will be further refined and activated by airspace management processes.

2) Airspace Organisation Long-Term Planning: this sub-system is used in the business development phase. It supports the elaboration of the military environment (airspace & routes e.g. CDR, TSA, TRA) in a collaborative way with ACC, FAB & airports and in close co-operation with ATFCM/Capacity Planning Management.

3) ASM Scenario Management: this sub-system supports the elaboration of military pre-defined scenarios in a collaborative way with civil local/regional entities and ATFCM/ATFCM Scenario Management.

2.4.5.5.4 Aeronautical Information Management System

The Aeronautical Information Management System as described in Figure 26 supports the other systems.

The local/regional AIM systems will need to be more integrated into a network of co-operating AIM systems and to handle more real time information, such as the operational status of navigation aids, airspace access and organisation. This will impact the existing EAD and national AIS systems.

In addition, three new sub-systems are foreseen:

1) An Aircraft Information sub-system to maintain static reference data about the aircraft fleet (e.g. equipment fitted, performance information).

2) A Terrain Information sub-system to hold common terrain information

3) An Airport Mapping sub-system to hold common airport maps and make them available to other systems, including aircraft systems.

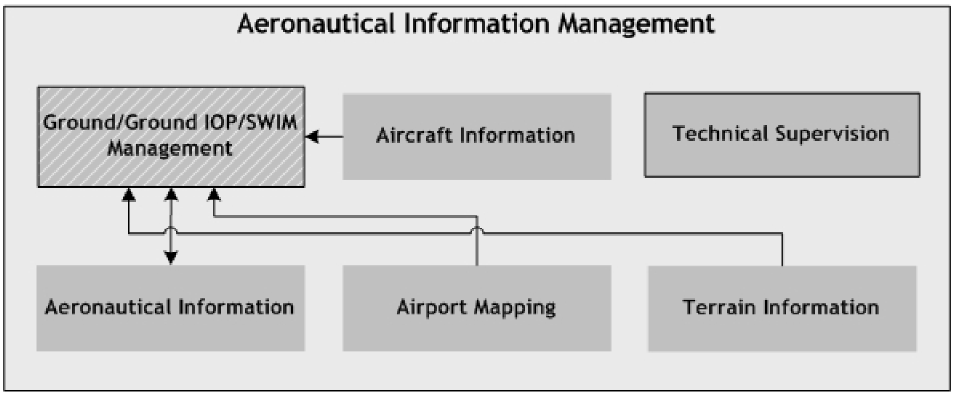


Figure 26: Aeronautical Information Management

2.4.5.6 External Systems

Not all the systems interacting with the European ATM System future architecture described in this document have been systematically addressed, these are:

- Meteo Systems: Meteorological data are key to the success of the concept. The meteorological service providers are not part of the European ATM System while the information they provide is. It is expected that all Meteo information necessary to support the ATM Target Concept will be delivered to the European ATM System through the usage of a Virtual Distributed Meteo Data Portal connected to SWIM, providing weather safety related information (validation of new weather data fusion functions allowing also to merge information collected on board);
- Military Systems: While many military ATS units are, in some way, interconnected with the civil ANSPs some other external military systems (e.g. NATO ACCS), available in Air Operations Centres and Wing Operations Centres, supporting the command and control of military air operations (including air policing/air defence) might not have a significant level of interaction with civil ATM. Those external military systems will participate in SWIM;
- Airspace Users Agent Systems: These systems might provide all necessary services to On-Demand Operators;
- Ground Pilot supporting Systems: UAS can be fully automatic systems or systems connected to a ground pilot. When a ground pilot exists, the systems supporting it will be connected to the SWIM infrastructure. The technical UAS architecture will be such that irrespective of the actual path its connection to SWIM is transparent to the European ATM System

Potentially any other systems in the CNS/ATM framework can be connected to SWIM through a process that will have to be clearly defined and commonly agreed in order to fulfil Safety and Security requirements.

2.4.6 Architecture and Safety

The future European ATM System architecture, instead of being an aggregation of local systems as today, will be distributed. Air and Ground systems will have to be considered as one integrated system. More automation will be required in order to accommodate both the increase in traffic and the future safety and environmental requirements. The key sub-systems have been recognized as the ones that should meet the highest expectations in terms of availability, continuity and integrity as they directly impact the safety performance of the future European ATM System architecture (refer to the DLT 2.4.4/D3 [Ref.17] for details). As a result, hardware and software solutions (among which for instance: fault tolerance mechanisms, redundancy, diversity of code, fallback systems) should be implemented to meet the required level of safety.

2.4.7 Architecture and Security

The future European ATM System architecture will provide a framework that allows for a stepwise implementation of the security measures as the threat evolves. System wide security management function (e.g. access control, network management) will be integrated.

The sharing of information by a SWIM infrastructure will be central to enabling the Operational Concept. As a result, ATM information networks will be protected so that the ATM applications may function securely (e.g. CDM, 4D-Trajectory Management, ADS-B, TIS-B). The security of the information will have to be managed commensurate with the potential increased access to the infrastructure. The implementation of SWIM will raise the same security concerns as the ones existing today for the Internet system. Security of SWIM based information networks will be harmonized with the on-board networks of connected aircraft and the data links.

To fully protect the information during its lifetime, each component of the information processing system must have its own protection mechanisms, by building up, layering on and overlapping of security measures through a so-called defence in depth mechanism. The main layers of intervention are at network and data level.

The first level of security from cyber attacks is established by securing the network infrastructure used to transport the information.

2.5 CNS Technologies

2.5.1 Introduction

This chapter provides an initial view of the CNS technology necessary to support the ATM ConOps and architecture for 2020 and beyond. It has been developed through a mapping process whereby each enabler has been assessed as far as possible against the operational and architecture needs and requirements, and the deployment considerations. The level of compliance of the candidate technology has been weighted against different performance criteria, e.g. availability, continuity, integrity, deployment, standardisation (refer to the DLT 2.5/D3 [Ref.18] for more details).

CNS capital replacement costs account for approximately 40% of the total European En-Route ATM/CNS infrastructure and hence a common theme in the technology evolution strategy is the progressive rationalisation of the multitude of today's aeronautical technologies, and the exploitation, where feasible, of mass market technology in order to seek improved cost efficiency. In consultation with stakeholders and appropriate planning, decommissioning of some elements of the ground system will be possible.

A common objective is a continuous and balanced evolution of CNS technology and technical enablers from now to 2020, and beyond to support the ATM ConOps.

It should be noted that many of the technologies necessary to support the ConOps and its associated architecture, up to and including **ATM Capability 3**, are already, (or planned to be) implemented to fulfil the needs of ATM to service all aircraft from legacy carriers and military to ultra-light aircraft. To meet **ATM Capability 4** and support the ConOps in areas such as advanced 4-D trajectory-based operations and advanced ASAS applications, and **subsequent to the development of detailed**

operational requirements, new technologies will need to be agreed globally, developed and validated by the SESAR Joint Undertaking.

Specific technologies needed for UAV/UAS to ensure a transparent operation similar to a manned aircraft (e.g. dedicated high integrity UAV/operator command and control data links) fall outside SESAR. It is however conceivable that some technologies that will be developed in the coming years by and for the UAV community will find their way to manned aircraft as well as we know of the requirements of advanced business aviation where sense and avoid technologies are sought for in the not too far future.

2.5.2 Technology Assessment Process

The overall objective of the Technology Assessment is to define a CNS Technology strategy at the 2020 horizon and propose a sound roadmap with achievable transition steps. This was made possible by first deriving and refining **Technical Needs** from both the ConOps and from the Architecture drivers. Coordination and consistency were ensured with the ConOps, and more specifically the derived set of system functions. In specific areas, particularly in the Communication and Surveillance domains, this was complemented by inputs provided by the Architecture.

The relationship with the various customer tasks is illustrated in Figure 27.

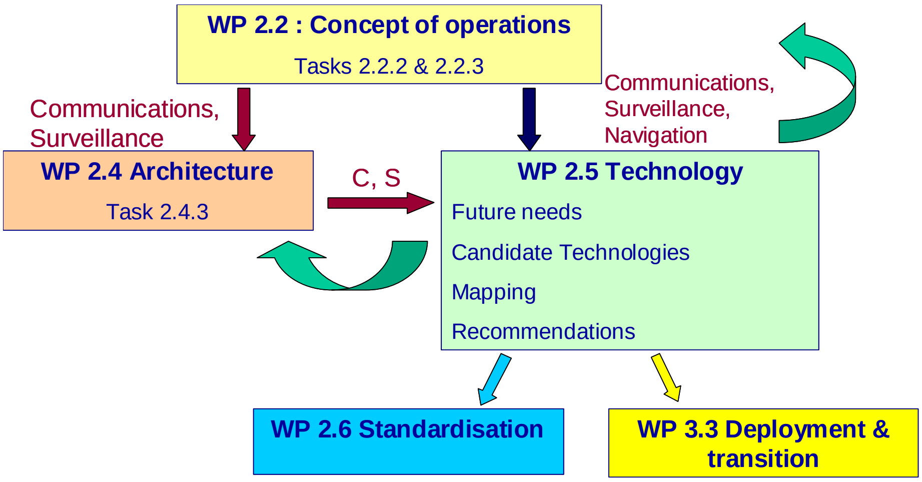


Figure 27: the relationship of CNS technologies with ConOps and Architecture

It has been necessary within the mapping process to use expert judgement, together with the previous work of EUROCONTROL and the FAA to propose an initial set of candidate technologies. Final choices will have to be made after further development of detailed performance requirements and international agreements. In parallel, the technology group refined the inventory of the existing and future promising technologies previously developed in D1. Technologies were mapped to needs with the goal of determining the shortfalls (i.e. gaps) in technological development that should be addressed before the SESAR CNS needs can be regarded as fully satisfied. For each need, the following three-step process was conducted:

1. Identification of the technical enabler(s) that potentially address the need.
2. Identification of the "Critical Design Features (CDFs)" (e.g. integrity, availability, continuity) of the need and assess the extent to which the identified technologies fulfil the various CDFs of the

need. Also consider deployment issues and steps to operational use (e.g. maturity, cost, standards).

3. Discussion on the pros and cons, and identification of the gaps and overlaps. This resulted in a set of **key issues** and **recommendations** related to the necessary development validation and certification activities to prepare the 2020 timeframe.

Further details are provided in the DLT 2.5/D3 [Ref.18].

2.5.3 Evolution Towards 2020 and Beyond

In its simplest form, the 2020 CNS baseline can be characterised as follows:

- Communication technologies that enable improved voice and data exchanges between service actors within the system, such as those necessary to support the SWIM functionality and CDM process;
- Navigation technologies that enable precision positioning, timing and guidance of the aircraft to support high performance, efficient 4D trajectory operations in all phases of flight;
- Surveillance technologies that enable precision monitoring of all traffic to assure safe and efficient operations, including enhanced Traffic Situational Awareness and ASAS.

2.5.3.1 The Communication Evolution

The following table provide the list of the initial set of candidate technologies that meet the high level technical needs for communication.

COMMUNICATION TECHNOLOGIES / COMMUNICATION NEEDS	Terrestrial									SAT	Airport	Ground-Ground network				
	VHF (25 kHz and 8,33 kHz)	VDL2	ATN	Mobile IP	B-AMC (Broadband VHF)	P-34	Wideband CDMA	AMACS	Narrowband LDL	SATCOM	'802.16 (C Band)	V-SAT	PENS IP V6 Transport Layer	AMHS	Voice Over IP	ATS Qsig
1) Mobile Communications																
Air-Ground: ATS and AOC data		✓			✓	✓	✓	✓	✓	✓	✓					
Air-Ground Voice	✓				✓					✓						
Network Management			✓	✓												
Air-Air Datalink					✓	✓	✓	✓	✓							
Air-Air Voice	✓				✓											
2) Fixed Communications																
Ground-Ground Datalink			✓	✓								✓	✓	✓		
Ground-Ground Voice Communications				✓								✓	✓		✓	✓

Table 4: Mapping of communication technologies

The evolution of the communications capabilities and technologies from analog to digital technology is driven by the increasing need to exchange data between the ATM stakeholders. A full integration of all actors and systems within the ATM system requires specific attention to security requirements. With the increasing use of data communication, voice will become an ultimate backup means.

The communication domain consists of two distinctive parts, the air-ground mobile and the ground-ground fixed communication environment. Due to different operating environments in space, air and ground, various physical (lower layers) communication systems will continue to exist. A major evolution will be the development of a common communication transport layer to ensure seamless, secure end-to-end Quality of Service management across the entire communications infrastructure, supporting SWIM for both ATS and AOC data services. Consideration needs to be given to improve the existing ATN/ISO protocols with new IP transport layer protocols accommodating also existing oceanic data link services and digital voice based on IP. The development of the transport layer is closely associated with the evolution of the various data communication sub-network capabilities.

Software defined radios will facilitate avionics integration and global transition, and might become available for all Airspace Users.

2.5.3.1.1 Air Ground Mobile Communication

The air ground mobile communication technology shall provide air to ground and air-to-air data and voice services.

Voice services

While the ATM Target Concept is oriented toward data exchanges between aircraft and ATM ground systems, voice will remain an essential means of communication at least until the 2020 timeframe. Voice services are expected to continue to be based on the premise of one channel per controller/sector. Beyond 2020, and as defined by the ConOps, voice will remain the primary means of communications, only in certain circumstances. The role of voice communications will essentially be a safety back-up means of communication.

In the near term, air traffic control operations and aeronautical operations control (AOC) will continue to use the allocated VHF spectrum (118-137 MHz) for voice communications. In order to service continued demand for additional voice channels, Europe has implemented 8.33 kHz channel spacing in the VHF band in designated airspaces. With the expected traffic increases, it will be necessary to extend the deployment of 8.33 kHz and progressively remove UHF (military) and 25 kHz channel spacing[15]. Further studies are needed to establish whether the migration to 8.33 kHz will be sufficient to solve the long-term requirements for voice communication. The voice service for 2020 will be complemented by SATCOM for oceanic and remote areas.

Data services

Data exchange will be progressively introduced for routine communications.

In the near term, the point-to-point air/ground data service link is based on ATN/VDL Mode 2 technology. This initial step will need to be enhanced and/or complemented to support the full deployment of the ATM Target Concept. It is important to highlight that higher performance (e.g. predictability, security, latency, availability, integrity and throughput) data-links will be required to support advanced services, such as the 4D contract, trajectory exchanges, as well as the increasing air-traffic volumes and density.

To meet the long-term data communication needs, a dual link system is likely to be necessary to cope with the higher availability requirements. New terrestrial mobile communication technologies system

[15] In order to enable a transition for GA, state and military aircrafts, and to cater for the situation where retrofit or upgrade is not practicable, VHF 25 kHz and UHF will need to be maintained as long as necessary in some parts of the airspace.

and satellite technologies can provide the advantage to offer complementarities in terms of infrastructure and radio spectrum diversity, and coverage. It is recommended to expedite research and development, finalise the technology selection, and then define as necessary, an implementation programme for these satellite and terrestrial systems.

For the terrestrial network, a number of candidate technologies operating in L band have been proposed. Wideband and narrowband options are proposed for more detailed investigation, but the final choice requires further design work and validation, taking into account aircraft equipment cohabitation and spectrum availability, which are the major constraints.

The **Wideband** candidate technologies are B-AMC, P34, WCDMA, among which the best option is likely to be a tailored designed system, satisfying the specific severe conditions of on board co-site constraints with other ATM key systems (e.g. SSR Mode S and DME) in the 960-1260 wide band domain. P34 and WCDMA are both standardized; unused spectrum needs to be identified in the lower part of the L-Band. B-AMC is a completely new system that would operate in-between existing DME allocations. Complementary activities are necessary to refine the final solution and to assess performance. A particular issue with this option is the on board compatibility with DME and SSR Mode S due to the use of the same band. However, such a method could provide extra capacity if an efficient sharing mechanism can be developed.

The **Narrowband** candidate technology is AMACS. AMACS is based on existing technologies and is using only the lower part of the L band (960 -975 MHz) not in use by the current DME system. Complementary activities are necessary to refine the final proposed solution, assess performance and spectrum capacity needs.

The limitation for all the above options could be the availability of usable spectrum in the currently free part of the L Band (960 -975 MHz). All options need to be investigated without delay within the next two years, including comparable capacity simulations, in order to make the final choice of the best solution. During the ongoing design of the two systems, significant coordination need to be performed in close cooperation with the FAA.

A satellite based infrastructure is proposed to complement the terrestrial part. In collaboration with the European Space Agency it is necessary to initiate activities to assess the feasibility, possibly leading to the definition of a satellite based communication standard, as an alternative high performance link to provide the necessary levels of availability and hence integrity for the more advanced concept elements, and reduce the spectrum used by terrestrial systems for the less (time) critical data communication (e.g. AOC services). Non geostationary satellites could be necessary depending on polar satellite coverage requirements, but would be significantly more expensive and complex, and probably not affordable. The new standard for satellite communications could be implemented either on dedicated payloads, on existing infrastructure, or new dedicated satellites depending upon the emergence of satellite operators business plan to offer such a service.

The main challenge for the satellite technology is not technical but institutional due to the fact that it is a highly centralised system providing trans-national services. The commercial and liability arrangements remain key issues to be solved. (These issues are not specific to the COM domain).

In order to accommodate the forecasted traffic on the airport surface and alleviate use of valuable VHF spectrum, it is proposed to use IEEE 802.16 technology to build an aviation airport surface data-link system supporting both AOC and ATS data exchanges. This technology will support surface routing and guidance functionalities of A-SMGCS, as well as the transmission of 4D trajectory data for the ground segment of the flight.

Military aircraft could benefit from the use of their Military LINK16 as a means to comply with a seamless requirement. This could be achieved by implementing a specific gateway making transparent the technology from an end-to-end perspective. The main objective is to avoid retrofit of military aircraft that are fitted with Link 16. It is anticipated that some institutional (service provision according to the Single Sky Regulation 2004/550) and technical (radio spectrum compatibility) issues will need to be addressed in order to avoid any negative impact on the civil navigation infrastructure.

Prior to the selection of technology choices for air-to-air data communications, more accurate requirements still need to be defined and validated in respect of the air-air point-to-point and broadcast services that will support the 4D trajectory exchanges and advanced ASAS applications to be implemented beyond 2020. The air-air data link is likely to exploit the technologies developed for air-ground point to point and/or for those used for air-air broadcast.

The existence of VDL Mode 4 as an air-air/air-ground data link is acknowledged, but it is not considered to be a candidate technology as it is not supported by the majority of the stakeholders after consideration of the risks and investments associated to its implementation versus the added value. However, VDL Mode 4 is being implemented in Sweden for initial surveillance and communication services. The VDL Mode 4 based infrastructure is one possible tool for developing, validating, testing and demonstrating the viability of new ATM services (e.g. provision of traffic information, weather, NOTAMs, etc. as requested by General Aviation).[16]

2.5.3.1.2 Ground-Ground Fixed Communication

Ground-ground communications are the means to enable information flows between ATC centres, and to national, sub-regional or regional organisations.

Data volumes and the level of automation will continue to increase to support the higher levels of co-ordination in the future operational environment, where ATC, AOC and airport systems are integrated. In order to derive maximum benefit from the underlying data network services, the strategy envisages sharing resources for both operational and administrative data communications purposes.

Today voice telephony services using analog signalling protocols such as MFC/R2 are predominant for ATS applications. By 2020 ground installations will be connected using a fixed ground-ground IP based network supporting both data and voice (Voice over IP - VoIP). Implementation of VoIP for ground segments of voice communication will be enabled by the provision of a common IP based ground data network, including the ground segment of the air ground voice link . It will provide efficiency improvements by enabling sharing of voice and data on the same network, and will enable the provision of some security features. ATS-QSIG, currently being deployed by some ANSPs will migrate to VoIP.

The Pan-European Fixed Network Service (as developed by the PENS project) is foreseen as the long-term strategic ground telecommunications infrastructure for voice and data transmission and switching for the aeronautical community, providing the core supporting infrastructure for SWIM. It

[16] LFV, Austro Control and IAOPA disagree with this paragraph. The statement of disagreement of LFV, Austro Control and IAOPA and the associated rationale can be found in Annex IV.

will be a procured IP network service supporting new data and legacy applications using IPv6 and IPv4 protocols. The procured value added services contain the network management, provision of bandwidth and the connections to provide the circuit level connectivity between fixed locations.

In terms of information distribution services, the AFTN has been the primary aeronautical message interchange technology for the last 30 years. The Aeronautical Message Handling Service (AMHS) has now been specified by ICAO for future message handling applications. ANSPs are already deploying AMHS technology for international messaging applications to replace the current AFTN. AMHS is being deployed over TCP/IP in the European region.

2.5.3.1.3 The 2020 Communication Baseline

The 2020 communication baseline is consisting of the technologies which need to be fully operational by 2020 towards the ATM Target Concept whereas their deployment schedule will be defined within the various Implementation Packages in D4:

- Ground-Ground
    - A IP based ground-ground communications network supporting all the ATM applications and SWIM services, together with VoIP for ground segments, including VoIP for the ground segment of the air-ground voice link.
- Voice
    - 8.33KHz is the standard for voice communications;
    - SATCOM voice for oceanic and remote areas.
- Air-Ground Data link
    - VDL2/ATN.
- Airport
    - A new Airport data-link to support surface communication, using a derivation of the IEEE 802.16.

2.5.3.1.4 Communication Beyond 2020

Development and R&D work on other technologies needed to support the expected traffic increase and the ATM Target Concept will be launched and undertaken prior to 2020 to ensure the sufficient timely deployment of these new technologies.

- Data link becomes the primary means of communications. Voice remains as a back-up;
- Common inter-networking transport mechanism to support the various data-links, managing an end to end Quality of Service;
- Post 2020 implementation of new communications components, comprising terrestrial (wide or narrowband) and space based components in complement of VDL2/ATN to support the new most demanding data-link services.

2.5.3.2 The Navigation Evolution

The following table provide the list of the initial set of candidate technologies that meet the high level technical needs for navigation:

NAVIGATION TECHNOLOGIES / NAVIGATION NEEDS	GNSS					Terrestrial Aids		On-Board Navigation Means				Airport	FMS
	NT11	NT13	NT14	NT17	NT18	NT22	NT25	NT31	NT16	NT32	NT33	NT63	
	GPS L1 and L5	Galileo	Glonass	SBAS (EGNOS-WAAS)	GBAS	DME / DME	ILS, MLS	Inertial Navigation Systems (INS/IRS)	ABAS (RAIM only)	Barometric Altimetry	HUD, EVS	Airport Surface Guidance Technologies	
1) En-route & TMA: Positioning													
Horizontal Position	✓	✓	✓	✓		✓		✓	✓				
Vertical Position										✓			
Time													
2) En-route & TMA: Trajectory Management													
2D-RNAV													✓
2D-RNP													✓
3D / Vertical Navigation													✓
4D / Time Constrained Navigation													✓
3) Approach & Landing: Navigation & Positioning													
Non-Precision Approaches	✓	✓	✓	✓		✓							
Cat I / Near Cat I Approaches	✓	✓	✓	✓			✓		✓				
Cat II/III Approach & Landing	✓	✓	✓		✓		✓				✓		
Special Approaches (Curved, Steep, Offset)	✓	✓	✓	✓					✓				
4) Airport Surface: Navigation & Positioning													
Airport Surface Positioning	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	

Table 5: Mapping of navigation technologies

The objective of the navigation services is to provide aircraft positioning and trajectory management in all phases of flight.

The evolution of the navigation technologies will be dominated by the transition from a predominantly ground-based to a satellite-based infrastructure based on the navigation performance requirements.

