On 13th May 2009, the Members of the SCG, agreed that the proposed Strategic Guidance material, aimed at clarifying the first version of the European ATM Master Plan, be published as replacement of the existing 13 EUROCONTROL Strategies.
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Executive Summary

Positioning

The SESAR Definition Phase lead to the European ATM Master Plan (see section 1.2), which will structure the future of ATM in Europe over the next decades. This Strategic Guidance has been produced to both support the implementation and development of the Master Plan and to describe how to achieve set targets.

This “Strategic Guidance in support of the Execution of the European ATM Master Plan” is structured around four elements of the ATM System: Performance, Network, Information Management and Infrastructure and will play an important role in the European ATM Master Plan Update process.

The background rationale of the European ATM Master Plan information from four complementary perspectives is described together with guidance for deployment. The current knowledge from concept and development work conducted by ATM Stakeholders in the European (SJU, SES, EUR Region, etc.) and global context (ICAO) is reflected.

How the phased delivery of Operational Improvements described from the Network perspective (Annex B) will exploit the evolving capabilities described in the areas of Infrastructure (Annex D) and Information Management (Annex C) to deliver ATM operational services in line with the Performance requirements (Annex A) is described.

The document provides a consolidated overview of how the European ATM System will accommodate the forecasted demand and respond to Stakeholder needs. The audience are the experts involved in long term and medium term ATM planning.

Figure 1 illustrates the positioning of the Strategic Guidance within the context of the European ATM Master Plan and the overall global context.
The development of this strategic guidance serves multiple purposes:

**Establish a consistent baseline that can be maintained as an integral part of the Master Plan maintenance process.** It is recognised that the SESAR definition phase deliverables serve as a baseline. The intention is however to let the Strategic Guidance evolve over the years, together with the Master Plan, the Concept of Operation and other SESAR documentation. The Guidance will be maintained as an integral part of the Master Plan maintenance process.

**Communicate the essence of the European ATM Master Plan** (in particular the underlying evolution plan) in a clear, explicit, easily understandable way. This includes explaining the rationale behind the choices made.

**Build on the main SESAR definition phase deliverables.** In particular it has been ensured that the Strategic Guidance is aligned—both in terms of terminology and content—with the SESAR Performance Framework, the Target Concept and Architecture, the Deployment Sequence and the Master Plan. Alignment with the European ATM Master Plan is illustrated in Table 1.

**Complement the SESAR definition phase deliverables** by extending the scope and covering certain subjects in more detail (e.g. deployment, reduction of fragmentation, spectrum management, UAV/UAS).

**To replace, update and restructure existing material.** Due to the changed European ATM context there was a need to publish up-to-date material which brings together the old EUROCONTROL strategic documentation (the ATM2000+ Strategy and its associated Domain Strategies) in a different format, while integrating information from recently updated and approved Domain Strategies such as the one on Airspace and Navigation.

The present edition of this document reflects the results of the SESAR Definition Phase. It is aligned to the initial Master Plan as endorsed by the European Council. It establishes a baseline, without pre-empting any of the work that is planned to be conducted as part of the SESAR Development Phase or in conjunction with the introduction of the SES II performance scheme.

**Document Structure**

This document comprises two Chapters.

Chapter 1, Steps Towards the SESAR Future Operational Concept, provides a brief overview of the key SESAR documents, their terminology and the need for change.

Chapter 2, Strategic Guidance in support of the European ATM Master Plan, provides a strategic overview of the envisaged SESAR ATM system through the four perspectives Performance Network, Information Management and Infrastructure, in line with the evolving Operational Concept.

4 Annexes provide strategic guidance from the perspective of ATM Performance (Annex A), ATM Network (Annex B), ATM Information Management (Annex C) and ATM Infrastructure (Annex D).
CHAPTER 1 – Steps Towards the SESAR Future Operational Concept

1.1 Need for Change

The need for change is driven by a number of external factors and Europe’s intent to adopt a performance based approach in its transition to the future European ATM System.

These external factors can be summarised as follows:

Traffic Demand

The main factor driving the need for change in Air Traffic Management is the predicted substantial growth in air traffic over the next 20 years and its increased complexity and density. Traffic patterns may also change significantly. Under these circumstances, optimised shared use of scarce airspace resources by civil and military airspace users will become even more important than today [Ref 3].

Aircraft Fleet

The aircraft fleet operating in Europe will be progressively renewed and we will see the size of the fleet grow in proportion with the number of flights. In addition the fleet will include more and more new types of aircraft with different performance characteristics and needs (e.g. VLJs and UAVs).

Airport Needs

Airports are predicted to invest in more capacity, however not as much as the growth in traffic demand. This will lead to an increasing number of congested airports, which will rely on ATM to optimise their airside operations to the maximum extent possible. Some of the demand which cannot be accommodated at major airports will be “driven” to smaller, regional airports which will also continue to grow due to airlines proactively seeking new markets.

Quality of Service Requirements

To support their business adequately, airspace users are demanding much higher Quality of Service (QoS) levels—i.e. efficiency, flexibility and predictability—than ATM has been able to offer in the past.

Safety

In the light of the increased traffic complexity and density, one can expect more accidents and incidents if nothing is done to prevent this. Therefore society is expecting that ATM contributes to substantially increased safety levels, both in the air and on the airport.

Environmental Performance

For environmental reasons, aviation is expected to make serious efforts to reduce fuel consumption, noxious emissions and noise. ATM is expected to contribute by optimising gate-to-gate traffic flows in line with environmental performance objectives.

Security

At the same time, we live in a world in which civil aviation faces an increasing risk of security attacks. ATM is expected to play a more active role in preventing civil air traffic from becoming a security risk, and managing the security (self-protection) of ATM services, infrastructure, information and staff. ATM will also need to improve its collaboration with other authorities active in security management.

Cost Effectiveness

Airspace users come under increasing pressure to reduce costs to remain competitive. This translates into the need to increase their own ATM capabilities at minimum cost (through investments in aircraft and Flight Operations Centre equipage), to reduce indirect ATM costs (associated with delays, inefficient routing etc.) to the
maximum extent possible, and for the ANSPs to significantly reduce the cost of service provision. Studies have shown that in Europe, ATM costs are higher than strictly necessary due to the fragmentation of European airspace and corresponding service provision. The required cost reduction cannot be achieved without addressing the issue of fragmentation as a matter of priority.

New Technologies

The availability of technologies—while being an enabler for ATM change—also creates opportunities. As such, the proven use of state-of-the-art technology (in particular Information and Communication Technology, ICT) in other industries acts as a catalyst and driver for changing ATM at a faster pace than in the previous decades. Within this context, the time is ripe to undertake a substantial revision of the methods and paradigms used for managing ATM information.

Obsolete Technologies

Technological evolution also leads to technologies and equipment which become obsolete, and are no longer supported by the manufacturing industry. In such cases there is definitively a need for change.

Human Aspects

The human is and will remain central in ATM, both in the air and on the ground. In the coming 20 years, the transition to the SESAR Target Concept and the associated restructuring of the ATM system will affect hundreds of thousands of people working in the aviation industry. The magnitude of this Human change process is unprecedented. To guarantee a successful outcome (social aspects, human factors, etc.), Human Performance Management will need to change substantially.

Global Context

ATM in other parts of the world is changing also. Aviation is truly global in nature and this requires global interoperability. Europe cannot undertake its ATM upgrade in isolation. Europe has to work with ICAO and other regions to conduct SESAR within the global context. In other words: global change affects European change.

Institutional Context

A changing European institutional context will affect ATM change also. SESAR may be able to change the institutional context to some extent to satisfy its own ATM requirements, but one has to expect the opposite also: the forced need for ATM to adapt to institutional changes which take place within a wider policy context (e.g. European transport policy in general).

In conclusion, this section underlines that the need to change and improve ATM is driven by many more factors than just the expected traffic growth.

1.2 European ATM Master Plan

The European ATM Master Plan [Ref 2] addresses the future of ATM in Europe over the next decades and forms the basis for the work programme of SESAR. It is a “rolling” plan that will be regularly updated in accordance with the results from the R&D activities starting under the responsibility of the SESAR JU.

The Implementation of the European ATM Master Plan together with the SES II package will lead to a better performing ATM system in Europe.

The European ATM Master Plan establishes the R&D and deployment roadmaps for Operational Evolution, Enabler Development & Deployment and Supporting Changes (e.g. safety, environment, etc.) with the common goal to implement the ATM Target Concept. It is important that the core components of the ATM Target Concept are implemented timely and consistently at European network level to enable full benefits.

The concept of ATM Service and Capability Levels is used as the top-level, system-wide basis to identify the performance characteristics by which all components of the future European ATM system will be linked. A level of performance is provided at each ATM Service Level with higher performance provided at each successive Service Level.

Capability Levels:

A Capability Level is associated with an individual ATM component such as an aircraft and relates to the Stakeholder systems, procedures, human resources etc. For a Stakeholder to upgrade their capability in any area new enablers will need to be deployed and this will require investment to be made in their system.

Service Levels:

Service Levels relate to the operational services exchanged between stakeholders, service providers and service users. To upgrade a Service Level operational improvement steps will need to be deployed which will lead to performance improvements.
SESAR defines 6 Capability and Service Levels: 0-5 (see Figure 2).

For an ATM service to be delivered at a particular Service Level both the provider and the user of that service must have at least the Capability Level equivalent to that Service Level. There is also a need for backward compatibility so that a system at a particular Capability Level is able to provide and receive services at a lower level. This will ensure interoperability between systems of different capability levels.

As the various parts of the European ATM System evolve there will be mismatches in capability between the various participants. The aim in the deployment will be to synchronise upgrades geographically to avoid wasting capabilities and the underachievement of expected performance benefits.

### 1.3 Operational Concept

The SESAR ATM Target Concept [Ref 1] which includes the Concept of Operations (ConOps), Architecture and Technologies, is the basis of the future European ATM System. Section 2.2 identifies the key features of the concept.

To achieve the Target Concept a performance based European ATM System will be developed, driven by a set of performance targets. The future ATM system will be governed through three distinct ATM frameworks:

- The Performance Framework
  - This framework will be used to drive management decisions in the development of the future ATM system.
  - ATM Performance covers a number of interdependent aspects which are represented in Key Performance Areas (KPAs).

- The Business Framework
  - Responsible for establishing the ATM Performance Partnership between all stakeholders (Civil Airspace Users, Military, ANS Providers, Airports, Supply Industry, EUROCONTROL and Social Partners) including the establishment of roles and targets based on a shared set of values, priorities and network interactions.
  - This framework will improve on the current fragmented decision making process. Leading to common and shared ATM strategic planning.
  - The framework will also implement the concept of the “Business Trajectory”.

- The Institutional and Regulatory Framework
  - This will comprise a simple and well-structured set of regulations and regulatory actions allocated to global, European or national level. Member States will remain responsible for enforcement.
  - This framework needs to be flexible to adapt to business and societal changes.

Global Interoperability is of major importance for the development of the ATM Target Concept. Compliance with the ICAO Operational Concept Document [Ref 4] has been the objective from the outset and will be the basis for convergence with worldwide ongoing initiatives (e.g. NextGen in the USA).
CHAPTER 2 – Strategic Guidance in support of the Execution of the European ATM Master Plan

2.1 Introduction

The Strategic Guidance structured around Network, Information Management, Infrastructure and Performance details how the elements described in the European ATM Master Plan [Ref 2] can be deployed to implement the evolving SESAR Operational Concept [Ref 1] and ultimately deliver the ATM Performance expected of the SESAR programme.

2.2 Concept Evolution

The SESAR ATM Concept of Operations represents a paradigm shift from an airspace-based environment to a trajectory-based environment. Key to the concept is the “Business/Mission Trajectory” principle in which the airspace users and ANSPs define together, through a collaborative process, the optimal flight path.

Initially network operations will be characterised by Airspace Scenarios, these refer to pre-defined ATS routes, associated ATC sectors and airspace reservations known to ATFCM and ATC. Airspace Scenarios enable demand and capacity balancing. As the concept evolves Airspace Scenarios will be extended into Airspace Configurations. Airspace Configurations refer to the pre-defined and co-ordinated organisation of ATS routes of the ARN and/or Terminal Routes and their associated airspace structures and ATC sectorisation. These Airspace Configurations are aimed at responding to differing strategic objectives (capacity, flight efficiency, environment) at airspace network level and result from improvements in the organisation of the airspace and Network Management. As the concept further develops the Airspace Configurations will evolve into a full Trajectory Based Network based upon user preferred Business/Mission Trajectories between TMA exit and entry and increasingly precise Terminal Routes.

Taking full advantage of existing and newly developed technologies SESAR’s target concept relies on 5 key features (see Figure 3)

1. optimal Trajectory Management, introducing a new approach to airspace design and management reducing the constraints of airspace organisation to a minimum and the core of the concept introducing the Business Trajectory;
2. Collaborative planning which is continuously reflected in the Network Operations Plan: a dynamic rolling plan for continuous operations that ensures a common view of the network situation;
3. full Integration of Airport operations, as part of ATM and the planning process, contributing to capacity gains
4. New separation modes to allow for increased safety and capacity;
5. System Wide Information Management which is integrating all ATM business related data; an environment connecting all ATM stakeholders, aircraft as well as all ground facilities, supporting CDM 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; controllers and pilots will be assisted by new automated functions to ease their workload and handle their complex decision-making processes.

The concept of operations has an evolutionary approach which aims to deliver the Performance improvements in a phased manner through a number of Service Levels.

The “Strategic Guidance in support of the Execution of the European ATM Master Plan” presents the European ATM Master
Plan information from four complementary perspectives. It collectively addresses the key features of the concept and complements the European ATM Master Plan with guidance for deployment.
2.2.1 Trajectory Management is Introducing a New Approach to Airspace Design and Management

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.

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 recognised 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.

The foundation of the ATM Target Concept is trajectory-based operations. A trajectory representing the business intentions of the Airspace Users and integrating ATM and airport constraints is negotiated. During this process the trajectory is known as the Shared Business Trajectory (SBT) or Mission Trajectory for military users. Once the negotiation process is complete the Reference Business Trajectory (RBT) is defined, this is the trajectory that a user agrees to fly and the ANSP and airport agrees to facilitate.

The trajectory-based operations ensure that the Airspace User flies a trajectory close to its intent in the most efficient way allowing the environmental impact to be minimised. 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 areas.

The Airspace User owns the Business Trajectory (BT) 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 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 Trajectories will be described as well as executed with the required precision in all 4 dimensions.

Service Level 0

At Service Level 0 progress towards trajectory management and new airspace design will be achieved through the on-going deployment of Best Practices, i.e. cross-border operations facilitated through CDM with neighbours, flexible sectorisation management, automated support for Traffic Load (Density) management, etc.

Service Level 1

At Service Level 1 changes will be made to several aspects of the network. The initial step towards trajectory based operations will be to implement optimum trajectories in defined airspace at particular times. At this Service Level more optimised trajectories will be achieved through coordination of optimised en-route cruise-climb setting between pilots and controllers.

To successfully manage these trajectories in real time controllers will be provided with automated support to continuously monitor and evaluate traffic complexity. This will enable upcoming congestion to be predicted and the airspace to be managed dynamically.

A full set of Complexity Management Tools will be deployed to provide trajectory management across several sectors (i.e. MSP). Tools will also be provided at this Service Level to enable controllers to identify
and resolve local complex situations and also to perform near-time conflict detection and resolution and trajectory conformance monitoring.

Ground System route allocation tools will be introduced in the TMA to assist the controller in managing the large number of interacting routes and also monitoring conformance to aircraft clearances.

Changes to airspace design and management will be aimed at improving the airspace and route network structures to better align routes and sectors with traffic flow and accommodate the various types of airspace users. To help achieve this automatic support will be provided to assist with the dynamic management of airspace/route structures based on pre-defined sector sizing and constraint management. The aim will be to deconflict the traffic and make best use of the controller workforce.

The design of terminal airspace will also be addressed with the deployment of RNAV routes to facilitate improvements in efficiency and capacity through the provision of increased flexibility and reduced route separation.

ASM and ATFCM will collaborate to optimise the utilisation of the available capacity. Systems and procedures will be developed which will enable ASM to design, allocate, open and close military airspace structures on the day of operations.

To improve capacity at airports tailored arrival procedures will be deployed in appropriate airport areas and Advanced Continuous Descent Approaches will be introduced in higher traffic densities. These will be optimised for each airport arrival procedure and will enable aircraft more opportunity to fly their individual optimum descent profile. At the same time Advanced Continuous Climb Departure will be deployed in higher traffic densities.

In the cockpit ACAS will be linked to autopilot or flight director.

As an initial step towards re-categorisation of airspace the rules associated with the current 7 ICAO classifications will be applied uniformly at or below FL 195.

The planning and operation of military flights will become more integrated into the overall ATM system. As an initial step towards this flight plans for all military flights requiring flight plans will be filed in a common (ICAO) format at Service Level 1. Also a pan-European OAT-IFR Transit service will be deployed connecting national structures and arrangements which will facilitate OAT-IFR flights across Europe.

**Service Level 2**

At Service Level 2 the use of Business Trajectories for commercial aircraft will be deployed. Military Mission trajectories will also be developed which will interface with these Business trajectories.

Further changes to airspace structures will also be implemented at Service Level 2, spacing between routes will be reduced where required using Advanced RNP and this will place requirements on airborne navigation capabilities. Also, tactical parallel offsets will be used as an alternative to vectoring.

Increasingly free routing will become more widespread. At Service Level 2 this will lead to free routing in cruise being deployed in Upper Airspace, where appropriate and made possible with enabling trajectory prediction tools.

Terminal airspace will further be improved at Service Level 2 through the deployment of RNP operations, implementing A-RNP1 SIDs and STARs and redefining holding areas according to size and location. RNP-based instrument procedures will also be introduced for the provision of stabilised approaches.

**Service Level 3**

Revision of the Reference Business Trajectory (RBT) will be achieved through information exchange between ground and airborne systems at Service Level 3. This will be supplemented by procedures which will require clearances and instructions to be issued by voice in some circumstances.

Multiple Controlled times of Over-fly (CTOs) are embedded in the RBT which is coordinated between airborne and ground systems. Also at Service Level 3 coordination-free Transfer of Control through use of common 4D trajectories will be implemented although there may be times when coordination is still required.

To support this use of Business Trajectories a full set of Advanced Controller Tools using the SBT/RBT will be deployed. These will be upgraded to exploit the increased amount and quality of information, in particular reduced uncertainty on trajectory prediction, and to reflect new separation modes and (possible) lower separation minima.

ACAS resolution advisories will be downlinked from aircraft and displayed to the
controller. Upstream Ground Based Speed Adjustments will also be introduced to reduce conflicts. STCA will also be improved at Service Level 3 to make use of enriched surveillance information.

The use of free routing will be extended at Service Level 3 to apply from ToC to ToD. Pre-defined routes will only be maintained where necessary. The dynamic adjustment of TMA boundaries according to traffic patterns and runway usage will also be introduced.

At Service Level 3 the new model of airspace based on three categories will be deployed. Also shared, flexible military airspace structures, including training areas, will be developed across Europe. These will be based on ad-hoc structure delineation (not pre-defined structures and/or scenarios).

**Service Level 4**

At Service Level 4 further changes will be made to tools and to the airspace structure. Ground based safety net performance will be improved based on widely shared aircraft position and intent data. Also, although the operation of airborne and ground safety nets must remain independent, improved compatibility will be developed to ensure that STCA and ASAS are consistent in collision detection and resolution. STCA will be adapted to work with the new separation modes and the ACAS function will be updated to ensure that it is still effective in the context of new separation modes and lower separation minima.

The use of free routing will be further extended at Service Level 4 and will be deployed from TMA exit to TMA entry when not operating in high complexity airspace. The capability to deploy dynamic mobile airspace exclusion areas will also be developed.

At Service Level 4 the airspace model will be modified to reduce the number of airspace categories to two, managed (a separation service will be provided although this may be delegated to the pilot) and unmanaged (separation is a pilot task).

**Service Level 5**

Finally, the use of dynamic sector shapes will be deployed, ATC sector shapes and volumes will be adapted in real-time in response to changes in traffic patterns and/or user intentions.
Collaborative Planning Continuously Reflected in the Network Operations Plan (NOP)

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.

The Target Concept requires that collaborative layered planning will be undertaken at local, sub-regional and European level. This planning will balance capacity and demand whilst taking into account constraints and events that impact on the system. Important to the concept is the efficient management of queues which will optimise the access to constrained resources (mainly airports). The results of the on-going planning process will be reflected in the Network Operations Plan (NOP) which will be continuously updated. The aim will be to ensure a degree of strategic deconfliction whilst minimising holding and ground queues.

**Service Level 0**

At Service Level 0 the collaborative planning and network management activities will be achieved through the on-going deployment of Best Practices, i.e. interactive network capacity planning.

**Service Level 1**

The first step to collaborative planning will be the implementation of an interactive Network Operations Plan which will provide an overview of the ATFCM situation from strategic planning to real-time operations. This will be readily available to stakeholders, subject to access rights and security controls, for consultation and update. The aim at this stage is also to narrow the gap between ATC and ATFCM, operational procedures will be developed which involve coordination between more than one ACC, Airport Operations and the CFMU.

Consistent use and management of ATS routes (permanent or conditional) is ensured at the Network level through the use of Airspace Scenarios. Pre-defined scenarios are established taking into account partners' requirements (ATC, airports, military) for usage of the network in relation to ATC sector configuration, route and airspace availability, special events, etc.

Initially a manual User Driven Prioritization Process (UDPP) will be introduced in Service Level 1 to enhance efficiency. Also at this Service Level techniques will be introduced to assess aspects of the performance of the system, i.e. civil-military cooperation, environmental performance.

**Service Level 2**

As the network develops the progressive availability of SWIM will lead to a SWIM enabled NOP based around SBTs and RBTs driven through a process of Collaborative Flight Planning at Service Level 2.

UDPP will be deployed and the network management function will be implemented to assist airspace users in the UDPP process.

**Service Level 3**

Collaborative coordination and a systematic approach to select Airspace Configurations becomes available. The basis for collaborations is the Network Operations Plan (NOP).

The possibility for ad-hoc structure delineation at short notice is offered to respond to short-term airspace users' (civil or military) requirements not covered by pre-defined structures and/or scenarios. Such changes in the airspace status are provided to the pilot by the system in real time.

4D trajectory updates will be used in the ATFCM process to optimise network usage. The aim is to make best use of capacity opportunities and to also support queue management and improve on the accuracy of arrival times.
2.2.3 Integrated Airport Operations Contributing to Capacity Gains

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. Initially airport capacity at a local level will be enhanced, increasingly airports will be connected to the network and with traffic at and between airports synchronised through the Network. 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.

Airport Operations will become increasingly integrated into the overall ATM system through the extension of trajectory management.

**Service Level 0**

At Service Level 0 airport throughput, safety and environment will be enhanced by the on-going deployment of Best Practices. This will include, but not be limited to, additional Rapid Exit Taxiways (RET), Improved Operations in Adverse Conditions through Airport CDM, Interlaced Take-Off and Landing, Brake to Vacate (BTV) Procedure.

**Service Level 1**

At Service Level 1 airport capacity will be enhanced at local level. Surface Management procedures will be introduced supporting CDM processes to improve operations in adverse conditions such as establishing de-icing sequences. Techniques for improving the controller and pilot awareness of aircraft and vehicles on the movement area will be introduced.

Runway Occupancy Time (ROT) reduction techniques will be provided for Runway Management including:

- enhancing the airport layout;
- forecasted wake vortex data which will enable both reduced separations for crosswind departures and arrivals.

In addition capacity gains will be achieved by increased utilisation of the combined runways made possible by reducing dependencies between runways by implementing more accurate surveillance techniques and controller tools as well as advanced procedures.

**Departure Management** will be introduced synchronised with pre-departure sequencing and **Arrival Management** Extended to En-Route Airspace will also be introduced. Further to this integrated Arrival Departure Management will be introduced for full traffic optimisations. This will include provision of assistance to the controller within the TMA to manage mixed mode runway operations and resolve complex interacting traffic flows.

**Service Levels 2 and 3**

At Service Levels 2 and 3 Airports will be increasingly connected to the network and traffic synchronisation will occur between the en route and airports. **Surface Management** will be integrated into **Arrival and Departure Management** to ensure a more stable departure sequence based on the ground traffic situation.

Departure Management will be optimised in the Queue Management process. Given appropriate information DMAN will calculate the optimum take-off time and SMAN will determine the associated start-up and push-back times and taxi route.

**Advanced aircraft automated systems** such as auto-brake and auto-taxi will be introduced through flight deck automation to enhance trajectory management.

**Automated systems** will detect potential conflicts/incursions involving mobile and stationary traffic on runways, taxiways and in the apron/stand/gate area. Alarms will be provided as appropriate. There will also be automated assistance for planning surface movements and then monitoring for deviations. **Dynamic traffic context displays** will also be available.

**Low Visibility Runway Operations** based on GNSS / GBAS are applied in precision approaches. In Low Visibility Conditions pilots can use enhance vision that provides for “out the window” positional awareness.
Service Levels 4 and 5

With Service Levels 4 and 5 traffic at and between Airports will be synchronised through the Network. Synthetic vision systems will become available in the cockpit to provide the pilot with a synthetic/graphical view in low visibility environments.

2.2.4 New Separation Modes to Allow for Increased Capacity

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.

New separation modes will be introduced in a phased manner and tools will be provided both on the ground and in the air to assist with the separation activity.

Service Level 1

At Service Level 1 tools will be provided in the cockpit to display surrounding traffic whilst in the air or on the ground. At the same time Airborne Traffic Situation Awareness In Trail procedures will be deployed in Oceanic airspace.

Also Manual ASAS Sequencing and Merging (S&M) operations will be introduced in some TMAs.

Service Level 2

Enhancements to arrival sequencing will be made at Service Level 2 through the introduction of the ASAS S&M application, with the flight crew ensuring that time or distance based separation is maintained from a designated aircraft as stipulated in new controller instructions.

Precision Trajectory Clearance (PTC) will also be introduced based on 2D pre-defined routes.

Service Level 3

At Service Level 3 separation application In Trail Procedures for use En-route in an Oceanic environment will be deployed as a further step towards ASAS application deployment.

The use of Precision Trajectory Clearances will be enhanced at Service Level 3, in 2 dimensions they will be based on User Preferred Trajectories and in 3 dimensions on pre-defined 3D routes.

Service Level 4

At Service Level 4 delegation of separation by the controller to an aircraft for Crossing and Passing manoeuvres relative to a designated target aircraft will be introduced.

PTC will be further enhanced at Service Level 4 when 3D-PTC will be deployed based on User Preferred Trajectories.

Service Level 5

Ultimately, at Service Level 5, Self-adjustment by the pilot of spacing depending on the actual position of the wake vortex of a preceding aircraft will be deployed along with the delegation of separation by the controller between an aircraft and all other aircraft in mixed-mode environment. This will require broadcast and reception of trajectory data and the support of new on-board conflict detection and resolution functions.

Finally, also at Service Level 5, 4D PTC will be deployed using longitudinal navigation performance management from the aircraft.
2.2.5 System Wide Information Management – Integrating all ATM Related Data

A net-centric operation is proposed where the ATM network is considered as a series of nodes, including the aircraft, providing or using information. Aircraft operators with operational control centre facilities will share information 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.

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.

SWIM is an essential enabler for ATM applications which provides an appropriate infrastructure and ensures the availability of the information needed by the applications run by the users. The related geo / time enabled, seamless and open interoperable data exchange relies on the use of common methodology and the use of a suitable technology and compliant system interfaces. The availability of SWIM will make possible the deployment of advance end-user applications as it will provide extensive information sharing and the capability to find the right information wherever the provider is.

The phased approach to the deployment of SWIM has been developed to ensure that benefits start of be realised at the earliest possible time by integrating simple end-user applications first. The deployment of SWIM is not dependent on the deployment of ATM changes, benefits can be achieved in largely legacy environments though regulations might be required notably concerning the liability aspects of data provision.

At each stage, the phased implementation of SWIM will consider the three inter-related dimensions (applications, information, infrastructure):

- **Applications**, represent the user side of SWIM. They will be addressed through the identification of “communities of interest” gathering stakeholders that have to share information to serve their interests. The partners in the community know the information they need to share with what quality of service and for effective collaboration they require a common understanding of the information and the information has to be available in a commonly agreed structure. Initially the communities will comprise a core of airports and aircraft operators evolving to include more complex collaborations across the whole ATM business chain.

- **Information** covers both the semantic and syntactic aspects of data composing information and the Information Management functions. The former is dealt with by modelling activities which aim to use and or define common standards while the latter include mainly distribution, quality, maintenance, user identity and profile to enable data exchange and sharing within a community of interest and between communities independently of the underlying communication infrastructure.

- **Infrastructure** will be concerned mainly by the connectivity aspects; It will be built on existing legacy infrastructure as far as practicable until an European IP based network communications is available. The air/ground segment is an example of SWIM connectivity that is intended to be added at a later stage as aircraft are integrated into the communities of interest.

The combination of the above three areas at particular stages of their common evolution constitute the ATM Capability Levels for Information Management.
2.2.6 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 roles and responsibilities of all the actors within the ATM System and up to a successful implementation of the ATM Target Concept.