The Navigation technology considerations are dependant on the flight phases

- En-route/Terminal navigation ;
- Approach and landing guidance;
- Airport surface movement.

2.5.3.2.1 General Considerations

In general the Aircraft navigation will be improved with an appropriate combination of global navigation satellite system (GNSS), self-contained navigation systems (IRU/IRS) and navigation aids enabling progressive implementation and exploitation of various navigation concepts[17].

[17] A full range of concepts (RNAV and RNP concepts) are for example defined in the Performance-based Navigation - PBN - manual (ICAO doc. 9613)

GPS complemented by significant ABAS systems[18], enables large commercial aircraft to perform a variety of operations to support the demanding operations envisaged in the ConOps. For these categories of aircraft SBAS, provided in Europe by EGNOS, and by WAAS in the USA, provides limited performance benefit over and above their existing capabilities. Hence airlines are reluctant to equip (and pay) for these services. On the other hand, GA, regional aircraft and other Airspace Users, not equipped with the same types of ABAS systems require the provision of SBAS based LPV services, particularly as they tend to fly to less (ILS) equipped airfields and airports. Hence, SBAS in itself becomes an important intermediate step for some categories of Airspace Users, until the deployment and exploitation of new constellations such as Galileo and GPS L5.

The addition of the Galileo constellation and the addition of the GPS L5 signal will improve the accuracy, availability and the integrity of the navigation signal, and the user community agrees that by 2020 the latest airborne GNSS equipment will have the capability to use all GNSS signals (e.g. Galileo, GPS, Glonass and SBAS). Nevertheless, a key issue revolves around the institutional establishment of commercial arrangements (e.g. legal liability, certification and service charges) to provide the GNSS services. The biggest risk associated with provision of GNSS is the potential for denial of service by deliberate jamming, and consequently backup mechanisms are required. Terrestrial navigation aids such as DME/DME (TACAN for military) will be kept as back-up means, as most aircraft are already equipped, crews are trained and a basic ground infrastructure exists.

The transition to GNSS based operations will enable the necessary **decommissioning** of conventional navaids (VOR, NDB/ADF)[19], freeing up valuable radio spectrum that could be exploited for new or other aeronautical services. A back up for GA, where DME installations are not feasible may need to be found.

2.5.3.2.2 Navigating in the TMA

Whilst ILS is the core landing technology, the trend will be to move to GNSS based landing in order to improve airport accessibility, either in Cat I conditions (ILS and GNSS as backup/complementary systems) or Cat II/III conditions (GBAS Cat II/III with ILS/MLS backup). As GNSS landing is progressively introduced, ILS will revert to a backup system to support the risk of GNSS outage.

CAT I performance will be widely provided as there may not be a need for an ILS backup at locations where GNSS CAT I or near CAT is an improvement to previous NPA approaches.

Finally, aircraft will increasingly rely on GNSS to fly steep, curved and segmented approaches in the terminal area, to improve capacity and reduce environmental impact.

For LVP (Low Visibility Procedures) operations, lighting presents more than 50% of the investment cost. As more airports are able to handle these types of operation as a result of widespread GNSS precision navigation, lower cost lighting technologies will be developed and made available.

[18] Large aircraft are equipped with precision inertial systems. These are not generally carried by GA and regional aircraft.

[19] With consultation and appropriate planning with the users (including GA and military), progressive decommissioning towards 2020 should be possible.

2.5.3.2.3 Airport Surface Movement

GNSS combined with CDTI technology improves the situational awareness on an airport. The introduction of a moving map display including presentation of surrounding traffic enabled by ADS-B-In/Out will significantly reduce runway and taxiway incursions. By providing the pilot with conflict free routing, together with target times, the system will considerably improve taxiway throughput and reduce taxiway delays.

2.5.3.2.4 Time Reference

GNSS is a potential source of common time reference, as required by ConOps.

2.5.3.2.5 The 2020 Navigation Baseline

In summary the 2020 navigation baseline is consisting of the technologies which need to be fully operational by 2020 towards the ATM Target Concept whereas their deployment schedule will be defined within the various Implementation Packages in D4:

Primary aircraft positioning means will be satellite based for all flight phases.

- Positioning is expected to rely on a minimum of two dual frequency satellite constellations (Galileo, GPS L1/L5 and potentially other constellations, assuming interoperability) and augmentation as required:
  - Aircraft based augmentation (ABAS) such as INS and multiple GNSS processing receiver,
  - Satellite based augmentation (SBAS) such as EGNOS and WAAS
- Terrestrial Navigation infrastructure based on DME/DME is maintained to provide a backup for en route and TMA;
- Enhanced on-board trajectory management systems and ATS Flight processing systems to support the trajectory Concept.

2.5.3.2.6 Navigation Beyond 2020

The availability of other constellations enables increased accuracy and availability. Multi constellation receivers are able to exploit available constellations/satellites (e.g. China, Russia), if the benefits outweigh the added complexity compared to a basic GPS + Galileo combination.

Ground based augmentation (GBAS) for Cat II/III approach and landing with backup provided by ILS/MLS, and specific GBAS features may be necessary to meet high performance guidance requirements for airport surface navigation

2.5.3.3 The Surveillance Evolution

SURVEILLANCE NEEDS / SURVEILLANCE TECHNOLOGIES	1) Independent Non Cooperative			2) Independent Cooperative			3) Dependant Cooperative	
	PSR	SMR	Multi Static PSR	SSR	WAM	Airport Multilateration (MLAT)	ADS-B	TIS-B
1) ATC Surveillance								
ATC Surveillance Means ER/TMA	✓		✓	✓	✓		✓	
ATC Surveillance Means App&Land	✓		✓	✓	✓		✓	
ATC Surveillance Means Airport Surface		✓	✓			✓	✓	
A-SMGCS (ATC Surveillance Functions)		✓	✓			✓	✓	
2) Airborne Surveillance								
Airborne Surveillance: ATSAW							✓	✓
Airborne Surveillance: ASAS Spacing							✓	
Airborne Surveillance: ASAS Separation							✓	
Airborne Surveillance: ASAS Self separation							✓	

Table 6: Mapping of surveillance technologies

The objective of the surveillance service is to provide a complete picture of the actual traffic situation to ensure a safe separation and an efficient traffic flow.

The evolution of the surveillance technology can be characterised by a combination of various surveillance related sources, ranging from independent to aircraft derived, as necessary to meet the performance requirements.

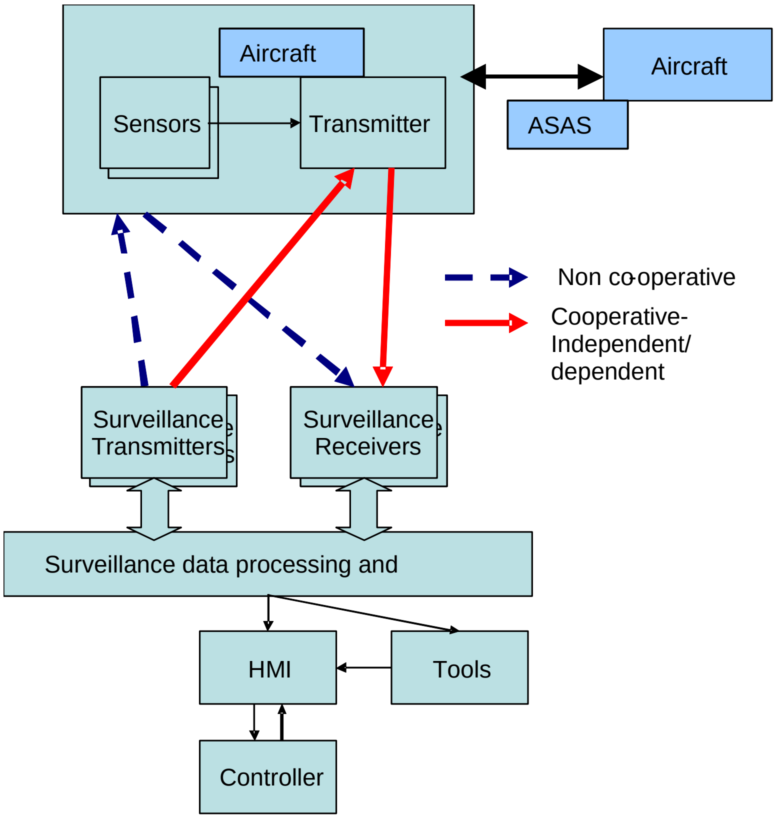


Figure 28: Surveillance principles

Four basic surveillance principles can be distinguished:

Independent Non Cooperative Surveillance (Primary Surveillance Radar PSR) which does not rely on any form of airborne avionics will continue to be deployed, as necessary, for safety and security as necessary, in order to detect transponder failure or unidentified vehicles. However, by 2020, new cheaper forms of PSR using multi-static techniques (MSPSR) are expected to be available.

Cooperative Independent Surveillance provides the principal means of surveillance in 2020 based on SSR Mode S or WAM (Wide Area Multi-lateration). WAM involves the use of ground based antennas, rather than heavy rotating equipment and hence there are potentially significant cost efficiencies, made more attractive as the migration to this new technology has no impact on the aircraft systems.

Cooperative Dependent Surveillance which is based on aircraft providing their position, altitude, identity and other parameters by means of a data link, and is therefore fully dependent on the aircraft systems. Cooperative dependent surveillance will develop as a solution for low-density non-radar airspace or as a complement to independent surveillance in medium to high-density airspace.

Air to Air surveillance: ADS-B-In/Out applications must be developed to provide the aircraft with the necessary capability to support the basic ASAS ATSAW, spacing and initial separation applications identified in the ConOps.

However, in order to support demanding future operational requirements such as ASAS self-separation, it will be necessary to improve the air-air data capacity, integrity, security and availability to support additional functions such as trajectory intent data. The 1090 ES system must therefore be improved and/or complemented with a high performance data link as envisaged for the data communication infrastructure.

TIS-B could be used to provide the traffic situation of those aircraft not ADS-B-Out equipped. However, the main arguments against are:

- Those aircraft/airlines having invested in the ADS-B-In/Out technology to profit from improved operations would in fact be paying for both the conventional surveillance service and for a TIS-B service to cover the fact that other had not invested;
- It is doubtful whether TIS-B could achieve the necessary levels of performance in terms of update and latency, in the areas identified in the concept, primarily in support of approach spacing. Therefore TIS-B benefits could be a transitional step, limited to basic ATSAW application.

Considering that most carriers' aircraft can be easily adapted to provide 1090 ES-ADS-B-Out, it is reasonable to consider a mandate for short term improvements of the current ATM system.

Airport surface movement

Airport surface movement surveillance will be based on combination of Cooperative and Independent Non-cooperative systems in order to achieve the necessary levels of performance to support A-SMGCS.

Independent Non-Cooperative Surface Movement Radar (SMR) is a currently deployed technology, but its performance degrades at airports with complex layouts due to the number of buildings, obstacles, etc. This may require more than one SMR, which would increase the already high cost of SMR installations. Importantly, SMR can detect non-cooperative targets. New, smaller and cheaper primary radar sensors in the 75-95GHz frequency band are currently developed and will be deployed to smaller airports in the future.

Airport Multilateration (MLAT) is a form of Cooperative Surveillance providing high performance surveillance for surface movement. Its modular system design can cover areas shaded from radar sensors. It is a mature technology, although certification is still pending. A considerable advantage of MLAT over SMR, is its lower cost (approximately 30% compared to SMR). Also the physical problem of locating MLAT receivers is considerably less than SMR due to their smaller size (although a greater number of MLAT receivers will be required and good quality ground-ground data links are needed). However, MLAT detects only cooperative targets, which means that mandates for transponder carriage for *all* vehicles will be necessary. Providing ground vehicles with transponders could cause a shortage of national Mode S addresses.

Finally, ADS-B is an important enabler and is becoming of increasing interest to regional airports. Full equipage of ADS-B-Out (both aircraft and ground vehicles) will be required if ADS-B is to be relied upon as a means of ATC ground surveillance.

Air and ground based wake vortex prediction and detection technologies will support enhanced runway operations.

2.5.3.3.1 The 2020 Surveillance Baseline

In summary the 2020 surveillance baseline is consisting of the technologies which need to be fully operational by 2020 towards the ATM Target Concept whereas their deployment schedule will be defined within the various Implementation Packages in D4:

- For the airspace, Cooperative surveillance will be the norm, complemented as required by Independent Non Cooperative surveillance to satisfy safety and security requirements. For the Airport both Cooperative and Independent Non-Cooperative surveillance systems will be necessary.
    - PSR will provide Independent Non-Cooperative surveillance;
    - Since aircraft will have the necessary mode S and ADS-B equipage, the choice of Cooperative surveillance technology (Mode S, ADS-B, MLAT) remains flexible, with the service provider determining the best solution for their particular operating environment, based on cost and performance;
    - SMR will provide the Independent Non-Cooperative airport surveillance.
- ADS-B-In/Out is provided by 1090 ES;
- With a mandate of 1090 ES-ADS-B-Out, TIS-B will not be needed in the transition to support ASAS applications;
- Satellite based ADS-C for oceanic and remote areas.

2.5.3.3.2 Surveillance Beyond 2020

- PSR is replaced by cheaper forms of Independent Non-Cooperative surveillance;
- The 1090 ES system supporting ADS-B-In/Out is improved and/or complemented with an additional high performance data link.

2.5.4 Key Issues

The key issues that constitute risks or opportunities to the timely deployment of the technologies, necessary to support the ConOps are summarised as follows:

- **Deployment schedule:** The time frame for the deployment of new CNS technologies has been up to now in the order of 15 years or more. This is the period of time necessary for standardisation and certification, assuming that research development and validation have been completed before. To achieve the SESAR objectives, a time frame of approximately 7 to 10 years will be required. This implies that all stakeholders must coordinate and mobilise their efforts;
- **ATM Technology Specificities:** Few if any mass-market technologies can be readily and directly exploited in the ATM system due to the specific aviation environment, particularly in the areas of radio spectrum, safety and mobility. It requires significant adaptation of the technology to meet the ATM performance requirements and/or significant verification, validation and certification;

- **Mature Requirements:** A lack of mature requirements, prior to the full-scale development and deployment phase, is considered to be the major risk in terms of schedule and costs overrun in large complex programmes such as SESAR. At the ICAO ANC/11 endorsement of the ICAO Global ATM Operational Concepts Document, developments on the CNS technologies were considered to be developed without a clear operational vision. Steering was based on what could be used, rather on what was needed for best performance outcome. Necessary policies to progress was taken by the Airspace Users to mitigate against possible new and costly technical solutions, and therefore focused on exploitation of available on-board capabilities;
- **Interoperability:** Global, worldwide interoperability is a key issue in respect of CNS technologies. Airspace Users expect to be able to exploit their aircraft equipment in multiple regions. Thus considerable effort is needed to ensure coordination with other regions, with the goal to obtain recognised ICAO standards. Joint ongoing activities to evaluate and select new technologies and technical enablers based on performance requirements must be further encouraged and reinforced. Civil-military interoperability requirements will also have to be considered to enable the maximum re-use of available military capabilities. It is regrettable that at European level there appears to be a general tendency to reduce the available resources for CNS coordination, selection, standardisation and validation activities. The resulting loss of industrial expertise is difficult to reverse in the short term;
- **Provision of Pan European Services:** Further concerns relate to the arrangement for the provision of pan European CNS services, in particular satellite and pan European data transport network. ATM will increasingly rely on the provision of Pan European Services, and requires the necessary institutional and commercial arrangements to ensure perpetuity of service, value for money and legal responsibility;
- **Spectrum:** A key issue is the availability of sufficient radio spectrum free of harmful interference and allocated for the CNS technologies. The possible reuse for aeronautical needs of available spectrum when decommissioning elements of the current system (VOR, NDB etc.) should be promoted. Radio spectrum is increasingly a commercial commodity and hence, aviation is under pressure from other sectors. Representation and defence of aviation positions at ITU needs to be reinforced at the European level.

2.5.5 Recommendations

In order to ensure timely delivery of the technologies necessary to support the operational concept, the following key recommendations for the specified areas, in respect of research, implementation and validation have been developed. In accordance with the SESAR definition phase project contract, these initial recommendations will be further refined and detailed in D4 in terms of the packages of activities necessary to implement the technologies.

2.5.5.1 Management and Planning

- Secure frequency spectrum and improve its use and management;
- Define a fair commercial and institutional framework to operate and provide satellite services for Communication (SATCOM) and Navigation (Galileo and EGNOS);

- Coordinate at European level the evaluation, development, standardisation and validation of CNS technologies and the potential for enhanced operations enabled by these new technologies and procedures (e.g. Simultaneous Non-Interfering Procedures for Rotorcrafts);
- Investigate the use of Link 16 Data link by military aircraft for civil ATM applications;
- Further investigate how the technical recommendations can be adapted to regional/local needs outside core Europe (e.g. geostationary satellites does not cover high latitudes) and for lower end Airspace Users and low density traffic areas in an interoperable and cost-effective way.

2.5.5.2 Communication

- Refocus as a programme, at European level, the R&D activities to define and develop the future air-ground communication system, and the necessary transport mechanism. This should include, as necessary all the terrestrial, space segment and airborne components and infrastructure;
- Expedite activities to build a harmonised ground-ground communication system;
- Commence activities to develop a new standard on the IEEE 802.16 basis and to deploy it for airport surface communication;
- Adopt an Implementing Rule for carriage of VHF 8.33 kHz in all managed airspace;
- Expedite the wider deployment of ATN/VDL Mode 2 air-ground data link.

2.5.5.3 Navigation

- Expedite studies to determine the necessary satellite configurations to achieve the required integrity performance;
- Standardise and launch the development of multi GNSS (e.g. GPS and Galileo) signal processing onboard receivers;
- Deploy SBAS as required depending on local business cases, subject also to commercial arrangement;
- Implement GBAS to provide higher Cat 2 and 3 approach capacity and support high precision movement;
- Update and rationalise the DME/DME network to provide an appropriate backup system in case of GNSS outage. In consultation with the Airspace Users, develop a European plan for progressive decommissioning of conventional Navaids;
- Implement new low cost lighting technologies for non-equipped airports that will provide precision approach and landing (SBAS/GBAS);
- Implement cockpit moving map technology to improve surface navigation.

2.5.5.4 Surveillance

- Improve the 1090 ES technology and complement as necessary with an additional technology supporting ADS-B;
- Expedite equipage of 1090 ES-ADS-B-Out. Evaluate the consequences on key performance areas of a mandate in European airspace;
- Implement 1090 ES-ADS-B-In for initial ASAS applications. Further evaluate requirements for other ASAS applications and how they can be supported;
- Maintain and improve Independent Non Cooperative Surveillance where necessary for safety and security reasons;
- Launch an R&D programme on Multi-Static PSR for non-cooperative targets;
- Maintain and improve Independent Cooperative Surveillance as the principal surveillance means using SSR Mode S or Wide Area Multi-lateration.

3 Performance Analysis of the ATM Target Concept

3.1 Introduction

This chapter provides a description and the main findings for the Performance Analysis of the ATM Target Concept as performed during Milestone 3.

3.1.1 Overall Performance Analysis Process in D3

The following flowchart illustrates the overall process followed for analysing the ATM Target Concept performance, highlighting the three principal activities.

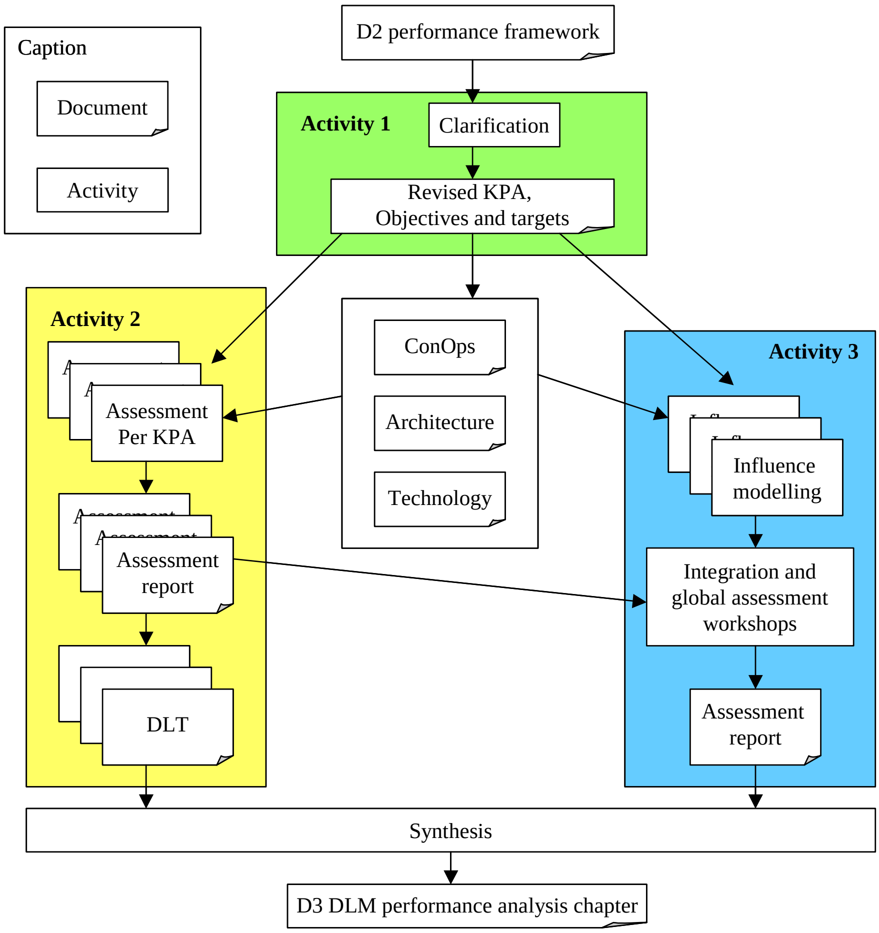


Figure 29: Overall performance analysis process

- Activity 1 was conducted by a panel of specialists previously involved in the definition of the performance framework during D2 and performance domain specialists. This is documented in the SESAR performance objectives and targets [Ref.22] capturing the evolution of the performance objectives and targets;

- Activity 2 was conducted for each performance domain (each individual assessment is documented in the corresponding task deliverable);
- Activity 3 was conducted by a dedicated team involving the main stakeholders' experts addressing KPA interdependencies (using Influence modelling approach[20]) and trade-off methodology (DLT 3.3.1/D3 [Ref.20]) so as to get a consolidated assessment with the highest level of confidence achievable at this stage. This activity also supported the selection of alternatives in architecture and technologies through use of the trade-off methodology.

3.1.2 Performance Framework Input from D2 and D3 Enhancements

The D2 performance framework has grouped the 11 ICAO KPAs into three KPA groups, as depicted by Figure 30.

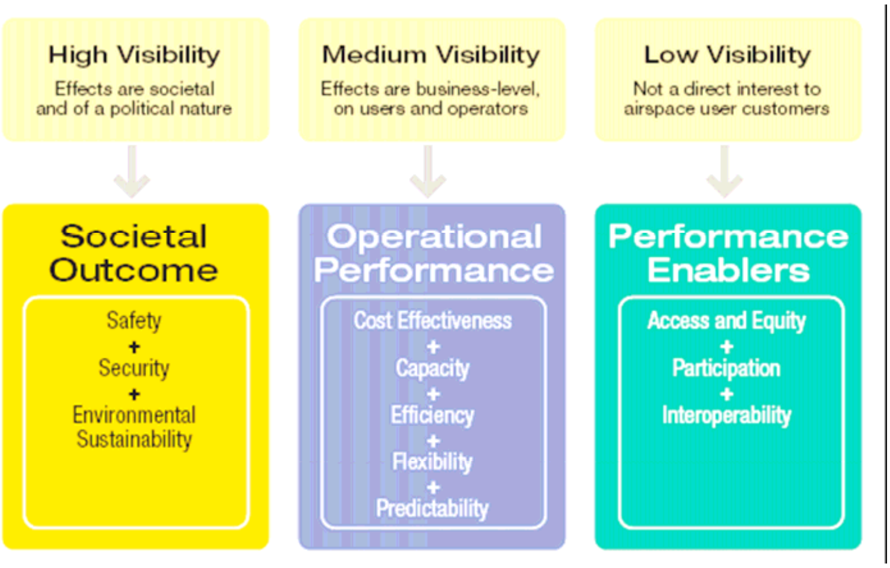


Figure 30: Groups of KPAs

Interdependencies between KPA have been outlined in D2. The figure below illustrates the dependencies within operational KPAs.

[20] Influence Modelling consist in building graphical views of relationships between the concept and the KPIs. See 2.3.1/D3 DLT

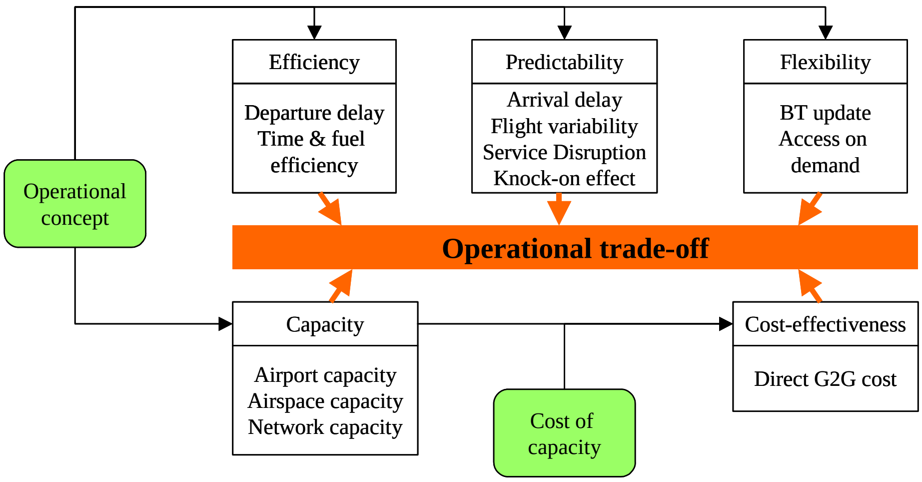


Figure 31: Operational KPA with dependencies

The initial set of objectives, KPIs and targets established in D2 has been clarified, with an updated definition and additional elements in order to remove ambiguity (see [Ref.22]).

Main areas affected were:

- Airport Capacity targets;
- Flexibility objectives (new focus areas);
- Safety objectives and targets;
- Security objectives.

This includes clarification of some operational processes and associated definitions that are required for accurate definition of performance indicators (e.g. BT lifecycle and associated events).

A first attempt to build a set of current baseline values for KPIs has been made by the Performance Review Unit (PRU) of EUROCONTROL. This has been beneficial both for clarifying the operational meaning of some KPIs and for supporting the assessment of the performance related to those KPIs.

3.1.3 Methods and Expertise Involved

The assessment methods that were used are briefly listed below:

- Fast time simulation was used for the quantitative evaluation of Capacity and Efficiency improvements resulting from specific ConOps elements compatible with the existing models from ATM Research Centres (see DLT 2.3.1/D3 [Ref.16]);
- Screening was a systematic inspection method used for the qualitative assessment of the ConOps, the architecture and the technology in the areas where no modelling activity was foreseen (safety, security, environment sustainability, human factors);
- Influence modelling was used for a comprehensive analysis of the relationship between the ConOps and the Capacity, Predictability, Efficiency, Flexibility and Environmental Sustainability KPAs;

- Expert Judgement was extensively used for providing estimates of benefits, identification of dependencies, and other assessment results.

Expertise has been provided by:

- The members of the teams in charge of the KPAs;
- Additional stakeholders' representatives for specific assessment sessions.

The following table summarizes the assessment methods and expertise involved in Activity 2.

KPA	Methods	Expertise	Comment/reference
Safety	Safety Screening (qualitative)	Safety experts in key tasks in coordination with the specialist task	Supported by a questionnaire and interviews. See DLT 1.6.2/D3 [Ref.11]
Security	Security screening, (qualitative)	Security experts in key tasks in coordination with the specialist task	See DLT 1.1.3/D3 [Ref.5]
Environmental Sustainability	Various methods: * Environment screening * Influence modelling	Environment experts in specialist task	Environment screening supported by a questionnaire See DLT 1.1.4/D3 [Ref.6]
Capacity, Predictability, Efficiency, Flexibility	Various methods: * Fast time simulation * Expert judgement * Influence modelling	Performance evaluation Specialists + ATM domain experts	Past studies results + Fast time simulation models from EEC, NLR, AENA and DSNA used with EEC traffic data See DLT 2.3.1/D3 [Ref.16]
Cost-Effectiveness	Cost assessment and Financing models,	Specialist tasks experts in costs, financing & funding	See DLT 3.3.2/D3 [Ref.21] and DLT 1.3.2/D3 [Ref.8]
Access & Equity	Screening (qualitative)	Specialist tasks experts	See DLT 1.5.2/D3 [Ref.10]
Participation	Screening (qualitative)	Specialist tasks experts	See DLT 1.2.2/D3 [Ref.7] and DLT 1.7/D3 [Ref.12]
Interoperability	Screening (qualitative)	Specialist tasks experts	See DLT 2.6.2/D3 [Ref.19]

Table 7: Methods and expertise involved in performance analysis

Activity 3 has been conducted through questionnaires and workshops to gather and consolidate expert judgement:

- One intermediary workshop for consolidating the Capacity, Predictability, Efficiency and Flexibility KPAs including interdependencies;
- One final workshop for consolidating all the KPAs and analysing global dependencies.

3.2 Performance Analysis

3.2.1 KPA Assessment

The following tables in this chapter represent the findings of the performance analysis.

For readability, there are two tables per KPA group: one table describes the assessment and the second provides additional comments, identified by tags in bold font (e.g. "**SAF-1**") in the first table.

Columns caption:

- KPA: The KPA under assessment;
- Focus area/KPI: The performance attribute that is assessed;
- Baseline: The current value of the performance attribute;
- 2020 Target: The value established in the revised performance framework;
- Assessment: The result of the assessment;
- Concept contribution: Main features of the ATM Target Concept that justify the assessment;
- Maturity level of the assessment process.

3.2.1.1 Societal KPAs

KPA	Focus area/ KPI	Baseline	2020 Target	Assessment	Concept contribution	Maturity level
Safety	Operational safety indicators under development	Not available. SRC/PRC values available as references **See SAF-1**	Not defined, but expectations for an increase by a factor 10 for the long-term and by a factor 3 for 2020	Screening results identified risk areas, however, no global safety performance assessment conclusion.	Advanced automation, monitoring and conflict tools. Increased situation awareness. Improved safety net systems. **See SAF-2**	Screening initiated and ongoing

KPA	Focus area/ KPI	Baseline	2020 Target	Assessment	Concept contribution	Maturity level
Security	ATM Self protection and Collaborative Security Support	Not available. **See SEC-1**	Not defined	Screening results identified risk areas for confidentiality, integrity and availability, however, no global security performance assessment conclusion.	Increase security of the airspace using the new operational possibilities for trajectory management. **See SEC-2**	Screening initiated and ongoing
Environmental Sustainability	Climate Change: CO_2 emission	Flight Inefficiencies due to ATM amount to about 9% **See ENV-2**.	Not defined, but long-term expectation about reduction of 10% per flight	It is expected that most of the flight inefficiencies will be removed by the ATM Target Concept. However, they cannot be all removed without impairing objectives/targets in others KPAs. **See ENV-3**	Fuel Efficiency (see Efficiency KPA) is beneficial for CO_2	Medium/ High
	Noise	Not available	Not defined	Non-ATM influences such as residential encroachment degrade the performance. However expert judgement identifies noise reduction benefits from the concept. **See ENV-1**	Improved navigation capability, trajectory management, procedures and airspace design.	Medium/ High
	Local Air Quality	Not available	Not defined	Expert judgement identifies air quality improvement benefits from the concept **See ENV 1 & ENV-2**	Fuel Efficiency (see Efficiency KPA).	Medium/ High

Table 8 – Societal KPA Assessment

Tag	Comment
SAF-1	The current observed frequency of ATM-attributable accident per flight hour is $1.5*10^{-8}$. However, this figure cannot be taken as a target to be decomposed into lower level targets without an agreed model of incident-accident relationship, to be used as the basis for an Operational safety Focus area decomposition in the Performance Framework.
SAF-2	The major changes anticipated to achieve the safety performance goal of the ATM Target Concept appear to come from a combination of automated detection in the ATM system of all aircraft interactions at a far earlier stage, together with increasingly capable ground and airborne safety nets, as for example: o *Advanced airport automation, monitoring and conflict tools (i.e. ASMGCS), that have the potential to eliminate runway incursions and ground, based incidents;* o *Advanced automation support for controllers, including conflict detection and resolution (strategic and tactical); conformance monitoring (CM); intent monitoring (IM) and complexity monitoring;* o *Automated support tools that are able to display and communicate activation and de-activation of*

	airspace reservations/segregations for military/civil use (pre-planned or ad-hoc areas) and provide automated guidance to avoid these areas with appropriate separation; o *Automation that is coupled with fail-safe modes that do not require full reliance on human situational awareness as a backup for automation failures;* o *Airborne Separation Assistance Systems improve situational awareness on the ground and air;* o *Reduction of wake vortex encounters via improved prediction and detection;* o *Precise management of trajectories supporting a high degree of strategic deconfliction as required for periods and in airspace where high complexity is predicted (2D-RNP and 3D route structures);* o *Tools to assist the controllers in building and maintaining their situational awareness;* o *Improved safety net systems (ACAS and STCA;.* o *An integrated pre-flight planning tool (AIS & Weather Briefing, Flight Plan Filing, both for VFR and IFR) will facilitate today's complex process;* o *Access to in-flight weather information will reduce the risk of flight into hazardous weather or restricted airspace;* o *Affordable Traffic information systems will reduce the risk of both midair and runway collisions.*
SEC-1	Security management process has to accompany the development and appropriate security assessment methodology is required.
SEC-2	The ATM information networks will be protected so that the ATM applications may function securely (e.g. CDM, 4D-Trajectory Management, ADS-B, TIS-B).
ENV-1	The non CO_2 environmental performance focus areas are offered here together with the key elements that will support their achievement. o *100% compliance with environmental regulations:* Supported by collaborative environmental management, community dialogue, SWIM including environmental rules and performance information, transparent assessment; o *Avoid counter-effective or optimise proposed environmental regulations*: (as above); o *Adopt a sustainability scope:* Supported by all elements that help to safely, efficiently and securely serve demand, providing European sustainability benefits[21]; o *Reduce global and local atmospheric impacts* Supported by all improvements for efficiency: - <3,000ft for air quality, upper atmosphere for NOx and potentially route flexibility to avoid contrail-cirrus critical air masses; o *Reduce noise impact.* Supported by OCEs that allow improved trajectory accuracy and more enhanced CNS plus punctuality (curfews) and profile optimisation. All the above are supported through Collaborative Environmental Management.

[21] In efficiently, safely and securely serving society's increased demand for air transport, as part of and intermodal pan-European transport network, SESAR will support, inter alia, mobility, security, competitiveness, cultural enrichment and employment etc.

ENV-2	The following table presents the compilation of inefficiencies per flight phase, and the corresponding weighted effect in terms of fuel used. **Flight phase** / **Inefficiency** / **% Fuel used in phase** / **Weighted inefficiency** Horizontal en-route / 6% / 67% / 4% Vertical en-route / 3% / 67% / 2% TMA / 10% / 13% / 1% Ground / 10% / 20% / 2% **Total inefficiency** / / / **9%** From the present assessment, the maximum ATM inefficiency in the Gate-to-Gate is around 9%. However, to achieve this level of performance an elimination of <u>100%</u> of ATM inefficiency would be needed, which may not be fully achievable in practice given the influences of weather, and the continuing need for structure in the TMA. In addition, fuel optimisation is not the only criterion used by Airspace Users to determine their Business Trajectory (cost-index).
ENV-3	For air quality, quantified assessment was not possible, because of non-ATM influences such as residential encroachment. Because of scientific uncertainty, performance in non-CO_2 climate change aspects such as contrail induced Cirrus and NOx emissions is not possible.

Inner table (ENV-2):

Flight phase	Inefficiency	% Fuel used in phase	Weighted inefficiency
Horizontal en-route	6%	67%	4%
Vertical en-route	3%	67%	2%
TMA	10%	13%	1%
Ground	10%	20%	2%
Total inefficiency			**9%**

Table 9 - Societal KPA Assessment Comments

3.2.1.2 Operational KPAs

KPA	Focus area/ KPI	Baseline	2020 Target	Assessment	Concept contribution	Maturity level
Capacity	Airport capacity/ Accommodate the busy hour demand	2006 traffic figures. **See CAP-1**	Dependent on airport demand	Can be achieved except for highly constrained airports (additional runways and/or displacement to secondary airports needed).	Runway capacity enhancement. Higher airport utilization and better scheduling. **See CAP-1**	High
	En-route Airspace capacity/ Accommodate the busy hour demand	2006 traffic figures	Dependent on airspace volume demand	Can be achieved in low/medium density airspace. Tactical sector capability.	Network DCB AFUA	**See CAP-2** High
				May be difficult to achieve in high density airspace.	Tactical sector capability	Low
	Terminal area Airspace capacity/ Accommodate the busy hour demand	2006 traffic figures	Dependent on airspace volume demand	Can be achieved in most TMA except possibly in some high density TMAs connected to several airports (including military airfields).	Strategic deconfliction through closely spaced separated routes (funnels/ tubes) in terminal areas. Traffic synchronization through AMAN/ DMAN.	Medium
	Network/ Accommodate the network demand	2006 traffic figures	+95% (unconstrained demand i.e.18m flights)	Possible displacement of traffic due to airports or TMA capacity gaps. Uncertainty on network resilience.	Network Management DCB **See CAP-3**	High
Predictability	On time operation/ Improve arrival punctuality	Not available.	Less than 5% of flight suffering arrival delay greater than 3 min	Qualitative: Positive impact of the concept. Submitted to the trade-off with capacity (to be investigated).	4D Trajectory management and PTC reduce uncertainty on flight events time stamps.	Medium
	On time operation/ Reduction of variability of operations	Not available. PRU estimate for variability of flight time: **see PRD-1**	Coefficient of variation of flight time less than 0.015	Qualitative: Positive impact of the concept	Improvement of on-time operations has a positive side effect on reduction of variability in non-disrupted situations. DCB and collaborative planning will reduce the impact of disruption.	Medium

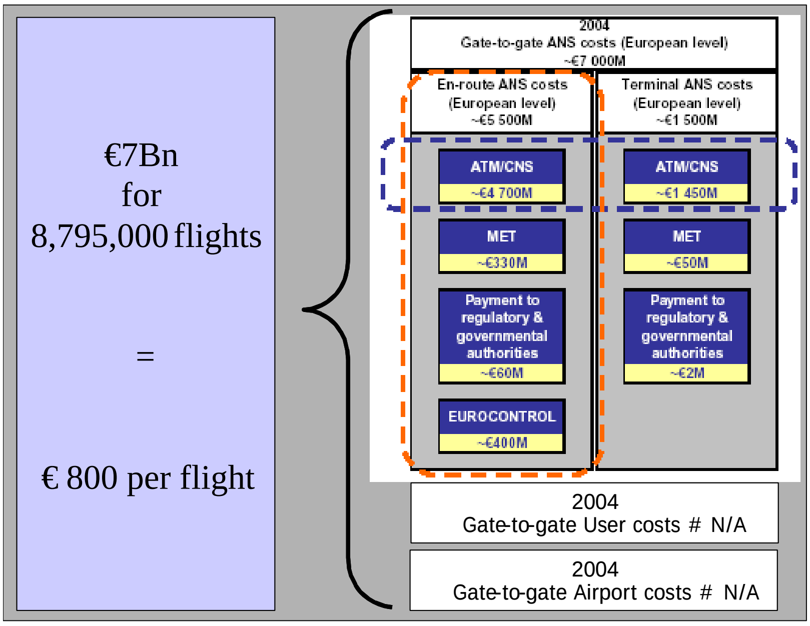
KPA	Focus area/ KPI	Baseline	2020 Target	Assessment	Concept contribution	Maturity level
	Service disruption	Not available. PRU estimate is that 3.6% of flights are disrupted due to ATM reasons.	Reduced by 50%	Qualitative only: Positive impact of the concept.	DCB and collaborative planning reduce the impact of service disruption.	Medium
	Knock-on effect	Not available. PRU estimate is that reactionary delay is the cause of 46% of delayed flights.	Reduced by 50%	Qualitative only: Positive impact of the concept.		Medium
Efficiency	Temporal efficiency	Not available PRU estimate for departure delay: **See EFF-1**	98% of flights departing on time	Qualitative: Positive impact of the concept. Trade-off to be investigated with capacity.	Awareness of traffic demand with shared information: BT, DCB, Airport CDM, Surveillance, and A-SMGCS. Less queuing with AMAN/DMAN, PTC, AFUA.	Medium
	Fuel efficiency	Total inefficiency estimated 9% **See EFF-2**	Less than 5% of flights with extra fuel consumption. For those flights, average extra-fuel consumption less than 5%.	Qualitative: Positive impact of the concept. Trade-off to be investigated with capacity.	BT optimized for fuel by Airspace User, and facilitated by ATM (Enhanced trajectory management and controller automation tools) CDA and enhanced queue management. **See EFF-3**	Medium
	Mission effectivenes s				Not assessed	
Flexibility	BT update/ Departure time	Not available See PRU baseline estimate in **See FLX-1**	Less than 2% of scheduled flights requesting departure time change suffer a delay penalty greater than 3 min.	Qualitative: Positive impact of the concept. Trade-off to be investigated with capacity.	Airport CDM, Information sharing, UDPP.	Low/ Medium

KPA	Focus area/ KPI	Baseline	2020 Target	Assessment	Concept contribution	Maturity level
	Flexible access on demand				Not assessed	
	Service location flexibility				Not assessed	
	Suitability for military requirements				Not assessed	
Cost-Effective-ness	Direct cost of gate-to-gate flight	800€/flight on average **See CEF-1**	400€/flight on average	450€/flight on average by 2020 with a range of 300-600€/flight depending on the airspace complexity. **See CEF-2**	Network capacity uplift with constant operational staff cost and limited system cost increase. **See CEF-2**	Medium

Table 10: Operational KPA Assessment

Tag	Comment
CAP-1	In the ECAC area, the top 130 airports accounting for 90% of IFR movements have different demand/capacity profiles. Some are limited by their runway throughput, others by airside capacity (apron, gates), others by restrictions to operations (environmental measures). Using the ACI-Europe 2006 airport passenger statistics and the IATA Airport Development Reference Manual, for benchmarking the SESAR concept, reasoning on average values per airport segments leads to a global confidence on the ability of airports to accommodate the demand increase. More precisely, full deployment of SESAR enhancements in the top 60 airports and partial deployment in the next top 20 airports would provide the required capacity increase. Nevertheless, by uplifting the airport capacity over the current average at busy hours over the ECAC area has a negative impact on QoS KPAs and makes QoS targets more difficult to meet owing to induced queuing.
CAP-2	Reduction in trajectory uncertainty will lead to a decreased number of potential conflicts and less controller workload. There will also be a better prediction and smoothing of workload, and a longer time horizon for taking decisions (e.g. Collaborative planning). New separation modes such as 4D trajectory management and self-separation will translate into smaller containment per aircraft.
CAP-3	The network capacity is obtained by consolidating capacity indicators related to airports and airspace volumes (e.g. control sectors) in a consistent way, typically based on city-pairs flows at given time periods of the day. When facing an airport or airspace volume capacity issue, displacement of traffic (e.g. moving from one congested airport to the nearest less congested airport) can solve the issue at the network level. The actual feasibility of displacement depends on business decision from Airspace Users.
PRD-1	EUROCONTROL PRU estimate of the variability of the gate-to-gate flight times (for flights with a monthly frequency greater than 20) amounts to 0.075. The variability is expressed as the coefficient of variation of flight time, i.e. the ratio of the standard deviation to the mean. For a average flight time of 100 min, this leads to a standard deviation of 7.5 min.
EFF-1	Based on ATFM delay, EUROCONTROL PRU estimates that about 7% of flights requesting a new departure get a delay that amounts to 16 min on average. However, the comparison with the D2 target is difficult because the D2 target is based on the initial RBT and the actual departure time, and not on today flight-plan EOBT and the allocated ATC departure slot.
EFF-2	Compilation of previous results described in the Environment KPA table.
EFF-3	Airspace Users optimize the business trajectory according to several criteria (cost index). Fuel consumption is only one component. Therefore, Jet-Fuel unit cost and Carbon emission cost will augment the interest for fuel efficiency, but still considering other business drivers (e.g. on time operations).

<table>
<tr><th>Tag</th><th>Comment</th></tr>
<tr><td>FLX-1</td><td>Based on ATFM delay following request to change a departure time, EUROCONTROL PRU estimates that about 6% of flights get a departure delay that amounts to 17 min on average. However, the comparison with the D2 target is difficult because the D2 target is based on two successive versions of the RBT and not on today revised EOBT and further slot allocation.</td></tr>
<tr><td>CEF-1</td><td>The current cost breakdown structure is described below.



The direct cost of gate-to-gate ATM covers the total costs incurred by ATM stakeholders (regulatory & governmental authorities, intergovernmental organisations, service providers, Airspace Users, airports etc.), however, Airspace Users and airports costs are considered only to the extent of any increased role in ATM with respect to the 2004 reference.</td></tr>
<tr><td>CEF-2</td><td>During D3, the assessment of the contribution of ATM Target Concept to the achievement of this cost effectiveness target by 2020 has been done with the following <u>assumptions</u>:
* All financial values are 2005 normalized;
* The calculations for 2020 use the unconstrained demand scenario, resulting in 18 Million flights;
* The implementation of the ATM Target Concept by 2020 is considered to contain no transfer of responsibilities from ANSPs to Airspace Users and/or airports. Consequently, Airspace Users and airport costs are not taken into account in the cost effectiveness calculation;
* The implementation of the ATM Target Concept by 2020 is considered to allow the management of the increased traffic without significantly increasing the average number and total cost of the "ATCOs in operation". This assumption is further extended to the non-ATCO costs;
* Available historical and forecasted data shows total ANSP investment costs to be in the order of €1.2Bn/year. This is further assumed to stay stable until 2020 with only a small increase of €700M over the 12-year period. The total over 2008-2020 being 12*€1.2Bn = 14.4+0.7 = €15.1Bn. Around 25% (€3.4Bn of the €14.4Bn) of the assets are directly impacted by the SESAR programme. See chapter 5.3.1 for more information. This 25-75% distribution is used for the further calculations;
* The categories MET (€390M), Payments to regulatory and governmental authorities (€62M) and EUROCONTROL (€490M) have all been assumed constant, totalling €942M for 2005.</td></tr>
</table>

Tag	Comment
	The following table, using the breakdown of ATM/CNS costs as used in PRC reports, shows the figures for 2005 (ref ACE2005 [Ref.23]) and estimates for 2020.