Human Factors Case will be developed to systematically and in a timely manner identify, prioritise and manage human performance issues for all Service Levels.

A Human Performance Steering Function (HPSF) will also be established to ensure that all human performance aspects are systematically and consistently managed throughout SESAR. Pro active management of Recruitment, Training, Competence and Staffing (RTCS) will be fostered. Social factors and change management (SFCM) risks will be assessed and managed for all Service Levels.

Service Levels 0 and 1

At Service Levels 0 and 1 best practices in Human Performance Management in ATM will continue to be further implemented across Europe.

A competence baseline will be established for all European ATM operational staff to enable implementation of harmonised systems and procedures in all areas of the ATM system (e.g. for ATCOs, ATSEPs).

Training will be developed and delivered to prepare operational staff for the implementation of Service Level 1 improvement steps.

Service Levels 2 and 3

Specific to Service Levels 2 and 3 will be the conduct of Human Factors certification as part of the overall certification processes. International/national and local RCTS standards, regulations and infrastructure will start to be adapted. RTCS in all SESAR R&D related to operational improvement steps will be identified.

Cultural, organisational diversity and future social challenges will be managed. Leadership competence will be enhanced. New forms of industrial relations will enhance change processes.

There will be common use of a toolbox of generic Human Performance methods and techniques.

New training modes will be introduced to prepare for enhanced information sharing and CDM processes and for increasing automation. Training will be developed and delivered to prepare operational staff for the implementation of Service Level 2 & 3 improvement steps.

Service Level 4

International/national and local RCTS standards, regulations and infrastructure will continue to be adapted.

Training will be developed and delivered to prepare operational staff for the implementation of Service Level 4 improvement steps. Staffing levels will be adapted to accommodate the implications of the SESAR deployment activities.

Human Performance aspects will be implemented in the Integrated Management System.
2.3 Realising the Concept

2.3.1 Performance Objectives (Political Vision)

In November 2005, during the public announcement of the SESAR Definition Phase contract, EC Vice-President Jacques Barrot expressed the EC objectives of the SESAR programme, which are to achieve a future European Air Traffic Management (ATM) System for 2020 and beyond which can, relative to today’s (i.e. the 2005) performance:

- Enable a 3-fold increase in capacity which will also reduce delays, both on the ground and in the air,
- Improve the safety performance by a factor of 10,
- Enable a 10% reduction in the effects flights have on the environment and
- Provide ATM services at a cost to the airspace users which is at least 50% less.

These statements have been widely communicated amongst the ATM community, and even amongst the general public. Although they can be interpreted in different ways, they constitute the political vision for the performance of the future ATM System. This vision expresses—in a simple message—the main challenges that the SESAR programme, in terms of Performance Objectives must respond to.

During the SESAR Definition Phase, the ATM Stakeholders have elaborated the above political vision into a more complete and precise set of Strategic Performance Objectives, indicators and targets.

2.3.2 Phased Performance Based Approach

A performance based, service oriented, net-centric approach realised by capability improvements and enhancements in Infrastructure and Information Management will lead to the delivery of the required ATM performance.

The SESAR Performance Framework was developed to deliver the high-level Performance Objectives (Political Vision) and is structured around the 11 ICAO Key Performance Areas (KPAs) as defined in ICAO Doc 9883 [Ref 4].

![Figure 4 Hierarchy of Performance Objectives and Targets](image)

This Strategic Guidance developed in the area of performance, Annex A, proposes to cascade down the SESAR Strategic Performance Objectives and targets to secondary (i.e. more specific) objectives, indicators and design targets. By being more specific, they are intended to trigger and drive change at a level which is closer to the “solution level” presented in the Network, Information Management and Infrastructure areas. Each of these areas responds to these secondary objectives and targets, rather than providing direct traceability to the highest level Performance Objectives. Further the performance guidance identifies a phased approach to the delivery of performance through increasing levels of performance corresponding to defined levels of service (Service Levels).

2.3.3 ATM System

The ATM Network, the ATM Infrastructure and ATM Information Management together form the ATM system, which will evolve in line with the performance requirements to deliver the performance improvements.

Figure 5 illustrates the high-level target architecture for the ATM system in Europe.

Specifically, the ATM Network which comprises airspace, airports and network management activities will evolve, from an operational perspective, to satisfy the ATM performance needs. The changes will be oriented to implement the SESAR Operational Concept inline with the performance framework and will be aimed at delivering operational capabilities for a specific level of service. In order to achieve the ATM Service Levels, requirements will be placed on Infrastructure and Information Management to deliver capabilities to support the ATM Network.
The ATM Infrastructure is an enabler for the provision and interchange of information supporting the elements of the SESAR Operational Concept. The evolution of the existing ATM Infrastructure is determined by new operational requirements, identified for the ATM Network, emerging from future ATM concepts together with associated information distribution and performance requirements defined by ATM Information Management. The objective of an improved infrastructure is therefore to provide a safe, efficient and cost-effective set of interoperable systems which support, in a globally compatible manner and with due regard for backward compatibility, the performance targets and the evolution of European Air Traffic Management and other identified air navigation services for the ECAC area.

In this context ATM Infrastructure includes the following:

- Airspace User systems, including aircraft systems and Airline Operations Centre (AOC) ATM systems
- Airport systems, consisting of Aerodrome ATC system and the Airport Airside Operations system
- En Route and TMA systems
- ATM Regional systems, which include the Aeronautical Information Management system, the Network Information Management system, the Advanced Airspace Management system, the A/G Datalink Ground Management system (AGDLGMS) and the SWIM Supervision system, all acting at regional level

The systems are underpinned by Communications, Navigation and Surveillance (CNS) technologies together with availability of radio spectrum.

ATM Information Management will establish the framework that defines seamless information exchange between all providers and users of shared ATM information including the performance and operational requirements for system wide information sharing identified for the ATM Network. The aim of Information Management is to provide users with the right information at the right time and at the right place, enabled through the concept of net-centric ATM operations. This will be enabled through effective information filtering including the use of time based and location based information selection.
A System Wide Information Management (SWIM) environment underpins the entire ATM system, and is essential to its efficient operation. It includes aircraft as well as all ground facilities. It will support CDM processes using efficient end user applications to exploit the power of shared information. Fundamental to the entire ATM Target Concept is a ‘net centric’ operation based on:

- a powerful information handling network for sharing data;
- new air-ground data communications systems; and
- an increased reliance on airborne and ground based automated support tools.

Figure 6 depicts the technical architecture.

2.3.4 Relationship between the ATM System Elements

Figure 7 illustrates the relationship between the ATM Network, ATM Infrastructure and ATM Information Management working with the performance requirements as described in ATM Performance, Annex A, to deliver capabilities to support the evolving ATM Service Levels. The unidirectional arrows depict the performance requirements on the individual ATM elements whilst the bidirectional arrows in one direction represent the operational requirements and in the other direction the provision of capabilities to support the requirements.

2.3.5 The Integrated Management System

The purpose of the Integrated Management System is to bring together today’s individual management systems, such as quality, environment and health and safety, which many organisation currently treat separately. The objective of this integration is to achieve the benefits of reduced costs, improved effectiveness, removal of duplications and conflicts and better change management.
2.3.6 Service Oriented Approach

An ATM Service Level provides a level of performance derived from the capabilities of the airborne and ground based ATM systems interoperating at that level. More advanced ATM Service Levels are associated with higher performance and deliver more benefits.

However, at any one time traffic composed of aircraft with different levels of ATM Capability will be operating at several different Service Levels in the European ATM system this will have an impact on the performance that can be delivered at the overall network level. The greater the number of flights operating at the higher service levels the greater will be the overall performance benefits.

The deployment scenario envisages that “new” traffic will make use of the most advanced ATM service level available at the time. “Old” traffic will progressively migrate to more advanced Service Levels, as a result of aircraft being retrofitted/upgraded and will be able to interoperate with flight operation centres, airports and ATM facilities with higher ATM Capability Levels. “New” or “old” in this context relates to the Capability Levels of the aircraft.

2.3.7 European ATM Enterprise Architecture

To support the Business Management framework (section 1.1) SESAR has proposed the establishment of an ATM Performance Partnership to:

- Reconcile the different partners’ business and/or mission objectives,
- Identify those aspects of their visions which are common in terms of creating and managing the future ATM system,
- Defining how the partners should interact to create and manage the future system

The partnership is intended to be based on the principles of the European ATM Enterprise Architecture.

The Enterprise Architecture considers European ATM to be a virtual single enterprise in which the constituent parts work together in a networked, service-based operation with the business processes driving the services. It encompasses the structure and behaviour of the virtual single enterprise’s ATM related processes, functions, information systems, personnel and organisational sub-units aligned with the Performance Partnership’s goals and strategic direction.
2.4 **Standardisation and Regulation**

This section addresses some key aspects of Standardisation and Regulation applicable to SESAR.

2.4.1 Legislation and Regulation – the SESAR findings

SESAR identified the need to work towards the following:

- A simpler, more coherent framework of legislation and regulation, matching the ATM business model is needed [Ref 6].

- Distinct business & regulatory management framework with a “dynamic working relationship” to ensure the best outcome for the ATM industry as a whole [Ref 7].

2.4.2 Legislation Pragmatics

The key messages are:

- Establishing a single European Legislative Framework: The rationalisation and alignment of European and national regulations is essential for the full implementation of the Single European Sky. However, regulation should only be used where necessary in accordance with "better regulation" principles to reach agreements and to support enforcement of commitments across the diversity of Member States and stakeholder interests.

- a lead time of at least 3 years is required to develop EU legislation such as implementing rules

- It is prudent only to develop legislation when it is clearly the only/best way to achieve the desired outcome
  - In most cases, the format of a Regulation could be the appropriate tool of EC law as a regulation has general application, is binding in its entirety and directly applicable in all EC States. On the other hand, where specific national circumstances have a major impact on the need for and feasibility of various proposed improvements, the format of a Directive may be more appropriate as it would enable the EC States to choose the form and methods to reach the result to be achieved.

2.4.3 Applied Legislation in SESAR

Within SESAR legislation is a tool to achieve the political objectives. The relevant political and legislative processes are necessary give priority to enablers which support the implementation of the ATM Target Concept.

SESAR's predicted legislation could either be addressed by Implementing Rules, developed under the SES Interoperability Regulation No 552/2004 of 10 March 2004, or by the adoption of regulations/directives from the European Parliament and the Council of the European Union e.g. the Security requirements for SWIM.

Whatever the form of the legislation the complex issues of national security and defence requirements will require strong coordination among States to ensure harmonised and compatible applicability dates when changes to national legislation are necessary. With the challenging timescales in SESAR, political backing and appropriate level of certainty over any performance/design/technical requirements needing legislation are essential. It is also essential that any current discrepancies between EUROCONTROL and EC regulations are resolved to avoid double regulation.

The proposed second SES legislation package has concentrated on the reduction of fragmentation and costs and has taken full account of SESAR developments when determining the appropriate regulatory needs.

An Institutional and Regulatory Framework comprising a simple and well-structured set of regulations and regulatory actions allocated at global, European or national level is required with Member States remaining responsible for enforcement. The framework needs to be flexible to adapt to business and societal changes.

An example of such a framework is the development of the ATM safety regulatory framework to provide a clear, unambiguous set of regulations across the whole of the air transport industry. This will comprise definition of regulatory activities necessary to support this ATM Deployment Sequence and its development together with all ATM regulators in parallel to the SESAR JU.

Further evolvement of appropriate legal frameworks to support all envisaged solutions and their timely implementation is required. For example, SWIM and ASAS will require appropriate legal framework evolutions.
2.4.4 Standardisation

Global interoperability and harmonisation are the major foundations of international aviation operations and can only be achieved through an appropriate implementation and adoption of Standards (i.e. ICAO). Therefore the needs for standardisation activities have to be considered throughout the ATM deployment sequence by application of consistent and efficient standardisation scenarios.

It is essential that the development of standards is seen in a holistic manner rather than the fragmented way in which standards have previously been developed.

The time taken for standardisation to be achieved is dependent on the commitment of the various Stakeholders to the process. The level of effectiveness of the standardisation activity could be improved by the development and application of appropriate management processes.
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## ABBREVIATIONS

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<td>A/G</td>
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<td>ACARE</td>
<td>Advisory Council for Aeronautics Research in Europe</td>
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<td>ACARS</td>
<td>Aircraft Communications Addressing and Reporting System</td>
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<td><strong>RNP1</strong></td>
<td>Required Navigation Performance (1nm minimum performance)</td>
</tr>
<tr>
<td><strong>ROT</strong></td>
<td>Runway Occupancy Time</td>
</tr>
<tr>
<td><strong>RTA</strong></td>
<td>Required Time of Arrival</td>
</tr>
<tr>
<td><strong>RTCS</strong></td>
<td>Recruitment, Training, Competence and Selection</td>
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<td><strong>RWY</strong></td>
<td>Runway</td>
</tr>
<tr>
<td><strong>S&amp;M</strong></td>
<td>Sequencing &amp; Merging</td>
</tr>
<tr>
<td><strong>SARPS</strong></td>
<td>Standards and Recommended Practices (ICAO)</td>
</tr>
<tr>
<td><strong>SATCOM</strong></td>
<td>Satellite Communications</td>
</tr>
<tr>
<td><strong>SBAS</strong></td>
<td>Satellite-Based Augmentation System</td>
</tr>
<tr>
<td><strong>SBT</strong></td>
<td>Shared Business Trajectory</td>
</tr>
<tr>
<td><strong>SCAT</strong></td>
<td>Special Category</td>
</tr>
<tr>
<td><strong>SDPD</strong></td>
<td>Surveillance Data Processing and Distribution</td>
</tr>
<tr>
<td><strong>SecMS</strong></td>
<td>Security Management Systems</td>
</tr>
<tr>
<td><strong>SES</strong></td>
<td>Single European Sky</td>
</tr>
<tr>
<td><strong>SESAR</strong></td>
<td>Single European Sky ATM Research (Programme)</td>
</tr>
<tr>
<td><strong>SFCM</strong></td>
<td>Social factors and change management</td>
</tr>
<tr>
<td><strong>SGML</strong></td>
<td>Standard Generalised Markup Language</td>
</tr>
<tr>
<td><strong>SI</strong></td>
<td>Surveillance Identifier</td>
</tr>
<tr>
<td><strong>SID</strong></td>
<td>Standard Instrument Departure</td>
</tr>
<tr>
<td><strong>SIGMET</strong></td>
<td>Significant Meteorological Information</td>
</tr>
<tr>
<td><strong>SL</strong></td>
<td>Service Level</td>
</tr>
<tr>
<td><strong>SLA</strong></td>
<td>Service Level Agreement</td>
</tr>
<tr>
<td><strong>SMAN</strong></td>
<td>Surface Manager</td>
</tr>
<tr>
<td><strong>SMR</strong></td>
<td>Surface Movement Radar</td>
</tr>
<tr>
<td><strong>SMS</strong></td>
<td>Safety Management System</td>
</tr>
<tr>
<td><strong>SNOWTAM</strong></td>
<td>NOTAM on SNOW conditions</td>
</tr>
<tr>
<td><strong>SOA</strong></td>
<td>Service Oriented Approach/Architecture</td>
</tr>
<tr>
<td><strong>SOAP</strong></td>
<td>Simple Object Access Protocol</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>SSR</td>
<td>Secondary Surveillance Radar</td>
</tr>
<tr>
<td>STAR</td>
<td>Safety Target Achievement Roadmap</td>
</tr>
<tr>
<td>STAR</td>
<td>Standard Terminal Arrival Route</td>
</tr>
<tr>
<td>STCA</td>
<td>Short Term Conflict Alert</td>
</tr>
<tr>
<td>SUA</td>
<td>Special Use Airspace</td>
</tr>
<tr>
<td>SUR</td>
<td>Surveillance</td>
</tr>
<tr>
<td>SWIM</td>
<td>System Wide Information Management</td>
</tr>
<tr>
<td>SYSCO</td>
<td>System Supported Co-ordination</td>
</tr>
<tr>
<td>TACAN</td>
<td>Tactical Air Navigation</td>
</tr>
<tr>
<td>TAF</td>
<td>Terminal Area (Aerodrome) Forecast</td>
</tr>
<tr>
<td>TAS</td>
<td>Terminal Airspace</td>
</tr>
<tr>
<td>TCP IP</td>
<td>Transmission Control Protocol / Internet Protocol</td>
</tr>
<tr>
<td>TIXM</td>
<td>Exchange Model for TOD</td>
</tr>
<tr>
<td>TMA</td>
<td>Terminal Manoeuvring Area</td>
</tr>
<tr>
<td>TMR</td>
<td>Trajectory Management Requirements</td>
</tr>
<tr>
<td>ToC</td>
<td>Top of Climb</td>
</tr>
<tr>
<td>TOD</td>
<td>Terrain and Obstacle Database</td>
</tr>
<tr>
<td>ToD</td>
<td>Top of Descent</td>
</tr>
<tr>
<td>TTA</td>
<td>Target Time of Arrival</td>
</tr>
<tr>
<td>UAS</td>
<td>Unmanned Aircraft Systems</td>
</tr>
<tr>
<td>UAV C&amp;C</td>
<td>UAV Command and Control</td>
</tr>
<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
</tr>
<tr>
<td>UDPP</td>
<td>User Driven Prioritisation Process</td>
</tr>
</tbody>
</table>
Table of References to the Master Plan

The Strategic Guidance material has been developed from four complementary perspectives, (Performance, Network, Information Management and Infrastructure) to both support the implementation and development of the European ATM Master Plan and to describe how to achieve set targets. It has been ensured that the Strategic Guidance is aligned – in terminology and content – with the European ATM Master Plan. The table of reference to the European ATM Master Plan illustrates this alignment and will serve as a tool to ensure continuing alignment throughout the maintenance phase.

### Table 1 Table of References to the Master Plan

<table>
<thead>
<tr>
<th>Strategic Guidance in Support of the Execution of the European ATM Master Plan</th>
<th>European ATM Master Plan - Reference</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Steps Towards the SESAR Future Operational Concept</td>
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<td>Human Performance Management</td>
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<td>B</td>
<td>Network</td>
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<tr>
<td>C</td>
<td>Information Management</td>
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<td>D</td>
<td>Infrastructure</td>
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Annex A – ATM Performance

A1 Scope

The ATM Performance Guidance relates to the other elements of the ATM System: Network, Information Management and Infrastructure, through the performance requirements and targets. These relationships are captured through the links to the key features of the SESAR ATM target concept: trajectory management, collaborative planning, integration of airport operations, new separation modes, SWIM and the infrastructure to enable the achievement of the target concept.

A1.1 ATM Performance Management at Various Time Horizons

ATM performance management in Europe takes place at various time horizons and involves a variety of stakeholders, processes, mechanisms and feedback & feed forward loops. Without claiming to be complete or perfectly accurate, this can be briefly described as follows (as illustrated in Figure 8):

- **Performance Review**: The Performance Review Commission (PRC) monitors the ex-post performance of ATM in Europe and makes recommendations for action to the Governing Bodies of EUROCONTROL, ie the Provisional Council (PC). The performance review
results are also used to support R&D and Master Planning (incl. implementation planning). The PRC role is expected to evolve into the Performance Review Body (PRB) under the SES II Performance scheme.

- **Network Management & Local ATM Service Delivery**: during day-to-day operations, ATM performance is optimised in function of traffic demand, operational constraints and the performance objectives of the various Stakeholders. Performance data is recorded for use in the above mentioned performance review.

- **Short and Medium Term Targets**: currently, the PC adopts pan-European targets with a time horizon of about 5 years. As part of European and Local Single Sky Implementation (ESSI/LSSI) Planning\(^1\), local targets are defined to guide the development of rolling implementation plans. Under the SES II Performance scheme, it is envisaged to adopt binding performance targets for ANSPs. Other targets may emanate from applicable European and national law (e.g. EU noise legislation).

- **Political Vision and Target Concept**: as part of the SESAR Definition Phase, a political vision was adopted for the European ATM performance of 2020 and beyond. The SESAR Target Concept was developed to respond to this vision.

- **SESAR Initial Performance Framework**: this is a collection of performance objectives, indicator/metric definitions and targets, with appropriate categorisation, ie grouping these items into Focus Areas which in turn are grouped into Key Performance Areas (KPA). During the SESAR Definition Phase, the political vision was expanded into a more complete performance framework: an extended set of strategic objectives and targets (mostly for 2020) to provide design guidance to the SESAR Definition Phase participants.

- **ATM Performance guidance material**: is a further development of the SESAR Initial Performance Framework. The guidance material provides non-binding design guidance beyond the short/medium term target setting of the PC, SES II and the ESSI/LSSI planning. The role and added value of the guidance material for performance will be to support Master Planning during the SESAR Development Phase. Throughout its future update history, the objective of this guidance material will be to reflect the result of maintaining and enhancing the SESAR initial performance framework by:
  
  o Translating strategic indicators and targets into a combination of secondary more specific (enabling) indicators and targets. This covers the result of trade-off decision making and target setting for the drivers of strategic performance;
  o For each of the long-term targets, adding intermediate targets, ie outlining a proposal for a consistent and feasible performance evolution path through time, seamlessly connected to the medium-term targets, up to 2020 and beyond;
  o Modifying the categorisation framework (the hierarchy of Focus Areas) in the interest of clarity and to reflect improved understanding of ATM performance;
  o Adding additional objectives, indicators and targets that were found missing from the SESAR Initial Performance Framework.

- The present first version of this guidance material does not yet fully address all of the four above objectives. The above list does however provide a good indication of the kind of changes that should be expected during future updates of this document.

### A1.2 Principles, Benefits and Terminology of the Performance Based Approach

As indicated above, it is Europe’s intention to adopt a performance based approach in its transition to the future European ATM System. The SESAR Performance Framework [Ref 2, section 2 & Annex 9.4] has been developed to reflect the Performance Objectives and is structured around the 11 ICAO Key Performance Areas (KPAs) using the guidance material defined in ICAO Doc 9883 (Manual on Global Performance of the Air Navigation System) [Ref 5].

The 11 ICAO KPAs are: Capacity, Cost Effectiveness, Efficiency, Flexibility, Predictability, Safety, Security, Environmental Sustainability, Access & Equity, Interoperability and Participation.

---

\(^1\) Formerly called ECIP/LCIP.
This performance-based approach (PBA) is based on the following principles:

- strong focus on desired/required results through adoption of performance objectives and targets;
- informed decision making, driven by the desired/required results; and
- reliance on facts and data for decision making.

The implementation of the PBA will require that achievements are periodically checked through performance review. This will require the deployment of adequate performance measurement and data collection capabilities. For the PBA to be successfully deployed there will also need to be knowledge sharing, training and specific expertise applied.

ICAO [Ref 5] identifies that, “In the long run, all of this is expected to result in a more efficient system through identified cost savings, reduction in waste of resources, more equitable charging practices, and more efficient provision of services. As the work effort is challenging, requiring a globally coordinated effort, the aviation community should be encouraged to follow a common approach toward development and implementing a performance-based air navigation system.”

Doc 9883 [Ref 5] introduces performance framework terminology such as Key Performance Area (KPA), Focus Area, Performance Objective, Performance Indicator, Performance Target, and Supporting Metric (see Figure 9). This guidance material is compliant with the ICAO terminology.

![Figure 9 ICAO Performance Framework Terminology](image)

**A1.3 Transition to Integrated Management System**

In addition to specifying performance requirements in the various Key Performance Areas, this document also describes an approach to meet the challenges in four of the Transversal Areas: safety management, security management, environmental management and human performance management. It proposes the transformation of today’s individual management systems into the envisaged future Integrated Management System (IMS). The IMS will build on the identified synergies and interdependencies between these four transversal areas and will also enable the transfer of knowledge and experience between them.
A2 ATM Performance Strategic Guidance

A2.1 Introduction

In this document, the term Performance Framework refers to “the set of definitions and terminology describing the building blocks used by a group of ATM community Members to collaborate on performance management activities. This set of definitions includes the levels in the Global ATM Performance Hierarchy, the Key Performance Areas, a set of Process Capability Areas, Focus Areas, Performance Objectives, Indicators, Targets, Supporting Metrics, lists of dimension objects, their aggregation hierarchies and classification schemes” (ICAO Doc 9883 definition).

The term Guidance for Performance refers to the approach followed to achieve a given set of performance targets in one or more KPAs at some future point in time. This may include defining:

- A translation of the strategic targets into a combination of secondary more specific (enabling) targets. The secondary targets represent policy and/or design decisions which explain how the strategic targets will be reached. This covers the result of trade-off decision making and target setting for the factors which are the drivers of strategic performance.
- Intermediate targets for each of the long-term targets, i.e. outlining a proposal for a consistent and feasible performance evolution path through time;
- How performance delivery will be distributed geographically, time-wise and stakeholder-wise in order to meet a given aggregated performance target (for example an annual pan-European target).

The guidance material for Performance represents the set of performance requirements to be satisfied by operational (services and processes), information management and infrastructure improvements. The improvements themselves are not part of the guidance for performance.

A2.2 SESAR Key Performance Areas and Targets

During the SESAR Definition Phase, the ATM Stakeholders have elaborated the political vision of section 2.3.1 into a more complete and precise set of strategic performance objectives, indicators and targets.

The SESAR Performance Framework is structured around the 11 ICAO Key Performance Areas (KPAs) as defined in ICAO Doc 9883 [Ref 5]. The 11 ICAO KPAs are shown in Figure 10. Additionally, the SESAR concept relies on the Human as a key enabler to achieve the expected targets: “Human will remain central in the future European ATM system as managers and decision makers”. For this reason, the Human Performance of the people working in the aviation industry (both from an individual and a workforce perspective) will also be covered and addressed as a complementary performance area.
Table 2 provides the structured summary of the 2020 strategic design targets as identified in the European ATM Master Plan [Ref 2, section 2.1.1, Table 1]. The SESAR strategic performance objectives and targets represent the design goal for the performance to be achieved in 2020. In a number of cases, intermediate (pre-2020) and long-term (post-2020) targets have also been defined. Some targets are at the level of total annual performance of the European ATM Network, others at hourly local level. In most cases, the objectives and targets specify the desired ATM outcome; in some specific cases they address internal ATM aspects, i.e. the need to improve the performance of certain management processes.
## Table 2 Summary of the 2020 Performance Targets as defined by the SESAR Definition Phase

<table>
<thead>
<tr>
<th>KPA</th>
<th>Key Performance Indicator (KPI)</th>
<th>Baseline</th>
<th>2020 Design Target</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Year</td>
<td>Value</td>
</tr>
<tr>
<td>Capacity</td>
<td>Annual IFR flights in Europe</td>
<td>2005</td>
<td>9.2 M</td>
</tr>
<tr>
<td></td>
<td>Daily IFR flights in Europe</td>
<td>2005</td>
<td>29,000</td>
</tr>
<tr>
<td></td>
<td>Best In Class (BIC) declared airport capacity in VMC (1 RWY), mov/hr</td>
<td>2008</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>BIC declared airport capacity in VMC (2 parallel dependent RWYs), mov/hr</td>
<td>2008</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>BIC declared airport capacity in VMC (2 parallel independent RWYs), mov/hr</td>
<td>2008</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>BIC declared airport capacity in IMC (1 RWY), mov/hr</td>
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<td></td>
<td>BIC declared airport capacity in IMC (2 parallel dependent RWYs), mov/hr</td>
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<td>45</td>
</tr>
<tr>
<td></td>
<td>BIC declared airport capacity in IMC (2 parallel independent RWYs), mov/hr</td>
<td>2008</td>
<td>45</td>
</tr>
<tr>
<td>Cost</td>
<td>Total annual en-route and terminal ANS cost in Europe, €/flight</td>
<td>2004</td>
<td>800</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Scheduled flights departing on time (as planned)</td>
<td></td>
<td>&gt;98%</td>
</tr>
<tr>
<td></td>
<td>Avg. delay of the remaining scheduled flights</td>
<td></td>
<td>&lt;10 min</td>
</tr>
<tr>
<td></td>
<td>Flights with block-to-block time as planned</td>
<td></td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>Avg. block-to-block time extension of the remaining flights</td>
<td></td>
<td>&lt;10 min</td>
</tr>
<tr>
<td></td>
<td>Flights with fuel consumption as planned</td>
<td></td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>Avg. additional fuel consumption of the remaining flights</td>
<td></td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Accommodation of VFR-IFR change requests</td>
<td></td>
<td>&gt;98%</td>
</tr>
<tr>
<td></td>
<td>Unscheduled flights departing on time (as requested)</td>
<td></td>
<td>&gt;98%</td>
</tr>
<tr>
<td></td>
<td>Avg. delay of the remaining unscheduled flights</td>
<td></td>
<td>&lt;5 min</td>
</tr>
<tr>
<td></td>
<td>Scheduled flights with departure time as requested (after change request)</td>
<td></td>
<td>&gt;98%</td>
</tr>
<tr>
<td></td>
<td>Avg. delay of the remaining scheduled flights</td>
<td></td>
<td>&lt;5 min</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Coefficient of variation for actual block-to-block times: for repeatedly flown routes</td>
<td></td>
<td>&lt;1.5%</td>
</tr>
<tr>
<td></td>
<td>Flights arriving on time (as planned)</td>
<td></td>
<td>&gt;95%</td>
</tr>
<tr>
<td></td>
<td>Avg. arrival delay of the remaining flights</td>
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<td>&lt;5 min</td>
</tr>
<tr>
<td></td>
<td>Total reactionary delay</td>
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<td>&lt;10 min</td>
</tr>
<tr>
<td></td>
<td>Reactionary flight cancellation rate</td>
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</tr>
<tr>
<td></td>
<td>Total service disruption delay</td>
<td>2010</td>
<td></td>
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<tr>
<td></td>
<td>Percentage of diversions caused by service disruption</td>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>Annual European-wide absolute number of ATM induced accidents and serious or risk bearing incidents</td>
<td>2005</td>
<td></td>
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<tr>
<td></td>
<td>Safety level (per flight)</td>
<td>2005</td>
<td></td>
</tr>
</tbody>
</table>
A2.3 Performance Framework

The following sections reiterate the high level overview of the SESAR performance framework as it appears in the D5 document [Ref 2, section 9.4] in Table 31 per KPA. Due to the different nature and maturity of the various KPAs, there is a mix of quantified requirements (i.e. objectives with performance targets) and qualitative requirements (i.e. performance objectives without quantitative targets).

A2.3.1 Performance Objectives and Targets at Different Levels

The evolution of ATM performance is expressed in terms of a top-down hierarchy of objectives and targets, as schematically illustrated in Figure 11:

![Figure 11 Hierarchy of Performance Objectives and Targets](image)

1. At the highest level, we find the political vision for capacity, safety, environmental effects and cost. These statements drive the SESAR programme at political level. They are widely communicated amongst the general public. This political vision is outlined in section 2.3.1.

2. Below this are the SESAR Strategic Performance Objectives and Targets in the eleven ICAO Key Performance Areas. This is the set of high level targets which have been elaborated during the SESAR Definition Phase. This is design guidance for the SESAR Development Phase. Section A2.1 provides an overview, whereas section A2.3 provides more detail and clarification.
3. The third level is the home for the so-called “secondary” (i.e. cascaded-down, more specific) objectives, indicators and design targets for performance drivers which underpin the strategic objectives and targets\(^2\). Most of these are yet to be developed — hence they are not included in this edition of the guidance material. On one hand, they will incorporate the top-level (strategic) trade-off decisions to be made during the SESAR Development Phase. On the other hand, by being more specific, they will trigger and drive change at a level which is closer to the “solution level” described in the other Annexes. In other words, in future editions the role of the guidance material contained in these other Annexes will be to respond to these secondary objectives and targets, rather than to provide direct traceability to the highest level of the performance framework (link changes only to KPAs).

4. The bottom level comprises the community-wide plus the local and regional deployment targets. Only this level represents commitment to deployment. This information does not belong in the guidance material for Performance. It will be found in the European and Local Single Sky Implementation (ESSI/LSSI) Plans.

A2.3.2 Common Themes (Lifecycle Oriented Focus Areas)

The performance in all KPAs is the result of a chain of various elements, which build upon each other\(^3\). They are summarised in Figure 12, which serves to illustrate the top-level framework which has been used for defining the main Focus Areas in some of the performance areas.

![Figure 12 Common Themes for Performance Management](image)

**Knowledge Management**: to achieve continuous improvement, some of the performance areas rely heavily on a growing body of knowledge. This Focus Area is intended to cover improvements to the build-up of KPA-related knowledge, the collection and dissemination (sharing) of such information. For example improvements to the Safety Library, improvements to incident reporting, etc.

**Design**: this Focus Area is intended to cover improvements to the drivers, enablers and building blocks for organisational maturity. This includes the timely availability of methods to stimulate or enforce organisational performance (guidance material, specifications, standards, regulations, incentives, target setting, performance review etc.) at National, European and Global level; built-in (latent) performance capabilities of operating concepts/procedures and technical system designs (as developed during SESAR and demonstrated during pre-operational validation), and common methods/tools to support validation.

**Deployment**: this Focus Area takes a “static” view of individual Stakeholder organisations. It covers capability levels which translate into organisational maturity, i.e. the extent to which individual Stakeholder organisations (such as ANSPs) comply with applicable standards and regulations. In addition it covers how these organisations have implemented formal (standard) processes to manage performance (e.g. safety management system etc.), and have improved less tangible aspects such as their ‘internal culture’. By taking the ECAC-wide perspective (looking at the evolving maturity score of

\(^2\) For all secondary targets which will be set during the SESAR Development Phase, traceability will be established from secondary targets to the strategic targets (through influence models). Typical examples of secondary targets for performance drivers would be: required evolution of the controller population in Europe (long-term manpower requirement), required evolution of controller productivity as a result of automation, required evolution of the number of sectors in Europe, etc. The above example targets would be made traceable to the strategic cost effectiveness target. The secondary targets represent policy and/or design decisions which explain how the strategic targets will be reached.

\(^3\) The Design / Deployment / Operations sequence is a simplified version of the SESAR ATM Lifecycle.
all organisations), it is possible to keep track of whether ATM modernisation progress takes place amongst Stakeholders as planned, and whether we are on the way to harmonise maturity levels throughout Europe. Organisational maturity targets through time (such as safety maturity targets of the PC) are an expression of the deployment strategy which is one of the subjects required to be addressed from each of the four perspectives: Performance, Network, Information Management and Infrastructure.

**Operations**: this Focus Area takes a “dynamic” view of individual organisations. It serves to describe (at the level of individual stakeholders) the performance of their performance management processes in terms of inputs (consumed resources) and outputs (direct results, with the exclusion of outcome).

**Outcome**: this Focus Area serves to express the effect of performance management in the field of interest, i.e. the (to be) achieved performance result in the KPA(s), aggregated over a certain time period, geographical scope etc.

All of the above Focus Areas can be approached in a performance based way, with the definition of objectives, indicators and possibly targets.

**A2.3.3 Societal Outcome KPAs**

**A2.3.3.1 Safety**

The Safety KPA addresses the risk, the prevention and the occurrence and mitigation of air traffic accidents.

Table 3 lists the strategic performance objectives for Safety. The table also lists the associated indicators and targets [Ref 2, section 9.4, Table 31].

**Table 3 Strategic Performance Objectives for Safety**

<table>
<thead>
<tr>
<th>KPA</th>
<th>Main Focus Areas</th>
<th>Lower Level Focus Areas</th>
<th>Objectives &amp; Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>ATM-related Safety Outcome</td>
<td>ATM Induced Accidents and Incidents</td>
<td>Ensure that the numbers of <strong>ATM induced accidents and serious or risk bearing incidents</strong> (includes those with direct and indirect ATM contribution) do not increase and, where possible, decrease (SESAR)</td>
</tr>
<tr>
<td></td>
<td>Safety Mgmt. Practices and Safety Culture</td>
<td>Maturity Level of Organisations</td>
<td>All ANSPs and regulators are expected to achieve agreed maturity levels</td>
</tr>
</tbody>
</table>

Figure 13 shows the Safety KPA focus areas, objectives and targets.

**A2.3.3.2 ATM-related Safety Outcome**

The strategic safety objective is to “ensure that the numbers of ATM induced accidents and serious or risk bearing incidents (includes those with direct and indirect ATM contribution) do not increase and, where possible, decrease”. It corresponds to a safety target which represents the **acceptable level of safety** in Europe.
Approximately 95% of all commercial air transport accidents in Europe do not have an ATM related contributing factor. From a scoping perspective, this means that the role of the ATM strategic safety objective is to focus on 5% of the total number of commercial air transport accidents.

In the light of the anticipated traffic increase, this objective implies the requirement to increase the relative safety level per flight. To meet the strategic objective under the most challenging traffic scenario (the one used to set the capacity targets), the safety level per flight will have to increase by at least a factor of 2.5 during the period 2005 to 2030.

This improvement will be achieved through:

- Safety management improvements outlined in section A3 of this document;
- Increased safety management maturity of stakeholders; and
- Safety features included in the new operational concept.

During the SESAR Definition Phase, no key performance indicators and associated performance targets had been formally identified for this KPA. As part of the implementation of an ATM Performance Strategic Guidance, these indicators and targets will have to be further defined and developed.

### A2.3.3.3 Security

The Security KPA covers a subset of aviation security. It addresses the risk, the prevention, the occurrence and mitigation of unlawful interference with flight operations of civil aircraft and other critical performance aspects of the ATM system. This includes attempts to use aircraft as weapons and to degrade air transport services. Unlawful interference can occur via direct interference with aircraft, or indirectly through interference with ATM service provision (e.g. via attacks compromising the integrity of ATM data or services). ATM security also includes the prevention of unauthorised access to and disclosure of ATM information.

Table 4 lists the strategic performance objectives for Security [Ref 2, section 9.4, Table 31].

**Table 4 Strategic Performance Objectives for Security**

- **Improve ATM Self Protection**: introduce improvements in managing the risk, the prevention, the occurrence and mitigation of unlawful interference with flight operations of civil aircraft and with ATM service provision (e.g. via attacks compromising the integrity of ATM data, services, facilities and staff). ATM Self Protection also includes the prevention of unauthorised access to and disclosure of ATM information;
- **Improve Collaborative Security Support**: provide improved support to State institutions / agencies that deal with in flight security incidents and to respond effectively to such incidents when they happen.

The focus areas, objectives and targets for the Security KPA are shown in Figure 14.
### KPA Main Focus Areas Lower Level Focus Areas Objectives & Targets

<table>
<thead>
<tr>
<th>Security</th>
<th>Security Outcome</th>
<th>Security Incidents</th>
<th>Lower Level Focus Areas</th>
<th>Objectives &amp; Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower Level Focus Areas</td>
<td>Ensure resilience of the ATM System (against security threats)...</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>While not placing any constraint on the operations of the ATM System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ATM Self Protection</td>
<td></td>
<td>Improve Collaborative Security Support</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collaborative Support</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Figure 14 Security Focus Areas, Objectives and Targets

The strategic security objective is to “ensure resilience of the ATM System while not placing any constraint on the operations of the ATM System”. The ATM System is a key enabler of air transportation. To ensure continued provision of services and the efficiency of the mission/business trajectory, disruptions shall be restricted to ‘extreme events’ and limited to a subset of system functions and capabilities. Degradation of service levels shall be recovered within a proportionate period of time.

ATM Security is concerned with those threats that are aimed at the ATM System directly, such as attacks on ATM assets, or where ATM plays a key role in prevention or response to threats aimed at other parts of the aviation system (or national/international assets of high value) and limiting the effect on the overall ATM network.

ATM Security Management Operations can be broken down into:

- Self-Protection; and
- Collaborative support.

Self-Protection of the ATM System aims to improve managing risk, prevention, occurrence and mitigation of unlawful interference with flight operations of civil aircraft and with ATM service provision (e.g. via attacks compromising the integrity of ATM data, services, facilities and staff). ATM Self Protection also includes the prevention of unauthorised access to and disclosure of ATM information.

Collaborative Support aims to improve the support to State institutions / agencies that deal with in-flight security incidents and to respond effectively to such incidents when they happen.

The latter is closely linked with Airspace Security. Airspace security is a national responsibility and deals with the safeguarding of the air or from unauthorised use, intrusion, illegal activities or any other violation.

Although not a new subject, the heightened and emerging threat from adversaries and vulnerabilities to these threats have gained higher importance. During the SESAR Definition phase an initial attempt took place to frame ATM Security by defining its scope. However, no strategic performance targets and associated key performance indicators have been identified. As part of the implementation of an ATM Performance Strategic Guidance, these indicators and targets will have to be further defined and developed.

#### A2.3.3.4 Environmental Sustainability

Aviation has a diverse impact on the environment, but not all aspects can be influenced by the ATM system. The Environmental Sustainability KPA addresses the role of ATM in the management and control of environmental impacts. The aims are to reduce adverse environmental impacts (average per flight); to ensure that air traffic related environmental constraints are respected; and, that as far as possible new environmentally driven non-optimal operations and constraints are avoided or optimised as far as possible. This focus on environment must take place within a wider “sustainability” scope that takes account of socio-economic effects and the synergies and trade-offs between different sustainability impacts.

Table 5 lists the strategic performance objectives for Environmental Sustainability [Ref 2, section 9.4, Table 31].
To meet society’s expectation to reduce the environmental impact of aviation, a collective effort is required from all Stakeholders in the European air transport industry. The “Clean Sky” JTI (Joint Technology Initiative) of the EC will accelerate the introduction of green technologies in new generation aircraft for a sooner green aviation, whereas the aim of SESAR is to complement this by improved air traffic services resulting in flight operations which are better optimised from an environmental sustainability perspective. The latter has been translated into the following SESAR performance objectives:

- **Achieve emission improvements** as an automatic consequence of the reduction of gate to gate excess fuel consumption addressed in the KPA Efficiency. The SESAR target for 2020 is to achieve 10% fuel savings per flight as a result of ATM improvements alone, thereby enabling a 10% reduction of CO₂ emissions per flight;

- **Improve the management of noise emissions and their impacts**: to ensure that these are minimised for each flight to the greatest extent possible;

- **Improve the role of ATM in enforcing local environmental rules**: ensure that flight operations comply 100% with aircraft type restrictions, night movement bans, noise routes, noise quotas, etc. Ensure that exceptions are only allowed for safety or security reasons;

- **Improve the role of ATM in developing environmental rules**: The aim is to ensure that all proposed environmentally related ATM constraints will be subject to a transparent assessment with an environment and socio economic scope; and, following this assessment the best alternative solutions from a European Sustainability perspective are adopted.

The Environmental Sustainability KPA focus areas, objectives and targets are shown in Figure 15.

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**Figure 15 Environmental Sustainability Focus Areas, Objectives and Targets**

Technological improvements will deliver the biggest environmental benefits from the aviation industry. However, the overall fleet’s environmental performance in 2020 will be driven more by incremental improvements related to the rate of fleet renewal than by the introduction of new production aircraft. This should improve efficiency by about 1% annually. Since the successors to the A320 and B737

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5 The purpose of Clean Sky is to demonstrate and validate the technology breakthroughs that are necessary to make major steps towards the environmental goals set by ACARE - Advisory Council for Aeronautics Research in Europe - the European Technology Platform for Aeronautics & Air Transport and to be reached in 2020: 50% reduction of CO₂ emissions through drastic reduction of fuel consumption; 80% reduction of NOx emissions (Nitrogen Oxides); 50% reduction of external noise; A green product life cycle: design, manufacturing, maintenance and disposal / recycling. (source: www.cleansky.eu)
aircraft are approximately a decade away from commercial operation, the environmental performance of the fleet in 2020 is more or less set. Even so, despite current economic problems, traffic should still grow significantly over the next decade. As a result, the environmental impact of aviation will inevitably grow at a time when both tolerance of this is decreasing and the impact of climate change is beginning to be felt.

Aviation stakeholders are now looking to ATM to help minimise the gap between growth and impact prior to the introduction of much more environmentally compatible aircraft. ATM has before it, therefore, a ten-year period during which its aviation sector partners will expect it to deliver a network that (a) decreases environmental impact per flight; (b) allows new production aircraft to achieve their maximum possible environmental performance; and (c) is sufficiently agile to adapt to environmental constraints as and when they emerge.

In general, therefore, the desired outcome is to ensure that ATM contributes to the aviation industry’s retaining its license to operate and grow, through the delivery of the most environmentally compatible gate-to-gate flow of traffic within the various business, operational, environmental and other constraints imposed by and upon the industry.

ATM can help to minimise the three principal environmental impacts of aviation, as follows.

**Atmospheric Effects**

The political objective is to reduce CO₂ emissions by 10% per flight by 2020. Given the linear relationship between fuel burn and CO₂ emissions, this in fact requires a reduction in fuel burn of an equivalent amount and is already covered in the Fuel Efficiency Focus Area of the Efficiency KPA.

A reduction in 10% in fuel burn per flight may in fact prove too costly to achieve at the network level. Hence, a close relationship between ATM (through SESAR) and CLEAN SKY will be necessary to ensure that this target will be met.

There is growing pressure to minimise the non-CO₂ effects of fuel burn on the atmosphere. ATM must be in a position to understand the impact this may have on operations when the scientific evidence is sufficiently strong for policy makers to demand such action.

**Local Air Quality Effects**

Local atmospheric pollution has an impact on public health. The majority of gaseous emissions in the vicinity of airports comes from road transport. Nevertheless, ATM can minimise air traffic’s contribution to local atmospheric pollution by ensuring the most efficient flow of air traffic to reduce fuel burn during surface operations. This is also covered in the Fuel Efficiency Focus Area of the Efficiency KPA.

**Noise Effects**

The European population adversely affected by aircraft noise is likely to increase as traffic grows at existing airports and spreads to other airports, despite improved airframe/engine noise performance. Although local land use planning regulations heavily determine the residential areas around an airport, ATM clearly has the capacity to minimise noise impact on the local population. It can achieve this by keeping aircraft higher for longer on approach, ensuring that they climb more quickly on departure, that they avoid noise-sensitive areas through strict adherence to noise abatement operational procedures, and the rigorous application of local environmental rules.

**Research and Development**

The SESAR Development Phase will be used to establish the processes, methodologies, tools and other resources to assess the environmental impact of ATM improvements, as well as the interdependencies across environmental issues and other performance areas. Operational mitigation of emerging environmental impacts will be investigated through SESAR, which will also analyse how to successfully introduce new aircraft designs within an ATM system handling up to 50,000 flights per day.

**Environmental Decision-Making within ATM**

ATM organisations have to ensure that all personnel whose actions could have an environmental impact possess a sufficient level of knowledge to understand the consequences of their actions or proposals; and that the management systems are in place to ensure that environment is incorporated into their decision making.
A2.3.4 Operational Performance KPAs

A2.3.4.1 Cost Effectiveness

The Cost Effectiveness KPA addresses the cost of gate-to-gate ATM in relation to the volume of air traffic that is managed.

Table 6 lists the strategic performance objectives for Cost Effectiveness. The table also lists the associated indicators and targets [Ref 2, section 9.4, Table 31].

Table 6 Strategic Performance Objectives for Cost Effectiveness

- Total annual en route and terminal ANS cost in Europe (gate to gate ATM cost): the 2004 baseline was €7,000M for 8.7 million flights (€800/flight). In 2020, this total annual cost should stay below €6,400M for 16 million flights (€400/flight, a reduction of 50% per flight). Baseline and 2020 target are expressed in 2005 euros.

Figure 16 shows the focus areas, objectives and targets for cost-effectiveness. It includes the targets for direct cost of gate to gate ANS and objectives for other airspace user costs.

The "Direct Cost of Gate-to-Gate ATM" includes:
- Future Airspace User costs to deploy SESAR and additional operating costs related to their increasing role in ATM;
- Gate-to-Gate ANS Costs comprising both en-route and terminal ANS costs.
Direct costs of ATM include both costs of investing and operating infrastructure used for ATM on the ground and on-board of aircraft. Operational improvements can reduce direct costs through for example, increases in ANS productivity.

The Fragmentation Study [Ref 8] has estimated that the fragmentation of European airspace and corresponding service provision costs more that €1bn a year to airspace users. The required cost reduction cannot be achieved without addressing this fragmentation as a matter of priority.

Indirect ATM costs are attributable to non-optimal gate-to-gate ATM performance. The scope covers the extra costs incurred by airspace users through non-optimum performance in the Efficiency, Flexibility and Predictability KPAs (the so-called “Quality of Service” KPAs). In practical terms: indirect ATM cost is the extra cost incurred by airspace users through delays, route inefficiencies, extra fuel consumption etc.

The political target of 50% direct cost reduction between 2004 and 2020 is to be achieved via a 3% per annum ANS cost reduction until 2010 (matching the PC target), followed by a 5% per annum ANS cost reduction until 2020. A major consequence of setting such targets is that the total European gate-to-gate ANS cost will still be increasing in absolute terms until 2010, but thereafter would have to start decreasing. This is graphically shown in Figure 17, which corresponds to Figure 94 in PRR2007\(^6\).

![Cost Effectiveness Target](image)

**Figure 17 Planned Evolution of Gate-to-Gate ANS Cost (total for Europe)**

**A2.3.4.2 Capacity**

The Capacity KPA addresses the ability of the ATM system to cope with air traffic demand (in number and distribution through time and space).

Table 7 lists the strategic performance objectives for Capacity. The table also lists the associated indicators and targets [Ref 2, section 9.4, Table 31].

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\(^6\) Note that Figure 94 in PRR2007 [Ref 10] is expressed in 2006 euro’s, whereas Figure 17 in this document is expressed in 2005 euro’s to match the values as published during the SESAR Definition Phase.
Table 7 Strategic Performance Objectives for Capacity

- **ATM Network capacity**: ability to accommodate 16 Million flights/year and 50,000 flights/day in Europe by the year 2020 (73% increase over 2005 traffic levels). The concept should be able to handle at least 3 times more traffic (en route and airport network), so as to be able to handle traffic growth well beyond 2020.

- **Local airspace capacity**: The above are the average European design targets (at network level). When transposing this to local targets, regional differences will exist. The ATM target concept should be able to support a tripling or more of traffic where required.

- **Best in class declared airport capacity in Visual Meteorological Conditions (VMC)**: 60 mov/hr (single RWY), 90 mov/hr (parallel dependent RWYs), 120 mov/hr (parallel independent RWYs). This represents an improvement of 20% with respect to current best in class performance.

- **Best in class declared airport capacity in Instrument Meteorological Conditions (IMC)**: 48 mov/hr (single RWY), 72 mov/hr (parallel dependent RWYs), 96 mov/hr (parallel independent RWYs). This aims to reduce the gap between IMC and VMC capacity from 50% (2008) to 20% (2020).

Notes:
1. No best in class targets have been defined for complex airports (3 or more runways). These airports will have to be looked at individually.
2. Capacity varies in function of the chosen/accepted trade offs with performance degradation in other KPAs. All capacity targets above are to be understood as the maximum throughputs that can be achieved while still respecting the targets for Safety and QoS (Quality of Service): Efficiency, Flexibility and Predictability. In order to meet these targets which are far more stringent than today’s QoS performance, extra capacity headroom will need to be created beyond the basic capacity enhancement that is required to accommodate the increased traffic demand.

Figure 18 shows the focus areas, objectives and targets for Capacity.

<table>
<thead>
<tr>
<th>KPA</th>
<th>Main Focus Areas</th>
<th>Lower Level Focus Areas</th>
<th>Objectives &amp; Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td></td>
<td></td>
<td><strong>Annual IFR Throughput</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>2020: 16 Million flts/year (SESAR)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Daily IFR Throughput</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>2020: 50,000 flts/day (SESAR)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>20XX (Full deployment of ATM Target Concept, i.e full deployment of ATM Service Level 5): tripling of capacity where required (SESAR)</strong></td>
</tr>
<tr>
<td><strong>Network Capacity</strong></td>
<td></td>
<td><strong>BIC Capacity in VMC</strong></td>
<td><strong>2020: 60 mov/hr (SESAR)</strong></td>
</tr>
<tr>
<td><strong>Local Airspace Cap</strong></td>
<td></td>
<td><strong>BIC Capacity in IMC</strong></td>
<td><strong>2020: 48 mov/hr (SESAR)</strong></td>
</tr>
<tr>
<td><strong>Airport Capacity</strong></td>
<td></td>
<td><strong>Single RWY</strong></td>
<td><strong>2020: 20 mov/hr (SESAR)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Parallel Dep. RWY</strong></td>
<td><strong>2020: 72 mov/hr (SESAR)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Parallel Indep. RWY</strong></td>
<td><strong>2020: 96 mov/hr (SESAR)</strong></td>
</tr>
</tbody>
</table>
**A2.3.4.2.1 Network Capacity**

The network-wide (i.e. European) capacity deployment target is driven by the most challenging (i.e. highest growth) scenario in the Long Term Forecast. This has led to the SESAR strategic performance targets for 2020: 16 million IFR flights annually and 50,000 IFR flights during peak days, which represents a 73% increase between 2005 and 2020. This leads to the objectives and targets as depicted in Figure 18.

![European Network-wide Capacity Target](image)

**Figure 19 European Network-wide Capacity Targets for Intermediate Years**

Figure 19 shows the evolution of the network-wide capacity target through time. From this, the targets for the SESAR key intermediate years have been derived.

The annual target (left axis, red line) shows the required throughput per calendar year. The daily target (right axis, dark blue boxes) shows the required throughput during the busiest day of each calendar year.

**A2.3.4.2.2 Airspace Capacity**

From an individual airspace volume perspective, it can be foreseen that the way to deploy capacity improvements is dependent on the traffic density and will not be needed in a uniform way. Due to the geographical differences in traffic density, some parts of European airspace need to deploy earlier than others. It is also expected to see a geographic mix of capacity improvements deployed in any given year, with highest levels in the core area of Europe. This is depicted with a geographic perspective in Figure 20 for the year 2025.
A2.3.4.2.3 Airport Capacity

The targets for airport capacity apply to the Best-in-Class (BIC) airports only. These airports represent the most challenging environments where concept changes (rather than best practices) are needed to break through the capacity barrier.

A2.3.4.3 Quality of Service - Principles and Definitions

To support their businesses (and missions) adequately, civil (and military) airspace users are demanding much higher Quality of Service (QoS) levels, i.e. efficiency, flexibility and predictability, than ATM has been able to offer in the past. Because the subject of QoS has many facets and the SESAR performance framework has proposed a number of changes with respect to the approach followed in today’s performance review practices, a number of principles and definitions are first clarified.

Quality of Service (QoS) covers the ICAO KPAs Efficiency, Flexibility and Predictability. Performance measurement in these areas consists of comparing “business trajectories as flown” with earlier versions of these trajectories, as recorded during the ATM planning process. The versions against which comparisons are to be made, need to be standardised. The SESAR performance framework uses the SESAR Business Trajectory (BT) Lifecycle to establish this standard. The scope of each QoS KPA with respect to the BT Lifecycle is illustrated in Figure 21 which is based on definitions contained in “SESAR Performance Objectives and Targets” [Ref 9].

- **Efficiency KPA**: comparison of Executed BT against the Initial Shared Business Trajectory (ISBT), adjusted for actual weather. The adjustment is necessary because the ISBT is based on weather assumptions which may be significantly different from the weather actually encountered:
  - The adjusted ISBT represents the “business optimum” of the Airspace User, and is therefore the yardstick for assessing the level of Flight Efficiency that should be enabled by ATM.

- **Flexibility KPA**: comparison of Executed BT against the Coordinated Shared Business Trajectory (CSBT):
  - The CSBT is the end result of Collaborative Decision Making (CDM);
  - Trajectory changes made during CDM are outside the scope of the Flexibility KPA.

- **Predictability KPA**: comparison of Executed BT against the Reference Business Trajectory (RBT) at the time of departure (off-blocks):
  - All pre-departure changes are considered out-of-scope for the Predictability KPA;
  - Focus of the Predictability KPA is on block-to-block and arrival performance.
### Figure 21 SESAR Business Trajectory Lifecycle

During the development of the SESAR performance framework, the Stakeholders have provided some additional guidance with respect to the future management, measurement and evolution of QoS performance. The following list summarises some of the most salient points:

- Higher QoS expectations place a higher emphasis on counting the number of flights which operate “on-time”, while reducing the role of delay measurement:
  - Today a variety of definitions for “on-time” are used. In some cases a delay threshold of 15 minutes delay is used, sometimes it is 5 minutes etc. In the SESAR performance framework a more stringent definition of “on-time” is adopted: all related indicators use a standard delay threshold of 3 minutes, which is a value commonly used by the airlines for internal purposes. Likewise, a threshold of -3 minutes is used to determine whether early flights are classified as early or on-time;
  - Delay indicators are used throughout the SESAR performance framework, but their purpose is to ensure an acceptable QoS for those flights which are not on-time (with delay > 3 min). On average, the on-time flights may have a delay of 1 to 2 minutes, but these delay minutes are not included in the calculation of the SESAR delay indicators.

- The SESAR performance framework implies the introduction of the principle of segmented QoS management: different sub-segments within the total flight population will be managed to different performance targets. Because SESAR has defined QoS indicators and targets per sub-segment, each individual flight will need to be assigned to the appropriate sub-segment during planning, operations and post-operational data collection:
  - Distinction is made between unaccommodated demand and successfully accommodated flights: “Successfully accommodated” means that the Business Development Trajectory (BDT) could successfully be transformed into an Initial SBT (ISBT). This is related to the capacity of the ATM network in the pre-tactical and tactical time frame. A strategic demand/capacity balancing process has already taken place (e.g. airport slots allocation, airspace capacity planning), which ensures that in nominal conditions (see below), all ISBT flights can be accommodated with the expected quality of service;
Annex A: Performance

- QoS distinction will be made between flights which issue “requests for flexibility” and those which do not ask for trajectory changes after the completion of CDM. Requests for flexibility are those (late) trajectory change requests which are initiated by the Airspace Users for reasons other than ATM;

- QoS distinction will be made between flights which take place under:
  - nominal conditions (capacity > 90% of nominal declared capacity);
  - degraded conditions (capacity 50-90% of nominal declared capacity); and
  - disrupted conditions (capacity < 50% of nominal declared capacity).

- QoS distinction will be made between flights which are on-time and those which are not on-time (see above);

- QoS distinction will be made between flights which suffer from “reactive conditions” (late arrival of aircraft or crew, leading to reactionary delays, diversions or cancellations) and those which are not subject to reactionary conditions;

- QoS distinction will be made between:
  - scheduled and unscheduled traffic;
  - civil and military traffic;
  - IFR and VFR traffic.