	2005 (Bn€)	**2020 (Bn€)**
Staff-ATCO	1.863	1.863
Staff-Support	2.06	2.06
Operating -staff	1.21	0.64*+0.91 (75% from 1.21)
Depreciation	0.91	0.30** +0.68 (75% from 0.91)
Cost of capital	0.1	0.14** + 0.31 (75% from 0.41)
	€6.5Bn	€6.91Bn

*=See chapter 5.3.1, **=see chapter 5.3.2

The total direct Gate-to-Gate costs will therefore be €6.91Bn + €942M (MET, REG, EURC)=€7.9Bn. Consequently the approximate unit cost becomes €7.9Bn/18M flights= ~ €450 / flight.
NB: Knowing that currently there is deviation of ~40% on the average unit cost across Europe due to local differences (see PRR2006), a high complex airspace may create a variation up to a €600 cost per flight.

Table 11: Operational KPA Assessments comments

3.2.1.3 Enablers KPAs

KPA	Focus area/ KPI	Baseline	2020 Target	Assessment	Concept contribution	Maturity level
Access & Equity	Access	Not Available	Not defined	Qualitative: Some Airspace Users (e.g. GA) consider that their access might be impacted by additional necessary equipage. **See A&E-1**	More details of the Concept required before assessing the impact for GA.	Medium /low
	Equity	Not Available	Not defined	Qualitative: The ATM Target Concept with proper design of system and procedures will enable adequate levels of equity.	Priority rules need to be developed in the ConOps. **See A&E-2**	
Participation		Not Available	Not defined	Qualitative: Positive impact on the Concept.	Increased participation, cooperative working & information sharing (SWIM and Collaborative Decision Making). **See PART-1**	Medium /High
Interoperability		Not Available	Not defined	Qualitative: Positive impact on the Concept.	Applicability to all users. 4D trajectory exchange. SWIM. **See INT-1**	Medium /High

Table 12 – Enabler KPAs

Tag	Comment
A&E-1	For Access: * Ideally, there should be no segregation of airspace due to aircraft equipage. Where necessary any applicable minimum aircraft equipment levels or associated rules must be stated. Of vital importance will be a need for access to the ATM market to be 'open' to all ensuring that user size and wealth is not the pre-determining factor so that smaller, less well off and occasional users have their interests protected.
A&E-2	For Equity: * It is important that SWIM and Collaborative Decision Making (CDM) are implemented in such a way as to safeguard against business practices that could negatively impact upon Equity. Priority rules must be clear, approved by the appropriate regulator, and applied in a consistent and transparent manner. If a process such as the User Driven Prioritisation Process is applied on a regional/European level then it must be regulated at that level – this could influence the choice of the appropriate regulatory body.
PART-1	The ATM Target Concept assessment from the Participation point of view highlights the need for specific activities for: * Collaborative Planning: success will be dependent on stakeholder participation;

	* Disruption and CDM: buy in of predefined scenario will require high level of participation of the stakeholders; * UDPP and FUA: rules need to be public and agreed by all stakeholders.
INT-1	CDM and SWIM to be standardized at European level while air-air and air-ground 4D trajectory exchanges to be standardized at ICAO level.

Table 13 – Enabler KPA Comments

3.2.2 Key Findings

3.2.2.1 Societal Outcome KPAs

The major contribution to **safety performance improvement** will mainly come from better planning, increased situational awareness and automated tools detecting all aircraft interactions at a far earlier stage than current methods allow. In order to show evidence of these expected safety benefits, the potential risk contributions need to be identified by continuous appropriate screening for any safety issues during the development and deployment of the ATM Target Concept and by developing appropriate safety assessment methodologies and procedures.

Security aspects of the ATM Target Concept, e.g. the extensive use of IT Infrastructure, have been analysed in respect of self-protection and collaborative security support. In order to show evidence of the expected security benefits, the potential risk contributions need to be identified by continuous appropriate screening of security issues during the development and deployment of the ATM Target Concept and by developing appropriate security assessment methodologies.

The ATM Target Concept will significantly contribute to the reduction of the environmental impact that can be attributed to ATM in terms of noise, local air quality, fuel burn and CO_2 emissions[22]. Key environmental strengths of the ATM Target Concept are: the drive for trajectory efficiency from gate-to-gate which will lead to reduced fuel use; improved navigation capability and trajectory management which will allow for improved noise control; Collaborative Environment Management that is provided with high quality and up to date information.

However, there is a trade-off between further environmental improvements and operational KPAs. Understanding and effectively managing this trade-off is vital to the deployment of the ATM Target Concept. For instance, the aim to develop regional airport capacity may have adverse environmental implications in terms of the number of people affected by noise, induced aircraft lower load factors, and increased ground transport impacts.

3.2.2.2 Operational Performance KPAs

The ATM Target Concept provides solutions for accommodating the traffic demand with the corresponding capacity in airports and en-route airspace. Nevertheless some uncertainties or limitations still need further analysis:

[22] CO_2 is inextricably linked to fuel use and hence operational and cost efficiency. Its importance increases as fuel supply becomes more costly and as CO_2 acquires a value through emissions trading.

- Some airports are constrained by their infrastructure and cannot satisfy the expected traffic increase despite all possible ConOps improvements;
- Some high density TMAs connected to several airports are constrained by the complexity of their arrival and departure traffic patterns. This may lead to TMA capacity limitations below the demand expected to be handled by these airports, despite the ConOps improvements.

The ATM Target Concept can improve Efficiency, Predictability and Flexibility although the assessment of these KPAs is less mature (mostly qualitative) than for Capacity. The assessment indicates that the ATM Target Concept has the potential to meet the predictability targets as set out in D2 by reducing uncertainty on operation times throughout the flight life-cycle.

Whilst the ATM Target Concept was generally thought to contribute positively to efficiency, the initial indicative Efficiency targets defined in D2 were considered to be more difficult to meet due to the need to retain the structure in the TMA and to the difficulty in containing temporal inefficiency when the demand is close to capacity.

Although the contribution of the ATM Target Concept on Flexibility has to be further investigated, the following elements have been identified:

- As a side-effect of capacity improvement, some capacity buffer can be used to accommodate unexpected demand subject to trade-off with other KPAs;
- Automation and Controller/Pilot Situational Awareness Tools will allow controllers to be aware of available options and to be more proactive to change;
- CDM and Information Sharing (User Driven Prioritisation Process (UDPP) and other CDM mechanisms including Airport CDM and DCB) will allow better use of available capacity and opportunities.

However, DCB and the reliance on automation were also mentioned as potentially having a negative impact on flexibility.

This initial ATM Target Concept could reduce the direct cost of providing gate-to-gate ATM services from €800 to €450 (up to €600 for highly complex airspace) per flight when fully implemented. Additional measures external to the SESAR programme but within the framework of the Single European Sky (de-fragmentation of service provision) will be needed to meet the D2 goal of reducing direct gate-to-gate ATM costs to €400 per flight.

3.2.2.3 Performance Enablers KPAs

The ATM Target Concept shall be developed following the performance partnership principles ensuring Participation, Access & Equity and Global Interoperability. While priority rules must be clear, approved by the appropriate regulator and applied in a consistent and transparent manner, numerous standardisation activities at both ICAO and regional levels will need to be included in the ATM Master Plan to ensure the level of interoperability and global harmonization required to support the ATM Target Concept. This standardisation activity shall be carefully monitored from planning and resource perspectives to ensure standard availability for 2020 during D4.

3.3 Conclusion

The preliminary assessment of the ATM Target Concept indicates that it has the potential to meet the capacity targets defined in D2 except in a few identified areas like highly congested airports and/or high density TMAs. Capacity will be provided with the required level of safety and security while minimizing the environmental impact. The demonstration of the required level of safety and security needs further extensive validation during development of the SESAR ATM system. The assessment of the other performance areas shows positive contributions from the concept.

Most importantly, a shared belief in this preliminary assessment has been achieved with the Stakeholder 'Experts' through various analysis and assessment methods ranging from expert judgement to influence diagrams linking the ATM Target Concept to the delivery of the expected performance. The next stages in the SESAR Definition Phase should take these results as a starting point considering the following points:

1. The initial performance analysis has partly been based on a commonly agreed set of influence diagrams, which provided a comprehensive link between the ATM Target Concept and the KPAs as well as a traceable method to document the rationale. It is therefore recommended to build on the work done so far by using the existing influence models within the context of D4 and by providing more quantitative results. In particular, such activity would provide constructive inputs to cost effectiveness criteria to be used for decisions on the implementation packages of the ATM Target Concept.

2. To improve the confidence and consistency of the analysis outcome, the options being assessed need to be explained in greater detail to the stakeholder experts assessing them to improve the quality of the results. In addition, as much as feasible, a panel of experts rather than just one should assess the performance of the option (this was already done for the capacity and QoS areas during milestone 3).

3. The existing safety assessment methodologies (e.g. interdependencies, human reliability) will not be sufficient to analyse emerging safety performance issues. Appropriate safety assessment methods must be developed to meet the entire scope of risk contributions emerging from the concept.

4. Appropriate environment sustainability assessment methods must be developed to meet the entire scope of environment sustainability within the ATM Target Concept.

4 Cost assessment and Financial Aspects of the ATM Target Concept

The cost-assessment, financing analysis and CBA work developed for the SESAR Definition Phase study have been conducted by the creation, application and joint usage of a number of tools, shared by all stakeholders that will now be used for further analysis and decision making assistance.

This preliminary estimate of airborne and ground costs should be read and used only with all the underlying assumptions. It represents only the first step of the more detailed cost assessments activities.

4.1 Cost assessment

4.1.1 Approach

The cost assessment has focused on the investment and operating costs[23] incurred for the ATM Target Concept up to 2020. It has been based on the architecture systems, sub-systems and mapping of associated technologies defined in chapter 2. The cost per unit (systems, aircraft, etc.) for each system and technology has been assessed by the main stakeholder groups (civil Airspace Users, military, ANSP and airports) with the support of the supply industry. Finally the overall cost has been aggregated taking into account the number of units in ECAC. Low, base and high ranges of the costs have been calculated for all stakeholder groups in order to express various uncertainties[24].

The following chapters detail the assumptions and results for each of the different stakeholder groups.

4.1.2 Airspace Users

4.1.2.1 Important Notes and Caveats

- The wide range of cost estimates reflects the current uncertainty of equipage cost for individual aircraft and of ground equipment for individual aircraft operators;
- The airborne cost estimates include ATM avionics costs for European registered aircraft only, for all scheduled airlines (legacy, low fares, regional and charter airlines) as well as on-demand aircraft operators (business and general aviation) and represents 100% of the ATM avionics costs foreseen until 2020;
- The ground cost estimates include ATM ground costs for European aircraft operators only and represents about 80% of the ATM ground costs foreseen until 2020 since ground costs related to on-going and short-term initiatives like DMEAN are not included.

[23] All financial values are 2005 normalised except for airspace users which are 2007.
[24] Only for Airspace Users they are detailed in the presented tables, for others they exist in the DLT 3.3.2/D3 [Ref.21].

4.1.2.2 Airborne Costs

Unit cost per aircraft:

- For scheduled airlines and business aviation it has been assumed that aircraft will be equipped in order to comply with the ATM capability level-3 by 2020;
- For General Aviation it has been assumed that GA aircraft will be equipped with only ATM capability level-1 by 2020.

Within the airborne costs, Airspace Users have considered two types of avionics packages for the purpose of this cost assessment exercise, the 'structural' avionic package (requiring retrofit and forward fit, assuming the counterpart of the ANSP implementation is aligned), and the 'incidental' avionic package (retrofit and forward fit needed only if supported by a positive business case). The 'incidental' avionic package includes: Advanced aircraft satellite-based communication systems, advanced aircraft ground and approach navigation systems, a second satellite-based back-up system for advanced aircraft positioning capabilities.

For scheduled airlines and business aviation, the costs per aircraft estimation assumed that avionic packages are not standard part of the aircraft at the time of ordering but optional, meaning that forward fit costs need to be considered. The 'structural' avionic package includes: Advanced aircraft communications capabilities (ADS-B-In/Out, access to SWIM), advanced aircraft navigation capabilities (4D trajectory-based operations), advanced aircraft surveillance capabilities (airborne separation assistance system, TCAS upgrade and wake vortex prediction).

Within the General Aviation community, two subcategories have been identified: (1) GA aircraft to be equipped to operate IFR and (2) all other aircraft to be equipped to operate VFR. For subcategory (1) the 'structural' avionic package includes advanced aircraft communications capabilities (ADS-B In/Out, access to SWIM). It also includes an 'incidental' package containing SBAS based navigation. Subcategory (2) includes a 'structural' package consisting of advanced communication capabilities, GNSS based navigation capabilities and a 'squitter'. Table 14 provides the cost per aircraft.

Airspace User type		Scheduled Airlines		Business Aviation		GA IFR (fully equipped)		GA VFR
Package		Structural	Incidental	Structural	Incidental	Structural	Incidental	Structural
Investment per a/c	Retrofit per a/c							
	Base	k€ 1 400	k€ 1 300	k€ 700	k€ 800	k€ 17	k€ 12	k€ 6
	Low	k€ 800	k€ 600	k€ 400	k€ 400	k€ 12	k€ 2	k€ 5
	High	k€ 2 300	k€ 2 700	k€ 1 000	k€ 1 400	k€ 23	k€ 22	k€ 7
	Forward Fit per a/c							
	Base	k€ 700	k€ 500	k€ 600	k€ 500	k€ -	k€ -	k€ -
	Low	k€ 400	k€ 300	k€ 400	k€ 200	k€ -	k€ -	k€ -
	High	k€ 1 200	k€ 1 100	k€ 900	k€ 800	k€ -	k€ -	k€ -

Table 14: Unit Cost per aircraft

Figure 32 shows that the cost breakdown per sub-system is similar between Scheduled Airlines and Business Aviation with the structural avionic package representing approximately 50% of the costs. The main difference comes from the navigation package 'approach and ground' that is more important for Business Aviation since their flights use a higher diversity of airports. The structural package for GA operating IFR also represents slightly more than 50% but the content only includes advanced communication capabilities.

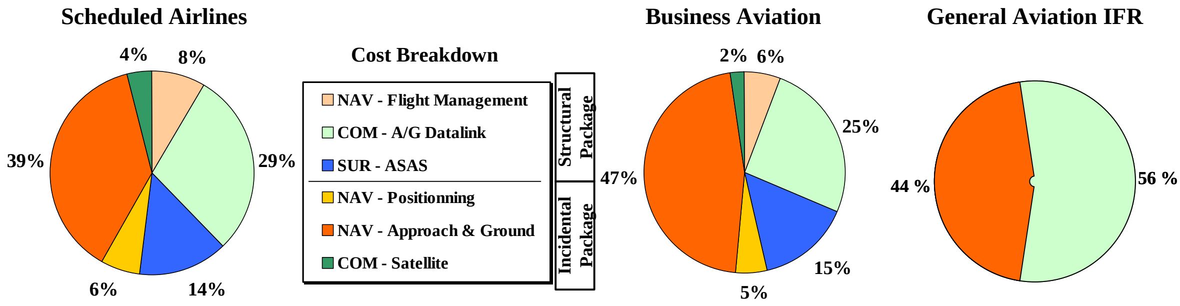


Figure 32: Cost Distribution for scheduled airlines, business aviation and GA operating IFR.

Total airborne cost estimate

For Scheduled Airlines and Business Aviation, it is assumed that it will be required to fully equip 100% (ATM capability level-3) of aircraft by 2020 either through retrofit or forward fit (i.e. about 12,500 aircraft in 2020). General Aviation also assumes a 100% participation by 2020 either through retrofit or new aircraft purchase (i.e. about 132,000 powered aircraft and aerial vehicles in 2020).
In addition to the equipment costs, additional costs have been considered: R&D costs and one-off costs (mainly additional training crew cost). It is assumed that no additional operating costs will be needed to operate this equipment. Table 15 presents the total airborne cost estimate.

		All Airspace Users			
Package		**R&D (M€)**	**Retrofit (M€)**	**Forward fit (M€)**	**One-Off (M€)**
Structural	**Base**	**3.6**	**8,000**	**4,900**	**1,220**
	Low High	1.8 5.4	4,500 13,800	2,600 8,600	480 2,140
Incidental	**Base**		**7,000**	**3,800**	
	Low High		3,000 15,700	1,800 7,700	
Cost Breakdown		**R&D (%)**	**Retrofit (%)**	**Forward fit (%)**	**One-Off (%)**
Scheduled Airlines		100%	76%	73%	24%
Business Aviation			17%	27%	1%
General Aviation			6%		75%

Table 15: Total Airborne Cost Estimate

Note that the total airborne cost estimation, as presented in Table 15, might:

- Decrease, as not all aircraft will be equipped and/or not all incidental avionics packages will be implemented if the business case is negative;
- Rise, as specification refinement usually increases the avionics costs. Further, the current estimate assumes that no revisions to early installed packages are needed.

4.1.2.3 Ground Costs

Airspace Users have considered the following ground systems: Business trajectory management, schedule management and SWIM[25].

For scheduled airlines, it is considered that ground costs are based on a yearly subscription from a third party 'business trajectory system provider' (e.g. from Lido, Jeppesen) and will be charged per flight for the trajectory management. This 'cost per flight' approach has also been used for the schedule management and SWIM improvements. This means that costs are estimated as operating costs per flight which includes the investment amortisation costs. NB: Some airlines (such as the current situation) might still decide to develop their own software.

For Business and General Aviation, the same approach is used except that it is a yearly cost per aircraft.

It is assumed that the ground package will be used by 100% of the legacy airlines while for the other aircraft operators; it is assumed that the ground package will be used only if it demonstrates a positive business case for them.

Total Airspace User ground cost estimate

	All Airspace Users - Annual Ground Operating Cost		
	Staff (M€)	**Maintenance (M€)**	**Communication (M€)**
Base	**7.5**	**39.8**	**10.9**
Low High	4.4 11.1	30.5 51.2	7.2 15.5
Cost Breakdown	**Staff (%)**	**Maintenance (%)**	**Communication (%)**
Scheduled Airlines	100%	59%	9%
Business Aviation	0%	1%	1%
General Aviation	0%	41%	89%

Table 16: Total Airspace Users Ground Costs

Note that the total Airspace Users ground cost estimation, as presented in Table 16, might:

- Decrease, as not all aircraft operators will use this service and/or not all ground functionalities will be implemented in case the business case is negative;
- Rise, as the specification refinement usually increases the ground costs.

4.1.3 Air Navigation Service Providers

Scope of the assessment

- For the ANSPs, the following systems have been taken into consideration: En-route/approach, aerodrome ATC system, network management/capacity planning, advanced airspace management, air ground data link gateway and SWIM supervision.

Assumptions

- The investment costs calculated by ANSPs represent the costs linked to the development, deployment and operation of the specific aspects of the ATM Target Concept. They do not

[25] UDDP included as R&D cost only since specifications are not enough defined.

represent the complete level of ANSP investments, which is currently around €1.2Bn/year and assumed to stay stable till 2020;

- All the CNS technologies recommended in chapter 2.5 'Technology' in relation to ATM sub-systems are included in either the present detailed cost assessment or in the overall ANSP investment costs discussed at the end of this chapter. CNS technology is assumed (based on historical values) to constitute 40% of total investment costs. The following caveats are to be noted:
    - Ground – Ground network infrastructure, system interfaces and management required for the SWIM concept have so many unknowns that there is a high degree of uncertainty on the cost assessment specific to SWIM;
    - The costs of EGNOS usage are included in this cost assessment. Future SATNAV service cost estimates is not available.
- Investment costs have been decomposed into:
    - Pre-implementation costs based on the assumption that there will be one or two different developments (as reflected by the current flight data processing development industry 'grouping');
    - Implementation costs (including training, one-off and capital costs) for all units at European level.
- Implementation/staff training costs are extracted from the DLT 1.7/D3 [Ref.17];
- Implementation/One-off costs are calculated on the basis of 30 % of implementation/capital costs;
- Implementation capital costs have been calculated by multiplying the capital cost per unit by the number of unit instances. Considering the uncertainty existing at the moment on the forecast of units to equip, the number of units (and so costs) relates to the year 2005 (source: EUROCONTROL CRCO, STATFOR, PRU[26]) and amount to 66 ACCs, 638 sectors, 208 approach, 78 main towers and 342 other towers;
- On the basis of expert/industry experience a percentage of total investment costs (13.8% for base systems and 21.5% for advanced systems) have been used to calculate operating non-staff costs including maintenance, communications and other industrial costs like electricity.

Total ANSP costs

[26] Values extracted from PRC - ACE 2005

SYSTEM	ANSPs Systems Cost Assessment (M€)			
	Investment Costs			Yearly Operating Costs
	Pre-Impl Costs	Implementation Staff Training & One off	Implementation Capital	Operating
	Base			
EN ROUTE / APPROACH ATC CENTRE	975.45	465.87	527.91	361.29
AERODROME ATC SYSTEM	210.00	232.20	558.00	191.83
NETWORK INFORMATION MANAGEMENT	157.50	19.20	30.00	44.44
ADVANCED AIRSPACE MANAGEMENT	31.50	7.60	6.00	9.70
AERONAUTICAL INFORMATION MANAGEMENT	31.50	16.30	6.00	11.57
A/G DATALINK GATEWAY	21.00	32.30	90.00	19.70
SWIM SUPERVISION	15.75	18.50	3.00	8.01
TOTAL	1,442.70	791.97	1,222.91	646.54

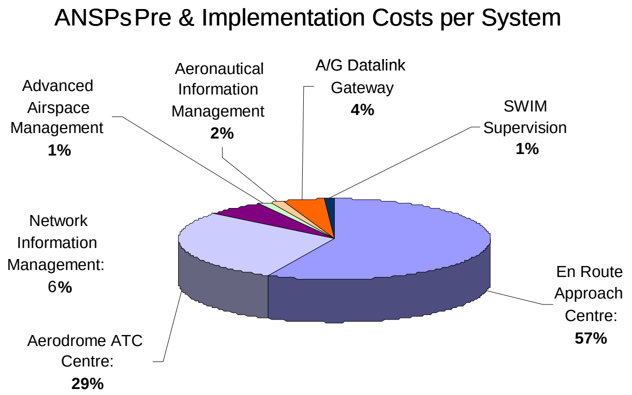


Table 17: Specific ANSP costs and relative cost distribution over systems

The sum of the investment costs linked to changes or new functions necessary for the realisation of the ATM Target Concept, determined in accordance with the above assumptions, is around €3.4Bn[27].

It is estimated that approximately 80% of €3.4Bn investment costs will consist of a re-orientation of planned budgets and 20% (€0.7Bn) are to be regarded as additional costs for the adaptation of existing plans to the implementation of the SESAR programme. The overall level of ANSP investments for ATM/CNS, currently around €1.2Bn/year[28] i.e. €14.4Bn for the 2008-2020 period, is therefore expected to slightly increase as a result of the investments needed for the implementation of the SESAR programme to around €15.1Bn.

4.1.4 Military

4.1.4.1 General Assumptions and Caveats

- Information on military procurement programmes and associated costs is not readily available and difficult to retrieve. Therefore the cost estimates presented should be seen as providing only an "order of magnitude" of estimated costs;
- Military stakeholders are not only interested in the costs which may impact on the user charges (e.g. when services are provided by military units to GAT), but also all the costs for military organizations in order to adapt their fleets or ground segments (ATC as well as Air

[27] These results are supported by a complementary top-down analysis. For further information please refer to the DLT 332/D3 [Ref.21].