It is clear that QoS delivery is strongly linked with the BT Lifecycle, the SESAR Concept of Operations (ConOps) and the roles and responsibilities in the ATM Performance Partnership (ATMPP). It is recognised that there are still some ambiguities. These areas are subject to refinement as part of the SESAR Development Phase. Correspondingly, the underlying definitions for QoS performance are also subject to refinement. This will be reflected in future editions of this guidance material.

A2.3.4.4 Efficiency

The Efficiency KPA addresses the extent to which ATM facilitates temporal efficiency (on-time departure and optimum gate-to-gate flight duration), gate-to-gate fuel efficiency (prevention of unnecessary fuel consumption) and military mission effectiveness (ability to conduct training missions in the vicinity of air bases).

The strategic objectives and targets for flight efficiency established by SESAR are shown in Table 8.

<table>
<thead>
<tr>
<th>Table 8 Strategic Performance Objectives for Efficiency</th>
</tr>
</thead>
</table>

For those airspace users ready to fly as initially planned (Initial Shared Business Trajectory), the performance objectives and targets for 2020 are:

- **Better departure punctuality**: 98% of flights departing as planned (3 min tolerance); for the other flights, the ATM delay should be less than 10 minutes (on average);

- **Less deviation from the planned block to block time**: 95% of flights flown as planned (3 min tolerance); for the other flights, the block to block extension should be less than 10 minutes (on average);

- **Improved fuel efficiency**: 95% of flights flown with fuel consumption as planned (2.5% tolerance); for the other flights, additional fuel consumption should be less than 5% (on average).

For the military airspace users who conduct training activities:

- **Reduce the economic impact of transit**: measured as the total cost of transit from base to training area and back;

- **Improve the impact of airspace location on training efficiency**: more time spent actually in the designated operating area, achieving the mission training objectives, compared with the total time airborne.

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7 Definition in SESAR: scheduled means that the ISBT is made available at least the day before operations; non-scheduled means that the ISBT is made available on the day of operation.
Target on G2G Flight Duration: the loss of time during taxi and airborne flight phases is to be kept to less than 2.5% of the reference flight duration, for at least 95% of all flights operating during non-disrupted conditions. For the flights which exceed this threshold, the loss of time should be less than 10 minutes on average. This reference flight duration is based on the business trajectory (route, vertical profile and airspeed) as published in the ISBT, with ground speed corrected for actual weather (actual wind speed and direction).

Target on G2G Fuel Efficiency: the combined fuel consumption penalty from taxi and airborne flight phases is to be kept to less than 2.5% of the reference fuel consumption, for at least 95% of all flights operating during non-disrupted conditions. For the flights which exceed this threshold, the fuel consumption penalty should be less than 5% on average.

**A2.3.4.5 Flexibility**

The Flexibility KPA addresses the ability of the ATM system and airports to respond to “sudden” changes in demand and capacity: rapid changes in traffic patterns, last minute notifications or cancellations of flights, changes to the Reference Business Trajectory (pre-departure changes as well as in-flight changes, with or without diversion), late aircraft substitutions, sudden airport capacity changes, late airspace segregation requests, weather, crisis situations, etc.

Table 9 lists the strategic performance objectives for Flexibility. The table also lists the associated indicators and targets [Ref 2, section 9.4, Table 31].
Table 9 Strategic Performance Objectives for Flexibility

For VFR flights, the performance objectives and targets for 2020 are:

- **Improved accommodation of VFR IFR change requests**: 98% of such requests should be accommodated without delay penalties.

For unscheduled IFR flights (users not providing early notification of flight intentions), the performance objectives and targets for 2020 are:

- **Better on time departure**: 98% of flights departing as requested (3min tolerance); the delay should be less than 5 minutes (on average).

For those airspace users unable to fly as initially planned, i.e. requesting late changes to the original plan, the performance objectives and targets for 2020 are:

- **Increased accommodation of new departure time for scheduled flights**: 98% of these flights departing as requested (3min tolerance); the imposed delay should be less than 5 minutes (on average);

- **Increased accommodation of new departure time, route, level and/or destination for scheduled and unscheduled flights**: 95% of such requests accommodated. Of these flights, 90% should be accommodated without imposing departure or arrival delays (3min tolerance); the other flights, the imposed delay should be less than 5 minutes (on average).

For all airspace users, there are additional objectives related to flexibility:

- Keep the number of flexibility requests (see above) as low as possible (in relation to the total volume of traffic);

- Inform the ATM System of the flexibility requests (see above) as early as possible.

With regard to the suitability of the ATM System for military requirements related to the flexibility in the use of airspace and reaction to short notice changes:

- Improve the ability to increase/decrease the amount of airspace segregation as required;

- Maximise adherence of military training activities to optimum airspace dimension;

- Improve the utilisation of segregated airspace by military training activities;

- **Improve the actual airspace usage** by military users compared with that booked by planners;

- Increase the amount of time that training in non segregated airspace is possible;

- Improve the release of airspace by military users.

Figure 23 shows the focus areas, objectives and targets for the Flexibility KPA.
Figure 23 Flexibility Focus Areas, Objectives and Targets

The Flexibility KPA covers the ATM system’s ability to accommodate non-scheduled\(^8\) IFR traffic; to support airspace user requests to modify their Business Trajectory after the CSBT has been established; to allow flexible use of airspace; and to respond to rapidly changing service delivery requirements.

\textbf{A2.3.4.5.1 Non-scheduled Traffic}

Non-scheduled IFR traffic consists mostly of military flights, Business Aviation, General Aviation IFR traffic and certain airline flights (e.g. repositioning and training flights). This includes flights which depart IFR but publish their ISBT only on the day of operation (“late filing”), as well as flights which have departed VFR but request an in-flight change to IFR (“air filing”).

At European annual level, it is expected that the total number of such flights will not exceed 20% of the overall IFR traffic volume. Locally however, wide variations will be seen. For example, there will be airports with almost no non-scheduled traffic, and airports exclusively used by non-scheduled traffic.

According to the SESAR performance targets, the vast majority of these flights should be accommodated without penalties. This means that the local demand for non-scheduled traffic should be forecasted with sufficient accuracy, and that a corresponding amount of spare capacity must be set aside during collaborative planning to accommodate such traffic.

\textbf{A2.3.4.5.2 Trajectory Modifications}

Airspace user requests to modify their Business Trajectory after the CSBT has been established are called “flexibility requests”. They imply a re-planning of traffic flows at a late stage (during flight or less than one hour before departure).

These requests are subdivided into two categories:

- “Time translation” flexibility requests modify the departure time and/or speed on the airspace user’s initiative, but leave the 3-D trajectory unchanged;
- “Full trajectory redefinition” flexibility requests include route and/or vertical profile changes.

\(^8\) Definition in SESAR: scheduled means that the ISBT is made available at least the day before operations; non-scheduled means that the ISBT is made available on the day of operation.
Similar to the requirement for non-scheduled traffic, the vast majority of these trajectory modification requests should be accommodated without penalties. This also means that a certain amount of spare capacity must be set aside to accommodate such traffic.

A2.3.4.5.3 Flexible Civil/Military Use of Airspace

A first objective is to improve civil-military coordination in order to be able to conduct a larger portion of military training in general use airspace. This is intended to lead to a reduction of the need to reserve Special Use Airspace (SUA).

In those cases where the use of SUA is unavoidable, booking procedures will need to be optimised to avoid overbooking as well as underbooking. This implies maximising adherence of the booking to the optimum airspace dimensions required for the mission, improving the utilisation of booked time, and in case missions are cancelled, to release the allocated SUA back to civil use as soon as possible, preferably before the planned start time of the airspace allocation. After such a release, a replanning of traffic flows must be triggered to ensure that the released airspace is used to full advantage of GAT traffic.

A2.3.4.5.4 Service Location Flexibility

Historically, there has been a mismatch between the speed at which airlines (in particular low cost carriers) open new routes, and the ability of ANSPs to respond to the corresponding ATM service delivery requirement. It has been easier to increase ATM capacity at locations where there was already service provision, than to establish services at airports and in airspace where previously no service was available. To do so may require substantial changes, such as installation of new ground equipment, new ATC facilities (e.g. TWR) with associated staff, reallocation and training of staff, new airspace structures, design of new procedures etc.

The performance objective in this Focus Area is to increase the responsiveness of ANSPs in such cases. This will be particularly important in the long term because many major airports will be congested, and the unaccommodated demand will be “driven” to smaller, regional airports.

A2.3.4.6 Predictability

The Predictability KPA addresses the ability of the ATM system to ensure a reliable and consistent level of 4D trajectory performance. In other words: across many flights, the ability to control the variability of the deviation between the actually flown 4D trajectories of aircraft in relationship to the Reference Business Trajectory.

Table 10 lists the strategic performance objectives for Predictability. The table also lists the associated indicators and targets [Ref 2, section 9.4, Table 31].
At European annual level, the predictability objectives and targets for 2020 are:

- **Less variation in the actual block to block times**: for repeatedly flown routes using aircraft with comparable performance, the statistical distribution of the actual block to block times should be sufficiently narrow: standard deviation less than 1.5% of the mean value for that route;

- **Better arrival punctuality**: 95% of flights arriving as planned (3 min tolerance); for the other flights, the delay should be less than 10 minutes (on average);

- **Less reactionary delay**: with respect to the total number of flights, reduced total amount of delay caused by the late arrival of the aircraft or the crew from previous journeys (between 2010 and 2020: 50% improvement);

- **Less reactionary flight cancellations**: with respect to the total number of flights, reduced percentage of cancellations caused by the late arrival of the aircraft or the crew from previous journeys (between 2010 and 2020: 50% improvement);

- **Less service disruption delay**: with respect to the total number of flights, reduced total amount of delay caused by service disruption (between 2010 and 2020: 50% improvement);

- **Less service disruption diversions**: with respect to the total number of flights, reduced percentage of diversions caused by service disruption (between 2010 and 2020: 50% improvement);

- **Less service disruption flight cancellations**: with respect to the total number of planned flights, reduced percentage of cancellations caused by service disruption (between 2010 and 2020: 50% improvement).

The focus areas, objectives and targets for the Predictability KPA are shown in Figure 24.
A2.3.4.6.1 Nominal Conditions

The performance targets for on-time operation and knock-on effects apply only to those flights which operate during nominal conditions, i.e. do not use airports or airspace which are operating below 90% of nominal capacity.

The purpose of reducing gate-to-gate variability is to allow airlines to reduce the schedule buffers during the production of Business Development Trajectories.

The purpose of improving arrival punctuality is to improve the effectiveness of hub operations, turn around management and airport operations (gate management).

Reactionary delays and cancellations can occur when arrival delays are bigger than the schedule buffer. So improved arrival punctuality also serves to prevent reactionary delays and cancellations.

A2.3.4.6.2 Degraded and Disrupted Conditions

Degraded conditions occur when airports or airspace are operating between 50 and 90% of nominal capacity, for whatever reason (low visibility, equipment failure, staff shortage, industrial action, blocked runway, etc.). Degraded conditions deteriorate into disrupted conditions when capacity sinks below 50%.

The approach for this type of situation is to reduce the number of times that degraded or disrupted conditions occur by reducing the impact of their causes on capacity. In other words, the network will be made more resilient against external disruptive causes which are not under control of ATM (e.g. low visibility conditions should have less effect on airport capacity), and by reducing the occurrence of internal (manageable) disruptive causes.

In those cases where degraded or disrupted conditions occur, the ATM system will need to ensure that nominal conditions are re-established as quickly as possible. The objective is to reduce the amount of time that ATM network nodes are operating below 90% of nominal capacity.

The benefit of this approach is that more flights will be operating under nominal conditions, thereby resulting in better predictability of traffic flows at network level, which in turn is an enabler for improved (daily and annual) network capacity.

Referring to the SESAR objectives of reducing the service disruption effect:

- Reducing the service disruption cancellation rate serves to protect daily and annual network capacity. It also helps to prevent airline schedule disruptions by reducing the number of displaced aircraft, crew and passengers due to cancellations;
- Reducing the service disruption flight diversion rate serves to prevent airline schedule disruptions by reducing the number of displaced aircraft, crew and passengers due to diversions;
- Reducing the service disruption delay serves to prevent knock-on effects (reactionary delays and cancellations) later during the day.

The solutions for improving performance in this area will need to come from:

- Better resilience against external causes of reduced capacity (e.g. low visibility);
- Better prevention of ATM-internal causes;
- Better contingency management;
- Better crisis management and disaster recovery.

A2.3.5 Performance Enabler KPAs

A2.3.5.1 Access and Equity

The Access and Equity KPA splits the management of airspace usage (and usage of other ATM resources such as airports and ATM services) into two distinct issues: access/segregation and equity/prioritization.

Table 11 lists the strategic performance objectives for Access and Equity [Ref 2, section 9.4, Table 31].
Table 11 Strategic Performance Objectives for Access and Equity

**Improve access:**
- Ensure that *shared use of airspace and airports* by different classes of airspace users will be significantly improved (classes defined by type of user, type of aircraft, type of flight rule);
- Where *shared use is conflicting* with other performance expectations (safety, security, capacity, etc.), ensure that viable airspace/airport alternatives will be provided to satisfy the airspace users’ needs, in consultation with all affected stakeholder (see Participation KPA).

**Improve equity:**
- For priority management, ensure that more options will be available than just the ‘first come first serve’ rule;
- Ensure that priority rules will always be applied in a transparent, correct manner.

The focus areas, objectives and targets for the Access & Equity KPA are shown in Figure 25.

**Figure 25 Access and Equity Focus Areas, Objectives and Targets**

No quantified design targets for access and equity have been defined yet; however qualitative strategic performance objectives have been formulated in section A2.1. Figure 25 is proposing a further break down into lower level focus areas and associated objectives and targets.

**A2.3.5.1.1 Access**

Scenarios for better shared use of airspace and use of airports shall be evaluated under the constraints being placed by the other KPAs. In the case of conflicts with other performance expectations, alternatives shall be provided for both consultation with stakeholders and subsequent agreements on trade-off scenarios.
A2.3.5.1.2 Equity

Improved priority management - going beyond the ‘first come, first serve’ rule – shall be provided. Priority management is to be assessed for potential conflicts with requirements from other performance expectations. Any rules shall be applied in a transparent and correct manner.

A2.3.5.2 Participation

At the level of overall ATM performance, the Participation KPA covers quite a diversity of objectives and involvement levels. Participation by the ATM community, both civil and military, can be considered in the following dimensions:

a) Separate involvement issues and approaches apply for each of the ATM lifecycle phases: planning, development, deployment, operation and evaluation/improvement of the system.

b) “Meeting the (sometimes conflicting) expectations of the community” implies that participation and involvement should be explicitly pursued for each of the other Key Performance Areas: access and equity, capacity, cost effectiveness, efficiency, environment, flexibility, global interoperability, predictability, safety, security.

c) Involvement should be monitored and managed per segment of the ATM community.

The three dimensions serve as a framework for focused tracking of the various participation and involvement initiatives, assessment of the actual level of involvement against the desired level, and identification of weaknesses and improvement opportunities.

The aim is to achieve a balanced approach to ATM community involvement.

Different methods and levels of involvement are possible: informing the community, obtaining feedback and advice from the community, collaborative decision making and consensus building.

Table 12 lists the strategic performance objectives for Participation [Ref 2, section 9.4, Table 31].

**Table 12 Strategic Performance Objectives for Participation**

- Improve participation by the Stakeholders / ATM Community:
  - During planning, development, deployment, operation and evaluation/improvement of the ATM system;
  - For all performance areas: access and equity, capacity, cost effectiveness, efficiency, environment, flexibility, interoperability, predictability, safety, security;
  - By involvement of all ATM community segments;
  - While respecting all applicable rules, regulations and legislation.

- Choose the most appropriate (combination of) method(s) and level of involvement (depending on the circumstances):
  - informing the community;
  - obtaining feedback and advice from the community;
  - collaborative decision making (CDM);
  - consensus building.

- Establish focused tracking of the various participation and involvement initiatives, assessment of the actual level of involvement against the desired level, and identification of weaknesses and improvement opportunities. The aim is to achieve a balanced approach to ATM community involvement.

The Participation KPA focus areas, objectives and targets are shown in Figure 26.
### Figure 26 Participation Focus Areas, Objectives and Targets

1. **Stakeholders involved during Performance Management**
   - a) Participation in Performance Framework Maintenance
      - i) Participation in definition of objectives & targets - each stakeholder shall have the opportunity to contribute to the definition of objectives and targets.
      - ii) Participation in definition of metrics & KPIs – these should reflect the needs of stakeholders.
   - b) Participation in Performance Review
      - i) Participation in performance assessment – the process shall be transparent to all stakeholders – the system shall allow each stakeholder to be involved in the assessment of performance.
      - ii) Participate in performance data reporting – stakeholders shall be part of a transparent performance reporting process, subject to the limitations of commercial confidentiality.

2. **Stakeholders involved during Operations**
   - a) Participation during planning - equal opportunity shall be provided to each stakeholder to participate in the planning – each stakeholder shall have the opportunity to be involved in the planning process at the appropriate time.
   - b) Participation during tactical ops – provide timely transfer of the CDM decision to the aircraft and crew – secure stakeholders involvement in pre-flight changes in an appropriate time frame – provide in-flight changes within the acceptable limits of safety and cost effectiveness.

3. **Stakeholders involved during Deployment**
   
   Participation during deployment planning – this should take into account individual stakeholder needs regarding the planning of deployment of new equipment, procedures or systems.

4. **Stakeholders involved during Design**
   
   Participation during R&D – all stakeholders shall have the opportunity to be involved in the R&D process.
5. Stakeholders involved during Regulation

Participation in development of new regulations – stakeholders shall be involved in the consultation phase avoiding conflicts of interest.

A2.3.5.3 Interoperability

At the level of overall ATM performance, the main purpose of the Interoperability KPA is to facilitate homogeneous and non-discriminatory global and regional traffic flows.

Applying standards and uniform principles, and ensuring the technical and operational interoperability of aircraft and ATM systems are to be seen as supporting (enabling) objectives for the above main objective.

Table 13 lists the strategic performance objectives for Interoperability [Ref 2, section 9.4, Table 31].

<table>
<thead>
<tr>
<th>Table 13 Strategic Performance Objectives for Interoperability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure that the application of standards and uniform principles, together with improved technical and operational interoperability of aircraft and ATM Systems will enable a measurable improvement of:</td>
</tr>
<tr>
<td>• The efficiency and flexibility of mission/business trajectories for intra European and intercontinental flights;</td>
</tr>
<tr>
<td>• Airspace and airport related access for intra European and intercontinental flights (both civil and military);</td>
</tr>
<tr>
<td>• Airspace and airport related equity for intra European and intercontinental flights (both civil and military).</td>
</tr>
</tbody>
</table>

The focus areas, objectives and targets for the Interoperability KPA are shown in Figure 27.
Figure 27 Interoperability Focus Areas, Objectives and Targets

The overall objective of Interoperability is to facilitate homogeneous and non-discriminatory global and regional traffic flows for both civil and military traffic.

Applying global standards and uniform principles and ensuring the technical and operational interoperability of aircraft and ATM Systems, both civil and military, are to be seen as supporting (enabling) objectives.

Interoperability breaks down into the following Main Focus Areas:

- impact of interoperability;
- deployment of interoperability;
- design of interoperability.

Impact of interoperability refers to the technical and operational benefits that can be exploited on the basis of application of standards and uniform principles. The principle of interoperability revolves around the positive impact on mission/business trajectory for flight operations, equity and access to airports and airspace.

In order to meet these objectives there is a requirement for interoperability to ensure a consistent set of capabilities. Based on this set of capabilities non-discriminatory operations of all airspace users can be assured through the provision of tailored service levels by ANSPs.
The harmonised and consistent application/utilisation of service/capability levels enhances flight efficiency through homogeneous traffic flows. The latter forming a basis for the provision of a consistent set of capabilities.

As service levels are linked to ATM Service system features and capabilities, the requirement for homogeneous and nominal provision of services will drive the design, implementation and operation of ATM System elements. This will result in performance-driven and efficient resource deployment and investment. Thus, interoperability will have a positive impact on cost effectiveness of service levels/capabilities.

Application of Standards and Uniform Principles can be seen as an enabler to facilitate seamless service provision on a regional and global level. Airspace Users will not perceive any differences in service provision. The principle of matching service/capability levels will form the basis for ensuring an efficient mission/business trajectory. In order to meet this target ATM operations and system capabilities will have to be compliant to an agreed set of standards.

Interoperability will be driven by technological advancements. This is strongly connected to the timely availability of standards, specifications and procedures. In order to facilitate homogeneous and non-discriminatory flight operations standardisation efforts have to be undertaken for all modes of interoperability: air-air, air-ground and ground-ground.

An underlying principle for enhanced interoperability is a common set of standards and associated service/capability levels within a geographic region. As air transportation has a global dimension, it will be required to drive interoperability beyond a regionally constrained context on a global level.

### A2.3.5.4 Human Performance

The Human Performance KPA addresses the central role of the Human in the future European ATM system as managers and decision makers.

Table 14 lists the strategic performance objective related to Human Performance in ATM.

**Table 14 Strategic Performance Objectives for Human Performance**

- Sufficient ATM staff is available with the right skills, competencies and means to discharge their responsibilities and deliver the expected volume and quality of ATM service.

The focus areas, objectives and targets for the Human Performance KPA are shown in Figure 28.
A2.3.5.4.1 Human Performance Outcome

The main objective, from a Human Performance Outcome perspective, is that sufficient ATM staff is available with the right skills, competencies and means to discharge their responsibilities and deliver the expected volume and quality of ATM service.

Beyond these global expectations, the adequate quality and reliance on the human performance outcomes contribute and enable most of the ICAO KPAs, *inter alia*:

- Safety and Security improvements depend on ATM staff adequate competency and performance;
- The ATM Quality of Service is enabled by ATM staff through its availability, competency and performance;
- ATM Capacity relies also on adequate staff availability, competency and performance;
- ATM staff costs contribute to a large part to overall ATM cost.

It should be noted that the PRC performance framework for gate-to-gate cost effectiveness relates the financial cost effectiveness KPI to driving factors which include:

- Human Performance related metrics
  - Service delivery
    - Input: number of duty hours performed by ATCOs in OPS
    - Output: number of Composite Flight Hours controlled by ATCOs in OPS
  - Size of the staff population
    - Number of ATCOs in OPS
    - Number of support staff
  - Total employment cost
    - Employment cost of the ATCOs in OPS
    - Employment cost of the support staff

- Other expenditure
  - Capital costs
  - Non-staff operating costs
As part of the approach to meeting the pan-European cost effectiveness target within the context of a given traffic demand (which determines the number of Composite Flight Hours to be controlled), the Human Performance Outcome Focus Area will require coordinated performance objectives and associated targets for the long-term evolution of

- the pan-European size of the staff population (ATCOs in OPS and support staff),
- the pan-European employment cost, and
- the pan-European number of duty hours.

A2.3.5.4.2 Human Performance Management: associated Focus Areas

Considering that the current maturity of managing HP in European ATM varies significantly amongst the various stakeholders (Airlines, ANSPs, industry etc.), more effective Human Performance Management Systems must be defined and gradually deployed over Europe. The Focus Areas in which to improve performance are:

1. Manpower Planning
   - The main objective is to enable adequate availability of ATM staff on the ANSP payrolls and behind the working positions, through
     - Application of improved manpower planning tools, procedures and processes to better manage the population of operational and support staff;
     - Application of improved rostering tools, procedures and processes to better adapt the working hours of operational and support staff to the fluctuating demand for service delivery.

2. Recruitment, Training, Competence and Selection Management
   - The main objectives are to contribute to the availability and the competency of ATM staff over Europe, through e.g.
     - Efficient selection processes and career management to minimise risks of shortage of staff;
     - Harmonised and, when necessary standardised training to ensure the required levels of competence to work with automated decision and support tools are achieved and maintained;
     - Harmonised and, when necessary standardised competence schemes to sustain expected changes in the role and/or responsibility of licensed personnel.

3. Social Factors Management
   - The main objective is to ensure that the social and cultural factors impacting ATM changes are identified and addressed, through e.g.
     - Integration, in ATM organisations, of intervention techniques to identify and reduce the social, cultural and demographic factors that may impede the implementation of the required operational improvements;
     - Use of social intervention tools dealing with social and cultural factors impacting ATM change.

4. Optimised use of Human Performance
   - The main objective is to ensure improved productivity of operational staff when working with ATM technology and procedures, through e.g.
     - Systematic, consistent and timely investigation of Human Performance related matters by applying a pan-European HP Case in all lifecycle phases i.e. from early design to real operations with the aim to optimise the human contribution within the future highly automated environment.

5. Human Performance related knowledge management
   - The HP related improvements will be achieved if, in parallel, a body of knowledge is developed, shared and disseminated through the development of e.g.
     - European HP culture, training and awareness;
     - European Repository for recognised methods, tools, guidelines, R&D outputs, existing standards, etc.

6. Support to legislation and standardisation
• The main objective is to ensure the development of European policies as required with regard to HP related matters through, e.g.
  o HP certification specifications for new system;
  o Standards for training, selection and competence verification.

**A2.4 Performance Data Collection & Management**

Europe’s intention to adopt a performance based approach in its transition to the future European ATM System was already mentioned in section A1.1.

ATM performance management is very much a data driven process, with data quality and interoperability being critical success factors. Therefore the practical aspects of (performance) data collection and management are an integral part of the guidance material for Performance.

This is recognised via the “data collection and forecasting” layer in the ICAO performance framework terminology (see Figure 9 on page 3), which deals with supporting metrics and how they are populated with data. It is recalled that “supporting metrics determine (define) which data needs to be collected and/or forecasted to calculate historical and/or forward looking values for the performance indicators” [Ref 5]. In other words: without availability of appropriate supporting metrics data, performance indicator values cannot be determined, and progress in achieving performance objectives (i.e. comparison against targets) cannot be assessed in a quantified manner.

Throughout the ATM lifecycle from R&D through planning to operations, performance data is produced and/or used by applications such as:

- Target setting;
- R&D including validation;
- Planning, from Master Planning to local planning and deployment;
- Operations;
- Forecasting; and
- Performance Review.

This is illustrated in Figure 29. In reality, the situation is more complex. The diagram merely aims to show the main principles and to illustrate the fact that a body of closely related data needs to be shared in an interoperable way between a large diversity of performance management applications.

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9 Some KPAs need further development before suitable metrics and indicators can be defined. As long as this work is not completed, performance can only be assessed in a qualitative manner, and performance data collection does not (yet) apply.
The dissemination and access to performance data, both raw and aggregated, should be on a need-to-know basis after authorisation of the data owner. Also, for security or commercial confidentiality reasons, the level of granularity of performance data could be restricted.
For each of these areas, more detailed guidance material to improve existing best practices is available in:

- ICAO Doc 9883 Part I - Appendix D (Manual on Global Performance of the Air Navigation System) [Ref 5];
- SESAR Task Deliverable DLT-0607-212-01-03 (T2.1.2/D2 - Strategic Objectives Definition) [Ref 11].

Further improvements to data reporting will be triggered by applicable European legislation (e.g. SES II), which will require or encourage Stakeholders to provide certain data feeds.

As a starting point, this guidance material stresses the need to ensure that common definitions are available for all ‘supporting metrics’, taxonomies and aggregation hierarchies which are required for the calculation of the performance indicators in the various KPAs. This will require the development of some new data definition standards in order to cope with the introduction of the Business Trajectory lifecycle and other concept changes.

To ensure the utility of data collection during R&D, the validation models, simulations and trials will need to apply these common data definitions.

To automate data collection during operations, appropriate ‘hooks’ will need to be implemented in all ATM systems and infrastructure, to capture data according to the new definitions. SWIM will have to make appropriate provisions to support the collection of this data. Existing data warehouses such as PRISME and PRISMIL will need to be adapted accordingly. Performance review organisations will equally need to adapt to the new data definitions.

All of this will secure data integrity among the related KPAs for the purpose of in-depth analysis and performance data correlation.
A3 Transversal Areas – The Integrated Management System

A3.1 Introduction

This chapter describes an approach to meet the challenges in four of the Transversal Areas\(^\text{11}\): safety management, security management, environment management and human performance management. It proposes the transformation of today’s individual management systems into the envisaged future Integrated Management System (IMS). The IMS will build on the identified synergies and interdependencies between these four transversal areas and will also enable the transfer of knowledge and experience between them.

A3.2 Societal Vision

When the average fare-paying passenger sets off for an airport, he or she should have no hesitation about taking a flight to reach his or her destination. That passenger should be confident that flying is safe and good value for money; that the aircraft will depart and arrive on time; that there will be no security issues to worry about; and that feeling guilty about the environmental impact of the journey that is about to start is a thing of the past. This is the quality of service that air transportation should provide to its customers on a sustainable basis.

The quality of that service delivered to each passenger is the overall output of an air transport value chain in which almost all actors depend on many others. In effect, the air transport system as a whole delivers the service provided to passengers. Air traffic management is part of the delivery mechanism; it does not serve passengers directly, but it does serve those who do. A key element to maintaining the economic and operational aspects while addressing the societal performance is to ensure that a safe, secure, efficient and environmentally sustainable air navigation system is available. This requires the implementation of an air traffic management system that allows for optimum use to be made of enhanced capabilities.

Since there is no specific need for a passenger to be aware of air traffic management’s role in delivering the service received, something must be wrong if the passenger starts enquiring about air traffic management issues. Our job is to ensure that that never happens; that ATM never lets down its airspace and airport customers; and that the ATM components of the air transport system just “work”.

To reach this desired outcome, the pan-European ATM system has to be managed from a societal performance perspective, in which clear targets are set, the system is developed and operated to achieve them, and performance is regularly monitored. There are many system and operational improvements to be delivered along the way, but success will not be judged on whether each project or procedure was successfully completed. No; it will be assessed against the wider needs of society as a whole as expressed in the very first paragraph:

\[\text{Is my flight going to be safe; will it be delayed; can I afford it; will I feel secure; will it damage our environment too much; am I in the right hands?}\]

These societal business drivers cut right across the pan-European ATM system. They are inherent in everything we do. They have many common elements; but they also require unique solutions. Table 15 translates these expectations into ATM terminology for each of the societal areas, including human performance.

\(^{11}\) Additional Transversal Areas which were identified by SESAR are: Legislation/Regulation, and Standardisation.
### Table 15 Societal expectations translated into ATM terminology

<table>
<thead>
<tr>
<th>Expectation</th>
<th>Rationale</th>
<th>ATM Vision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is my flight going to be safe?</td>
<td>Fatal accidents are unacceptable to society</td>
<td>ATM Safety improves threefold to cope with the predicted increase in traffic by 2020, and by tenfold in the long term</td>
</tr>
<tr>
<td>Will I feel secure?</td>
<td>Security breaches are unacceptable to society</td>
<td>ATM is so resilient to attack, disruption or interference that it never suffers a security threat or breach</td>
</tr>
<tr>
<td>Will it damage our environment too much?</td>
<td>Society’s demands for mobility and environmental protection must be balanced to protect aviation’s licence to operate</td>
<td>ATM ensures that flights will minimise their environmental impact and checks that agreed environmental constraints are respected.</td>
</tr>
<tr>
<td>Am I in the right hands?</td>
<td>Loss of human dimension in ATM decision-making is unacceptable to society</td>
<td>ATM must have sufficient staff with appropriate skills, competencies and means to discharge their responsibilities</td>
</tr>
</tbody>
</table>

### A3.3 Integrated Management System

ATM organisations need to ensure themselves and the general public that the processes required to successfully meet each of these expectations are being handled responsibly. Current standard practice is to achieve this through the deployment of management systems. These provide a systematic and transparent approach to risk management and decision making within a framework of continuous improvement.

The level of management system maturity within ATM with respect to these societal outcomes is varied. Safety management systems are extensively used throughout the ATM community and set the benchmark. The challenges now are to determine where safety management within ATM organisations needs to be in 2020, and to drive security, environment and human performance management to a similar level in an accelerated push.

In order to ensure that ATM meets these societal expectations in the long term and addresses the interdependencies therein, ATM must move towards an integrated approach, building upon the individual management systems already in place.

In an ideal world, any organisation would have one simple management system covering all aspects of the achievement of its objectives. However, in practice many organisations have kept their management systems such as quality, environment or health and safety separate, thereby adding to costs and reducing effectiveness. One of the reasons has been the perceived difficulties in achieving integration. Nevertheless, an increasing number of ANSPs have overcome these difficulties and have integrated their decision making processes for safety, capacity and environment.

The benefits of Integrated Management Systems are that there will be, *inter alia*, a reduction in costs, improvement in effectiveness, removal of duplications and conflicts and better change management, as set out below:

- **Reduced costs** – by avoiding duplication in internal audits, document control, training and administration, adopting future management systems will be more effective.
- **Time savings** – by having only one management review.
- **A holistic approach to managing business risks** – by ensuring that all consequences of any action are taken into account, including how they affect each other and their associated risks.
- **Reduced duplication and bureaucracy** – by having one set of processes ensures the requirements of the specific standards are co-ordinated, workloads streamlined and disparate systems avoided.
• **Less conflict between systems** – by avoiding separate ‘empires’, responsibilities are made clear from the outset.

• **Improved communication, both internal and external** – by having one set of objectives, a common culture can thrive and improve communication.

• **Enhanced organisation focus** – by having one system linked to the strategic objectives of the organisation contributes to the overall continual improvement of the organisation.

• **Improved staff morale and motivation** – by involving and linking roles and responsibilities to objectives, it makes change and new initiatives easier to implement and makes for a more successful and dynamic organisation.

• **Optimized internal and external audits** – by minimizing the number of audits required and maximizing the number of people involved.

The transition from separate to integrated management systems shall take place in phases, as shown in Figure 30:

- Independent: Separate systems being used at the same time;
- Co-ordinated: Common elements have been identified;
- Combined: Common elements have been identified and are being integrated;
- Integrated: One system incorporating all common elements.

![Figure 30 Transition from separate to integrated management systems](image)

An element of the co-ordination phase is to identify how to ensure “catch-up” of the Security, Human Performance and Environment management maturity with that of Safety, without which integration cannot successfully take place. This should be achieved for SESAR Service Level 4. In order to address the twin challenges of determining where safety management within ATM organisations needs to be in 2020, and driving security, environment and human performance management to a similar level, improvements in areas common to the four management systems are to be addressed as well as specific developments in the individual areas.

The path towards Integrated Management Systems could be described as follows:

**SESAR Service Level 0&1 (Independent to Co-ordinated)** shall achieve the implementation of existing best practises, set the framework for and establish individual management systems and start the conduct of systematic performance and impact assessments in the societal outcome areas. The extent to which this will be achieved is a function of the maturity baseline in the different areas.

For **SESAR Service Level 2&3 (Co-ordinated to Combined)** management system practices shall be improved, and where possible approved. The implementation of elements of the individual management systems shall further progress, societal performance and impact assessments are carried out systematically for all relevant ATM projects.

For **SESAR Service Level 4 (Combined to Integrated)** mature Integrated Management Systems (IMS) are implemented. Common levels of maturity are achieved across the societal performance areas and across all relevant stakeholder organisations.

### A3.4 Complementary Capabilities

In addition to the processes that are common to the management systems established for the four societal outcome areas, there are a number of complementary capabilities that are unique to ATM which, when harnessed, can further ensure the successful integration of the management systems. These are explained in the following sections.
A3.4.1 Performance Management Processes for Transversal Areas

Performance needs to be monitored across the Transversal Areas. Indicators are to be defined, where they have not been defined yet. They should be centrally populated and monitored at European level. An analysis system will allow for continuous monitoring, identification of emerging trends and elaboration of appropriate improvement activities. The system will support future target setting and the design of future systems.

The requirement to assess societal impact can be satisfied through the application of robust processes based on the use of harmonized methodologies, common datasets and application of expert knowledge. A lot of the data required to conduct assessments is already held centrally. In addition, the resources required to manage, develop and maintain processes, models and datasets are now so considerable that many ATM organisations are simply finding that this is either too expensive to maintain or no longer part of their core activities. As a result, operational and regulatory stakeholders are increasingly looking to EUROCONTROL to provide a suite of societal performance assessment and monitoring capabilities upon which they can rely over the long term. This approach provides considerable economies of scale.

A3.4.2 Culture

An organisational culture is a pattern of beliefs, values and assumptions shared by members of an organisation that operates unconsciously, that defines in a basic taken-for-granted fashion an organisation’s view of itself and its environment. It underpins human performance management within the organisation.

Understanding the organisational culture is important for industries such as aviation where safety, security and environment are critical business drivers. Following the rules must be part of that culture and with no excuse for not doing so. A positive culture is one where the safety, security, environmental and human performance goals are part of the natural way of working, whether they are explicitly written as a procedure or not. In such a culture the rules do not have to be enforced, they are part of the normal attitude to work of everyone in the organisation.

A3.4.3 Training and Awareness

Training and awareness will be a key element in changing the culture within ATM organisations to embrace societal expectations. Over the long term, a critical element therein is to ensure that awareness about societal expectations is incorporated in the Common Core Content for *ab-initio* and refresher training of Air Traffic Controllers. In parallel, subject-specific courses must be developed for more in-depth training of ATM personnel in general, using the extensive suite of safety courses as an example to be followed by the other performance areas. Where mass awareness is required, then eLearning is the best option. But workshops, conferences and presentations should also be judiciously used.

Using a single platform through which such training and awareness can be delivered will ensure economies of scale and consistency of message since the training material is developed once, but used many times over.

A3.4.4 Support to Policy Making

It is important that regulations are based on relevant facts leading to the correct trade-offs between society’s competing demands for more mobility on the one hand, but more safety, security and less environmental damage on the other. These trade-offs are difficult to achieve. To bring the facts together, data have to be collected, understood and interpreted such that trade-offs can then be analysed for consideration by policy-makers with a view to subsequent regulation. This will require the correct interpretation of the facts to ensure that decision-makers understand the consequences of the rules and regulations that they intend to propose or approve. EUROCONTROL Member States, the European Commission, EASA, ICAO and ECAC all require such support for their work relating to societal outcome.

A3.4.5 Data, Information, Knowledge Management

It is clear that, to deliver the approach outlined above, a knowledge base of critical mass on societal performance is required. Since resources will be tight, the knowledge base must be managed with a view to providing a “dual-use” perspective to support both operational and regulatory improvements, each with the goal of enhancing the societal performance of European (and global) ATM.
Facilitating the exchange of data is essential to improve the ATM system. EUROCONTROL and its stakeholders possess an unrivalled combination of pan-European ATM expertise, experience and associated information. Sharing and exploiting this information across the actors and across the societal outcome areas can deliver superior input to improvement initiatives compared to what individual organisations with expertise in just one area could achieve.

Support to policy making is often based on the data and systems managed by EUROCONTROL and its stakeholders. They incorporate models and methodologies developed through ICAO and ECAC. Understanding the implications of a regulatory proposal implies that some sort of impact assessment is carried out. Such assessments rely on expertise, data, methodologies, models and systems. In fact they are often the same as those required to understand the impact of an operational improvement. Expertise, models and data are clearly, therefore, “dual use”, and this policy will be pursued wherever possible to avoid duplication of effort and ensure maximum economies of scale.

A3.4.6 Communication

ATM organisations need to respond to the growing demand for societal performance information related to aviation and to improve communication among themselves in the face of criticism from within and outside the industry.

In the first case, transparency should be provided as much as possible through the publication of regular reports on the societal outcome of the pan-European ATM system. It should be ensured that key facts, figures and issues are included in all relevant communication material. Press releases, for example, when highlighting a new ATM improvement, should state what benefit it brings to society. Monthly traffic statistics should include information of societal relevance. Senior personnel, when giving keynote speeches at important aviation events, should include ATM’s contribution to society in as many of their speeches as possible. All personnel likely to encounter stakeholders should have some basic societal performance information and “positions” to work from.

Wherever possible, a web-site such as that of EUROCONTROL should be used as a one-stop resource where all interested parties can get the information that they need, be it current status of our work, to briefing sheets on specific issues, newsletters, copies of speeches, articles and presentations etc. Regular consultation meetings must be hold interspersed with workshops on specific topics.

Such a web-site could give ANSPs (and other bona fide stakeholders) controlled access to societal performance data such that they can extract from this (or have sent) datasets tailored to their needs. This provides stakeholders with data at a significant economy of scale which is maintained in a professional way over the long term. Moreover, by working through a central system using harmonized data and methodologies, this greatly decreases the barriers to successful performance benchmarking – a means of improving performance.

A3.5 Towards the Integrated Management System

This section sets out the improvement areas for each of the Transversal Areas of safety management, security management, environmental management and human performance management during the transition to the integrated management system. More detailed explanations can be found at Annexes 1 to 4.

A3.5.1 Safety Management

It is required to continuously improve safety management practices within ATM and enhance the already strong safety culture in ATM. Contributions will be made to eliminate the major causes of aviation accidents. Emerging risk arising from changes to the ATM System and its environment are to be addressed. Improvements in the following areas are foreseen:

- Implement the ICAO Global Aviation Safety Roadmap;
- Further enhance ANSP’s Safety Culture;
- Continuously monitor Safety Management and Safety Culture;
- Ensure evolution of safety management practices;
- Support the implementation of Safety Legislation and Regulation;
- Centrally monitor pan-European ATM safety performance;
- Conduct data driven safety improvement initiatives;
- Facilitate the exchange of safety information;
- Initiate R&D Projects aiming to ATM Safety Improvements;
Annex A: Performance

- Ensure consistency of the safety objectives in SESAR;
- Develop of a top-down model for accident-incident causation;
- Further develop safety assessment techniques;
- Develop knowledge base system to support the SESAR Safety Case development;
- Maintain and Enhance the Level Of Expertise In Safety Assessment;
- Support the Local Implementation of Operational Improvement.

A3.5.2 Security Management

The objectives for Security Management while transiting towards an Integrated Management System are to eliminate security scares and incidents, achieve uniform levels of security, ensure that the costs of delivering security performance are proportionate to system resilience, and to avoid any security-imposed constraints on air traffic operations. Improvements in the following areas are foreseen:

- Resilience Framework:
  - Develop and Implement an ECAC-wide ATM Resilience Framework;
  - Continuously monitor, assess and mitigate emerging threats and vulnerabilities;
  - Ensure resilient development and operations of new ATM Systems;
  - Drive R&D projects aiming at ATM Security/Resilience;
  - Ensure alignment with other transversal areas.
- Security Partnership:
  - Establish a holistic aviation security partnership including national security;
  - Develop and implement security interoperability;
  - Foster pan-European and international cooperation and collaboration;
  - Facilitate the exchange of security information.

A3.5.3 Environmental Management

The goals for Environment Management are to deliver a more environmentally efficient ATM network, change the culture within ATM organisations to embrace environmental improvements as a normal way of doing business. In addition it needs to be ensured that both regulatory and operational decisions are taken on the basis of sound facts and figures, and that the “dual use” capabilities of expertise and system tools is maintained and exploited to the full. Improvements in the following areas are foreseen:

- Implement collaborative environmental management among operational stakeholders;
- Improve network/airport planning and operations to deliver operational improvements that reduce environmental impact;
- Deliver environmentally-driven operational improvements;
- Develop competencies and systems to support decision-making;
- Enhance the environmental knowledge base among ATM staff;
- Ensure transparent and credible communication on environment issues within and beyond the industry.

A3.5.4 Human Performance Management

The overarching goals set for Human Performance Management are the systematic, consistent, and timely management of Human Performance aspects and the mitigation of the identified interferences on Human Performance within the new ATM System. Improvements in the following areas are foreseen:

- Management and co-ordination of all HP activities;
- Consistent application, support and monitoring of HP processes & tools;
- Evolution to HP Case Methodology with associated support tools;
- Proactive research for issues related to advance ATM automation support;
- Centralised HP tools’ repository;
- Identification of interferences on HP and generation of large scale solutions;
- Implementation of recommendations/requirements related to interferences originated in the system design;
Annex A: Performance

- Implementation of requirements and standards related to Recruitment, Training, Competence and Staffing;
- Dissemination of intervention tools related to social and cultural factors impacting SESAR changes;
- Initiation of required HP certification and regulation processes.
A4 Relationships with other parts of the ATM System

A4.1 Overview

ATM Performance has direct relationships to the other elements of the ATM System: ATM Network, ATM Information Management and ATM Infrastructure, through the performance requirements and targets in the various KPAs, as shown in Figure 31.

Most ATM performance requirements are directly addressed to the ATM Network. The corresponding performance improvements (benefits) will be achieved by deploying higher Service Levels. These Service Levels are supported (enabled) by the deployment of higher Capability Levels of the individual ATM components such as aircraft and ground systems, as reflected by ATM Information Management and ATM Infrastructure. Likewise, there is a relationship from Information Management to Infrastructure, e.g. through the need for communication capabilities.

Indirectly, Information Management and Infrastructure contribute to all ATM performance benefits. This contribution is indirect because it is dependent on the use that the Network makes of the Capability Levels. There are however some specific ATM performance requirements which are addressed directly to Information Management and Infrastructure without “passing through” the ATM Network. This is particularly the case for the KPAs Cost Effectiveness (investments and operating costs are directly associated with Stakeholder systems and therefore with the ATM Infrastructure), Interoperability (information exchange and technical interoperability aspects), and specific parts of the Security KPA (i.e. information security).

The following sections provide some more detail on the mapping of the ATM performance requirements.
A4.2 Performance Requirements for ATM Network

This section provides an overview of the most significant links between ATM Performance and ATM Network, at a medium level of granularity:

- For ATM Performance, at the level of Focus Areas;
- For ATM Network, at the level of the key features of the SESAR ATM target concept, namely:
  - Trajectory Management;
  - Collaborative Planning;
  - Integration of Airport Operations;
  - New Separation Modes.

A4.2.1 Safety

Detailed Objectives and Targets for Safety can be found in section A2.3.3.1.

Figure 32 Relationship between Safety KPA and Key Features

A4.2.2 Human Performance

Detailed Objectives and Targets for Human Performance can be found in section A2.3.5.4.

Figure 33 Relationship between Human Performance and Key Features
A4.2.3 Capacity

Detailed Objectives and Targets for Capacity can be found in section A2.3.4.2.

A4.2.4 Efficiency

Detailed Objectives and Targets for Efficiency can be found in section A2.3.4.4.
A4.2.5 Flexibility

Detailed Objectives and Targets for Flexibility can be found in section A2.3.4.5.

![Figure 36 Relationship between Flexibility KPA and Key Features](image)

A4.2.6 Predictability

Detailed Objectives and Targets for Predictability can be found in section A2.3.4.6.

![Figure 37 Relationship between Predictability KPA and Key Features](image)
A4.2.7 Access and Equity

Detailed Objectives and Targets for Access and Equity can be found in section A2.3.5.

Figure 38 Relationship between Access and Equity KPA and Key Features

A4.2.8 Participation

Detailed Objectives and Targets for Participation can be found in section A2.3.5.2.

Figure 39 Relationship between Participation KPA and Key Features
A4.2.9 Interoperability

Detailed Objectives and Targets for Interoperability can be found in section A2.3.5.3.

Figure 40 Relationship between Interoperability KPA and Key Features

A4.3 Performance Requirements for ATM Information Management

The main direct relationship between ATM Performance and ATM Information Management is in the KPAs Interoperability, Participation and Security:

- **Interoperability**: the interoperability stack mentioned in the ATM Information Management Annex comprises business and operational interoperability at the top, supported by interoperable information exchange\(^{12}\) in the middle, in turn supported by technical interoperability at the bottom. In section A2.3.5.3, the ATM Performance Annex includes the Focus Area Design of Interoperability, which further focuses on standardisation needs for system interoperability. This Focus Area includes the information management interoperability requirements.

- **Participation**: this KPA includes Focus Areas for Stakeholder involvement during performance management and operations (A2.3.5.2). The net-centric approach outlined in the ATM Information Management Annex will need to allow Stakeholders to reach the level of participation required in the future ATM system.

- **Security**: the scope of the Security KPA (A2.3.3.3) includes the requirement to prevent unauthorised access to and disclosure of ATM information. This requirement is part of the scope of ATM Information Management.

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\(^{12}\) the ATM Information Management Annex quotes IEEE which defines interoperability as the ability of two or more systems or components to exchange information and to use the information that has been exchanged. This includes syntactic and semantic interoperability.
A4.4 Performance Requirements for ATM Infrastructure

The main direct relationship between ATM Performance and ATM Infrastructure is in the KPAs Interoperability and Cost Effectiveness:

- **Interoperability**: the technical interoperability at the bottom of the interoperability stack is part of the scope of ATM Infrastructure.
- **Cost Effectiveness**: an important contribution to the required reduction of the Direct Cost of Gate to Gate ATM (A2.3.4.1) will need to come from the ATM Infrastructure. Hence the cost aspects of air and ground infrastructure are part of the scope of ATM Infrastructure.
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B1 Scope

The ATM Network Guidance specifies how the ATM Network, comprising airspace, airports and network management activities, will evolve, from an operational perspective, to satisfy the ATM performance needs. The changes will be oriented to implement the SESAR Operational Concept inline with the performance framework and will be aimed at delivering operational capabilities for a specific level of service. In order to provide the ATM Service Levels requirements will be placed on Infrastructure and Information Management to deliver capabilities to support the ATM Network.
B2 Responding to Key Performance Requirements

B2.1 Introduction

This chapter presents the Network Vision during the lifetime of the SESAR programme. It identifies key areas to be targeted, and proposes a structured response for the ATM Network.

Eighteen strategic areas have been identified in response to the challenges faced by the ATM Network; these have been derived by reviewing the SESAR target concept and the strategic documentation covering Airspace, Airports, ATC Tools and ATFCM. Ten of the eighteen areas focus on the period 2009-2012, a further five focus on the period 2013-2019, one focuses on 2020 and beyond and two, Network Performance Assessment and Network Capacity Planning, are ongoing throughout the period.

B2.2 Targeting Key Issues

SESAR envisages air transport operating as a perfectly smooth network with sufficient capacity headroom both at airports and in the airspace, with minimal differences between planned and actual operations. The goal is to enable air transport to meet the unconstrained end customer demand.

However, during the lifetime of SESAR, the ATM Network has to continue operate and develop within the existing constraints of airspace, airports and variability in time keeping.

The main functions driving a need for change in ATM Network are:

- Elimination of fragmentation, at all levels, of the European ATM System with a preference for short term solutions, prior to the implementation of SESAR defined ATM enhancements.
- Addressing the lack of flexibility at ATM network and local levels to adjust the level of operational ATM capacity to meet varying demand.
- Emphasising the need to implement a truly integrated ATM network that includes airports, terminal and enroute airspace, instead of a collection of separate, isolated ATM systems. From an airport perspective, critical to the success of the Strategic Guidance is changing current general airport perception that air traffic management has only a remote impact on the airport business. It is extremely important to recognise and understand the considerable impact that airport business has on the Air Traffic Management Network.
- Promotion of a simplified European framework together with a performance-based approach satisfying all categories of airspace users’ requirements. All stakeholders have a role in ensuring that Europe’s ATM System is progressively optimised to safely cope with the expected traffic growth and diverse and often incompatible user requirements.
- A sizeable percentage of traffic (~ 50%) operates to and from congested airports. This affects time keeping across the network, and consequently there is a need for the ATM System to collaboratively manage time variability.
- There is no common agreement on airport scheduling. All airports, constrained and with headroom, will be part of a cooperative network scheduling activity to agree scheduling levels to underpin the schedule integrity of the overall air transport network.
- Network-wide traffic management, accommodating business trajectories, geared to streaming of traffic flows around major airports will remove little or no schedule visibility and enable a coordinated collective schedule / daily plan for the busiest areas where
throughput, as defined by the “performance partnership agreement”, predominates over individual business trajectories.

- Limited possibility to reduce airspace users’ operating variability associated with flight and passenger handling to ensure these are optimised with respect to meeting the overall schedule.

- Civil-military coordination needs to be enhanced to more effectively deal with tactical allocation around an optimised strategic allocation.

- Traffic smoothing and prioritisation will improve the currently insufficient flexibility to accommodate changing user requirements. Stakeholders within the ATM System will work collaboratively to prioritise activities and resources with the aim of smoothing traffic flows and “repairing” the network schedule where airspace and airport capacity headroom permits.

- Airspace capacity essentially remains designed around demand patterns although the use of some new ATM concepts and technological solutions reduces the need to trade-off capacity with flight efficiency (i.e. more flights can be executed at a higher level of efficiency, so increasing overall network performance).

In order to meet the challenge of the SESAR long term performance objectives, the concept of operations will evolve and benefit from greater support from automation and an increased integration of airborne and ground capabilities. People will continue to direct the performance of the overall ATM system including the management of threats, errors and unpredictable events.

**B2.3 Strategic improvement areas**

The above needs for change put a number of requirements on the ATM network. To respond to these challenges, 18 areas of strategic importance are identified. These areas are fully consistent with SESAR’s Operational Improvements, Operational Improvement steps and Lines of Change.

The 18 Strategic areas can be grouped into 4 Key Features of the evolving SESAR Operational Concept:

<table>
<thead>
<tr>
<th>Strategic Areas</th>
<th>Key Features of the evolving SESAR Operational Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Network capacity planning</td>
<td>All Key Features</td>
</tr>
<tr>
<td>2. Initiating integrated demand / capacity balancing</td>
<td>Trajectory Management</td>
</tr>
<tr>
<td>3. Integrating military traffic into the network</td>
<td>Collaborative planning</td>
</tr>
<tr>
<td>4. Reduce tactical re-routings</td>
<td>Collaborative planning</td>
</tr>
<tr>
<td>5. Reduce ATC routine tasks</td>
<td>Collaborative planning</td>
</tr>
<tr>
<td>6. 7 Airspace classes below 195</td>
<td>Collaborative planning</td>
</tr>
<tr>
<td>7. Enabling optimum trajectories</td>
<td>Collaborative planning</td>
</tr>
<tr>
<td>8. Managing environmental impact</td>
<td>Collaborative planning</td>
</tr>
<tr>
<td>9. Initiating integrated terminal areas</td>
<td>Integrated Airport Operations</td>
</tr>
<tr>
<td>10. Runway management</td>
<td>Integrated Airport Operations</td>
</tr>
<tr>
<td>11. Turn-round and surface management</td>
<td>Integrated Airport Operations</td>
</tr>
<tr>
<td>12. Network performance assessment</td>
<td>All Key Features</td>
</tr>
<tr>
<td>13. DCB &amp; UDPP</td>
<td>Collaborative planning</td>
</tr>
<tr>
<td>14. Airspace classes re-categorisation</td>
<td>Trajectory Management</td>
</tr>
<tr>
<td>15. Trajectory-based operations</td>
<td>Trajectory Management</td>
</tr>
<tr>
<td>16. Minimising tactical interventions</td>
<td>New Separation Modes</td>
</tr>
</tbody>
</table>

13 Lines of change represent the main operational areas that describe the evolution of the ATM environment.
Note the 5th Key feature SWIM, is a prerequisite for the Strategic Areas.

Each area is briefly described below, together with the main Key Performance Area(s) and focus area(s) that it targets.

1) Network capacity planning
This is the ability of ATM network to plan and prepare for the airspace capacity required to meet the future air traffic demand. It relies on effective demand forecasting and capacity planning processes at network and local level, and the coordinated efforts of air navigation service providers and aircraft operators.

<table>
<thead>
<tr>
<th>KPA/Focus area</th>
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<tbody>
<tr>
<td>Capacity</td>
<td>/Airspace Capacity</td>
</tr>
<tr>
<td></td>
<td>/Network Capacity</td>
</tr>
</tbody>
</table>

2) Initiating integrated demand / capacity balancing
This is ability of the ATM network to adjust, in real-time, the available airspace capacity to the variations of traffic demand, while ensuring that the situation remains safe at all times. In crisis situation (e.g. sudden loss of capacity), it enables safe expedition of traffic whilst minimising penalties on airspace users. It relies on integrated and responsive ASM/ATFCM processes.

<table>
<thead>
<tr>
<th>KPA/Focus area</th>
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<tbody>
<tr>
<td>Capacity</td>
<td>/Network capacity</td>
</tr>
<tr>
<td>Flexibility</td>
<td>/Service location flexibility</td>
</tr>
<tr>
<td></td>
<td>/Suitability for military requirements</td>
</tr>
<tr>
<td>Predictability</td>
<td>/Service Disruption Effect</td>
</tr>
<tr>
<td>Safety</td>
<td>/ATM-related safety outcome</td>
</tr>
</tbody>
</table>

3) Integrating military traffic into the network
This is the ability of the ATM network to accommodate OAT requirements. It relies on harmonised procedures and flexible routing options.

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<thead>
<tr>
<th>KPA/Focus area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>/ATM-related safety outcome</td>
</tr>
<tr>
<td>Flexibility</td>
<td>/Suitability for military requirements</td>
</tr>
</tbody>
</table>

4) Reducing tactical re-routings
This is the ability of the ATM network to provide airspace users and air traffic controllers with reliable information on the foreseen ATM situation (e.g. airspace availability), so that users can make informed flight planning decisions and both ATC and users can ensure the correct execution of the flight. It relies on effective flight planning and information management processes.

<table>
<thead>
<tr>
<th>KPA/Focus area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>/Temporal efficiency</td>
</tr>
<tr>
<td>Predictability</td>
<td>/On-time operation</td>
</tr>
</tbody>
</table>
5) Reducing ATC routine tasks
This is the ability of the ATM network to free up air traffic controller mental resources. It relies on increasing automation of routine tasks.

<table>
<thead>
<tr>
<th>KPA/Focus area</th>
<th>/Airspace Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td></td>
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</table>

6) 7 Airspace classes below FL195
This is the ability of the ATM network to make the access to lower airspace simpler to airspace users. It relies on a uniform application of the 7 ICAO airspace classes.

<table>
<thead>
<tr>
<th>KPA/Focus area</th>
<th>/ATM-related safety outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
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</table>

7) Enabling optimum trajectories
This is the ability of the ATM network to offer direct routes to airspace users where and when possible. It relies on route network enhancements and dynamic airspace management processes.