[28] http://www.eurocontrol.int/prc/gallery/content/public/Docs/ace2005/ace2005.pdf --> page 78

Defence) to ensure full interoperability with the future environment while maintaining the required operational flexibility;

- For the cost of Military Organizations as Airspace Users estimates are based on the estimates of civil Airspace Users and were customized further in accordance with the number of State aircraft to be equipped and the airborne equipments required. Only investment costs have been estimated;
- For the cost of Military Organizations as ANSPs**,** estimates are based on the estimates of the (civil) ANSPs. It covers the capability of the en-route ATM system required for supporting military operations (OAT) and encompasses more than just the required ATC-capability. The cost is to be deducted from the ANSP costs since it is recovered from Military authorities;
- Estimation of the cost of Military Organizations as airport operators, i.e. operators of civil-military airports, has not been pursued since it is assumed that investments related to the implementation of the SESAR programme required at civil-military airports in principle would be borne by the (civil) airport operator and thus would not be recovered on the military stakeholder;
- Local Air Defence systems as well as the NATO Air Command and Control System (ACCS) will need to be adapted to the new information management environment in order to remain interoperable and allow for the required information flow. Cost estimates however are not available at this stage and should be performed by the appropriate authorities.

4.1.4.2 Air Platform Equipment

Based on the approach of the civil Airspace Users, the following systems were considered by the Military Stakeholder:

- NAV: Flight Management, Positioning, Approach, Ground;
- COM: AGDL, Voice (SATCOM), VHF 8.33 kHz;
- SUR: ASAS, Mode S – ELS & EHS, Wake Vortex.

The airborne systems & technologies and associated costs considered are those for the corresponding category of civil Airspace Users. The typical operational context is the ATM capability level 3.

Assumptions

- For the cost of the military equipment a multiplication factor has been applied to the cost figure of the corresponding civil equipment (higher cost of military avionics and equipment integration);
- Numbers of aircraft taken from publicly available sources:
    - Number of military transport type aircraft: 1,111 aircraft, 100% required to fly as GAT;
    - Number of fighters: 3,360; 60% required to fly as GAT;
    - Number of light aircraft, helicopters, etc.: 7,392; 60% required to fly as GAT;
    - Number of UAS was not considered.

- Number of aircraft for VHF 8.33 kHz and Mode S has been taken from the national State aircraft operators equipage plans provided to EUROCONTROL;
- A one-off investment cost is estimated for the crew training for the whole SESAR package. Cost figures are those estimated for the corresponding categories of civil Airspace Users.

The overall air platform investment cost for all Military Airspace Users is estimated at €11.4Bn.

4.1.4.3 Ground Equipment

Some of the specific ground segment costs for the military were identified from public sources or on-going estimation efforts in EUROCONTROL i.e. Mode S – Interrogator Code Allocation Implementing Rule preparation, DMEAN CBA and EAD Migration. These costs are not considered to be overlapping with any other costs mentioned. The investment cost for ground equipment for the military stakeholder is estimated at €6.2M. The associated yearly operating cost is estimated at €4.9M.

4.1.4.4 ATM Costs

Based upon an input from the military stakeholders a fixed percentage (base estimate: 9 %) of the ANSP costs (investments & yearly operating costs) is being used. The total investment cost is estimated at €311M. The associated yearly operating cost is estimated at €58M.

<u>Total cost for the Military stakeholder</u>

	Investment cost	Yearly Operating costs
Air Platform Equipment	€11.4 Bn	-
Ground Equipment	€6.2 M	€4.9 M
Military ATM costs	€311 M	€58 M
Information Management& services	Not Available	Not Available
Total	€11.7 Bn	€62.9 M

Table 18: Total costs for the military stakeholders

4.1.5 Airports

The following systems and sub-systems have been taken into consideration:

- Airport Resource Management including Stand & Gate Management, Turnaround Management, Stand Turnaround;
- Airport Capacity Management including Airport Demand & Capacity, De-icing, Environment & performance management;
- Airport Information Management including Airport mapping, Ground-Ground IOP/SWIM, Technical Supervision. It includes the network operations plan.

Technological enablers[29] have been taken into consideration and have been mapped over the different sub-systems.

[29] Please note that surveillance has been taken in charge by ANSPs, which means that ARPT costs have been considered as almost exclusively IT cost to

Assumptions

The following numerical assumptions have been taken in order to make the cost computations

- 150[30] airports, 60 'large' and 90 'medium/small' together covering the vast majority of total ATM/year (airports with more than 1.5 Million pax and more than 20,000 movements/year);
- For existing subsystems (available on the market and currently operational at some airports), airports are further split between equipped and non-equipped airports;
- The pre-implementation and implementation costs for the network operation plan and the central element of airport mapping are incurred only once, other systems multiple times;
- The Airport costs assessment includes only direct costs incurred by Airport operators for ATM. Costs for other airport stakeholders such as ground-handlers have not been included.

Airport unit cost

AIRPORT Systems Cost Assessment (LARGE)	Investment Cost per airport (in MI)						Annual Operating Cost per airport (in MI)		
	Pre-implem.	Implement.	One-Off	Capital	Staff Training	Total Investment	Staff	Other Operating	Total Operating
EQUIPPED AIRPORTS (include existing in service sub-systems costs and new sub-system costs)	0.41	2.56	1.08	1.28	0.20	2.96	0.14	0.13	0.26
NON-EQUIPPED AIRPORTS (include existing no-in service sub-systems costs and new sub-systems costs)	0.70	3.84	1.74	1.66	0.44	4.54	0.31	0.21	0.53

AIRPORT Systems Cost Assessment (MEDIUM/SMALL)	Investment Cost per airport (in MI)						Annual Operating Cost per airport (in MI)		
	Pre-implem.	Implementation	One-Off (Proj.Mgmt +other costs)	Implementation Capital	Staff Training	Total Investment	Staff	Other Operating	Total Operating
EQUIPPED AIRPORTS (include existing in service sub-systems costs and new sub-system costs)	0.34	1.79	0.67	0.94	0.18	2.13	0.10	0.10	0.19
NON-EQUIPPED AIRPORTS (include existing no-in service sub-systems and new sub-systems costs incurred by own local decision)	0.58	2.58	1.06	1.17	0.35	3.15	0.27	0.16	0.42

Table 19: Airport unit costs

Table 19 shows the airport cost per unit which are shown per sub-system in Figure 33. The breakdown of sub-systems over medium/small and large airport shows that resource management investment is more important for medium/small airports whereas large airports will need to invest more in capacity management sub-systems.

update the systems in order to acquire the new capabilities required by the SESAR systems requirements

[30] This number is on purpose slightly higher than the value used for the capacity assessment in chapter 4.

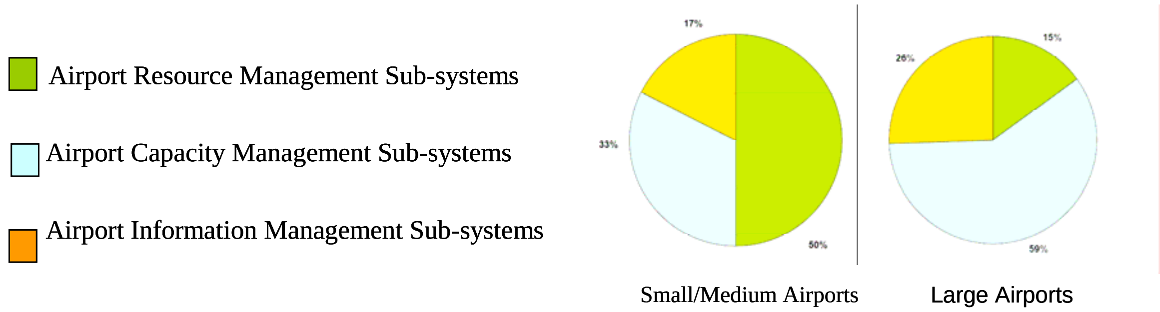


Figure 33 – Sub-systems investment for medium/small and large airports

Total airports costs

With these assumptions and considering the above-mentioned sub-systems for the cost breakdown, the total airports costs are provided in Table 20.

AIRPORT Systems Cost Assessment		Total Investment Cost (M€)	Total Yearly Operating Cost (M€)
Systems	All sub-systems	Base	
Airport Airside Operations System	Large Airports	199.3	19.2
	Medium/Small Airports	123.1	19.1
	Total Airports	322.4	38.3
Airport Mapping System	Central Airport Mapping (new subsystem)	1.9	0.6
TOTAL AIRPORT COSTS		324.4	39.0

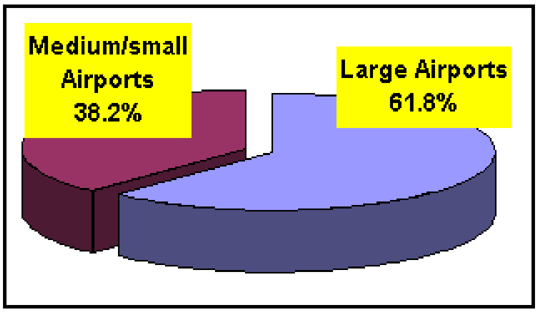


Table 20: Total airports costs and distribution of investment costs over airport type

4.2 Financing the ATM Target Concept

This chapter describes the additional financing costs. The cost inputs for all stakeholder groups have been retrieved from the cost assessment described in more detail in the previous chapters and include investment and operating costs.

4.2.1 Assumptions

The financing analysis of the ATM Target Concept costs has been performed with the following assumptions:

- The capital investment level for the implementation of the SESAR programme (capital employed) will be aligned with the already planned investment level of each stakeholder;

- In order not to hinder implementation and to avoid pre-financing costs impacting the ATM unit cost, the capital investment (and perhaps some portions of operations costs) will be financed via debts and refinanced (paid back) at a later stage when efficiency gains out of the system cover financing costs;
- The financing costs imply additional cost-effectiveness efforts.

For ANSP cost development this can be illustrated in the graphs of Figure 34 from the financing model. This model will be used for financing and investment planning in the ATM Master plan.

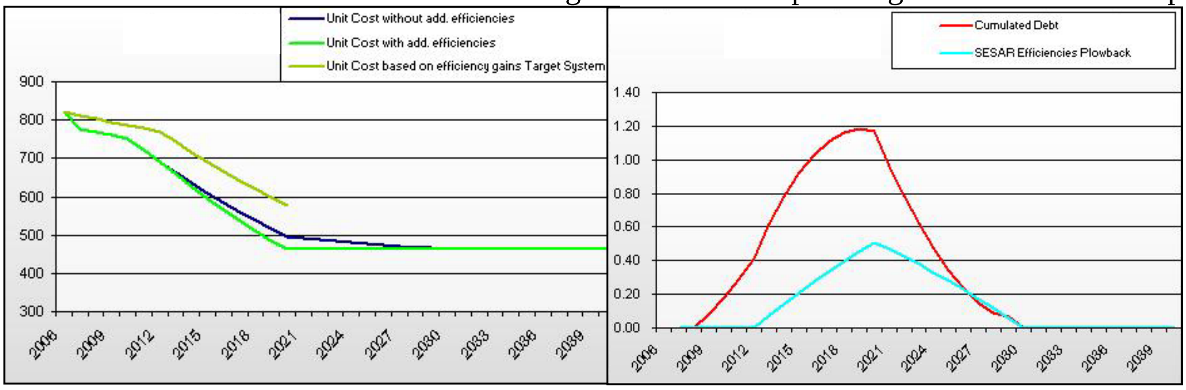


Figure 34: Financial model graphs

To achieve the defined ATM cost-effectiveness profile (from 2004-2020), the graphs identify the additional efficiency required of the system per year (light blue line) to finance the investment costs. The green line shows the target unit cost development including financing costs, the dark blue line shows the unit cost development without financing costs. The red line shows the cumulated debt up to 2030 (target cut off year for repayment of financing costs).

Results

For ANSPs an additional (on top of standard financing costs including 2% inflation) financing cost amount of €0.5Bn - €1Bn (low/high cost case) will be needed between 2008-2020. For Airspace Users this additional financing costs level has been computed in a range of €14.7Bn – €18.4Bn between 2008-2020 for the total investment (low/high cost case). For airports and MIL currently no alignment figures with standard investments have been defined, therefore financing costs are computed for total investment and are computed in the base cost scenario for airports as €0.3Bn and MIL as €2.3Bn. NB: Only for ANSPs an alignment calculation has been considered.

The associated 2020 depreciation costs for ANSPs are €300M and €140M 'cost of capital' costs. For Airspace Users the costs for 2020 are €1.5Bn, for airports €25M[31].

4.2.2 Conclusion on Financing

- Annual unit cost efficiencies of 6.5% (low case), 6.8% (base case) and 7.0% (high case) may be required between 2011 and 2020[32] to meet the cost-effectiveness target whilst financing the transition[33];

[31] 2020 values are 2005 price level normalized.

- Of this, the additional cost reduction efficiencies (starting from 2011) that need to be achieved by the ANSPs in order to meet the cost-effectiveness targets under a low and high case cost scenario are 0.5% up to 1% respectively;
- In order to overcome the misalignment of investments until 2013 a contribution of governmental grants for impaired assets for ANSPs of up to €0.42Bn during the pre-implementation phase has been estimated. A comparative measure for Airspace Users (10% grant) in the same period would require €2.5Bn (base case) in total in the development period;
- Any delay to align investments beyond 2013 will further increase the impact of impaired costs;
- To enable the use of more advanced financing schemes; optimised use of external debt/equity ratio financing mechanisms, increased procurement coordination and coordinated grants mechanisms, a central special purpose financing structure is recommended. These proposals could reduce the required efficiencies by 1.9% between 2013-2020. Possible gains of such a set-up could potentially reduce the need for the otherwise required additional efficiencies to cover the financing costs of the implementation of the ATM Target Concept for ANSPs.

4.3 Cost Benefit Analysis

This chapter presents the results of the analysis of the expected costs and benefits of the future ATM Target Concept.

4.3.1 Important Notes and Caveats

The outcome of this Cost Benefit Analysis (CBA) is to be used as 'what-if' scenarios with only trend and rough order of magnitude results. They will evolve when refinements of the costs and operational benefits, derived from further performance assessments will be available during the next milestone of the SESAR Definition Phase. This chapter provides guidance material rather than a single figure for challenging and discussion purposes.

The benefits have been calculated until 2025 since no information regarding the baseline scenario beyond 2025 exists.

4.3.2 Assumptions and Inputs

Main assumptions

- The CBA has been performed for the ATM Target Concept by 2020 and at the level of Europe (ECAC);

[32] Before 2013 from other means than SESAR.

[33] These figures are expressed in 2005 values, regardless of inflation and for the European Statistical Reference Area (ESRA, EUROCONTROL STATFOR) meaning that using current 2007 traffic and/or cost figures will require adaptation before any comparison is made. Based on current figures (incl. forecast 2007) an increase from 5% up to 6% required cost reduction from 2011 – 2020 might be necessary.

- The CBA has been performed using the EMOSIA[34] (European Model for Strategic ATM Investment Analysis) methodology and toolset. This uses one model per stakeholder group (ANSP, Airport Airlines, Business/General Aviation and Military as service providers and Airspace Users) and one overall model that aggregates the outputs of all of the stakeholder group models;
- The model for the ANSPs is based on "full cost recovery" as it is today, with no economic regulation methods like "price capping";
- Societal benefits like safety benefits and environment benefits have not been quantified monetarily.

Inputs

- Costs: The costs inputs for all stakeholder groups have been retrieved from the cost assessment described in more detail in the previous chapters and include investment and operating costs;
- Benefits: The benefits inputs for all stakeholder groups come from the operational benefits derived from the performance assessment described in chapter four. The monetary values of the operational benefits are computed by comparing the performance to a baseline performance defined as 'business as usual/do nothing';
- Baseline: the short-term baseline has been defined by assuming a full implementation of the current ECIP/LCIP objectives by 2012. The mid/long term Baseline has been extrapolated from 2013 and beyond 2020 supposing no breakthrough of the current ConOps and assuming that the overall network capacity will continue to develop through traditional means.

4.3.3 Non Airspace User models

The ANSPs, MIL and airports models are in different stages of maturity.

- The ANSP model has been verified to run correctly and has been used to assess 'what-if' scenarios on cost effectiveness evolution;
- The airport model includes for the moment non-ATM aspects and will need further refinement;
- The MIL model (incorporating Airspace User and ANSP aspects) has been developed but it is proven difficult to quantify monetarily certain ATM incurred aspects.

4.3.4 Civil Airspace Users Results

The block diagram in Figure 35 shows how the inputs and outputs flow from various sub-models to compute the incremental cash flows associated with an ATM improvement for the Airspace Users.

[34] EMOSIA is a EUROCNTROL toolset, more information on http://www.eurocontrol.int/ecosoc/public/standard_page/emosia.html

Blue boxes are external sources of information and orange boxes contain internal EMOSIA model calculations.

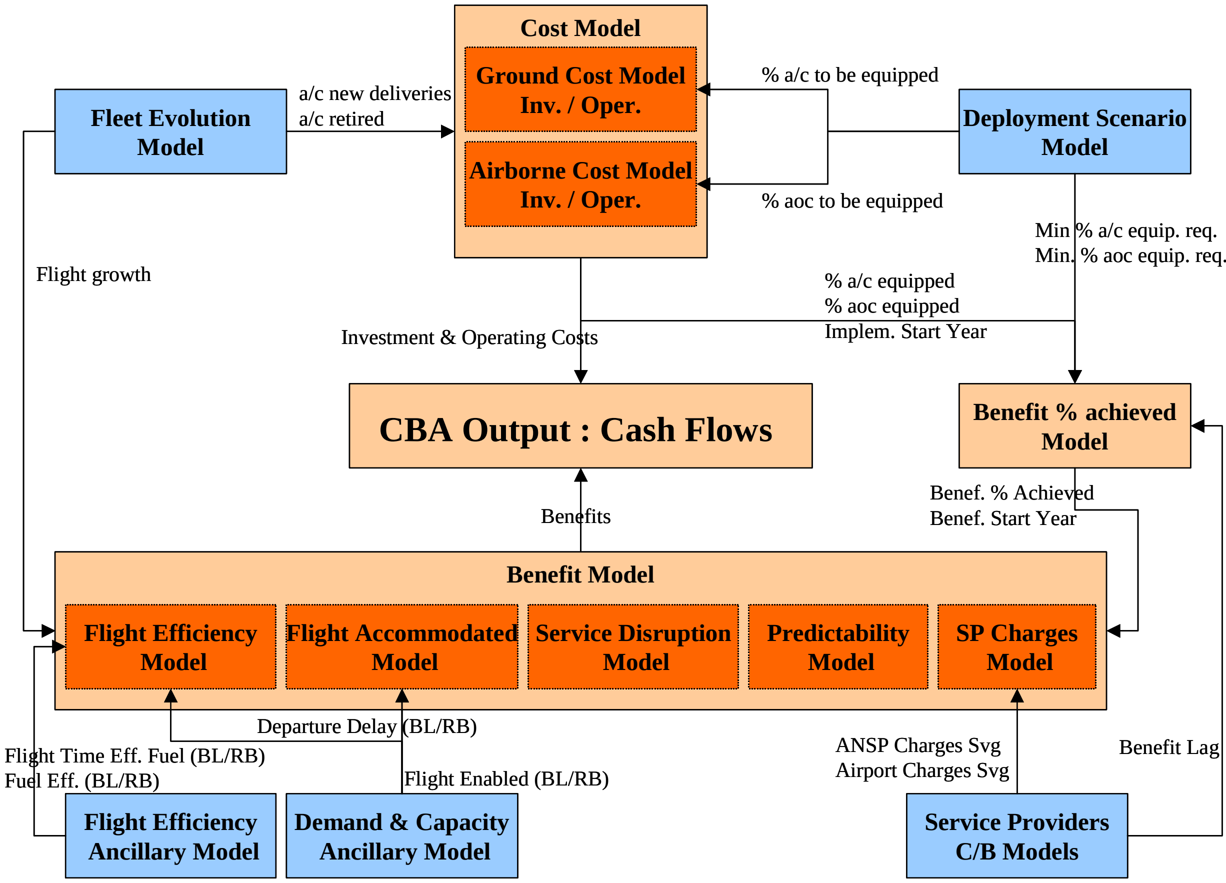


Figure 35: Airspace Users Cost and Benefit Block Diagram

Details of the Benefits

The benefits are expected from a reduction of the direct Gate-to-Gate ATM Costs by the service providers meeting the cost effectiveness target as well as from a reduction of the indirect costs by meeting the quality of service targets.

- Direct Gate-to-Gate ATM Costs savings/Cost Effectiveness: At this stage, there is incomplete evidence that the cost effectiveness target is going to be met. As a consequence, only "What-if" analysis have been developed in the frame of the CBA in order to assess the impact of the direct Gate-to-Gate ATM costs savings with regard to the overall benefits and to see to what extent the business case is positive for Airspace Users. A scenario corresponding to half of the Cost Effectiveness target (from €800 to €600 in stead of €400/flight) being delivered by SESAR is further explored;
- Indirect Costs savings/Quality of Service (Efficiency, Flexibility and Predictability): The quality of service targets should be met if the capacity target is going to be met. However at this stage, there is incomplete evidence that the capacity target is going to be met. As a consequence, only "What-if" analysis have been developed in the frame of the CBA in order to assess the impact of the indirect costs savings with regards to the overall benefits and to see to which extent the SESAR business case for Airspace Users is positive. Two different

scenarios have been developed: (1) The capacity and quality of service targets are met, (2) the capacity target is not met and the quality of service in 2020 will be similar to today's quality of service.

Several quality of service related benefits have been defined as inputs for CBA:

- (Capacity) Flight Accommodation: Reduction of non-accommodated flights calculated from performance assessment;
- (Efficiency) Departure Delay: Reduction of departure delay (% of flights delayed and the average minute of delay per delayed flight) calculated from performance assessment;
- (Efficiency) Time & Fuel Efficiency: Reduction of time and fuel current inefficiency. NB: This has not been assessed at this stage but some qualitative indication of benefits is possible;
- (Predictability) Service Disruptions: Reduction of number of flights cancelled and diverted during service disruptions. It has not been assessed at this stage but some qualitative indication of the benefits is possible.

The Table 21 summarises the baseline assumptions used in the CBA. It is important to note that the different results that will be presented hereafter are very sensitive to the baseline scenario values. The validation of such a baseline is one of the major tasks in the next SESAR milestone deliverable. The results of the simulation made so far to compute the capacity performance of the baseline raise a quality of service issue for 2012 unless the refinement of the baseline with the inclusion of other on going initiatives allows for eliminating the issue.

	Baseline			
Benefits Area	**2007**	**2012**	**2020**	**2025**
Flight Non accommodated (M flights)	**0.5**	**1.8**	**3.3**	**5**
Flight Delayed (%)	**11%**	**18%**	**27%**	**34%**
Delay per delay flights (Minute)	**10**	**15**	**17**	**19**

Table 21: Baseline Summary

Results scenario 1: Capacity target and quality of services targets are met

This scenario assesses the impact of the direct Gate-to-Gate ATM costs savings with a cost effectiveness of half of the target in order to assess up to which extent the SESAR business case could become positive.

	Rolling Baseline Scenario 1			
Benefits Area	**2007**	**2012**	**2020**	**2025**
Annual User Charges Savings (Bn€)	**0**	**0**	**1.8**	**2.8**
Additional Flight accommodated (M flights)	**0**	**0**	**2.3**	**4.6**
Flight Delayed (%)	**11%**	**18%**	**2%**	**3%**
Delay per delay flights (Minute)	**10**	**15**	**10**	**11**

Table 22: Rolling Baseline Summary for scenario 1

The overall Net Present Value (NPV) is in a range from €-3Bn to €6Bn with a positive base case of €1.8Bn (with an interval of confidence of 80%). However, the case is not positive for all Airspace Users, see details in the Table 23, and there is a 40% probability to be negative.