<table>
<thead>
<tr>
<th>KPA/Focus area</th>
<th>Fuel efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Mission effectiveness</td>
</tr>
<tr>
<td>Environmental Sustainability</td>
<td>Atmospheric impacts</td>
</tr>
</tbody>
</table>

8) Managing environmental impact
This is the ability of the ATM network to contain the pollution (incl. noise and emissions) due to ATM operations within margins acceptable to society so that it does not constitute a barrier to the development of air transport business. It relies on the rolling out of best practices and application of environmental management processes.

<table>
<thead>
<tr>
<th>KPA/Focus area</th>
<th>Environmental constraint management</th>
</tr>
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<tr>
<td>Environmental sustainability</td>
<td>Best ATM practice in Environmental Management</td>
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9) Initiating integrated Terminal Airspace
This is the ability of the ATM network to include all aspects of terminal airspace capacity development into the European ATM Network design, and to ensure that terminal airspace operations are performed in an increasingly integrated gate-to-gate approach. It relies on optimised arrival/departure streams and includes appropriate terminal airspace structures and links to airports and en route segments.

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<th>KPA/Focus area</th>
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<td>Capacity</td>
<td>Network capacity</td>
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<tr>
<td>Environmental sustainability</td>
<td>Noise impacts</td>
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</table>
10) Runway management
This is the ability of the ATM network to unlock latent airport capacity (in addition to long term planning for the development of new runways) by increasing runway utilisation. It is of special interest to airports that already have largely exploited existing best practices, as well for airports that frequently experience reduced capacity due to extreme weather conditions.

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<td>/On-time operation</td>
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<td><strong>Safety</strong></td>
<td>/ATM-related safety outcome</td>
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11) Turn around and surface management
This is the ability to address the interface between the airport service and the remainder of the network (e.g. during the period “closure of aircraft doors” and “off-block”), so that the take-off time meets the requirements of the network. It includes the ability to manage the taxiway systems as a feeder function to the runways and the en route network.

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<td><strong>Safety</strong></td>
<td>/ATM-related safety outcome</td>
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12) Network performance assessment
This is the ability of the ATM network to evaluate how well it meets the expectations of the stakeholders.

- This is a contribution to the ATM Performance process as a whole

13) Dynamic DCB & UDPP
This is the ability of the ATM network to integrate diverse airspace use requirements. It is based on a highly flexible approach to airspace usage which ensures that possible constraints imposed by any airspace activity on other airspace operations are kept to the absolute minimum in both time and space. In case of unavoidable capacity losses, it ensures that airspace users can agree between themselves on departure prioritisation.

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<td><strong>Access and Equity</strong></td>
<td>/Equity</td>
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<td><strong>Flexibility</strong></td>
<td>/Business Trajectory update flexibility for scheduled and non-scheduled flights</td>
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<td>/Flexible access-on-demand for non-scheduled flights</td>
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<td>/Service location flexibility</td>
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<td><strong>Predictability</strong></td>
<td>/Service Disruption Effect</td>
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<td><strong>Safety</strong></td>
<td>/ATM-related safety outcome</td>
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</table>
14) **Airspace Classes Re-categorisation**
This is the ability of the ATM network to progress European airspace towards a continuum where the only distinction is between “Managed Airspace” and “Unmanaged Airspace”. It is recognised that this target will not be achievable by 2020 and the transition is a research issue.

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<td>/Access</td>
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<td>Safety</td>
<td>/ATM-related safety outcome</td>
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15) **Trajectory-based operations**
This is the ability of the ATM network to accommodate the business/mission intentions of the airspace users, by safeguarding the integrity of these trajectories and minimising changes. It relies on the development of a user-preferred routing environment where and when traffic density permits, and on the sharing of business/mission trajectories by all ATM partners.

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<td>/Knock-on effect</td>
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16) **Minimise tactical interventions**
This is the ability of the ATM network to shift from a philosophy of “management through tactical intervention” to a more strategic “management through planning, with tactical intervention the exception”. This relies in particular on increased automated air traffic control assistance, taking advantage of more accurate 4D trajectories, and also on the possibility to delegate specific separation tasks to the cockpit under specified conditions mutually agreed between the controller and the pilot.

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<td>Predictability</td>
<td>/On-time operation</td>
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17) High Performance Integrated Terminal Airspace & Airports

This is the ability of the ATM network to optimise runway throughput at congested airports to levels that exceed current “best-in-class” operations, and to maintain levels close to normal in adverse weather conditions. It relies in particular on more integrated queue management processes. From an airport perspective, it aims at a global “en-route to en-route” integration (i.e. incl. all airport processes and arrival/landing).

It is recognised that the bulk of required increase in airport capacity will come from greater use of secondary airports with improved links to city centres and the major airport hubs.

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<td>Knock-on effect</td>
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<td>ATM-related safety outcome</td>
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18) Trajectory Based Network (Long Term)

This is the ability of the ATM network to achieve ultimately full 4D Trajectory management in a context where the role of separator will be increasingly transferred to capable aircraft.

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B3 ATM Network Strategic Guidance

B3.1 Introduction

This chapter presents guidance for the evolution of the ATM Network through Service Levels 1, 2 and 3, then 4 and 5. In so doing the 18 Network Strategic areas introduced in Chapter 2 are mapped diagrammatically against the Key Features of the evolving SESAR Operational Concept, described in the main body of the text, and then the areas themselves are presented in a manner which demonstrates the ATM Network’s evolution through the five Service Levels (SLs). At the end of each area description, a list of enablers is provided with a view of emphasising the reliance of the ATM Network’s evolution on all enablers. These enablers fall into three categories: information management, infrastructure and institutional; their evolution is described in the corresponding annexes.

Note: Strategic areas 1 and 12 start in SL 1 and continue through all SLs.
**B3.2 Service Level 1**

**B3.2.1 Network Capacity Planning**

Accurate and coherent short- to medium-term demand forecasts ensure that future capacity requirements are rational and enable ANSPs and airports to formulate robust capacity plans. The process offers an interactive support to stakeholders in the development of medium-term capacity plans; capacity planning information, demand data and tools are available on-line. Latent capacity is used to relieve bottlenecks through consolidated capacity planning process based on coordination and network synchronisation of ANSPs/airports, enabling the adaptation of capacity delivery where and when required.

![Sample Enablers](image)

**B3.2.2 Initiating Integrated DCB**

**Collaborative Decision Making and Functional Integration**

Collaborative Decision Making processes between ASM, ATFCM, ATC, airports and airspace users are enhanced at all ASM levels. The utilisation of the available capacity is based on the continuous assessment of network impact of expected airspace allocations. At the end of the SL time frame, the ASM and ATFCM are functionally merged at national and sub-regional level (e.g. FAB).

DCB operations are extended to the Day of Operation to make better usage of late opportunities and respond dynamically to late changes in airspace capacity (e.g. due to short notice military airspace requirements or changing weather). This maximises the efficiency of the system using flow and capacity management techniques close to the real time operations.

Integrated ATFCM measures with optimised collaborative procedures are in place at airports to manage cases of significant changes to airport capacity, in particular sudden capacity shortfalls and recovery from that situation. Aircraft Operators' tactical priorities are introduced in a cooperative process with the CFMU as a first step to UDPP implementation (through, e.g. ATFM slot exchanges) with the objective of minimising the total ATFM delay.

Cross-Border Operations are facilitated through collaborative airspace planning with neighbouring States by harmonising the ASM rules and procedures for the establishment, allocation and use of airspace structures. Sharing of cross-border areas as well as other reserved and segregated airspaces is increasing. Civil-Military real-time coordination is further enhanced through “what-if” functionalities and automated support to airspace booking and airspace management.

**Airspace Scenarios**

Consistent use and management of ATS routes (permanent or conditional) is ensured at the Network level. Predefined scenarios are established, taking into account partners’ requirements (ATC, airports, military) for usage of the network in relation to ATC sector configuration, route and airspace availability, social events, etc.

**Network Operations Plan**

Stakeholders contribute more efficiently to the elaboration of the NOP and updates are integrated more dynamically. At the end of the SL time-frame the NOP provides an overview of the ATFCM situation from strategic planning to real time operations as a rolling plan. The data is accessible online by stakeholders for consultation and update. The NOP is updated taking into account the actual traffic situation and real time flow and capacity management, which eliminates requirement for AUP and RAD.
Sample Enablers

IM:
- Real-time airspace, capacity & demand data collected, verified and shared among all stakeholders
- Accurate and coherent short- to medium-term demand forecasts

INFRA:
- Systems to support the ADR & improved information management
- Capacity & complexity prediction tools with ‘what-if?’ functionality

INST:
- Common rules and procedures

B3.2.3 Integrating military traffic into Network

Flexible Airspace Design

There is a modular design of reserved and segregated airspace to enable sub-divisions, creation of new areas or revised airspace requirements closer to air bases and define different airspace scenarios to address local, sub-regional and regional (network) impact.

Harmonised Military Operations

OAT operation across Europe is improved by harmonising relevant national OAT arrangements at regional (network) level.

OAT requirements are integrated into strategic ARN developments resulting in a Pan-European OAT Transit System, which connects national structures and arrangements to form a flexible system facilitating OAT-IFR flights across Europe. OATTS provides timely and flexible availability of adequate routing and airspace options according to military mission requirements for short transit into military training/exercise areas, and long-haul transit across States. Additionally, predefined scenarios are available to facilitate increased military OAT transit demands in the event of large-scale military operations and exercises (ATM contingency plans).

Sample Enablers

IM:
- Real-time airspace, capacity & demand data collected, verified and shared among all stakeholders
- Accurate and coherent short- to medium-term demand forecasts

INFRA:
- Systems to support modular sectorisation design & management
- Capacity & complexity prediction tools with ‘what-if?’ functionality

INST:
- Harmonisation of national OAT arrangements

B3.2.4 Reduce tactical rerouting

Collaborative Flight Planning leading to reduced tactical rerouting

Airspace users are assisted in filing their flight plans and in re-routing according to the airspace availability and the ATCFM situation, in collaboration with the CFMU, ANS providers and airports. Airspace users can make more informed decisions when compromises are needed between delay, re-routing, trajectory limitations or costs. On the basis of the offered routings, they can select the one which is best suited to their company policy for optimising flight time, fuel burn or other parameters.

The interface between airports and ATFCM is reinforced at the tactical level in order to improve predictability of operations through exchanges of accurate departure and arrival times, CFMU provides airports with arrival estimates up to 3 hours prior landing (taking account of updated information on flight progress) whilst airports provide CFMU with flight data updates before take-off.
Airspace users, airports and ATM have a consistent view of the filed flight plan including late updates until departure. Flight plans can be changed up to estimated off-block time in function of airspace availability.

ATFCM is aware of deviations from the flight plan, including route changes, diverting flights, missing flight plans, change of flight rules (IFR/VFR) or flight type (GAT/OAT). This enables a better assessment of the impact of airspace changes on aircraft while in flight, an improved monitoring of actual traffic situation and, if necessary, the triggering of revisions to the Network and Airports Operations Plan (NOP/AOP).

Filing of flight plans is done in a common format (=ICAO FPL format) for military flights i.e. GAT, mixed OAT/GAT and all OAT flights for which a filed flight plan is required (military authorities might have to revisit their existing flight planning regulations and procedures for pure OAT flights). OAT flight plans are not subject to flow management provisions or restrictions.

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**Sample Enablers**

**IM:**
- Real-time airspace, capacity & (civil & mil) demand data collected, verified and shared among all stakeholders
- Information on delay, airspace availability, route charges, fuel cost – and airline preferences available to IFPU in order to generate options for re-filing FPL or rerouting

**INFRA:**
- Systems to support (automatic) generation proposals for re-filing FPL or rerouting
- ‘what-if?’ functionality
- Automatic revisions to the NOP

---

**B3.2.5 Reduce ATC routine tasks**

**Automated Controller Assistance and Multi-sector Operations**

Automated support is available to assist the Planning Controller in conflict identification and planning by providing automated early detection of potential conflicts. Flight conformance to a clearance or plan is automated, providing the controller with warnings of aircraft deviations and reminders of instructions to be issued. Coordination, transfer and dialogue are conducted screen-to-screen between adjacent ATS Units and/or sectors, thus reducing workload associated with coordination, integration and identification tasks.

Sector Team operations are adapted to new roles for tactical and planning controllers e.g. one planning controller providing support to a number of tactical controllers operating in adjacent sectors. In this configuration, the planning controller filters predicted conflicts with a focus on conflict-free trajectories to alleviate or smooth the workload of the tactical controllers.

**Controller-Pilot exchanges through data link**

Voice controller-pilot communications are complemented by services allowing flight crews and controllers to conduct operational exchanges through data link.

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**Sample Enablers**

**INFRA:**
- controller tools for conflict detection & planning
- automated flight conformance verification
- controller screen coordination transfer & dialogue
- multi-sector planning tools
- data link

**HUMAN:**
- Human Factor implications assessment
B3.2.6 7 Airspace Classes below FL195

At and below FL195, ATS Routes of the ARN as well as Terminal routes will be contained within airspace where, for safety reasons, there is to be a uniform application of the rules associated with the 7 ICAO airspace classes. At or below FL195, where supplemental rules to the 7 ICAO airspace classes are required to respond to operational and safety requirements of an airspace, a Toolbox containing those additional rules will be created and applied in a standard manner throughout ECAC.

Sample Enablers

**INST:**

- Guidance material that enables the uniform application of the 7 ICAO airspace classes.
- Below FL 195, where supplementary rules to the 7 ICAO airspace classes are required to respond to operational and safety requirements of an airspace, a toolbox containing those additional rules will be created and applied in a standard manner throughout ECAC.
- Harmonised publication of airspace classification criteria in ECAC, to ensure clarity and understanding.

B3.2.7 Enabling optimum trajectories

**Optimised En Route Airspace**

The route network continues to be enhanced in accordance with Advance Airspace Scheme principles to further optimise airspace structures (route/sector) across airspace boundaries, to better align routes and sectors with traffic flows and to accommodate more efficiently the various types of airspace users (e.g. specialisation of routes and sectors where needed to enhance productivity and reduce controller workload).

Operations along optimum trajectories are possible in defined airspace volumes at particular times. An increasing number of cross border ATC sectors exist to support optimum flight trajectories along with FAB development. Route spacing is reduced using P-RNAV. More fixed and flexible routing options are developed and made available due to enhanced Flexible Use of Airspace and increased predictability.

![Figure 42 Sample Optimum Trajectory Area](image)

Optimum Trajectory Area (OTA) within which aircraft selects trajectory as per user preference, e.g.:

- Most flight efficient trajectory is A-B.
- Due to Area Z, trajectory A-B not viable. Therefore operator wants optimum trajectory A-X-Y-B (user preferred) which is not necessarily most flight efficient.

Modular ATC sector design, adaptable in pre-defined shape and size is available to facilitate sector configurations.
The revised route structure provides connectivity with major TMAs and accommodates expected traffic demand. The airspace design and pre-determined scenarios provide viable options to airspace users with multiple route options and modular temporary airspace structures. Airspace scenarios are agreed by airspace users, ANSPs, military and CFMU to enable more efficient routings on the day of operation (e.g. to fully utilise airspace released by the military).

Airspace is divided into small elementary sectors or modules and grouped into operationally defined air traffic control sectors and pre-defined sector configurations, according to the main traffic flows predicted for the day of operation. The appropriate sectorisation scenario is activated based on the assessment of the predicted traffic demand and diverse user requirements. Sector configuration management is improved as a function of the Network Operations Plan, ensuring a balance between demand and capacity at regional (network) level through more effective resource utilisation, improved flexibility in staff rostering, adaptation and synchronisation of opening schemes across centres, and harmonisation of working practices.

Automated support for dynamic sectorisation and dynamic constraint management is introduced at the end of the SL time-frame in support of dynamic management of the airspace structure (route network & sectorisation). The system provides support for decision making based on pre-defined sector sizing and constraint management in order to pre-deconflict traffic and optimise the use of the controller workforce.

Cruise-climb techniques and in-trail procedure

Cruise/climb techniques are introduced contributing to initial optimising of trajectories. Air Traffic Situation Awareness - In-Trail Procedure is enabled in oceanic airspace (ATSA-ITP)

### Sample Enablers

**IM:**
- Real-time airspace, capacity & (civil & mil) demand data collected, verified and shared among all stakeholders

**INFRA:**
- PRNAV
- Systems to support modular sector design & dynamic management
- Capacity & complexity prediction tools with ‘what-if?’ functionality
- Controller decision making support tools
- Medium term conflict detection tools

**INST:**
- Harmonisation of controller licensing and rostering practices

### B3.2.8 Managing Environmental Impact

**Aircraft noise management** and mitigation at and around airports ensures that aircraft noise emissions are minimised both in the air and on the ground and that the impact affects the least number of people. No unnecessary noise-driven limitations and restrictions are imposed. Constraints, i.e. non-optimal procedures or economic burdens that are imposed strike the most appropriate balance between social, economic and environmental imperatives. Where a bigger strategic gain can be made by the voluntary adoption of lesser restrictions, it is ensured that these are developed according to a balanced approach and with full input from all relevant stakeholders. The option with the best sustainability balance is selected, provided it does not affect safety requirements.

**Aircraft fuel use and emissions**

Aircraft fuel and emissions in the en route phase are managed to ensure that aircraft fuel use and emissions are minimised to the greatest extent possible, and that progress towards the target is adequately monitored, with recognition given for success.

Aircraft fuel use and emissions at and around airports is managed to ensure that aircraft fuel use and gaseous emissions are minimised both in the air and on the ground. The impacts considered associated with an airport reflect the emissions from that airport and not emissions from third party sources. Gaseous emissions from airport-related non-aircraft sources (e.g. ground transport) are minimised and, where appropriate, the reductions allow growth in aircraft movements. Emissions are
not permitted in locations where they unnecessarily adversely impact local residents and, where unavoidable, any impact on the local community is minimised and mitigated for. Constraints, i.e. non-optimal procedures or economic burdens that are imposed strike the most appropriate balance between social, economic and environmental imperatives. Where a bigger strategic gain can be won by the voluntary adoption of lesser restrictions, it is ensured that these are developed according to a balanced approach and with the full input from all relevant stakeholders. The option with the best sustainability balance is selected.

**Water pollution** is reduced by creating de-icing stations where the fluids, spoiled on the apron, are collected and treated. Furthermore, technical solutions for the bio-degradation of de-icing fluids are implemented. Application techniques are developed in collaboration with airlines to improve the anti-icing treatment on aircraft at the stands so that the amount of glycol released in the storm water is reduced.

**Environmental performance is monitored** locally. The environmental performance of ATM stakeholders at the airport is recorded and monitored as part of a continuous improvement process. In particular, it is possible to determine the amount of airport related versus external pollution. This involves use of noise monitoring system, flight tracking and air quality monitoring system.

Environmental restrictions are accommodated in the earliest phase of flight planning. They are becoming more significant for the planning and execution of the business trajectories of aircraft operators. It is in the interest of ATM-stakeholders (aircraft operators and airports) to take into account the environmental restrictions in the early phase of flight planning.

**Sample Enablers**

**IM:**
- Real-time environmental, airspace, capacity & (civil & mil) demand data collected, verified and shared among all stakeholders

**INFRA:**
- noise monitoring system,
- flight tracking and
- air quality monitoring system

**B3.2.9 Initiating Integrated Terminal Airspace**

**PRNAV supported Terminal Airspace Systems**

Airspace organisation is enhanced in Terminal Airspace with the use of RNAV and PRNAV, based on common agreed design criteria for SID/STARs and their increased use. Where precision approaches are not feasible, reductions in minima decisions with respect to conventional Non-Precision Approaches (NPA) are made possible through the implementation of RNAV Approach procedures with Vertical guidance (APV).

Entry/arrival gates into TMA or TAS are developed. Temporary terminal airspace structures are used to enable more dynamic airspace management, including application of FUA. Design of terminal airspace structures and ATC sectorisation is with a view to evenly distributing ATC workload and minimising adverse ATM-related environmental impact. Terminal airspace structures are designed having different dimensions (flexible) depending upon the routing configuration servicing multiple runways.

**Flight Efficiency and Environment Based Procedures**

Simple Continuous Descent Approach (CDA) is used through adapted procedures with no need for further ground system automation. When traffic permits, Continuous Climb Departure (CCD) is used to reduce noise around the airport. Fuel consumption is reduced by flying optimised profiles.

RNP-based curved/segmented approaches and steep approaches are implemented to respond to local operating requirements (e.g. terrain or environmental reasons)
Time Based Separation

At the end of the SL timeframe, time-based separation for arrivals is implemented to optimise runway throughput and maximize TMA capacity. This replaces the distance criteria currently used to separate trailing aircraft on the approach beyond the wake vortex of the leading aircraft.

Traffic from en-route into Terminal Airspace is metered in time along ATS routes.

Departure Management

Departure Management determines the optimum runway for departure and the optimum departure sequence, taking into account departure times, slot constraints and runway constraints such as departure rate, wake vortex separation, distance in trail, etc.

Arrival Management

Improved arrival management facilitates the use of PRNAV, together with the use of CDA approaches. Sequencing support is based upon trajectory prediction, allowing for a mixed navigation capability to operate within the same airspace and eventually provide a transition to 4D operations. Arrival management is extended to en-route airspace, integrating information from different arrival management systems to provide an enhanced and more consistent arrival sequence.

Air Traffic Situational Awareness-Visual Separation on Approach (ATSA-VSA) is introduced to help crew to achieve the visual acquisition of the preceding aircraft and to maintain visual separation.

Manual ASAS sequencing and merging application is introduced, whereby the flight crew follows the speed command to achieve the necessary spacing.

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<tr>
<td>• Real-time airspace, capacity &amp; demand data collected, verified and shared among all stakeholders</td>
</tr>
<tr>
<td><strong>INFRA:</strong></td>
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<tr>
<td>• Performance Based Navigation</td>
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<tr>
<td>• Capacity &amp; complexity prediction tools with ‘what-if?’ functionality</td>
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<tr>
<td>• Enhanced &amp; integrated arrival management tools</td>
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<tr>
<td>• Trajectory prediction tools to assist controller decision making</td>
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<tr>
<td>• Air traffic situational awareness - visual separation on approach</td>
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<td>• Airborne separation assistance assurance system</td>
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B3.2.10 Runway Management

Optimised Runway Throughput in All Conditions

Reduced separations for departures and arrivals are applied under certain crosswind conditions, eliminating the requirement for the application of wake vortex minima. ATC procedures are enhanced to improve operations in low visibility conditions. The controller is able to use reduced aircraft separations derived from forecast wake vortex behaviour.

Capacity gains are achieved by optimised utilisation of the combined runways by reducing dependencies between runways through the implementation of more accurate surveillance techniques, controller tools and advanced procedures.

Optimised Runway Occupancy

Runway Occupancy Time (ROT) reduction techniques are used to enhance operating practices of airlines and pilots. Brake to vacate at a pre-selected runway exit contributes to ROT reduction and is coordinated with ground controllers. ROT is also improved by enhancing the airport layout (e.g. runway exits provided for the aircraft mix, multiple runway entries and wide holding areas to optimise the sequencing process for departing aircraft).

Sample Enablers

INFRA:
- reduced aircraft separations derived from forecast wake vortex
- more accurate surveillance techniques
- controller tools
- advanced procedures
- Brake to vacate
B3.2.11 Turn around and Surface Management

Airport CDM

A set of milestones in the turn-round process are established at airports and flight progress is monitored against those milestones. The information is shared by all involved partners, e.g. the aircraft operator, the CFMU and the destination airport. Shared information on turn-round is used to estimate departure demand and enable arrival/departure balancing. Collaborative Decision Making process between all the partners improves operations in adverse conditions through systematic strategies agreed and applied. This includes de-icing stations managed through CDM procedures enabling airport and ANSP to know which flights require de-icing and establish sequences accordingly.

Pre-departure sequences are established collaboratively with the airport CDM partners, applying agreed principles (e.g. slot compliance, airline preferences, night curfew, evacuation of stand/gate for arriving aircraft, etc.). The resulting pre-departure list is used by ATC to sequence departing aircraft, as and when feasible.

Airport Integrated into the Network

Airport CDM is extended to include interconnected regional airports. Information is exchanged with the CFMU in order to improve the estimated time of arrival for all flights inbound to the region. Convergence is ensured between airport slots and ATFM slots with an improved airport slot monitoring process. This will improve consistency, reduce delays and improve airline schedules and slot compliance.

Situational Awareness

Ground controller situational awareness is enhanced in all weather conditions through providing the position and automatic identity of all relevant aircraft and vehicles on the movement area. Guidance on the airport surface is improved by providing the pilot and the vehicle drivers with an airport moving map showing taxiways, runways, fixed obstacles and own mobile position. Air Traffic Situational Awareness (ATSAW) application is introduced in the cockpit to provide the pilot with Information regarding the surrounding traffic (aircraft and airport vehicles) during taxi and runway operations.
At the end of the SL time-frame the dynamic traffic context information is displayed to the pilot, including status of runways and taxiways, obstacles, route to runway or stand. Ground signs (stop bars, centreline lights, etc.) are triggered automatically according to the route issued by ATC.

**Sample Enablers**

**IM:**
- Turn-round data collected and shared among all stakeholders
- Agreed principles

**INFRA:**
- Surface routeing and guidance, airport moving map
- Air traffic and vehicle situational awareness in the cockpit
- Automatic ground instruction signs
- SMAN determines associated start-up and push-back times and taxi route
- Information regarding the surrounding traffic, including aircraft and airport vehicles, during taxi and runway operations is displayed in the vehicle driver's cockpit.

**B3.2.12 Network performance assessment**

Key Performance Indicators are developed and used to assess how effective ATM is at meeting users' needs and to act as driver for further improvements of the ATM system. Both users and providers are able to monitor the actual operation (routes flown, usage of allocated airspace, runway utilisation, etc.) against the forecast operation and to assess the adequacy of the capacity provision.

Military KPIs for airspace efficiency, mission effectiveness and flexibility and agreed civil-military KPIs for airspace utilisation are developed and used. Deviations are highlighted and generated actions to continuously enhance civil-military cooperation and coordination.

**Sample Enablers**

**INFRA:**
- validation of KPIs

**B3.3 Service Levels 2 & 3**

**B3.3.1 Dynamic DCB & UDPP**

**Regional and Sub-regional Network Management**

Network Management is achieved through a Collaborative Decision Making (CDM) process involving all participants and is performed at regional (network), sub-regional (e.g. FAB/TAS) and national level, with the regional Network Manager maintaining the overall network picture. Sub-regional network management is undertaken at FAB level, and, at local level, coordination occurs between the Flow Management Position (FMP) and the Airspace Management Cell (AMC) of the national unit, including military, using the Network Information Management System (NIMS).

**User Driven Prioritisation Process (UDPP)**

Where there is no capacity shortfall, reference trajectories are handled on a first-come first-served basis. Prioritisation for departure in the event of reduced capacity is the result of a collaborative process involving all partners (User Driven Prioritisation Process UDPP). Airspace users can among themselves recommend to the Network Management a priority order for flights affected by delays caused by an unexpected reduction of capacity and will respond in a collaborative manner with a demand that best matches the available capacity. Towards the end of the SL time-frame, the optimisation of network usage by ATFCM is based on 4D trajectory updates.

Large airports make increasing use of automation, in close cooperation with Air Navigation Service Providers to enhance predictability, flexibility and efficiency. Information is stored and provided through System Wide Information Management (SWIM). Trajectory-based planning and execution of
the operations is taking place, enabling a User-Driven Prioritisation Process. Airports that have an impact on the network performance are recognised as an integral part of the ATM network.

**Airspace Configuration Management through NOP**

Collaborative coordination and a systematic approach for the selection of airspace configurations are available. The basis for collaboration is the Network Operations Plan (NOP) that has evolved into a 4-dimensional virtual model of the European ATM environment, providing a dynamic, rolling picture of the ATM environment for past, present and future.

The shared use of military temporary reserved and/or segregated and cross-border areas (CBA) is further extended at European level.

The possibility for ad-hoc structure delineation at short notice is offered to respond to short-term airspace users’ (civil or military) requirements that are not covered by pre-defined structures and/or scenarios. Such changes in the airspace status are provided to the pilot by the system in real time.

**Figure 45 Current Situation & Sample Airspace Configuration**

<table>
<thead>
<tr>
<th>Sample Enablers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IM:</strong></td>
</tr>
<tr>
<td>• 4D trajectory updates</td>
</tr>
<tr>
<td>• Information is stored and provided through System Wide Information Management (SWIM)</td>
</tr>
<tr>
<td>• Network Operations Plan (NOP) as a 4 dimensional virtual model of the European ATM environment, i.e. a dynamic, rolling picture providing a relational image of the state of the ATM environment for past, present and future</td>
</tr>
<tr>
<td>• Changes in the airspace status are provided to the pilot by the system in real time</td>
</tr>
<tr>
<td><strong>INFRA:</strong></td>
</tr>
<tr>
<td>• Airborne and ground systems, tools and equipment to enable 4D trajectory based operations</td>
</tr>
<tr>
<td>• NIMS</td>
</tr>
<tr>
<td><strong>INST:</strong></td>
</tr>
<tr>
<td>• Regional Network Manager maintaining the overall network picture</td>
</tr>
<tr>
<td>• Sub-regional network management is undertaken by FABs</td>
</tr>
<tr>
<td>• User Driven Prioritisation Process enabled</td>
</tr>
<tr>
<td>• Dynamic ATFCM using RBT</td>
</tr>
</tbody>
</table>

**B3.3.2 Airspace Classes Re-categorisation**

The airspace classification based on 7 ICAO Classes is re-categorised.
B3.3.3 Trajectory-based operations

Expansion of Optimum Trajectory Areas

Route constraints are removed in line with the development of 4D trajectory-based operations. The route network evolves to fewer pre-defined routes with the exploitation of advanced navigation capabilities and FABs, allowing for more direct routes and optimum trajectories.

At the end of the SL timeframe, it is anticipated that only a limited form of fixed route network is retained to cater for specific requirements related to non-capable aircraft,

There is a transition of medium complexity operations to/from Terminal Airspace, segregation between managed and unmanaged airspace, military flight planning, etc.

User-preferred routings are applied above a certain level across FABs. At the end of the SL timeframe, it is anticipated that free routing is enabled on larger segments of the trajectories (e.g. from top of climb to top of descent).

Precision-trajectories clearances

Precision-trajectory clearances are introduced to accommodate traffic in high density areas, enabling aircraft that are appropriately equipped to contain segments of their trajectories within 2D or 3D tubes.

Reduced Route Spacing

Spacing between routes is reduced where required, with commensurate requirements on airborne navigation and ground system capabilities. Operationally driven, cross-border sectorisation is applied along the route network optimised using advanced RNP1.

Business / Mission Trajectory Management

The conventional flight planning process is complemented by the development and publication by airspace users of a Shared Business / Mission Trajectory (SBT) made widely available for ATM planning purposes

Airspace users can refine the SBT through collaborative flight planning through a number of iterations, taking into account new and more accurate information. Through the NOP, they access an up-to-date picture of the traffic situation with the required level of detail for planning. The collaborative planning process terminates when the Reference Business / Mission Trajectory (RBT) is published.

During the execution of flights, changes to the RBT may be required by ATC to take account of ATM constraints arising from, for example, ad hoc airspace restrictions or closing of a runway. Such changes are negotiated with airspace users taking account of their preferences.

Similarly, changes to the RBT may be made to take advantage of unexpectedly released airspace, following proper coordination between all stakeholders (ATC, aircraft operator and airport)

It is the Network Manager’s role to facilitate the transition from the Shared Business trajectory to the Reference Business Trajectory (SBT/RBT). This requires:

- The integration of civil and military airspace management functions
- Closer interaction of all ASM levels at regional, sub-regional and local level through the Network Operations Plan (NOP)
- The functional merging of ASM and ATFCM tasks at national and sub-regional level
- Full consideration of both civil and military airspace user requirements and coordination at regional, sub-regional and local level
- Full utilisation of routes based on real-time knowledge of availability.
- Changes to flight plans, according to airspace availability, up to estimated off block time and/or when the aircraft is airborne.
- The incorporation into the rolling NOP of data currently available in the Airspace Use Plan (AUP), the CRAM (Conditional Route Availability Message), UUP (Updated Use Plan) and Route Availability Document (RAD).
Sample Enablers

**IM:**
- Flight planning process complemented by the development and publication by airspace users of a Shared Business / Mission Trajectory (SBT) made widely available for ATM planning purposes
- Successive authorisation of reference business/mission trajectory (RBT) segments possible using data link
- Precision-trajectories clearances to accommodate traffic in high density areas
- Precision trajectory clearances 3D based on predefined 3D routes
- Precision trajectory clearances 2D on user preferred trajectories
- NOP enables access an up-to-date picture of the traffic situation with the level of detail required for business/mission trajectory planning
- Changes to RBT possible during the flight using data link

**INFRA:**
- Airborne and ground systems, tools and equipment to enable 4D trajectory based operations
- Multiple control times of overfly (CTO) through use of datalink
- Advanced aircraft navigation capabilities
- Aircraft appropriately equipped contain segments of their trajectories within 2D or 3D tubes.
- NIMS (ADR, FDR)

**INST:**
- Agreed reference Business/Mission trajectory (RBT) through collaborative flight planning
- Spacing between routes reduced, with commensurate requirements on airborne navigation and ground systems capabilities
- Cross-border sectorisation applied along the Route Network optimised using advanced RNP1
- Integration of civil and military airspace management functions
- Functional merging of ASM and ATFCM tasks at national and sub-regional level

**B3.3.4 Minimise tactical interventions**

**Automated assistance to strategic de-confliction**

4D trajectories are shared and known with sufficient accuracy to be used by the system for detecting and reducing the number of potential conflicts. Automated tools assist controllers in identifying and resolving local complex situations and evaluating opportunities to de-conflict and/or synchronise trajectories in a multi-sector/multi-unit environment. Queue management is supported by Controlled Times of Over-fly (CTO) to be met by the aircraft with the required performance.

Route allocation tools that select the optimum conflict-free route are available to assist ATC in managing the potentially large number of interacting routes. They are used in high density terminal areas in support of Precision Trajectory Clearances (PTC).

**ASAS cooperative separation**

Towards the end of the SL time frame, controllers are able, under defined conditions, to delegate the responsibility for specific separation tasks (e.g. In-Trail Procedure) to the flight deck of suitably-equipped aircraft. Such delegations are part of the clearance resulting from mutual agreement between controllers and pilots (cooperative separation). The benefits are to discharge the controller, by delegation of tasks to the flight crew and to minimise the impact of conflict resolution on the trajectory.
Sample Enablers

IM:
- SWIM Air-Ground limited services
- Use of airborne data to enhance ATM ground system performance

INFRA:
- Airborne and ground systems, tools and equipment to enable 4D trajectory based operations
- Use of 4D shared trajectory as a mean to detect and reduce potential conflict number
- Conflict dilution by upstream action on speed
- Automated support for traffic complexity assessment
- Automated support for managing traffic complexity across several sectors
- Automated controller support for trajectory management
- Automated support for near-term conflict detection and resolution
- Trajectory conformance monitoring
- Trajectory intent monitoring
- System for detecting and reducing the number of potential conflicts based on 4D trajectories
- Queue management supported by Controlled Times of Over-fly (CTOs)
- Route allocation tools that select the optimum conflict-free route to assist ATC in managing the potentially large number of interacting routes

INST:
- Defined cooperative separation between controller and pilot
- Delegate the responsibility for specific separation tasks (e.g. In-Trail Procedure) to the flight deck of suitably-equipped aircraft

B3.3.5 High Performance Integrated Terminals & Airports

Optimised Terminal Airspace Design

There is increasing use of RNP SIDs and STARs. 3D management (along STARs/Instrument Approach Procedure (IAP), excluding final approach) is initiated, supported by predictable and repeatable turn performance. Terminal Airspace is further enhanced with the use of advanced RNP 1 terminal routes (incl. A-RNP1 SIDs and STARs). RNP-based instrument procedures with vertical guidance are used to increase safety and through the provision of stabilised approaches, thus reducing the potential for Controlled Flight Into Terrain (CFIT).

Dynamic Terminal Airspace Configurations

Terminal Airspace is dynamically managed, based upon configurations selected in a single terminal airspace or within a Terminal Airspace System. Terminal airspace structures are used with different dimensions depending on the routeing configuration, servicing multiple runways at different airports and/or military requirements. New or temporary terminal airspace structures or those with variable dimensions are developed to accommodate variable density operations.

Harmonised procedures for Advanced Continuous Descent Approach (ACDA) and Advanced Continuous Climb Departure (ACCD) are implemented in high density traffic areas. New controller tools and 3D trajectory management enable aircraft to fly, as far as possible, their individual optimum descent profile. Tailored arrival procedures are implemented, taking into account the other traffic and constraints, to optimise the descent.

ASAS sequencing and merging

ASAS sequencing and merging (ASPA-S&M) is applied as a contribution to traffic synchronisation in Terminal Airspace. The flight crew ensures a spacing from designated aircraft as stipulated in controller instructions. The crew is assisted by ASAS and automation as necessary.
Queue Management (including CTA Management)

All ATM partners work towards achieving Controlled Time of Arrival (CTA) and optimise the arrival sequence with enhanced accuracy. The CTA (which includes wake vortex optimisation) is calculated after the flight is airborne and published to the relevant controllers, arrival airport systems, user systems and the pilot.

Departure Management is optimised in the queue management process. With knowledge of the Target Time of Arrival (TTA), if applicable, the elapsed time derived from the trajectory, the departure and arrival demand for the runway/s and the dependent departure route demand from adjacent airports, the system (DMAN) calculates the optimum take-off time and the Surface Manager (SMAN) determines the associated start-up, push-back times and taxi route.

Departure management is applied to support departure metering and coordination of traffic flows from multiple airports to enable a constant delivery into the en-route phase of flight. Arrival management is applied to support coordination of traffic flows into multiple airports in the vicinity to enable smooth runway delivery.

The surface management constraint is integrated into departure and arrival management tools and processes, ensuring more stable departure sequence. The taxiing process is considered as an integral part of the process. There is full integration of AMAN, DMAN and the CDM process between airport operator, aircraft operators and air traffic service provider at the airport.

Automated assistance for surface movement planning and routing is available to provide controller with the best route with minimum delay according to planning, ground rules, and potential conflicts. The system informs the ground controller of any deviation from cleared or planned route. Enhanced guidance assistance is provided to airport vehicle drivers including routing display and dynamic traffic context information, including status of runways and taxiways, obstacles, and an airport moving map.

Reducing Separation

Controllers can optimise aircraft separations taking account of the actual wake-vortices strength.

Runway capacity is made less dependent on low visibility conditions with use of GNSS/GBAS landing system.

In low visibility conditions, pilots can also benefit from enhanced vision that provides for “out the window” positional awareness through the application of visual enhancement technologies thereby reducing the difficulties of transition from instrument to visual flight operations.

Airport Safety

Automated systems detect potential conflicts/incursions involving mobiles (and stationary traffic) on runways, taxiways and in the apron/stand/gate area. The alarms are provided to controllers, pilots, and vehicle drivers together with potential resolution advisories. The systems alert the controller in case of unauthorised / unidentified traffic. Information regarding the surrounding traffic, including aircraft and airport vehicles, during taxi and runway operations is displayed in the vehicle driver's cockpit.
Automated Brake to Vacate (BTV) is introduced to enable vacating runway at a pre-selected exit coordinated with ground ATC through data link. It is based on BTV avionics that controls the deceleration of the aircraft to a fixed speed at the selected exit.

Sample Enablers

**IM:**
- Data information (en-route and other relevant terminal airspace) exchanged as a function of identifying airspace configuration
- SWIM enabled NOP
- System wide information sharing through ADS-B

**INFRA:**
- 3D management along STARs/IAP, excluding final approach, enabled by required controller tools
- Route allocation tools that select the optimum conflict-free route to assist ATC in managing the potentially large number of interacting routes
- Predictable and repeatable turn performance
- ASAS sequencing and merging to synchronise traffic in TMA
- Automated assistance to ATC planning to prevent conflicts
- Controlled Time of Arrival (CTA) through use of datalink
- Departure management system from multiple airports
- CTA calculated to optimise arrival sequence (including wake vortex optimisation)
- DMAN calculates optimum take-off time
- SMAN determines associated start-up and push-back times and taxi route
- AMAN/DMAN integrated with CDM processes
- Automated assistance for surface movement planning and routing
- System informs ground controller of any deviation from route/plan it has detected
- Low Visibility Runway Operations based on GNSS / GBAS
- Enhanced vision in Low Visibility for pilots that provides for “out of the window” positional awareness through the application of visual enhancement technologies
- Automated system detects potential conflicts/incursions involving mobiles (and stationary traffic) on runways, taxiways and in the apron/stand/gate area
- Alarms are provided to controllers, pilots, and vehicle drivers together with potential resolution advisories
- Systems alert the controller in case of unauthorised / unidentified traffic
- System to provide controller with actual wake vortex measurement
- Information regarding the surrounding traffic, including aircraft and airport vehicles, during taxi and runway operations is displayed in the vehicle driver’s cockpit.
- Automated Brake to Vacate (BTV) through data link to enable vacating runway at a pre-selected exit coordinated with ground ATC based on BTV avionics that controls the deceleration of the aircraft to a fixed speed at the selected exit

**INST:**
- Tailored arrival procedures
- RNP based SID/STARS with vertical guidance
- Advanced RNP1 routes
- Terminal structures with variable dimensions
- ACDA and ACCD procedures implemented
### B3.4 Service Levels 4 & 5

#### B3.4.1 Trajectory Based Network

**Dynamic Airspace Design and Management**

Airspace reservations are now considered in the context of temporary airspace volumes optimised in time and size (Dynamic Mobile Areas) to meet the user’s needs while minimising the impact on other airspace users.

Sectors shape and volumes are adapted in real-time to respond to dynamic changes in traffic patterns. Other than terminal areas, free routing is in place.

Areas of responsibility can be transferred between air traffic service providers according to demand known through the publication of the RBT.

The Regional Network Management function is the “last resort broker” ensuring the stability of the whole network in the face of traffic demand and threats like weather phenomena.

**Airports fully Integrated**

Airports are fully integrated into the ATM network, and the 4D trajectory environment. Full automation of planning and operating phases making use of System Wide Information Management and using the aircraft as an active source of information are in place.

Remotely controlled surface operations at secondary airports are in place.

**Airspace Categorisation**

Two categories of airspace are applied.

**4D Precision Trajectory Clearances (PTC)**

The usage of Precision Trajectory Clearances (PTC) is generalised (including PTC-4D clearances) and applied more dynamically.

**Expanded Cooperative Separation**

The scope of cooperative separation applications is wider (e.g. incl. crossing and passing manoeuvres).

**Self-separation**

Spacing between aircraft in terminal areas is adjusted dynamically by pilots, based on the actual position of the wake vortex of the predecessor. Pilots benefit from synthetic vision systems to overcome low visibility environments.

Self-separation is introduced. At the end of the SL timeframe, self separation is expected to be used in a mixed-mode environment. The objective is to avoid segregation of flights according to aircraft capabilities in order to facilitate the transition to new modes of operation/separation and to facilitate access to all users (segregation may be unavoidable for other performance objectives). This means that the ground has to provide the required service to less capable users according to their capabilities without penalising the others. The transition to this objective is a long term research issue.
### Sample Enablers

**IM:**
- SWIM - Ground-Ground full services
- SWIM - Air-Ground extended services
- Air-Air Exchange services
- Aircraft Dissemination of Information on Weather Hazards to Other Aircraft

**INFRA:**
- Automatic RBT Update through TMR
- 4D Contract for Equipped Aircraft with Extended Clearance PTC-4D
- Precision Trajectory Clearances (PTC)-3D On User Preferred Trajectories (Dynamically applied 3D routes/profiles)
- ACAS adapted to new separation modes
- CTCA adapted to new separation modes
- Synthetic Vision for the Pilot in Low Visibility Conditions
- Automated support for dynamic sectorisation and dynamic constraint management
- Improved compatibility between ground and airborne safety nets

**INST:**
- Dynamically shaped sectors
- Dynamic Mobile Areas (DMA)
- Remotely Provided Aerodrome Control Service
- Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P)
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C1 Scope

The ATM Information Management, specifies how the Information Management (IM) network consisting of stakeholders and systems in the roles of ATM information users and information providers will evolve — from an operational IM perspective — to implement the SWIM concept and satisfy the strategic IM performance needs. It also specifies the changing IM roles, responsibilities and rules as well as (in general terms) requirements for the ATM Infrastructure needed to support Information Management.

C1.1 Glossary

ATM:

Air Traffic Management is used in these documents in the widest sense (like in all SESAR material) and not confined to the ICAO Doc 9082 definition.

Data:

A representation of fact, notion or instruction represented in a formalised form suitable for communication, interpretation or processing either by human or by automated systems.

This is the lowest level of abstraction, compared to information and knowledge.

Information:

A fact, notion or instruction that can be used, alone or associated with data or other information to support a decision making made by a human. Information is generally the result of the assembly, analysis and suitable formatting of data.

Note: It is acknowledged that within this document the terms “data” and “information” have been used interchangeably.

Aeronautical Data:

A representation of aeronautical facts, concepts or instructions in a formalised manner suitable for communication, interpretation or processing (source ICAO Annex 15).

Aeronautical Information:

Information resulting from the assembly, analysis and formatting of Aeronautical Data (source ICAO Annex 15).
Aeronautical Information Service (AIS):
A service established within a defined area of coverage responsible for the provision of aeronautical information / data necessary for the safety, regularity and efficiency of air navigation (ICAO Annex 15).

Such information includes the availability of air navigation facilities and services and the procedures associated with them, and must be provided to flight operations personnel and services responsible for flight information service.

Aeronautical Information Management (AIM):
The dynamic, integrated management of aeronautical information services — safely, economically and efficiently — through the provision and exchange of quality assured digital aeronautical data in collaboration with all parties. (source ICAO AISAIM Study Group)

Meteorological Information:
Meteorological information, as defined in ICAO Annex 3 to the Convention on International Civil Aviation “Meteorological Services for International Air Navigation” represents “meteorological report, analysis, forecast and any other statement relating to existing or expected meteorological conditions”.

Flight Domain:
Flight Data includes all data concerned with a single flight that needs to be shared between different systems during the life cycle of the flight.

Capacity Demand & Flow Management:
Capacity Demand & Flow Management covers both Capacity & Demand and ATFCM Scenarios data domains originally defined during SESAR Definition Phase.

Air Traffic Flow Management is a function established with the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilised to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate air traffic service providers (source EUROCONTROL)

Surveillance Domain:
The data domain that addresses the function which provides identification and accurate position information on aircraft, vehicles and obstacles within the designated area (source: ICAO DOC 9830).

Environmental Information:
The flow of information on environmental rules, restrictions and market based environmental instruments etc. (e.g. noise limits and emission trading data) into SWIM for use in operational planning and tactical optimisation; and, the flow of accurate operational information into environmental performance assessment and predictive tools to allow the ATM environmental performance KPA to be assessed and predicted thus helping to optimise mitigation and to minimise enviro-constraints.

Information Management (IM):
“The collection and management of information from one or more sources and the distribution of that information to one or more audiences.

Management means the organization of and control over the structure, processing and delivery of information” (Wikipedia)

System Wide Information Management: (SWIM):
The EUROCONTROL ATM Strategy 2000+ defined SWIM as: “The 'horizontal' support process, whose aim it is to establish the concepts and mechanisms which combine the forces of all suppliers of shared ATM information so as to assemble the best possible integrated picture of the past, present and (planned) future state of the ATM situation, as a basis for improved decision making by all ATM stakeholders during their strategic, pre-tactical and tactical planning processes, including real-time operations and post-flight activities”
The term SWIM has been interpreted differently over time by various organisations. In the interest of clarity, in this document SWIM represents the overall concept that is comprised of Information Management, and the SWIM Infrastructure.

Figure 47 presents the SWIM scope positioned with regard the three usual layers of:
- Applications making use of all appropriate data and providing added value to the end user;
- Information containing the data needed;
- Physical Infrastructure to send the data around on.

Plus the appropriate “environment” which comprises:
- Technology and systems to connect all together; and
- Common methodology.

![Figure 47 SWIM Scope](image)

**SWIM Infrastructure:**

The implementation aspects covering the physical network, protocols and systems facilitating Information Management.

**Product Centric:**

An approach to information management which focuses mainly on the delivery of products in whichever form (e.g. documents, publications) suitable for the widest possible range of users targeted by the product.

**Net Centric:**

Net-centricity is the realisation of a networked environment, including infrastructure, systems, processes, and people, that enables a completely different approach to operations. It is a globally interconnected, end-to-end set of information capabilities, associated processes, and personnel for collecting, processing, storing, disseminating, and managing information on demand to users. Users are empowered to more effectively exploit information; more efficiently use resources; and create extended, collaborative communities.

Founding on AIS / AIM, SWIM will further expand to include all other data domains, as depicted by Figure 48.
Interoperability:

The IEEE Standards Computer Dictionary defines interoperability as the ability of two or more systems or components to exchange information and to use the information that has been exchanged. It differentiates:

- Semantic interoperability
- Syntactic interoperability

Semantic interoperability:

the “Semantic interoperability” which considers that all users of the computer system parts agree on the definition.

With respect to software, the term interoperability is used to describe the capability of different programs to exchange data via a common set of exchange formats, to read and write the same file formats, and to use the same protocols. More precisely, in ISO/IEC 2382-01, interoperability is defined as follows: “The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units”.

Syntactic interoperability:

the “Syntactic interoperability” which considers that, for communicating data, specified data formats, communication protocols, interfaces of descriptions and the like are fundamental. In general XML or SQL standards provide syntactic interoperability.
C2 The Need for Change and Vision

C2.1 Introduction

The SESAR Masterplan states: “The whole basis of the SESAR Concept of Operations & business case is jeopardized if SWIM is neither implemented in its correct form nor sufficiently early”. Therefore SWIM is treated as the 5th Key feature of the Operational Concept and is a prerequisite for all Strategic Areas identified in Annex B.

ATM can be seen as a complex, distributed real-time information processing community. This community is populated (see Figure 49) by a large number of humans and automated systems in the roles of information providers (including sensors), decision makers and information users, all collaborating to ensure a safe, expeditious and efficient flow of air traffic. The objective of information management is to provide the decision makers and information users with the right information at the right time and the right place.

The humans and systems are part of different types of organisations and the way these organisations co-operate will determine largely the requirements for information management on the system of systems\(^*\) level. Information Management (IM) can be split into:

- Inter-organisational IM, for the IM aspects to be aligned between different co-operating organisations;
- Intra-organisational IM for the IM aspects within one single organisation.

Organisations have individually worked on solving their own IM issues since the sixties. The new challenge lies in aligning these intra-organisational IM approaches with a European inter-organisational Strategic Guidance for IM that also needs alignment on the global level to support the anticipated co-operations between continents.

Figure 49 ATM Information Processing Community

Viewing ATM as an information processing community, it can be seen that the performance of ATM depends on six information-related factors identified in Figure 49:

1. Existence of airborne and ground-based suppliers (systems and service providers) for the various types of ATM decision support information;

\(^*\) Sometimes system of system is referred to as a federation of systems, when any form of central control of the co-operating organisations is missing.
2. Quality and timeliness of the provided decision support information (quality includes integrity, accuracy, completeness, trustworthiness etc.);

3. Ability of airborne and ground-based ATM decision makers to receive, interpret and use available information;

4. Quality and timeliness of the airborne and ground-based decision making itself;

5. Effectiveness and timeliness of making the resulting ATM decision information available to (potential) airborne and ground-based users of that information (those who have to act on it);

6. Effective information filtering and prioritisation along the data processing chain from origin to end use.

All six factors need to be improved in order to enhance overall ATM performance.

Historically, the focus of attention has primarily been on how to improve algorithms, automated tools and procedures for decision making (items 2 to 4) in the various functional categories of airspace management, flow and capacity management, separation assurance, sequencing and metering etc. The guidance for information management is complementary to this focus as it considers improving all factors.

The guidance material for ATM Information Management translates the evolution of the ATM network, consisting of stakeholders and systems, into an IM perspective. It specifies the implementation of the SWIM concept and its contribution to the satisfaction of the strategic ATM performance needs.

Together with the Infrastructure guidance it describes in more detail the technical implementations of the requirements expressed from the Performance and Network perspectives.

C2.2 The Need for Change

Aviation is increasingly dependent on accurate and timely information.

Such information must be provided through means that support system-wide interoperability, secured seamless information access and information exchange organised over open means to bring information providers and users together into a net centric system.

Interoperable information exchange will facilitate new business process automation but will not eliminate the need for exception handling requiring human intervention. As a consequence, both data exchange and data presentation layers need powerful filtering and portrayal means for systems and human use.

For systems to co-operate and share data in an effective way, common references (e.g. common time reference) and processes have to be employed across the European ATM System.

The ATM infrastructure must be aligned with ATM’s business needs.

Some of the early IM activities are based on present systems’ evolution plans using the existing and uncoordinated system designs. Yet from 2013 the implementation of SWIM (including the management of its security and its safety), a cornerstone of the future European ATM System, will evolve from the paradigm of point-to-point message exchange to system-wide information provision and usage based on common definitions of the data and associated services. Within the SESAR development phase, the ATM architecture will be developed making use of a new architecture development process which will use an Enterprise Architecture (EA) Framework and will follow a Service Oriented Approach ensuring better alignment between the Information Technology systems and the Air Traffic Management business. This process will clearly distinguish between the ATM services that have to be provided, the underlying supporting services and the physical assets that will be needed to deploy it. All changes to be made to the ATM system will use this new approach and all SESAR Performance Partners will use one shared architectural framework based on European Air Traffic Management System (EATMS) Services which expose standard service interfaces.

For example, the En-Route and Approach ATC systems will transition from using specific, pre-established, direct sub-system to sub-system data exchange to information sharing, together with more reliance on data and services provided by systems owned by other stakeholders. This will depend on a supporting infrastructure, including security and supervision policies, rules and services.
The realisation of the SESAR Operational Concept is reliant on two key enablers that are directly related to Information Management:

1. **All partners share the same trajectory and other 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, 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 to post-operation activities. ATM planning, Collaborative Decision Making (CDM) 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. **System Wide Information Management (SWIM)**

   Underpinning the entire ATM system, and essential to its efficient operation, is a SWIM environment that includes aircraft as well as all ground facilities. It will support CDM processes using efficient end user applications to exploit the power of shared information. Fundamental to the entire ATM Target Concept is a ‘net centric’ operation based on:
   - a powerful information handling network for sharing data;
   - new air-ground data communications systems; and
   - an increased reliance on airborne and ground based automated support tools.

   The sharing of a Business Trajectory, depicted in Figure 50 is a typical example of the use of these enablers and the net centric approach.

   **Figure 50 The Business trajectory concept**

   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.

   **C2.3 The IM Strategic Vision**

   The IM Strategic Vision can be summarised by a split between data provision and data usage and requires the information to be based upon the following key generic characteristics illustrated in Figure 51:
   - Geo-enabled: information shall be geocoded to allow for location based filtering;
   - Time-enabled: information shall be time stamped in terms of validity for time based filtering;
- Seamless: barriers between systems shall be removed through globally and universally defined interfaces for authorised users;
- Open: standards such as common data models published in the public domain shall be used.

Figure 51 Data sharing fundamental characteristics

The separation between data provision and data usage, combined with the unlocking of the data by the application of the key generic characteristics will allow interoperable information sharing. This in turn will facilitate innovation by industry based on “one logic – many / new solutions”.

Currently applications exist that follow these principles and can be considered as SWIM-enabled applications. The following list gives examples of such applications:

- PAGODA;
- NOP Portal;
- Airport CDM.

This strategic vision will be implemented through Strategic Principles presented in section C3.2, leading to Deployment explained in section C3.3 that will be implemented according to a phased approach depicted in section C3.4.
C3 ATM Information Management Strategic Guidance

C3.1 Scope and Objectives

This guidance for IM addresses interoperable and seamless information sharing between ATM organisations and systems. The scope of this annex IM is therefore limited to the shared ATM information. It covers the Information Management aspects which require a common understanding between collaborating entities in ATM.

This annex addresses the following topics:

- The IM information that should be handled by the network for information sharing;
- The characteristics of a powerful information sharing network;
- The ATM information that should be exchanged by the existing or new air-ground data communication systems;
- The consequences of the paradigm shift from message exchange to information provision / use / contribution;
- The link between Enterprise Architecture and Information Management;
- The consequences of Service Oriented Architecture (SOA) for Information Management.

Though the focus of this document is mainly on digital data / information, the scope of this guidance material also addresses the current (mainly paper-based) form of data / information and its evolution towards full digital form to support a performance-based ATM system.

C3.2 Strategic Principles for ATM Information Management

C3.2.1 Information Management within European ATM Enterprise Architecture (EAEA)

Information Management will establish the framework that defines seamless information exchange between all providers and users of shared ATM information. This is captured in a reference framework for ATM Information Management (see section C3.3.1). The objective is to enable the assembly of the best possible integrated 4D picture of the past, present and (planned) future state of the ATM situation. Consequently, IM will integrate the ATM world in the information sense, a necessary step towards the realisation of Service Oriented Approach / Architecture.

The framework not only defines seamless information exchange between all providers and users of shared ATM information but also describes the performance and operational requirements of ATM wide information sharing. As such, it will strongly contribute to the definition of the shared information view of the EATM Architectural Framework and the ATM Information Reference Model (AIRM). It further encompasses those aspects which, within the SESAR context, describe architecture, principles, standards and processes such as the Business Process Management\(^\text{15}\), necessary for a coordinated and coherent implementation of the means required to share information among the ATM partners.

\(^{15}\) Wikipedia: Business process management (BPM) is a method of efficiently aligning an organization with the wants and needs of clients. It is a holistic management approach that promotes business effectiveness and efficiency while striving for innovation, flexibility and integration with technology.
C3.2.2 Information Management to support Business Processes

Currently all ATM systems are specified by the organisations using those systems. The consequences are that even the same type of systems for different organisations are different. On the operational level it means the operational service provision is fragmented, because of the differences in the supporting systems and procedures. These require that on the boundary between the organisations relatively large and therefore inefficient safety margins are needed which limit the throughput in the ATM network.