	Scenario 1				
	All Airspace Users	Scheduled Airlines	Business Aviation	IFR Gen Aviation	VFR Gen Aviation
NPV (Bn€)	**1.8**	**5.0**	**-2.5**	**-0.10**	**-0.59**
Benefit/Cost	**1.2**	**1.7**	**0.2**	**0.6**	**0.0**

Table 23: Scenario 1 Results

Benefit distribution and sensitivity analysis

			Scenario 1							
Benefit Distribution			Scheduled Airlines		Business Aviation		IFR Gen Aviation		VFR Gen Aviation	
Direct ATM Cost Savings	Bn€	%	5.2	42%	0.35	52%	0.11	76%		
Delay Savings	Bn€	%	4.3	34%	0.17	26%	0.01	5%		
Flight Accommodated Savings	Bn€	%	3.0	24%	0.15	22%	0.03	19%		
Sensitivity Analysis			Scheduled Airlines		Business Aviation		IFR Gen Aviation		VFR Gen Aviation	
Retrofit Cost impact on NPV	Low	High	2.0	6.6	-3.2	-2.1	-0.17	-0.03	-0.62	-0.55
Forward Fit Cost impact on NPV	Low	High	2.3	6.6	-3.7	-1.7				

Table 24: Scenario 1 Benefit distribution and Sensitivity Analysis

The benefit distribution depends on the Airspace Users category. The direct Gate-to-Gate ATM cost savings (cost effectiveness impact) are the main driver for benefit (representing from 40% to 75% of the benefits) and allow the case to be positive. The NPV is very sensitive to the Retrofit and Forward Fit Costs.

From the scenario 1 we can conclude that if the cost-effectiveness target and the capacity/quality of service targets are met, then the case is slightly positive. Under these conditions the ATM Target Concept seems affordable but should be seen as a long term strategic investment since the expected benefit/cost is lower than 2.

Results scenario 2: - Capacity target is not met, quality of service will be similar to today's situation in 2020

	Rolling Baseline Scenario 2			
Benefits Area	**2007**	**2012**	**2020**	**2025**
Annual User Charges Savings (Bn€)	**0**	**0**	**1.6**	**2.3**
Additional Flight accommodated (M flights)	**0**	**0**	**1.1**	**2.2**
Flight Delayed (%)	**11%**	**18%**	**13%**	**17%**
Delay per delay flights (Minute)	**10**	**15**	**10**	**11**

Table 25: Rolling Baseline Summary for scenario 2

The overall Net Present Value (NPV) is in a range from –6 to €2Bn with a negative base case of -€1.7Bn (with an interval of confidence of 80%). For the Schedule Airlines even if the base case is positive, the case could become negative; see details in the Table 26.

	Scenario 2				
	All Airspace Users	Scheduled Airlines	Business Aviation	IFR Gen Aviation	VFR Gen Aviation
NPV (Bn€)	**-1.7**	**1.7**	**-2.7**	**-0.11**	**-0.59**
Benefit/Cost	**0.9**	**1.2**	**0.2**	**0.5**	**0.0**

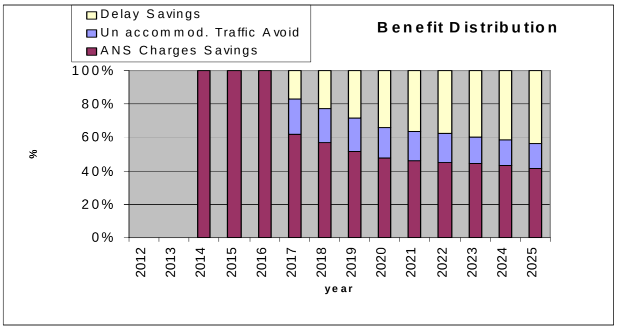
Table 26: Scenario 2 Results

Benefit distribution and Sensitivity Analysis:

			Scenario 2							
Benefit Distribution			Scheduled Airlines		Business Aviation		IFR Gen Aviation		VFR Gen Aviation	
Direct ATM Cost Savings	Bn€	%	4.6	51%	0.35	64%	0.106	85%		
Delay Savings	Bn€	%	3.0	33%	0.12	22%	0.005	4%		
Flight Accommodated Savings	Bn€	%	1.5	16%	0.08	14%	0.013	11%		
Sensitivity Analysis			Scheduled Airlines		Business Aviation		IFR Gen Aviation		VFR Gen Aviation	
Retrofit Cost impact on NPV	Low	High	-1.3	3.2	-3.3	-2.3	-0.19	-0.04	-0.62	-0.55
Forward Fit Cost impact on NPV	Low	High	-1.0	3.2	-3.9	-1.8				

Table 27: Scenario 2 Benefit distribution and Sensitivity Analysis

Like for the scenario1, the benefit distribution depends on the Airspace Users. The Gate-to-Gate ATM cost savings (cost effectiveness impact) are contributing even more strongly to the benefits (representing from 50% up to 85% of the benefits) and allows the case to be positive at least for the scheduled airlines. The NPV is very sensitive to the retrofit and forward fit costs and depending on the Low/High Value, the case could turn positive or negative for scheduled airlines.



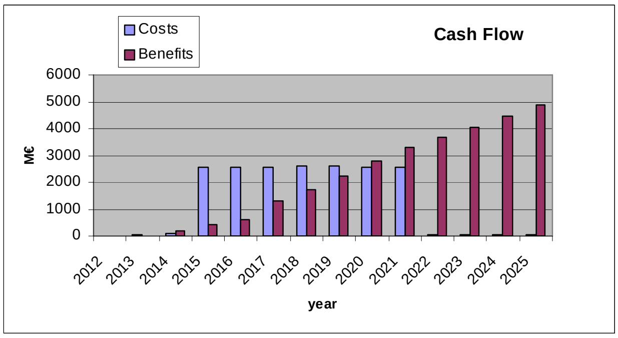


Figure 36 –Benefit distribution and cash flow for schedules airlines

The details of benefit distribution for scheduled airlines (as visualised in Figure 36) clearly show that without the Gate-to-Gate ATM costs savings the case cannot be positive. The direct ATM costs savings represents on average 50% of the benefits but between 100% and 50% of the benefits during the SESAR Deployment Phase and only 40% during the “Cruising Phase”. This reinforces the importance of such a benefit since the direct Gate-to-Gate ATM costs savings allow to financially support the airborne equipment investment during the first years.

Finally, in case the forward fit costs are not considered, then the NPV raises from €1.7Bn up to more than €5Bn for Scheduled Airlines and raises from €–2.7Bn up to €–0.5 Bn for Business Aviation.

Conclusions and recommendations

- For Scheduled Airlines, the case is likely to be positive for each scenario. Since it is only slightly positive in scenario 2, this leads to the conclusion that in order to reap the full benefits of SESAR, the cost effectiveness target has to be reached as well as the capacity target to the greatest extent;
- For the Business Aviation, the case is likely to be always negative mostly due to Business Aviation inability to quantify their specific benefits (door-to-door service improvement);
- For both Scheduled Airlines and Business Aviation, avionics manufacturers will have to make specific efforts to reduce avionics package cost. For example, for "forward fit" applications on next generation aircraft, it is expected that most of new functionalities will be provided as part of the standard aircraft, at no additional cost. In addition global interoperability activities, avoiding multiple equipage packages, and common solutions will need to be pursued;
- For the IFR General Aviation, the case is likely to be always negative and like Business Aviation, the result is due to the lack of significant benefits as well as difficulty to quantify some their specific benefits (door-to-door service improvement). In addition, the costs of retrofit are relatively high compared to the expected benefits;
- For VFR General Aviation, no benefit has been monetised and there are mainly only costs

Whilst noting that

- All scenarios developed should be considered as conservative since:
  - Benefits have been calculated until 2025 only. If costs and benefits remain constant during the 2025-2030 period, then it is estimated that in the scenario 2 the NPV for Scheduled Airlines will raise from €1.7Bn to more than €6Bn (Benefit/Cost around 1.8);
  - In terms of indirect costs savings benefits, it is anticipated that service disruptions cost savings could represent a €2Bn to €5Bn increase of the NPV for scheduled airlines. The same order of magnitude could also be obtained by the fuel efficiency cost savings (without taking into account the likely fuel cost increase). Finally, on top of this fuel efficiency cost savings, some environmental cost savings might arise as well. NB: Wider economical (air transport and societal) benefits are also excluded.

4.3.5 Further Observations

- The different results presented are very sensitive to the baseline scenario values. The validation of such a baseline is one of the major tasks in the next SESAR Milestone deliverable;

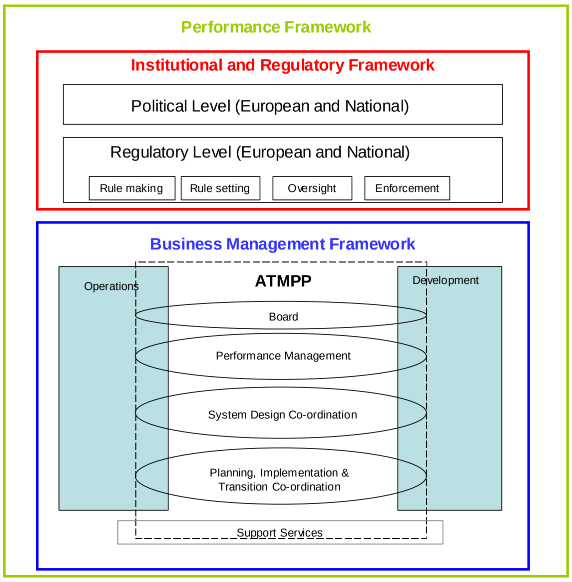
- D3 has not provided conclusive evidence that the ATM Target Concept will be affordable or economically viable from an Airspace Users perspective. This will require further work;
- The cost-assessment, financing analysis and CBA work have been conducted by a number of tools shared by all stakeholders that will now be used for further analysis and decision making assistance.

5 Enablers of the ATM Target Concept

5.1 Business Framework

SESAR Milestone Deliverable 2 (“Air Transport Framework - The Performance Target”) [Ref.2] outlined a future vision based on the “Performance Framework”, the “Business Management Framework” and the “Institutional and Regulatory” Framework[35].

5.1.1 ATM Performance Partnership



Integral to the operation of the Business Management Framework is the “ATM Performance Partnership” (ATMPP) to be created by the stakeholders. The ATMPP ensures co-ordinated, consistent stakeholder positions, agreed amongst the relevant partners according to the business under consideration. It strives to produce agreement on requirements based on integrated consultation amongst its members. To ensure adequate buy-in, the ATMPP includes representation from all stakeholder groups as equal partners.

Figure 37: Principal functions

The ATMPP interfaces with the differing regulatory structure at European, sub-regional and national level. The Figure 37 aims to clarify where the boundaries will be between the institutional/regulatory and business frameworks, and activities to be left to the market[36].

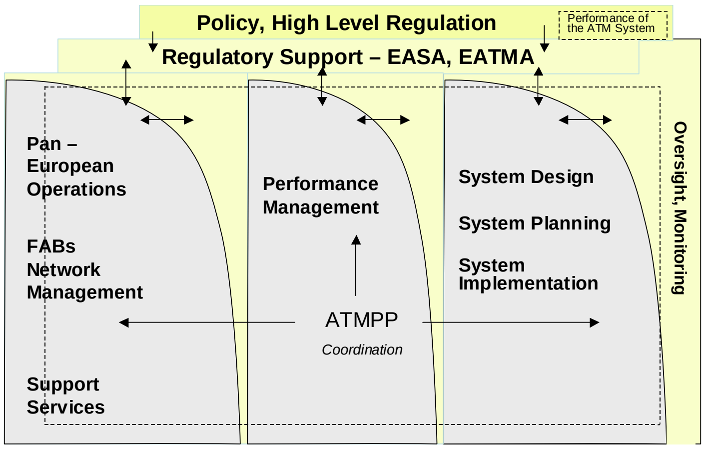


Figure 38: Interfaces

The actors involved do not change but the interactions between them may. This is depicted in the Figure 38 (which aims to show the likely role of the ATMPP).

[35] NB: Many of the institutional issues are currently under consideration by the European Commission’s High Level Group and thus are not addressed here. The impact of the High Level Group’s report [Ref.26] will be assessed as part of the later Milestone Deliverables.

[36] “Operations” includes, but is not necessarily limited to, Airports, Airspace Users, En-route and TMA ATC (individually or through FABS), Military, Network Management and Aerodrome ATC (including approach control functions where performed). “Support Services” includes, but is not necessarily limited to, AIS, CNS, Met, R&D and Training.

Since the ATMPP has no binding regulatory decision-making powers[37] it will only be able to take decisions on issues where voluntary adoption is adequate and there is no need for enforcement of the decision. The ATMPP would have to address the difficulty of ensuring commitment without its own formal means of enforcing compliance.

The ATMPP must achieve genuine participation and buy-in from all stakeholder groups and provide added value by producing coordinated and consistent positions to a level not achieved to date. Achieving this will be particularly demanding for non-corporatised organisations (e.g. Military, General Aviation), or organisations having different levels of ownership (e.g. airports) and/or different business and investment cycles.

The existing decision-making process is already complex and burdensome. The ATMPP should aim to improve the situation and avoid becoming yet another body or a replacement for an existing body.

5.1.1.1 Recommendations

1. The ATMPP:
   - Includes as equal partners all stakeholders including civil Airspace Users (both commercial and general), airport operators, ANSPs, military representatives, manufacturing industry and social partners. NB: Due consideration should be given to effective participation of Military Authorities in the future decision-making process;
   - Adds value by ensuring a coordinated, consistent stakeholder position which would be agreed amongst the relevant partners, across the principal functions;
   - Coordinates stakeholder views as inputs to the relevant parts of the existing and future institutional and regulatory framework and, gradually, the role of the ATMPP should establish itself with respect to these and other organisations where appropriate.
2. In close coordination with the ATMPP stakeholders ATM performance management monitoring builds upon existing EUROCONTROL processes/bodies (such as PRC and ECIP/LCIP). It should, however, focus on both performance outcomes and operational/technical coordination necessary for the successful implementation of the ATM Master Plan.
3. States should ensure that, where necessary, their consultation mechanisms and decision-making are brought up to best practices to fully profit from any improved co-ordination within the ATMPP.
4. An overall review of decision-making and standards organisations should be set up after EC consideration of the HLG Report [Ref.24] in order to identify where duplication or conflicting interests currently and potentially exist with a view to rationalisation.

[37] From consultation from legal experts of Task 1.5.2. No legal mechanism has been found which could permit the necessary delegation of legal decision-making authority and in any case this would go against the principle of separation of regulation from service provision.

5.1.1.2 Future Work To Be Undertaken

- Analyse the decision-making processes supporting the deployment and implementation stages of the ATM Master Plan, including the role of the ATMPP in coordinating stakeholder input and interfacing with the regulatory level;
- Examine potential options for creating a legal entity underpinning the ATMPP, governance arrangements, necessary levels of funding and resourcing. The ATMPP should be in place before 2013 so that its creation process does not further complicate the transition period when the SESAR JU is disbanded;
- Ascertain best practice methods of inclusion for all interested parties including those for whom involvement at every level of the current process is impractical but for whom the impact of decisions is nonetheless significant.

5.1.2 Human Change Management Aspects and Social Factors

The ATM Target Concept is a change of high complexity, magnitude and scale impacting fundamentally social partners' roles and responsibilities. The analysis of the ATM Target Concept identified impacts on social and change factors that must be anticipated and managed cooperatively in future with social partners. Further details of this analysis, including the description of relevant roles and responsibilities are available in the DLT 1.7/D3 [Ref.12].

Flight Crew	**Impacted Social Factors:** Job/Life Quality; Balance & Health; Working Conditions; Age or Gender; Job Recognition; Working together & People Management. **Impacted Change Factors:** Change Management Strategy & Planning; Acceptance & Resistance; Cultural Diversity & Flexibility; Training & Development.
Airspace User Operations Centre Staff	**Impacted Social Factors:** Working Conditions, Job Recognition **Impacted Change Factors:** Change Resources
Airport Operations Staff	**Impacted Social Factors:** Working Conditions; Social Dialogue; Age or Gender; Shift work & staffing; Job & Career Management; Job Recognition; Working together & People Management. **Impacted Change Factors:** Change Management Strategy & Planning; Acceptance & Resistance; Communication & Involvement; Change Resources; Cultural Diversity & Flexibility; Training & Development.
Airspace and Air Traffic Flow Management Staff	**Impacted Social Factors:** Job/Life Quality, Balance & Health; Working Conditions; Social Dialogue; Age or Gender. **Impacted Change Factors:** Change Management Strategy & Planning; Acceptance & Resistance; Communication & Involvement; Change Resources; Cultural Diversity & Flexibility; Training & Development.
Air Traffic Controllers	**Impacted Social Factors:** Job/Life Quality, Balance & Health; Working Conditions; Social Dialogue; Age or Gender; Shift work & staffing; Job & Career Management; Job Recognition; Working together & People Management. **Impacted Change Factors:** Change Management Strategy & Planning; Acceptance & Resistance; Communication & Involvement; Change Resources; Cultural Diversity & Flexibility; Training & Development.
Air Traffic Safety Electronics Personnel, CNS, ATM Automation systems services	**Impacted Social Factors:** Job/Life Quality, Balance & Health; Working Conditions; Social Dialogue; Age or Gender; Shift work & staffing; Job & Career Management; Job Recognition; Working together & People Management. **Impacted Change Factors:** Change Management Strategy & Planning; Acceptance & Resistance; Communication & Involvement; Change Resources; Cultural Diversity & Flexibility; Training & Development.

Table 28: Human change management assessment

5.1.2.1 Recommendations

From the perspective of social factors and change management, the implementation of the ATM Target Concept is considered feasible provided that a set of recommendations and common principles are followed to ensure a balanced management of social impacts. These recommendations are key-enablers contributing to the success of the SESAR Development and Deployment phases:

1. The staff representative in the SESAR JU Administrative Board to present the positions from staff of Airspace Users, ANSPs, airports and manufacturers ensuring that their interests are properly taken into account. In addition, the SESAR JU Administrative Board to consider agreements and discussion results of the European Sectoral Social Dialogue Committee for Civil Aviation so that balanced, effective and sustainable decisions are achieved.
2. Social partners in the European Sectoral Social Dialogue Committee for Civil Aviation to ensure that all affected parties are properly represented with stable participation structures and clearly defined mandates. Hereby:
   - Taking a positive, proactive, anticipating, coordinating and supporting role[38] for the successful implementation of the ATM Target Concept;
   - Transferring agreements and discussion results to the SESAR JU Administrative Board;
   - Social Partners in European Civil Aviation taking an active interest in achieving the buy-in of sub-regional, national and local Social Partners as well as of affected staff for their acceptance and support. This is to be assisted by the launching and facilitation of initiatives/activities supporting the decisions taken in the SESAR Joint Undertaking.
3. Each stakeholder to implement a structured and coordinated participative management approach to ensure consistency and coherence with the ATM Target Concept. This can best be achieved by:
   - Using cross-functional teams working towards common goals exchanging with the working groups and/or the Social Partners in the European Sectoral Social Dialogue Committee for Civil Aviation;
   - Managers and leaders, from both the employer and the employee side, to prepare (i.e. receive training) to become ‘trustworthy’ and capable partners;
   - Appointment and training of change management experts, to co-ordinate the changes and consult management.
4. Management and staff at sub-regional, national and/or local levels, as appropriate, to become involved and to develop local solutions for decisions taken in the SESAR Joint Undertaking. Hereby reflecting local needs and requirements for the implementation of the ATM Target Concept and ensuring a structured and coordinated participative management approach at working level.

[38] This is already the case today with the ATM Working Group (ATMWG), the ATM subgroup of the civil aviation sectoral dialogue committee.

5.2 Institutional and Regulatory Framework

5.2.1 Legal and Regulatory Considerations

The analysis indicates that there should be no outright legal showstoppers at European Level to the ATM Target Concept. Variation between National laws in some areas may complicate specific issues but not to the point that it becomes a blocking point for the implementation of the ATM Target Concept. In any case it is not realistic to expect legal harmonisation on matters such as civil and criminal liability within by 2020.

Legal and regulatory processes already exist to undertake any necessary changes to airspace and/or equipment requirements. However, they take several years and these timescales (especially due to new certification requirements) must be taken into account when planning implementations in the SESAR ATM Master Plan and its subsequent versions. Also, they will require State involvement in the process and thus may be affected by wider political considerations. (State involvement will also be necessary for any proposed changes, which could place new requirements/restrictions on the military.)

The existing liability regimes (both civil and criminal) are able to cope with the future development of ATM through the SESAR programme. It is not possible to pre-assess and legislate for all eventualities. Complex failures of the system leading to liability (e.g. aircraft accidents) will inevitably lead to Court proceedings (whether to apportion compensation payments or determine criminal guilt in extreme cases) and these will be all the more complicated in cross-border situations. States will retain ownership of their airspace and thus ultimate regulatory responsibility for it. Fault-based liability (negligence) schemes will assess the behaviour of ALL relevant actors (both corporate and individual) and apportion responsibility (and thus financial/other penalties) accordingly. Transfers of responsibility for activities from one party to another[39] do NOT necessarily absolve the first party from all risk or legal liability. The Table 29 identifies areas requiring further work from a legal assessment perspective.

5.2.1.1 Potential New Legislation

The analysis indicates that no major new European legislation is required to implement the ATM Target Concept up to 2020, although some supporting regulations (such as Implementing Rules under the SES Interoperability Regulation) may be necessary to achieve the necessary technical harmonisation. Regulatory engagement will be required during all phases. Further societal needs may drive the need for additional economic, environmental, safety and security regulations.

[39] E.g. from ANSP to Airline or ATCO to Pilot

Implementation of Operational concept elements	The quantity (and thus cost) of any supporting legislation will depend in part on the political decision as to whether the Operational Concept (and thus the associated ground and airborne equipment implementations) is implemented on a voluntary or compulsory basis. Compulsory implementation will naturally require extra legislation.
ASAS responsibilities liability issues	The implementation of Airborne Separation Assurance Systems (ASAS) post 2020 may represent a significant change in the way in which aircraft are controlled on a tactical basis. Such a radical step would almost certainly require major legislation to ensure the necessary technical and operational harmonisation across Europe and would also need to be co-ordinated globally through ICAO.
New roles and responsibilities	New roles and responsibilities are anticipated at both individual and organisational level but not yet fully defined. Some of these may have legal implications (e.g. changing the balance of the existing potential liabilities) but this is not assessable at this time.
SWIM recording	Detailed recording requirements will be governed by the specific legislation/regulations in force at the time but it would seem prudent at this stage to plan to record all the data which passes through SWIM as it could potentially be required for any legal/ investigation
Change to risk/liability burden	Changes to current operations as proposed by the concept (e.g. ASAS) may introduce changes to the existing risk or liability burdens.

Table 29: Regulatory Assessment

5.2.1.2 Liability

Liability is a key area of concern to stakeholders. New roles and responsibilities are anticipated at both individual and organisational level but not yet fully defined. For example, the responsibility allocation in automated systems may introduce changes between various actors (including pilots, ATCOs, ATSEPs). Some of these may have legal implications such as changing the balance of the existing potential liabilities shared between the various actors, but this is not assessable at this time.

Further, the legal viability of proposals does not automatically mean that individuals/organisations are willing to accept the personal/corporate liability implications.

5.2.1.3 Recommendations

1. The implementation of the ATM Target Concept should be performed within existing legal frameworks also noting that new legislation is expensive and time-consuming to develop.
2. When developing the ASAS/self-separation concept clarification of the responsibility and liability issues of ASAS, including mixed mode of operation, is required.
3. Future developments of the ATM Target Concept should include clarification of new roles and responsibilities in order that the legal implications may be assessed.
4. Future developments of the ATM Target Concept should plan to make all data flowing through SWIM available for recording in case it is required for legal/investigation purposes.
5. Although perceived as difficult to achieve, a uniform legal regime for liability and accident/incident investigation could be desirable, although not critical, in the context of a uniform European ATM system.

5.2.2 Safety Regulation

The ATM Target Concept will introduce significant changes to the way in which ATM is performed and will fundamentally change the roles of many of the stakeholders in the ATM system. Importantly, these roles will change dynamically within the operation as a flight progresses. This will result in new ATM safety responsibilities and new interfaces between stakeholders. The ATM Target Concept will also require significant changes to technology, both on the ground and in the air, and this will need to be developed within a clear safety regulatory framework, including all required civil-military co-ordination issues.

The different elements of the ATM Target Concept have been investigated with respect to the impact and feasibility on safety regulation, and vice versa. In order to fulfil this task, a systematic approach, the safety screening method, was applied to the key aspects of the ATM Target Concept. The current evaluation indicates that there are still safety issues to be clarified and that it is likely that more safety issues will emerge during the further development and implementation of the ATM Target Concept.

The Table 30 is a compilation of the safety regulatory assessment that relate to specific elements of the ATM Target Concept. This assessment has contributed to the definition of the main recommendations.

Trajectory Management	• Safety regulatory implications of changes of scope of ATM should be followed-up once the set-up of the centralized network management function is clarified
	• Economic set-up of an ATM service (e.g., via shareholders) should not negatively influence the capabilities of the organization to fulfil its safety management responsibilities
Airspace Organisation & Management	• The legal feasibility of regional services (AMCs) should be investigated with respect to: • The scope of activities of the service • Applicability of the SES legislation to the military (as inseparable part of the concept) • Safety regulatory rule-making and oversight (taking into account the previous bullet) • Implications for implementation of the legal framework on a national level • Establishment of safety regulatory responsibility
Separation Provision – Global Aspects	• A regulatory approach should be established to manage the simultaneous application of different modes of separation taking in particular into account the impact on: • Safety rulemaking and oversight • SMS (e.g. reporting schemes)
	• A safety regulatory approach in line with clear responsibilities, rules and procedures should be established to manage the impact on related licensing schemes for pilots and ATCOs.
Collaborative Planning & Network Management	• The concept needs clarification before having detailed assessment of the impact on the safety regulatory framework; (expected key issue: integrity of data); then to elaborate a legally sound proposal how this Collaborative Planning and Network Management function can be realized in the European context
System Wide Information Management	• A clear regulation should be developed to define the boundaries of SWIM in ATM with clear rules to access and use; (the three R's, Roles, Responsibilities and Rules, should be defined per stakeholder); this requires the following enabler: Responsibilities and boundaries of ATM should be clearly specified based on policies that relate to the functional criticality of the different concept elements

Area	Assessment
Collision Avoidance	• There is a requirement for the establishment of a clear description of roles and reliance on safety nets (i.e. role of air-borne Safety nets and ground-based Safety nets) addressing owner of the risk, owner of safety case, liability for risks in interrelated environments (e.g., human automation issues)
	• There is a requirement to assign to an empowered safety regulatory authority the responsibility to develop and implement an overall regulation addressing collision avoidance • Other airborne and ground based safety nets (e.g. APW, GPWS, runway incursion prevention, etc.) should also be addressed
	• There is a requirement for early clarification to support the development and validation processes; either to be taken up by SRC or EASA or another arrangement
General items encountered in the context of Collision Avoidance	• A new accident model should be developed that represents the SESAR operational concept (related to re-definition of ATM scope, functions and boundaries)
	• Appropriate safety assessment and monitoring methods should be developed to deal with the SESAR operational concept
	• Safety R&D programmes should be aligned in accordance with SESAR scope change
Interoperability	• Safety benefits in further standardizations required by SESAR should be specified
	• A process of establishing, updating and maintaining standards should be developed including; • Periodic review process • safety oversight of standardization • managing safety in the standardization process
	• Develop methodologies for safety assessment of standards and the development process of these standards

Table 30: Safety regulation assessment

Further, it has been identified that necessary precautions should be taken to:

- Ensure an appropriate approach (as expressed in the previous SESAR Milestone) towards safety in its widest sense during the remainder of the SESAR Definition Phase and the Development Phase;
- Enable a safe implementation of the ATM Target Concept or elements of it including supporting architecture and technologies;
- Minimise project risk and associated costs related to the development and implementation of the ATM Target Concept or elements of it including supporting architecture and technologies;
- Support the European Commission and the SESAR Joint Undertaking in their respective requirements to provide information and the discharge of their explicit responsibilities and accountability towards safety in ATM.

5.2.2.1 Recommendations

A set of key recommendations has been identified which should be further developed in the SESAR Development Phase in the 2008-2013 timeframe (under the SESAR Joint Undertaking).

1. In accordance with the basic principles for safety regulations, the European Union and its Member States should designate a safety regulatory authority, to act as the regulatory authority interacting with the SESAR JU at that time when the SESAR JU becomes the owner of the ATM Master Plan. A close civil-military interaction and the involvement of appropriate military expertise within this safety regulatory authority will be an essential requirement.

2. The designated safety regulatory authority should identify the required changes for safety regulations and safety regulatory arrangements necessary to support the development and implementation of the ATM Target Concept. It should establish the requirements for the Safety Management System (SMS) for the SESAR JU and oversee its effective implementation. Current legislation and emerging safety requirements defined within the SESAR programme should be aligned as appropriate through an effective transition process. Further developments within the SESAR programme should be aligned with the changes (or non-changes) in current legislation where appropriate.
3. The SESAR JU should implement an effective SMS that takes into account the initial safety screening findings and adequately addresses the change of scope, functions and boundaries of the ATM Target Concept as it develops, and align and coordinate requirements with the safety regulatory authority, and where appropriate propose amendments to safety regulations and safety regulatory arrangements.

The basic principles for safety regulations that were defined with the second deliverable of the SESAR Definition Phase should be used as the benchmark for the successful execution of these recommendations. The basic principles should also be considered as the basis for the terms of reference for the safety arrangements within the SESAR JU and the establishment for the overall SMS requirement for the SESAR JU.

5.2.3 Recruitment, Training, Competence and Staffing

In the area of training and verification of competence for operational staff, there is a significant amount of European and worldwide regulations which will be subject to change (summarised in the Table 31). NB: Changes currently take at least four years, for worldwide standards up to seven years, before they are implemented and applied.

Actors	Level of impact	Safety relatedness	Key elements/ systems affecting role	Main triggers	Probably affected regulations and standards
			Keywords only	*Keywords only*	
Commercial pilots and military pilots	+++	+++	BT management, CDM, arrival/departure routings, ASAS, CDTI, trajectory conformance monitoring, data link, new types of a/c, tilt rotor operations; eventually includes operation of UAS	4D trajectory-based ops, delegated separation responsibilities, new COM tools, monitoring aids, information exchange "ATC", AOC, etc.	ICAO Annexes (in particular Annex 1) JAR-OPS 1 JAR-OPS 3 JAR FCLs (according EASA regulations respectively) (including implementation in national law) National regulations on military pilots training and licensing
Aircraft maintenance organisation and staff	+++	+++	Advanced FMS (4D trajectory management, monitoring aids), advanced CNS (ASAS, Data link, auto break etc.)	Changes in working procedures; pursuit of BT, management of prioritisation issues, communication with AOC and "ATC", delegated responsibility for separation; airport management, etc.	EASA Part 66 (including implementation in national law) National regulations on military a/c maintenance staff training and licensing
Operations Planning of Airspace Users	+++	++	CDM, SWIM, systems for BT management, slot allocation process	BT management, planning and adaptation, delay management, CDM processes	No regulation in place; eventually stronger requirement in future

Actors	Level of impact	Safety relatedness	Key elements/ systems affecting role	Main triggers	Probably affected regulations and standards
			Keywords only	*Keywords only*	
Staff involved in airspace management	+++	++	CDM, SWIM, systems for BT management, traffic flow/queue management, airspace structure, CADF	New roles and responsibilities with regard to information, traffic flow and information management	ICAO Doc 4444 ESARR 3 EC Regulation on Common Requirements for ANS EC Common Requirements on Security Single European Sky Legislation
Staff involved in network management (Demand – capacity balancing)	+++	+	CDM, SWIM, Systems for BT management, Coll. Layered Planning, NOP, AFUA	New function, new concepts, extended coordination	ICAO Doc 4444 ESARR 3 EC Regulation on Common Requirements for ANS EC Common Requirements on Security Single European Sky Legislation X
ATCO	+++	+++	4D contract control, mixed separation modes, 3D/2D deconflicted routes (arrival/departure), AMAN, DMAN, SMAN, delegation of separation, AFUA, monitoring support, Data link; remote Tower control operations, merging of control centres	Changes in responsibilities, changes in airspace complexity and procedures over time, delegation of separation, 4D trajectory management, AFUA management etc.	ICAO Annex 1 ICAO Doc 4444 ESARR 3 ESARR 5 EC Regulation on Common Requirements for ANS EC Common Requirements on Security Single European Sky Legislation Guidelines for Common Core Content for ATCOs • Includes probable extension of competence requirements for APRON controllers • Partly also affect ATM support staff such as AIS and Flight Data Operators
ATSEP, CNS, ATM automation systems services	+++	+++	All CNS/ATM systems, plus SWIM, CDM, 4D Trajectory, MTCD, AMAN; DMAN, SMAN, data link and overall automation equipment	High responsibility of development, implementation and certification of systems (safety criticality, reliability etc.), increase in criticality of maintenance roles with increasing degree of automation; certification of systems and software	ICAO Doc 4444 ICAO Doc 7192 ESARR 3 ESARR 5 ESARR 6 EC Regulation on Common Requirements for ANS EC Common Requirements on Security Single European Sky Legislation Guidelines for Common Core Content for ATSEP Emerging standards for ATSEP competence verification National regulations on military ATM/CNS systems maintenance staff training

Table 31: Summary of probably affected regulations related to training and competence of operational staff

The minimum changes expected are:

- Additional training and competence standards for the operation of advanced procedures/ systems and redistributed responsibilities (especially systems automating human tasks such as monitoring, conflict detection or resolution, route allocation etc.);
- Eventual changes in license structures for pilots and air traffic controllers. The operation of new system elements automating safety critical tasks may require new ratings or endorsements in the license;
- Additional requirements for verification of competence for safety related staff and further harmonisation of competence verification (e.g. cf. ongoing discussion on harmonisation of ATSEP licensing and competence verification). The ATM Target Concept will probably impose changes on the competence requirements of Apron Controllers as the envisaged concept for airport operations may include the operation of enhanced automation (e.g. A-SMCGS) and an immediate influence on aircraft separation;

- To achieve a solid baseline to implement harmonised systems and procedures as envisaged in the ATM Target Concept, a further harmonisation of ATM staff training and competence is required. This should also include an enhanced alignment of civil and military staff competence as the use of common systems and intensified data exchange and collaborative decision-making are central elements of the ATM Target Concept;
- To agree a Pan-European **definition and assessment of 'safety relatedness'[40] of operational jobs** and competency verification;
- Security vetting procedures for staff and the access requirements will be harmonised to allow mobility of staff.

5.2.4 Operational and Organisational Change Perspective

Adequate change and transition management supports and contributes to aviation safety. Operational and organisational change has to be in compliance with the Common Requirements Regulation (EC 2096/2005) which stipulates that an ANSP has to notify National Supervisory Authorities (NSA) of any planned changes and any planned safety related changes to its provision of services. The changes to be notified cover the complete lifecycle from initial planning to decommissioning, including equipment, procedures and human resources as well as their interactions in the ATM system. Only after approval by the NSA, can a change take place.

5.2.4.1 Recommendations

The European Civil Aviation legislation requires a pan-European regulatory framework for change management that sets up stable procedures and participative processes. To support the development of this framework, and also to ensure a successful implementation of changes, three principal recommendations have been identified. These recommendations serve as key-enablers for the KPA Participation and describe the way forward to a successful implementation of the ATM Target Concept from a change management perspective:

- The European Union and the EU Member States should designate a safety regulatory authority at European level acting also as the regulatory interface for change management and interacting with the SESAR JU to be established at the latest by the end of the SESAR Definition Phase;
- The designated European safety regulatory authority should develop a (review) procedure for change management and where appropriate propose amendments to European Civil Aviation legislation and existing safety regulatory requirements and arrangements;
- The EUROCONTROL Agency should develop advisory material in a harmonised manner to support the effective implementation of change management. This should be in compliance with existing European Civil Aviation legislation and safety regulatory requirements, which ensures commonality.

[40] term applied in ESARR5

5.2.5 Environment Regulation

The purpose of this chapter is to give an overview of developments and considerations since the publication of the second SESAR Milestone deliverable.

5.2.5.1 Regulation Development

Key existing and planned environmental regulations that apply to European ATM are covered in the first two SESAR milestone deliverables. Most of the regulations apply to airports only but some (e.g. Strategic Environmental Assessment Directive[41] and environmental aspects of the SES Regulations) have a wider gate-to-gate significance. It is likely that these environmental regulations will be reviewed during the timeframe of the SESAR programme and the general trend is for increasing environmental stringency. Key relevant legislative developments may include:

- The planned inclusion of aircraft operations in the European Emissions Trading Scheme;
- Revision of EC Directives 2002/30 and 2002/49 which cover noise restrictions at airports, airport noise mapping and noise mitigation planning;
- Potential changes to the planning process timescale and lengthening of the already onerous planning process which could have severe and adverse implications on all other KPAs.

5.2.5.2 Institutional Requirements

The ATM Target Concept has numerous proposals that will deliver both operational and environmental benefits. Ensuring that the expected environmental performance improvements are seen to be delivered as cost-effectively as possible; and, ensuring that effective engagement with the wider external community provides a workable and effective ATM regulatory framework, shall remain a priority for the SESAR JU. A balance is required between the requirement to tailor local effort to match local needs; and, the need to harmonise solutions, to avoid proliferation, to avoid poor practice and to avoid unnecessary duplication and abortive effort. This will also require coordination.

5.2.5.3 Recommendations

1. Institutional arrangements to provide
    a. A pan-European environmental sustainability coordination mechanism/process to foster pan-ATM guidance, performance monitoring and assessment.
    b. A formal liaison and advisory role with relevant industry, policy, legislative and regulatory bodies.
2. Airports to be encouraged and offered guidance to produce a strategic master plan, of appropriate scope for their scale, and, which is fully integrated with local land-use planning allowing planned growth. In support of this, there should be adequate supervision of ATM relevant planning restrictions at national and international level (through EU working arrangements) to ensure that the implementation of the SESAR programme is not compromised.

[41] EU Directive 2001/42/EC

3. A European approach is taken to promoting the easing of the planning process timescale and obligations both for major airport developments and airspace changes (via States e.g. UK proposals under discussion).

5.2.6 Security Regulation

5.2.6.1 General Approach

The purpose of regulation of ATM security is to ensure that there will be a basis of trust amongst the participants and to ensure that the ATM system, as part of the European and global air transport system, will be able to operate effectively and efficiently and to remain resilient against threats of unlawful interference.

Within the SESAR programme, the objective of the ATM Target Concept is increased interconnection and inter-operation of all aspects of the ATM system to achieve the performance goals and the ConOps in order to continuously support national governmental institutions/agencies in responding to unlawful acts in the airspace and on the ground. A certain level of regulation will be needed to ensure a unified approach to the necessary cross-organisational security measures.

5.2.6.2 Concept Elements with Specific Security Regulation Requirements

Table 32 characterises the three concept elements that need to consider increased security regulation to achieve the required levels of trust among stakeholders:

Trajectory Management	This concept depends on the exchange of information that is flight critical and therefore it must be protected from unlawful interference so that its integrity, availability and the authentication of source and recipient are safeguarded. The level of security is high. Its confidentiality requires less protection. This security requirement applies to aircraft from all operators (globally) and to all who participate in trajectory management
Collaborative Planning & Network Management	The information that this concept element deals with is not flight critical and so the security requirements are less. However, they have a high level of confidentiality requirement because the information may be of commercial value and may have some value to those planning unlawful interference.
SWIM	The SWIM network must meet the highest requirements of the information it carries and the functions it connects.

Table 32: Security regulation assessment

5.2.6.3 Recommendations

- The collaborative planning and network management security requirements probably do not need a specific additional regulatory approach and could be met by the application of recognised best practices and the set-up of bilateral and/or multilateral agreements between stakeholders. However, the exact safety criticality and security of data requirement, remains to be further studied;
- Further work will be required to better understand the required level of security levels for certification purposes for trajectory management and SWIM. However the highest level of security requirements probably can only be achieved through a mandatory (EC) approach.

6 Transition to the ATM Target Concept

The overall transition towards the ATM Target Concept will be developed in the subsequent SESAR Milestone 4. In anticipation, this chapter analyses the contribution of ongoing initiatives (as identified in D2) to the ATM Target Concept; the purpose of this analysis is to give initial confidence that transition is feasible to the 2020 baseline and that the ongoing initiatives are directly on the path towards this 2020 baseline. This analysis has resulted in a first set of recommendations for the way forward and will be further elaborated in the work towards Milestone 4.

6.1 Contributions of Ongoing Initiatives

A preliminary and non-exhaustive list of on-going initiatives contributing to the ATM Target Concept has been considered in this chapter. These initiatives are ECIP/LCIP initiatives or local or sub-regional initiatives. In the work towards Milestone 4, about 40 on-going initiatives will be fully assessed against the ATM Target Concept and the selected initiatives will be grouped into Implementation Packages with the goal to achieve the intermediate performance objectives.

Many of the initiatives are traced in the European Convergence Implementation Plan (ECIP), a five years rolling plan maintained by the EUROCONTROL Agency and endorsed yearly by the States in the Provisional Council. It defines objectives and, for each one, detailed Stakeholder Lines of Action (SLOA) including due dates for completion. The 2008-2012 edition of the ECIP has been released in the meantime (July 2007). ECIP objectives are built on the operational improvements introduced by the ECAC ATM2000+ Strategy. They are also supposed to deliver those performances levels which are proposed by EUROCONTROL PRC and agreed by the States in the Provisional Council.

Local and sub-regional initiatives and investments complement ECIP objectives. They are expected to provide local benefits, but most of them will be worth the investments only if adopted and exploited at Pan-European level.

Operational/Technical

The table below outlines how these initiatives contribute to the foundations and enablers of the ATM Target Concept.

Initiative	Description	Contribution
EAD/CHAIN	Provides for improved Aeronautical Information publication, sharing and quality.	Foundation for the SWIM environment
DMEAN	Improves DCB, with a more effective integration of airports processes (including turnaround process) within the Network and a first implementation of the Network Operation Plan (integrating agreed scenarios to restore Network stability in reaction to changes generated by real-time events).	Foundation for the NOP and layered planning

Initiative	Description	Contribution
	Extends CDM at airport and at network level integrating the Airlines AOC, the Airport Operations Centre (APOC), Network Management, and ATC allowing trajectory optimisation and reduction of the effects of possible constraints.	Foundation for the CDM processes and Business Trajectory ownership
PENS	Implements pan-European ground communication network services	Foundation for the SWIM Transport Layer and the future Ground-Ground communication infrastructure
FUA	Improves Civil/Military coordination through the Airspace Management Cells (AMC) allowing more dynamic and flexible management of the airspace.	Foundation for the AFUA
	Harmonises OAT rules and mission-tailored routings via a pan-European OAT Transit System.	Foundation for the integration of the mission trajectories
Link 2000+ and CASCADE	Deploys CPDLC reducing conventional Radio Telecommunication workload for the Executive Controller.	Foundation for the automation and future trajectory air-ground exchange
	Deploys ADS capable transponders for the exploitation of cooperative and dependant surveillance delivering enhancements in the Surveillance Domain.	Foundation for the future surveillance infrastructure
Airspace Classification/ P-RNAV/ARNv5/ ARNv6	Introduces GNSS technologies as the primary Navigation means keeping ground-based navigation aids infrastructure as a backup.	Foundation for the new separation modes
	Improves Airport capacity through the optimisation of TMA design by extensive implementation of P-RNAV arrival and departure routes in conjunction with relevant airspace re-design.	Intermediate step to the management of high-density areas
	Simplifies the organisation of the airspace through the reduction to just three airspace categories • Managed with all traffic identified and all aircraft intent is known; • Managed where all traffic is identified but all intent is not known; • Unmanaged airspace.	Intermediate step to the 2-category airspace
eFDPs	- Supports enhanced automation; - Enhances Flight Plan interoperability (improved inter and intra ATC Units coordination and flight data management and initial air-ground data integration).	Foundation for trajectory management

Initiative	Description	Contribution
ATC Automation (FASTI, ATC Tools like AMAN, DMAN, MTCD, Multi-Sector Planning)	Supports air traffic controllers in moving towards the long-term goal of "tactical intervention by exception" thanks to: - Enhanced planning tools (e.g. MTCD); - Greater predictability of traffic demand and intent as a result of the layered planning process; - Better knowledge of aircraft intent through data link; - More consistent flight plan enabled by collaborative information sharing (e.g. NOP); - Multi-sector planning supported by automation tools for improved traffic synchronisation at ACC sector level	Foundation for trajectory automation and information sharing
	Improves arrival, departure and surface management systems	Foundation for queue management
A-SMGCS/CDTI	Improves surface surveillance and provides initial surface separation tools (A-SMGCS and CDTI), bringing benefits especially in low visibility conditions.	Further step towards airport surface management
FABs	Provide more efficient services delivery through the organisation of the areas of responsibility along structured traffic flows.	Foundation for the use of the airspace as a single continuum
Common Procurement	Reduces diversity of equipment	Support to de-fragmentation

All these initiatives need to be implemented in a fully interoperable manner in order to establish a solid basis for the ATM Target Concept.

Performance

In support to the CBA, a traffic "baseline" scenario has been established only considering the implementation of all ECIP initiatives by 2012. The first available results show that despite important performance improvements expected from some individual ECIP initiatives (for more information see also SESAR Task Deliverable 3.2.1/D2), the percentage of delayed flight is increasing by 2012 (see Chapter 4.3.3 in this document and in particular table 24 for more information).

These results need to be consolidated in D4 when a more comprehensive baseline will have been described in particular considering the non-ECIP short-term initiatives to ensure that the mid-term performance objectives are met.

6.2 Conclusions

The previous chapter has shown that the main on-going initiatives form solid foundations for the ATM Target Concept – the transition has started.

Nevertheless it still needs to be assessed whether the implementation of local/sub-regional initiatives in addition to the ECIP initiatives will deliver the expected mid term performance.

Should however European States and all other ATM stakeholders collectively fail to implement all such on-going initiatives within the agreed timeframe, the overall construction of the 2020 ATM Target Concept will be jeopardised and delayed.

The potential risks for failure have been identified as:

- ECIP objectives, unless declared "Pan-European", are implemented on a voluntary basis by stakeholders. This results, in most cases in slow, inconsistent and fragmented progress of the initiatives, preventing the expected benefits to be fully delivered in a network environment. Under these conditions, there is no incentive to fit the required technology on the aircraft. This results in a "wait and see" behaviour of all stakeholders;
- Sub-regional initiatives are facing many difficulties e.g. the development of FABs has proven to be a lengthy process due to several political, business, social and economical obstacles. Technical cooperation and common procurement initiatives are currently limited due to lack of common requirements / specifications and timely standards for interoperability;
- The non-uniform adoption at pan-European level of proven best practices is limiting their overall positive effect.

These risks need to be recognised and addressed urgently, e.g. by rapidly adopting the relevant High Level Group recommendations [Ref.24] which are applicable in the short-term time frame.

The implementation of the on-going initiatives needs to be accelerated in order to meet the agreed objectives. Furthermore a reorganisation of the ECIP/LCIP process together with the empowerment mechanisms is needed to ensure an alignment with, and implementation of, the SESAR Master Plan.

The successful achievement of these initiatives on time and in parallel with all R&D activities to be performed by the SESAR JU as a result of the Master Plan, will be a main milestone for implementation of the 2020 ATM Target Concept according to the planned timescales. Milestone 4 and 5 will define in particular the implementation package for the mid term time scale.

7 List of References

1. Milestone Objective Plan D3: ATM Target Concept - MGT-0506-003-03-00
2. Milestone Deliverable D2: Air Transport Framework – The Performance Target - DLM-0607-001-02-00
3. Milestone Deliverable D1: Air Transport Framework – The Current Situation - DLM-0602-001-03-00
4. ICAO Global Air Traffic Management Operational Concept (OCD) – Doc 9854
5. Task Deliverable: 1.1.3/D3 - Security
6. Task Deliverable: 1.1.4/D3 – Environment
7. Task Deliverable: 1.2.2/D3 – Definition of new mechanisms for timely and harmonised decision making
8. Task Deliverable: 1.3.2/D3 – Prepare a proposal for the financial and investment plan
9. Task Deliverable: 1.4.2/D3 – Consolidate and update the CBA model with data supporting the trade-offs and Financial Pans
10. Task Deliverable: 1.5.2/D3 – Identification of potential modifications to existing legislation and regulation
11. Task Deliverable: 1.6.2/D3 – Study of impact of new concepts and procedure on safety regulations, including compliance and synchronisation with ICAO safety standards
12. Task Deliverable: WP1.7/D3 – Human factors impacts; Recruitment, training and licensing; Social factors & Change Management
13. Task Deliverable: 2.2.2/D3 – Definition of future ATM concept of operations, highlighting airspace design aspects
14. Task Deliverable: 2.2.3/D3 – Identify and define the underlying ATM services and functions
15. Task Deliverable: 2.2.4/D3 – Resulting set of recommendations for operational concepts trade-off analysis
16. Task Deliverable: 2.3.1/D3 – Compute and map operational concepts & airspace KPIs based on identified available tools and methodologies
17. Task Deliverable: 2.4.4/D3 – Consolidation of mid- and long-term architecture
18. Task Deliverable: 2.5/D3 – Technology Assessment
19. Task Deliverable: 2.6.2/D3 – Active contribution to ongoing standardisation
20. Task Deliverable: 3.3.1/D3 – Methodology for transition strategy trade-offs
21. Task Deliverable: 3.3.2/D3 – Establishment of deployment costs
22. SESAR Performance Objectives and Targets

23 ATM Cost-Effectiveness 2005 Benchmarking Report – EUROCONTROL PRC

24 A framework for driving performance improvement (Report of the High Level Group for the future European Aviation Regulatory Framework)

8 List of Abbreviations and Terminology

Abbreviation	Explanation
ABAS	Aircraft Based Augmentation System
ACARE	Advisory Council for Aeronautics in Europe
ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
ADF	Automatic Direction Finding
ADS-B	Automatic Dependent Surveillance (Mode Broadcast)
AFTN	Aeronautical Fixed Telecommunication Network
AFUA	Advanced Flexible Use of Airspace concepts
AGDL	Air-Ground Data Link
AI	Aeronautical Information
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMAN	Arrival Management (tools)/Arrival Manager
AMC	Airspace Management Cells
AMHS	Aeronautical Message Handling System
ANSP	Air Navigation Service Provider
AO	Aerodrome Operations
AOC	Airline Operational Control
AOM	Airspace Organisation and Management
APOC	Airport Operations Centre
APP	APProach Control unit
APR	Automatic Position Reporting
ARDEP	Analysis of Research and Development in EUROCONTROL Programmes
ASAS	Airborne Separation Assistance System
ASM	Airspace Management
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
ATMPP	ATM Performance Partnership
ATM-SD	ATM Service Delivery
ATN	Aeronautical Telecommunication Network

Abbreviation	Explanation
ATPL	Air Transport Pilot Licence
ATS	Air Traffic Service
ATSEP	Air Traffic Safety Electronics Personnel
AUO	Airspace User Operations
AUP	Airspace Use Plan
BA	Business Aviation
BDT	Business Development Trajectory
CASA	Computer Assisted Slot Allocation
CAT	Category
CBA	Cost Benefit Analysis
CDM	Collaborative Decision Making
CDR	Conditional Route
CM	Conflict Management
CODA	Central Office of Delay Analysis
ConOps	Concept of Operations
COSAAC	Common Simulator to Assess ATFCM Concepts
COTS	Commercial Off-The-Shelf (System)
CPDLC	Controller Pilot Data Link Communication
CPR	Conflict Prediction and Resolution
CRCO	Central Route Charges Office
CTA	Controlled Time of Arrival
DCB	Demand and Capacity Balancing
DGPS	Differential GPS
DLM	Milestone Deliverable
DLT	Task Deliverable
DMAN	Departure Manager
DME	Distance Measuring Equipment
DMEAN	Dynamic Management of the European ATM Network
EA	Enterprise Architecture
EAD	European Aeronautical information Database
ECAC	European Civil Aviation Conference
ECIP	European Convergence and Implementation Plan
EGNOS	European Global Navigation Overlay Service
EHS	(Secondary Surveillance Mode-S Radar) Enhanced Surveillance

Abbreviation	Explanation
ELS	(Secondary Surveillance Mode-S Radar) Elementary Surveillance
EMOSIA	European Model for Strategic ATM
ETFMS	Enhanced Tactical Flow Management System
EU	European Union
EVS	Enhanced Visual System
ETA	Estimated Time of Arrival
FAB	Functional Airspace Blocks
FASTI	First ATC Support Tools Implementation
FDP	Flight Data Processing
FMS	Flight Management System
FPL	Flight Plan
FUA	Flexible Use of Airspace
GA	General Aviation
GAT	General Air Traffic
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HLG	High-Level Group
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFPS	Initial Flight Plan System
IFR	Instrumental Flight Rules
IM	Intent Monitoring
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
IOP	Interoperability
IRS	Inertial Reference System
ISO	International Organisation for Standardisation
KPA	Key Performance Area
KPI	Key Performance Indicator
ITP	In Trail Procedure
LCIP	Local Convergence and Implementation Plan
LVP	Low Visibility Procedure
MET	Meteorological information Service
MIL	Military

Abbreviation	Explanation
MLAT	Multi-lateration
MOP	Milestone Objective Plan
MSPSR	PSR using multi-static techniques
MTCD	Medium Term Conflict Detection
NATO ACCS	Air Control and Command System
NAVAID	Navigation(al) Aid
NIMS	Network Information Management System
NOP	Network Operation Plan
NOTAM	Notice to Airmen
NPV	Net Present Value
NSA	National Supervisory Authorities
OAT	Operational Air Traffic
OCC	Operational Concept Component
OCE	Operational Concept Element
OSI	Open Systems Interconnection
PEN	Pan-European Network
PENS	Pan-European Network System
PRC	Performance Review Commission
PRU	Performance Review Unit
PT	Predicted Trajectory
PTC	Precision Trajectory Clearances
QoS	Quality of Service
R&D	Research and Development
RAD	Route Availability Document
RAIM	Receiver Autonomous Integrity Monitoring
RBT	Reference Business Trajectory
RNAV	Area Navigation
RPL	Repetitive Flight Plan
RTA	Required Time of Arrival
SATCOM	Satellite Communications
SATNAV	Satellite Navigation Sub-Group
SBAS	Space/Satellite Based Augmentation System
SBT	Shared Business Trajectory
SES	Single European Sky
SESAR	Single European Sky ATM Research Programme

Abbreviation	Explanation
SJU	SESAR Join Undertaking
SMAN	Surface Manager
SOA	Service Oriented Architecture
STATFOR	Specialist Panel on Air Traffic Statistics
STCA	Short Term Conflict Alert
SWIM	System Wide Information Management
TACAN	Tactical Navigation
TMR	Trajectory Management Requirements
TRA	Temporary Restricted Area
TS	Traffic Synchronisation
TSA	Temporary Segregated Area
TWR	Aerodrome Control Tower
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UDPP	User Driven Prioritisation Process
VDL	VHF Data link
VMC	Visual Meteorological Conditions
VoIP	Voice over IP
VOR	Very High Frequency Omni directional Radio Range
VSAT	Very Small Aperture satellite Terminal
WAM	Wide Area Multi-lateration
WOC	WingOps

Terminology

This chapter provides definitions that explain how certain terminology is used (and intended to be understood) further in this document. Only those terms are included here, which are not defined in the body of the document where they are used for the first time.

ATM Capability Level 4	The very advanced capabilities that potentially offer the means to achieve the SESAR goals, in particular the very high-end capacity target. The timeframe for initial availability and progressive fleet equipage is in the range 2025 and beyond depending on the specific capability

ATM Capability Level 3	Main capabilities required by the key SESAR target date of 2020. These will be based upon the SESAR concept needs at that time and a realistic assessment of potential capabilities
ATM Capability Level 2	Capabilities of systems that are delivered and in-service from 2013 onwards with a range of new capabilities but which do not meet the full 2020 needs.
ATM Capability Level 1	Capabilities of existing systems and those that are delivered up to 2012/13 and largely have today's capabilities
ATM Capability Level 0	Systems that do not meet at least the ATM-1 capabilities
Tactical	Tactical relates to means employed to help achieve a certain goal (while strategic relates to the preparation a plan, which may involve complex patterns of individual tactics).
Net-centric	Participating as a part of a continuously-evolving, complex community of people, devices, information and services interconnected by a communications network to achieve optimal benefit of resources and better synchronization of events and their consequences. *(Source: Wikipedia)*

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10 Annexes

10.1 Annex I – Solution Risks

SESAR Solution Risks are defined as those risks which, if not appropriately mitigated, could prevent the ATM Master Plan from achieving its objectives. These risks are integrated into the project risk management process. This annex identifies the current Milestone or Definition Phase level solution risks selected from Task level and Milestone Progress Meeting assessment, an evaluation of their Impact on achieving Master Plan objectives (I) and Probability of Occurrence (P) as well as high level ongoing mitigation actions.

Risk	I	P	Ongoing Mitigation Actions
D1/R1 - Lack of a solution to break the capacity barrier	H	L	• Enhancing stakeholder involvement in the business decision processes through the applicable governance structure; • Better direction and management of activities related to R&D, validation and operational trials. D4 Tasks 2.3.2 & 3.1.1 and D5 Task 3.4.3 will further address R&D and validation; • Securing involvement of operational staff in the design and validation processes. D4 Work Package 1.7 will identify human enablers; • Further development and evaluation of the ATM Target Concept in terms of Operational Improvements and their evaluation and assessment at Implementation Package level by D4 Task 3.3.3.
D1/R2 - Not possible to address the fragmentation issue with respect to the cost effectiveness objectives	H	M	• Further development and evaluation of the ATM Target Concept in terms of Operational Improvements and their evaluation and assessment at Implementation Package level by D4 Task 3.3.3; • D4 Work Package 3.3 will evaluate and select short-term improvements for integration as Operational Improvements taking into account requirements such as cost-effectiveness and fragmentation.
D1/R3 - Lack of an assessment of the scope and content of the ATM Master Plan due to business planning and CBA modelling limitations	M	L	• D4 Work Package 1.4 will continue to work closely with all stakeholders to be able to improve and broaden the cost benefit analysis model, its' inputs, methodology and results; • D5 Task 3.4.4 will identify its' results and recommendations including those related to Master Plan contents that could not be fully assessed.
D1/R4 - Failure to address the enforcement of a common regulatory framework	H	M	• D4 Task 3.3.3 and associated enablers Tasks will identify enablers that should address the need for enforcement.

Risk	I	P	Ongoing Mitigation Actions
D1/R5 - Lack of a clear governance structure (including leadership, political and decision making arrangements)	H	M	• D4 Task 3.3.3 and associated enablers Tasks will identify enablers that should progressively establish the appropriate structures as previously identified.
D1/R6 - Lack of credible ATM performance assessment and monitoring – to support the performance-based approach	M	L	• The performance task force, representing all stakeholders, established in Milestone 3 will continue in D4.
D1/R7 - Lack of interoperability in a global context.	M	M	• Continued participation in relevant international bodies; • D4 Task 2.6.2 will identify relevant enablers into D4 Operational Improvement Steps.
D1/R8 - Lack of acceptance of the ATM Master Plan by all actors	H	M	• Continued proactively management of the buy-in of the ATM Master Plan by all Stakeholders (at all levels) at each milestone; • Additional actions coordinated with all stakeholders via the SESAR Communications Group.
D1/R9 - Lack of standardised and modular systems to facilitate the transition	M	L	• D4 Task 2.6.2 will identify relevant enablers into D4 Operational Improvement Steps; • D4 Work Package Task 2.4 will identify relevant enablers supporting architecture; • Content Integration Team will identify further actions with respect to the design authority.
D3/R1 - The detailed definition of the ATM Target Concept may induce technically infeasible requirements.	M	M	• D4 Implementation plans to include Operational Improvement Step feasibility in selection criteria; • R&D tasks to mitigate as soon as possible the technical risks
D3/R2 - Implementation schedule to implement the 2020 ATM Target Concept is unachievable.	H	M	• D4 Implementation Plans to include Operational Improvement Step maturity and benefits in selection criteria; • R&D Tasks to include maturity and benefits in selection criteria.
D3/R3 - Unachievable performance objectives – identified during future performance assessment.	M	M	• Episode 3 to perform early detailed validation; • Joint Undertaking validation activities; • Performance Partnership to then perform gap analysis and decide upon corrective actions; • The performance task force, representing all stakeholders, established in Milestone 3 will continue in D4.

Risk	I	P	Ongoing Mitigation Actions
D3/R4 - The lack of ATM business framework (ATMPP) may endanger the development of the ATM Target Concept.	M	H	• Continue work as identified in Chapter 5.1.1.2 related to the ATMPP; • Assess and integrate the results of the High Level Group.
D3/R5 - Unavailable spectrum capacity/capability	M	M	• Continued participation in relevant international bodies; • Identifying explicitly requirements for ATM Target Concept to work; • Integrate relevant enablers into D4 Operational Improvement Steps.
D3/R6 – Unavailability of a fair commercial and institutional framework to operate and provide Navigation and Communication satellite services	M	M	• Continued participation in relevant international bodies; • Identifying explicitly requirements for ATM Target Concept to work; • Integrate relevant enablers into D4 Operational Improvement Steps.
D3/R7 - The potential failure to demonstrate the safety of the SESAR Target Concept and also achievement of the goal of a 10x increase in safety performance.	H	M	• The need to 'ensure an appropriate approach towards safety for SESAR in its widest sense during the remainder of the SESAR Definition Phase and the Development Phase' has been recognised by WP1.6. Its recommendations should now be followed up
D3/R8 - Cost effectiveness target will not be met by SESAR and other ATM initiatives.	H	H	• More detailed cost and cost effectiveness assessments to be done during D4. Including 'non-SESAR' elements, more detailed technology cost assessment and better estimated of number of units by WP2.4/2.5/3.3.2

10.2 Annex II – Specific Process Assessment

10.2.1 Introduction

This chapter summarises how safety and environment have been considered in the Milestone 3 of SESAR. It also performs a sustainability impact assessment of the Milestone 3 of SESAR.

10.2.2 Consideration of Safety Management in D3

This chapter tracks how the safety has been considered in the Milestone 3.

The safety objectives identified in D2 have been considered as inputs for the Milestone 3. They have driven the definition of the ConOps as the other performances objectives. These objectives have then been used with the ConOps to define the architecture and the technologies.

The results of the performance assessment of the ATM Target Concept and in particular of how the safety targets have been met is described in chapter 4 of this document.

The different elements of the ATM Target Concept have been investigated with respect to the impact and feasibility on safety regulation, safety performances and safety management point of view. This has been done through a systematic approach, using a safety screening method applied to the key aspects of the ATM Target Concept and some critical aspects of architecture and technologies.

The safety screening tool has logged the identified safety issues which have been used to establish the safety performance assessment in chapter 4 and the analysis and recommendations of the safety regulation chapter in chapter 5. All the details are available in the DLT 1.6.2/D3 [Ref.11].

These safety issues will have to be considered in the SESAR Development Phase when the ATM Target Concept will be further detailed.

10.2.3 Consideration of Environment Management in D3

This chapter tracks how Environmental Management has been conducted during Milestone 3.

Unlike during milestone 1 and 2, the environment management activities during Milestone 3 have been concentrated in a limited number of work packages:

- The work packages that collectively design the ATM Target Concept: workpackage 2.2, 2.4 and 2.5;
- The workpackage that hosts the environment assessment task: Workpackage 1.1 (Task 1.1.4);
- And to some lesser extent, the workpackages that address institutional aspects and costs.

The Environmental Sustainability Key Performance Area has been defined during D2 and has been used during D3 used as the reference for:

- Driving the definition of the ConOps together with the other performances areas objectives of the performance framework;
- Assessing the environmental performance resulting from the ATM Target Concept definition. This assessment covers the ConOps, the ATM system architecture and the technology.

This assessment has been conducted through two complementary activities:

- Environment screening using a comprehensive reference table;
- Influence diagram modelling, for identifying the dependencies between concept elements and the Environmental KPA, including the dependencies between focus areas inside this KPA (e.g. emission and noise) and the dependencies between the environmental sustainability KPA and other KPA (e.g. fuel efficiency and environment).

The results of the performance assessment are described in chapter 4.3.3.

The details of the assessment are available in the DLT 1.1.4/D3 [Ref.6].

10.2.4 Sustainability Assessment

This chapter conforms to PART I/ section A/ of the Initial Impact Assessment Screening. It is an augmented version of Annex II of D2, enriched with the first part of the assessment of the SESAR Solution, as produced during M3.

As agreed with the Purchaser, the template is filled progressively at each milestone, so as to produce a completed Impact Assessment by the end of the Definition Phase.

Problem analysis: What are the main problems identified?

Air Transport is recognised for its direct (e.g. 1.5 Million jobs in Europe in 2004), indirect (1.8 Million jobs), and induced (0.8 Million jobs) social benefits. Moreover, catalytic benefits of Air Transport (effect on incomes, government finances, etc.) are estimated to amount to 6 times the direct benefits.

However, Air Transport is not sustainable under the current operating and societal conditions, according to the observed economic performance of European airlines. Moreover, the traffic growth forecast shows that the airport infrastructure in Europe will become a major bottleneck if no additional runways are made available. On the other hand there is a growing pressure put on Air Transport to reduce its environmental impact, especially in the vicinity of airports.

ATM is an actor of the value chain of Air Transport and as such, can improve its own processes to contribute to the sustainability of Air Transport by:

- Acting on the efficiency of flights and optimizing the usage of the bounded capacity of airspace and airport surface;
- While mitigating the environmental impact of operations.

This ATM improvement will address all sectors of ATM, including institutional, operational and technical aspects. A performance-based approach will be followed, starting from performance gap identification and appropriate analysis of solutions. The ICAO performance framework will be used to ensure balancing performance areas, including capacity, cost efficiency and environment.

Policy options: What are the main policy options?

Three main options can be considered, corresponding to improvements made in the institutional and operational/technical directions:

- The “do-nothing” option consists in having the ATM network expand its activities with the current environmental management approach (including the overall evolution of environmental regulation) and none of the SESAR concept elements that provide further environmental improvement;

- The "institutional improvement" option, based on seeking an harmonised management of environmental considerations across the ATM network by promoting Collaborative Environment Management Systems at different levels in the ATM network;
- The "SESAR option", which combines operational improvements based on the new ATM ConOps and the related technology uplift with the institutional improvements.

Impacts: Positive and negatives?

- In the "do-nothing" option, current efforts made to establish environmental best practices allow voluntary ATM actors (Airspace Users, Airports and ANSP) to improve their performance on a case-by-case basis. However, owing to the reinforcement of European regulations on environment, this means that the pressure to reduce the environmental impact of aviation is translated into weakly coordinated local approaches that in most cases lead to conservative operational restrictions on air transport operations, especially at busy airports. The consequence of this approach is the inability to accommodate the air transport demand and a negative impact on the economic development. The order of magnitude of the effect of this option is indicated by the long-term forecast study from EUROCONTROL, comparing scenarios with and without stringent Environmental restrictions: this might amount to 30% of un-accommodated demand;
- In the "institutional improvement" option, the harmonised management of environmental considerations across the ATM network is obtained by promoting Collaborative Management Systems at different levels in the ATM network. This would relieve to some extent the impact of local operational restrictions by offering benchmarking capabilities to actors across the network support for identifying and disseminating best practices and coordinate environmental policies so as to avoid network inefficiencies. However, the ConOps and associated technology currently in place limits the benefit of harmonisation. The lack of capacity at busy airports or in busy airspace volumes leads to flight inefficiencies that have negative environmental impact, and as a consequence may lead to operational restrictions when traffic demand increases;
- In the "SESAR option", in addition to the institutional improvements, ATM operations and system are improved, which leads to capacity increase giving simultaneously more throughput and a better flight-by-flight efficiency. The combination of both effects leads to decouple the economic progress from the environmental impact. In addition, local environmental rule-making, especially in terms of airport operation restrictions, which could lead to network inefficiencies and offset a part of the capacity increase, is prevented by the collaborative environmental management approach.

10.3 Annex III - Relationship with the ICAO Operational Concept Components

This chapter explains how the ICAO terminology has been interpreted in the target ATM Concept. A description is given of the high level relationship between the ICAO OCCs and the SESAR concept of operations:

ICAO OCC		Main SESAR Concept of Operations process involved
AUO	Airspace User Operations	Collaborative development and management of the user owned business/mission trajectory
AO	Aerodrome Operations	Planning and managing the airport resources
DCB	Demand and Capacity Balancing	Layered planning process to build the NOP
TS	Traffic Synchronisation	Queue management
AOM	Airspace Organisation and management	- Organization in managed/unmanaged airspace - Organization and Management of the managed airspace (e.g. high/low-medium density) - Organisation and Management for the integration of diverse airspace use requirements (e.g. AFUA)
CM	Conflict Management	- Strategic CM: implementation of route structure as required - Tactical CM: SESAR separation means - Improvements to collision avoidance/safety nets
ATM-SD	ATM Service Delivery	Delivery of the ATM Services tailored to the user's needs

10.4 Annex IV - Rationale for the LFV, Austro Control and IAOPA disagreement in chapter 2.5.3.1.1

The reasoning and rationale for LFV, Austro Control and IAOPA disagreement statement in chapter 2.5.3.1.1 is the following:

LFV, Austro Control and IAOPA accept the D3 with the initial ADS-B applications over 1090ES. However, the particular paragraph in 2.5.3.1.1 needs to reflect that integrated 4-D Trajectory and ADS-B is a consequence of the SESAR ConOps and the future ATM. By not recognising the global and European standardised VDL Mode 4 as a candidate, such early decision is out of scope in D3 and we are closing doors to the future instead of opening them when it comes to standardised and proven promising technologies and technical enablers. In D4, we have to find the trade-off between different alternatives for the future data link. We also believe that we must further explore the experience from stakeholders of the Consortium with the most experience in the operational applications of integrated 4-D Trajectories and ADS-B.

Therefore we strongly believe the full paragraph in 2.5.3.1.1 text should read:

"The existence of VDL Mode 4 as an available air-air/air-ground data link is acknowledged as a Global and European standardised technology and technical enabler. VDL Mode 4 is currently being implemented in Sweden with plans for implementation in other areas of Europe for initial surveillance and communication services. The VDL Mode 4 based infrastructure is a valuable tool for developing, validating, testing and demonstrating the viability of new ATM services (e.g. provision of traffic information, weather, NOTAMs etc. as requested by General Aviation) leading to the necessary operational experience for the development and deployment of the required future data link".