The ATM services are defined by the ATM Service Providers together with their customers. The requirements for these services will be expressed in a business process model and the associated information modelling will model all objects that are identified as belonging to the information input or output of those business processes. The business process model within EAEA describes at this level a set of complex business processes and relatively simple information structures. The processes are developed top-down.

Information Management has a more leading role in the definition of the support services that have to be provided to the ATM service providers. For instance, support services will have to be established to provide information about the airport infrastructure. The process to develop a correct conceptual model of what parts of an airport are relevant to ATM is mainly bottom-up. Based on that conceptual model an initial set of services required by ATM can be formulated.

While some of the support services will be defined in a bottom-up approach, Information Management will also propose other support services in a Top-down approach. They will be finalised based on the requirements resulting from the top-down development of business processes, supporting system services and the atomic services required by the systems of the ATM service providers.

C3.2.3 Separation between information provision and information use

The aim of IM is to provide information users with the right information at the right time and the right place, enabled through the concept of net centric ATM operations. This will be enabled through effective information filtering including the use of time based and location based information selection. With the wealth of information expected to be available and used within the ATM system, it is essential that such information is decomposed into its individual parts before being made available / distributed, selected, tailored and assembled to meet the precise needs of information users.

In a service oriented approach, data provision and its underlying data models and the usage of data are decoupled, in order to avoid over-reliance by the end-user applications on the data models. Figure 52 illustrates how this translates into the ATM world.

Any information exchange binds an information provider with an information user and a separation of tasks must be established:

- the task of the information provider is to provide the required information (comprising requested data elements);
- the task of the information user is to specify the required information.

As a consequence, information provision is separated from information use:

- with the intent to establish information services which can be used and re-used in various user contexts;
- with the intent to enable enhanced system flexibility and the promotion of innovation and of customised services;
- through the development and use of appropriate standards relating to data modelling and data exchange.

\[16\] In SOA, an atomic service cannot be decomposed into any further service.
C3.2.4 Data Modelling

The IM guidance material considers the following data models based on a number of frameworks for enterprise architecture:

- Conceptual Data Model - represents all business entities and enables a shared meaning of information in order to exploit the information meaningfully within business processes;
- Logical Data Model - represents the logic of how entities are related and enables direct derivation of the Physical Data Model;
- Physical Data Model - represents the data exchange mechanisms for system implementation.

In addition to these three models, a Data Dictionary will be needed which will capture definitions of all items in the EA.

For the rest of the document the combination of these three data model layers is referred to as the ATM Information Reference Model (AIRM). Consequently the AIRM is a key component which aligns the technical and business sides of the interoperability stack (see Figure 53) around the required common information concepts to achieve an agile mutual interplay between business requirements and system solutions.
C3.2.4.1 The ATM Information Reference Model (AIRM)

The information to be exchanged / shared needs to be modelled explicitly, to allow a precise and concrete definition to be agreed and adopted. Previous work has already defined some data models and the associated services within specific domains (e.g. Aeronautical Information and Flight Information). The data models and associated services will be organized around a number of data domains, as presented in Figure 54. Dividing the problem into specific domains has the advantage of keeping the activities to a 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 (AIRM) is required to define the semantics of all the ATM information to be shared. Integrating the inputs from the various Domains, the AIRM will form the master definitions, subsets of which will be used in lower level models supporting interoperability for data-sharing across domains.

The AIRM will provide both a neutral (i.e. independent of constraints on implementation) definition of the ATM information, through the conceptual and logical data models, and an implementation description of the ATM information through the physical data model. It will 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 will be a key asset in the ATM System design and will sit above a set of domain specific platform independent but compatible models, which may overlap with each other, without being incompatible. The overall reference model and existing models need to be reconciled. This means that existing data exchange models such as AIXM, WXXM, AMXM, ANXM and FOIPS will be used as a baseline for the creation of the AIRM.

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C3.2.4.2 Metadata and Common Data Concepts

Metadata is “data about data” describing context for data. The role played by any particular datum depends on the context. In any particular context, metadata characterises the data it describes, not the entity described by that data.

Metadata is structured, encoded data that describe characteristics of information-bearing entities to aid in the identification, discovery, assessment, and management of the described entities.

Even in the early phases of planning and designing it is necessary to keep track of all metadata created. It is not economical to start attaching metadata only after the production process has been completed.

In the context of the web and the work of the W3C (World Wide Web Consortium) in providing mark-up technologies of HTML, XML and SGML the concept of metadata has specific context that is perhaps clearer than in other information domains. With mark-up technologies there is metadata, mark-up and data content. The metadata describes characteristics about the data, while the mark-up identifies the specific type of data content and acts as a container for that document instance. When structured into a hierarchical arrangement, metadata is more properly called an ontology or schema. Both terms describe “what exists” for some purpose or for enabling some action.

In many applications of the ATM world, geospatial information is of particular importance. It represents one of the main axes of development in modelling.

Geospatial metadata (also geographic metadata or simply metadata when used in a geographic context) is a type of metadata that is applicable to objects that have an explicit or implicit geographic extent, in other words, are associated with some position on the surface of the Globe. The U.S. FGDC (Federal Geographic Data Committee) describes (geospatial) metadata as follows:

“A metadata record is a file of information, usually presented as an XML document, which captures the basic characteristics of a data or information resource. It represents the who, what, when, where, why and how of the resource. Geospatial metadata are used to document geographic digital resources such as Geographic Information System (GIS) files, geospatial databases, and earth imagery”.

The ISO 19115 standard specifies the metadata for geographic information. More generally the ISO 19100 series provides various standards related to geographic information, such as the spatial or temporal schemas. Those two aspects will facilitate the selection of relevant information to be made available to mobile users such as aircraft or airport vehicles.

While a data domain will focus on data composing the operational / technical information required by users, it is important that it also uses, at the same time those metadata, defined by common data models, which are relevant to the operational data, thus enabling easy retrieval of information and seamless data exchange. This separation between domain data and common data concepts (including metadata) is an essential component of AIRM.

C3.2.5 Common IM Standards

Within the SESAR IM WP (WP8) the concept of identified common Information Services, and supporting specifications and models as appropriate, will be developed and validated.

The ATM Target Concept choice for SOA is based on the intent to lift the data domains out of their current isolation and provide seamless and interoperable access to ATM data resources. It is therefore required to establish common cross ATM data domain IM standards as depicted in Figure 55.

These cross data domain common IM standards will together form the overall framework to organize interoperable and seamless ATM data sharing activities. It is clear that for interoperability reasons these common standards shall address the areas already identified based on the SESAR architectural choice regarding SOA. Consequently the core common data concepts, data interfaces, data processes, data services and products shall be defined throughout the whole pan-European and global systems. Furthermore the establishment of standards for information management practices, human factors aspects and institutional rules is required.
C3.2.6 IM Functions

Within the SESAR IM WP (WP8) the concept of identified common IM Functions, and supporting specifications, will be developed and validated.

Beside the interoperability enabled by the AIRM, there is a need for common functions for the provision, distribution, sharing and use of data and information. These are referred to as the “IM functions” which comprise:

- **Content**: Covers the information about the meaning of shared concepts. At an abstract level, the concepts shall be shared amongst providers and consumers of information for example through a shared database of meaning, i.e. common concepts and definitions.
- **Distribution**: Covers the required information about the distributor of information and the options to obtain a resource;
- **Quality**: Covers information about the required shared quality measures such as completeness, accuracy, resolution and integrity information;
- **Maintenance & Updating**: Covers required information about the maintenance and updating of an information resource. For example the update frequency;
- **Registration -> Required information provided by service providers to formally expose services and register them.**
- **Description & Discovery**: Required descriptive information about a resource such as an information service. This information allows to find a resource and use it in within context of its intended function;
- **Exchange & Access**: Required information which supports meaningful information exchange. For example the application schema of a resource and the exchange pattern;
- **User identity & profile**: Required information about users and their privileges within various user contexts;
- **Security & authentication**: Required information to express security and authentication aspects related to a resource;
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- Notification: Required information to express aspects of the event architecture. Notification information is used in push modes where a provider push is required and consumers need to acknowledge receipt;
- Digital data rights: Required information to express legal rights related to the use and exchange of information between provider and consumer. For example information ownership. Digital Data Rights shared information relates to the institutional view and reflects it;
- Charges: Required information to express cost charges related to the use of information.

These functions will require extended data models, Service Levels Agreements, recording and probably increased monitoring to cover shared information management requirements. IM will have to adopt existing, or develop further, standards for a certain number of these functions to ensure that the production – distribution – sharing and use of information respect the basic principles already identified. The IM functions will have to be applied to all domains as illustrated in Figure 56.

Figure 56 ATM Data Common IM Functions View

There will be a clear need for the formulation of the consequent requirements upon infrastructure such as bandwidth, storage capability, etc. to support a number of these functions.

C3.2.7 The Underpinning SWIM Infrastructure

Information Management addresses both Air-Ground and Ground-Ground data and ATM services exchange, the Aircraft being integrated via a unique access point, the Air Ground Data Link Ground Management System (AGDLGMS), see Figure 57. More details of the ATM systems (from the Logical Systems Architecture) that participate in SWIM (the coloured boxes on the figure) can be found in Annex D - Infrastructure.

Information Management is supported by a set of architectural elements (SWIM Infrastructure), underpinned by a communications network, allowing sharing of data and ATM services across the whole European ATM System. The SWIM Infrastructure aims at providing specific, value added information management services which will realise the common IM functions described in the previous section. These 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.

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18 Future developments of the ATM Target Concept should plan to make all data flowing through the systems available for recording in case it is required for legal/investigation purposes. 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.
Any system that wishes to connect to SWIM (including external systems such as Meteo systems, Military systems or systems from outside the ECAC area), will have to do so through these services, which will need to comply with potentially stringent Quality of Service (QoS) parameters, such as integrity, availability, latency, etc. The full impact of the QoS on the proposed architecture will require significant R&D activities. For instance, the availability will be restricted to users that have permission to access data within a domain (the data domain currently identified are shown by the small coloured ovals on the figure below, see also section C3.2.4.1).

The SWIM Infrastructure will address the provision or reception of shared information but it is also expected that it will support any point-to-point exchanges and/or dialogues. The architecture will allow to set-up virtual point-to-point connections whereas the physical network will remain the same as when the publish/subscribe pattern is used. The work in the SJU will identify the optimal solutions for centralised/distributed data storage and the systems that will be responsible for storing which data.

The implementation of the IM functions will be partly covered by the SWIM infrastructure which will deal with aspects such as Discovery/Lookup, Service invocation, Publish / subscribe, PKI security, technical supervision etc and technology & architecture choices19.

**C3.3 Deployment Strategic Guidance**

In the to-be-developed deployment strategy the following aspects need to be covered:

- Governance aspects like full control vs. more liberal governance e.g. Internet;
- Common developments / Standardised components / Standardised interfaces;
- Level of interoperability at global / regional / national level and consequences on associated regulations and standards;
- Usage / Availability of ‘portal’ solutions that will facilitate the access of “External Systems”.

**C3.3.1 Development of a Reference Framework for ATM IM**

The core of activities of IM will be focussed on the development of the IM institutional aspects, on the validation and development of common Information Models and on the identification and validation of common Information Services enabling the flexible access of information by ATM partners.

The ATM Process Model will decompose the ATM business into processes and will define the requirements for shared information to be exchanged between these identified business processes. The outcome of this will facilitate the definition of the initial operational information exchange / sharing

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19 ESB, Web Services, DDS, MoM/JMS, XML represent current potential technology candidates
requirements which will have to be consolidated to ensure consistency of information requirement across the network.

Based on these requirements for the shared information, IM will define the information model to further detail the operational information elements and their relationships. This will be an evolutionary and incremental approach with its final stage, the Reference Framework for ATM Information Management. It will provide the conceptual context for ATM Information Management through the application of the Enterprise Architecture methodology. This methodology will ensure the adequate link between the European ATM business as a whole, the associated Infrastructure and the Information Management component of the ‘business’, as such it will be the union and moreover consolidation of all the ATM Shared Information Requirements.

The first essential building blocks for the Reference Framework for ATM IM consist of information domain models and, where possible, information models at an aggregated level such as the ATM Information Reference Model (AIRM). The focus is on the creation of generic interoperable information sharing means without precluding any domain specific information sharing and information exchange mechanisms where appropriate. In a service-oriented approach, these information models need to be supplemented by a model of information services, which will give access to the information (see section C3.3.2). The other essential element compared with the AIRM is the full integration of the IM Functions which are related to the overall activity of Information Management, including aspects such as information publication, updating, protection, Quality of Service. This evolution of Information Management into the final stage of ‘the intranet of ATM’ is displayed in Figure 58 where the dates indicate the application of these concepts in the operational world, the development being already underway.

![Figure 58 Developments towards EAEA](image-url)
C3.3.2 Application of SOA

The SESAR ATM Target Concept clearly identified the need to document service models and detail the services in terms of Service Specifications. Whilst a number of services could be seen as fully independent of a specific ATM application, it is necessary to describe services that are common for all stakeholders to build common situational awareness amongst all ATM stakeholders in all phases of flight operations. These common Information Services are related to the SESAR Concept of Operations and/or to basic requirements set by ICAO, EC and other regulatory authorities to ensure the essential level of information provision and sharing at the national, regional and global levels.

C3.4 Phased Approach to SWIM Deployment

C3.4.1 Introduction

The implementation of this approach to Information Management shall accommodate the following three closely inter-related dimensions of SWIM which are linked to the layers identified in Figure 60.

1. “Communities of interest” linked with “Applications”;
2. IM functions and Data Modelling” linked with “Information”;

Figure 59 SOA in the EA Framework

Figure 60 SWIM dimensions and scope
3. Connectivity (incl. IT infrastructure) “linked with “Infrastructure”.

A Community of interest\(^{20}\) addresses the “Application” side by identifying the relevant stakeholders and their interests. Though it does not fall directly in the scope of SWIM the establishment of a community of interest requires that partners in the community know the information they need to share with what quality of service in order to be effective in their collaboration, that they have a common understanding of this information and that this information is available in a commonly agreed structure. They will contribute to SWIM definition through the definition of interface requirements.

The development of communities of interest is of strategic importance to SWIM expansion. The proposed approach is a step-wise evolution starting with a kernel of users. This kernel will then be extended to include more complex collaborations across the whole ATM business chain.

IM functions are another important axis for the implementation of SWIM. They enable data exchange and sharing within a community of interest and between communities to take place and develop, independently of the underlying communication medium/platform.

The last dimension is connectivity, i.e. the physical communication networks and interface layers without which users could not be connected through SWIM. The proposed approach is to build on the legacy infrastructure (e.g. by inter-networking local networks) as far as practicable until an European IP based network communications is available. The air/ground segment is an example of SWIM connectivity that is intended to be added at a later stage as aircraft are integrated into the SWIM network.

The combinations of these three dimensions at particular stages of their common evolution constitute the **ATM Capability Levels** for Information Management.

### C3.4.2 Capability Levels

Information Management and its enabling SWIM Infrastructure are recognised as essential enablers of ATM applications. The methodology of sharing information will apply to all ATM capability and service levels. In this context, "Capability Level" relates in some cases to an extension of geographical/spatial availability, although different ATM Service Levels may equally need more advanced and/or widespread implementation of Information Management and SWIM Infrastructure. Together they will make information more commonly available and consequently allow its usage by end-user applications. They will create the conditions for advanced end-user applications based on extensive information sharing and the capability of finding the most appropriate source of information.

The adoption and migration to simpler end-user applications first will provide early benefits, whilst proving the business case for IM. However, it should be noted that benefits will be available even in a largely legacy environment.

The development and implementation of Information Management is described according to the six (from Current situation to level 5) Capability Levels identified in SESAR ATM Master Plan\(^{21}\). These Capability Levels are designed to achieve early benefits and the most cost efficient build up of the Information Management capability taking into account the need to enable the overall ATM evolution.

In the interest of simplicity, for this guidance material, it has been decided to present Capability Levels 2 with 3, and 4 with 5.

### C3.4.3 Current situation

The means of information acquisition and distribution remain mainly traditional across organisations with growing instances of managed digital information sharing and exchange (e.g. the EAD). The following list provides a first overview of current data products, services and distribution means per data domain:

- For Flight Data:
  - ICAO Flight Plan and ADEXP;
  - OLDI;
  - CPDLC;
  - ICAO ATS messages;

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\(^{20}\) Community of interest will see participants from ANSPs, Aircraft Operators (including GA), Airport Operators, Military, AIS Providers, MET Service Providers, etc.

\(^{21}\) The D5 SWIM capability levels are aligned with the ATM Capability Levels in terms of content and dates.
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- Distribution through AFTN.

- For Aeronautical Information:
  - IAIP;
  - Move to digital environment (AICM/AIXM, eAIP);
  - EAD;
  - Other State managed AIS systems providing web services;
  - Integrated Briefing;
  - Distribution through paper, AFTN, EAD (VPN) and Web.

- For Aviation Meteorology:
  - METAR, TAF and SIGMET are structured messages, but they are difficult to be interpreted by an automated system;
  - Distribution through AFS.

- For Environment:
  - Environmental impact messages (CO2, NOX, local air emissions, noise);
  - Distribution through PAGODA web interface and reports.

- For Capacity, Demand & Flow:
  - DOP / NOP Document, CFMU Slot messages, CDM messages, Airport Slot messages;
  - Distribution through e-mail LAN/WAN and Web;
  - Air Traffic Flow Management Information Message (AIM), ATFM Notification Message (AMN), Conditional Route Availability Message (CRAM), Route Availability Document (RAD/electronic RAD) Airspace Use Plan (AUP) and Updated Airspace Use Plan (UUP);
  - Distribution through AFTN, EAD (VPN), CHMI, CIAO, CIA and the NOP Portal.

- For Surveillance:
  - ASTERIX;
  - Distribution through RADNET (X25) / RMCDE, RMCDS, SIR, .....

C3.4.4 Capability Level 1

A common ATM Information Reference Model and a secure IM infrastructure are expected to be available by the end of the Capability Level 1 period.

Priority will be given in the early years to enhanced communication and information sharing with aerodromes and ATC actors using legacy bi-lateral communication means for Airspace Users. This will be achieved through the implementation of the latest Airport operations plans coordinated through CDM. During this period updates to the ICAO Flight Plan format will be defined to allow both Operational Air Traffic (OAT) and General Air Traffic (GAT) flights to file flight plans consistently. The updated flight plan format will require some adaptations of Airline Operation Centres (AOC), military Wing Ops and other command and control centres.

Basic IM services will be made available and integrated within each existing EATMS system. New roles for IM technical and operational management (including security requirements such as access management) will be defined at local, sub-regional and regional levels and at stakeholders’ system level. Information exchange / sharing will use the Ground-Ground European IP based data transport network deployed through the Pan-European Network Service (PENS) initiative.

C3.4.5 Capability Levels 2 & 3

The second stage of IM Ground-Ground services implementation will support information sharing for the planning services related to the NOP, flight information services supporting exchanges of Shared Business / Mission Trajectory (SBT) and Referenced Business / Mission Trajectory (RBT), Airspace data (static and dynamic data) and Terrain and Obstacle data. Aircraft will be connected to the IM infrastructure through an Air Ground Data Link (AGDL) ground dedicated system (one single or one per FAB) that will interface with the various data-link network infrastructures. It will allow the uplink of appropriate up-to-date information (trajectory revisions and constraints) and the publication of accurate airborne information to all ATM stakeholders (Aircraft Derived Data (ADD) first and then Predicted Trajectory (PT) and enriched airborne weather data such as humidity, turbulence). All systems will be migrated over time to use the IM mechanisms to access or to provide information, and new services will be added as required. In consequence, all ATM stakeholders will have access to the most up-to-date information according to their requirements.
The planning process will occur in a collaborative manner among all the ATM partners. The conventional flight planning process and tools will be complemented by the development and publication by airspace users of a SBT made widely available for ATM planning purposes to authorised users subject to appropriate subscription mechanisms.

Through a holistic view of the NOP, users of the network (Airspace Users, Service Providers, etc) will access and update via SWIM the capacity, the demand on the system and the Strategic Guidance taken by Network Management to maintain its stability and efficiency. The airspace user is able to define the RBT around known traffic constraints through CDM processes. SWIM provides the information required to evaluate alternatives to attain the best ATM service whilst avoiding potentially costly delays or re-routes.

The aircraft communication architecture will be progressively integrated into the overall SWIM infrastructure by the downlink of the predicted trajectory in case of deviation and the reception of meteorological data provided by the ground system.

**C3.4.6 Capability Levels 4 & 5**

The uncertainty of trajectory predictions is reduced by the implementation of the Trajectory Management Requirements (TMR) that specify the requirement on the aircraft to share the updated trajectory in the event that the flight detects a “delta” from previous predictions or on a cyclical basis.

The SWIM deployment is achieved by the implementation of the full SWIM service composed of Ground-Ground full SWIM services (including exchange / sharing of dynamic mobile areas information) and the Air-Ground extended SWIM services (enriched trajectories information including TMR and ground broadcast of MET data). After this implementation, SWIM services are the sole means to share all relevant ATM information by all the concerned ATM stakeholders. Air-Ground extended services are supported by the future Air-Ground data link composed of a new terrestrial L-Band Air-Ground data link, complemented by a new Air-Ground Satellite data link system to provide high performance service availability.

The various information systems will be upgraded to accommodate the handling of the truly temporal temporary restricted areas and other airspace restrictions. Airlines will implement the provision of information in digital form to their aircraft fleets.

**C3.5 Evolution of Rules, Roles and Responsibilities**

The advent of SWIM will affect almost all the human roles within the ATM system. In particular, the interactions between the different roles will change. In addition, the management of information requires that policies related to the access and use of information are developed. These will both have a significant on human factors issues and training (e.g. there will be more need for interdisciplinary training).

Rules, roles and responsibilities will need to be defined, per stakeholder, taking into account the functional criticality of the information they handle. The role to be played by military organisations and their systems will have to be fully addressed.

**C3.5.1 Evolution of rules**

This specific element of the IM Functions will require a lot of work in order to redefine and possibly harmonise rules with respect to data ownership, data provision and data usage. For example, in some States, all information is made available free of charge, whereas others limit this to only safety critical data. Another example can be found with the setting of liability for data provision in the context of Functional Airspace Blocks (FAB).

In all circumstances, there is an increasing need for the definition and application of Service Level Agreements (SLA) between the different parties.

**C3.5.2 Evolution of IM actors roles and responsibilities**

The evolution of the provision of information to ATM will bring changes to the roles and responsibilities of existing actors, and will introduce some new ones.

SWIM Management actors will be required at different levels, either centrally or distributed (sub-regional, local) depending on the deployment of the SWIM network.
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.

Various organisations may provide and benefit from SWIM terrestrial and Ground/Air-Ground Network Services, e.g. Communications Service Providers, ANSP, third party providers, thus changing their current Roles & Responsibilities or bringing in new actors. Notably, as they play a major role in ATM as information providers, information users, ANSP and security providers on behalf of States, roles and responsibilities of Military Organizations, as well as the necessary interoperability between civil and military information exchange systems, must be carefully and adequately addressed.

The following new roles are of particular note:

- SWIM Network Manager to provide data access and services; to provide network timing service and to operate/maintain SWIM infrastructure;
- SWIM Access Manager to ensure secure access to SWIM Network and to monitor SWIM access and traffic;
- SWIM Regional Supervision function will establish a secure ATMS infrastructure as well as the necessary supervision infrastructure;
- Data quality monitoring: the recent developments made to ensure the best data quality in the AIS domain will have to be replicated to any data domain, thus creating new roles and responsibilities within some organisations.

Standard IT material identifies many more roles that will certainly have to be considered.

**C3.6  Impact on ATM Domains**

This approach to IM will certainly have an impact on existing ATM data domains. In order to start bringing this approach and currently planned activities within a data domain closer together, the next paragraphs give an overview of planned developments in a SWIM context.

**C3.6.1  Flight Domain**

Flight Information is at the very core of the ATM system and ensuring that it is up to date, consistent, accurate, and easily available to those that require it, is essential for the ATM system to operate efficiently. The strategic move in SESAR towards an operational concept centred on the management of business trajectories which are shared between all stakeholders only serves to strengthen this need and makes the effective sharing of consistent flight information a key enabler for SESAR.

The exchange of flight information in today’s systems is characterised by the exchange of messages, generally point to point, using a variety of different formats, data definitions, and triggering conditions. The diverse and uncoordinated nature of these exchanges leads to inconsistent views of the flight information being held across the different stakeholder systems, thereby reducing efficiency (because procedures need to accommodate these differences) and limiting opportunities for collaborative decision making and automated tools to support it. Metrics will be periodically produced to measure the level of flight data inconsistency in the European ATM system and to measure improvements.

The ‘Flight Object’ is a concept to support the sharing of consistent flight data between all types of stakeholder, during the planning stages as well as the tactical phases of the flight. The fundamental idea is that a single logical entity, the “Flight Object” is kept up to date by all parties wishing to share information about a flight. All parties use the Flight Object as a reference and all keep it updated with the latest information, thereby ensuring that all systems have the most up to date and consistent view of the flight data.

The Flight Object Interoperability Proposed Standard (FOIPS) model has been developed to provide a platform independent model of the Flight Object. The first implementations of the Flight Object for Civil ATC Flight Data Processing systems are now planned for the IP2 timeframe using a FOIPS based interface defined by EUROCAE (ED133). The implementation of the Flight Object for civil ATC will be based on a distributed architecture consisting of a network of ATC Flight Object Servers (FOS) each associated with an FDP system. The FOSs ensure the consistency of flight data across the network.
How to broaden the implementation of the Flight Object concept to other types of stakeholders requires further study. Following a specific CFMU study conducted in 2008, the development of an ATFCM-ATC Flight Object interface and a CFMU FOS based on the same design principles as the ATC FOSs is planned under WP13 of SESAR. However other types of stakeholders, for example airports or aircraft operators, may prefer different architectural solutions due to their more diverse nature. Further studies will be needed to consider how to integrate the Flight Object concept into the systems of each new kind of stakeholder: Military ATC, Airports Operators, Aircraft Operators, and Aircraft systems.

The initial implementation of the Flight Object in ATC systems will require further development to reflect a) the results of initial validation and b) new requirements coming from the SESAR concept, c) possible common SWIM requirements which would apply across all information domains.

The FOIPS model will become integrated into the overall ATM Information Reference Model, and thereafter the need to continue to maintain it as a separate model will then have to be reviewed. A common reference model of the Flight Object data will be required to support the integration of future stakeholders, but this need may be satisfied by the AIRM in which case the FOIPS model would no longer be required.

ICAO is developing a new concept and information model for the future flight planning processes, the FF-ICE (Flight and Flow Information for a Collaborative Environment) Concept. This will be consistent with SESAR requirements and will significantly change the way that flight plans are submitted and processed globally, becoming centred on the exchange of trajectory information.

The Flight Object is an important technical enabler for the FF-ICE Concept and the need for standardised processes to be applied globally will lead to the need to develop global standards for the Flight Object interface for aircraft operators.

C3.6.2 Aeronautical Information Domain

The major task of AIS, as defined in Annex 15 to the Chicago Convention, is to ensure the flow of aeronautical information necessary for the safety, regularity and efficiency of international air navigation. Annex 15 describes the extent of information required and the means by which it should be made available in the form of the Integrated Aeronautical Information Package. Each ICAO Contracting State is responsible for ensuring that these obligations are discharged.

The present provision of AIS and map can best be described as a semi-automated process which requires significant manual intervention and remains wedded to the principle of a master, paper reference document, even though the information may in many cases be maintained and transmitted electronically. Moreover, the provision of Aeronautical Information is mainly focussed on the requirements of pre-flight briefing rather than the whole spectrum of SESAR requirements.

Several actions to improve AIS in the ECAC member States have already been conducted / initiated, mainly through the increased use of automation and improvement of data quality. Amongst others, the Electronic AIP (eAIP), now being introduced by the States, is a major step towards the implementation of AIM. So is the European AIS Database (EAD) that is implemented by the majority of the ECAC States and provides quality assured Aeronautical Information, augmented by global data as required including a world-wide NOTAM database. Data quality is being improved through the implementation of mandates from the European Commission and with the support of the EUROCONTROL CHAIN (Controlled and Harmonized Aeronautical Information Network) project. Work is on-going to make available the NOTAM in electronic format, including extensive digital and/or graphical information.

It is important to note that the enhancements and developments described above are basically improvements to the traditional AIS environment, without changing its conceptual basis.

The followings are examples of end-user requirements for future developments that AIM addresses:

- All relevant pre-flight information should be distributed, in standardised formats that are easily understood / processed, in an unambiguous and timely manner. All users should have access to pre-flight information which should be user selectable to meet their own specific requirements;
- Make available airport mapping information, obstacle and terrain data in electronic interchangeable format.

Another aspect that AIM is considering carefully is the migration of Military AIS to AIM. Military AIS arrangements vary between States: in some cases, Aeronautical Information being provided by civil AIS, in others by a separate military AIS organisation. Military AIS are as well expected to provide and
maintain the Aeronautical Information they produce in the EAD. This will require the harmonization, to the maximum extent, of military Aeronautical Information to the civil standards; where it is not possible due to specific military requirements, appropriate solutions shall be identified and implemented.

SESAR in part is designed to address this through the specification of Capability Levels. Foreseen developments in this respect in the AIM domain are:

**C3.6.2.1 Current Situation**

The migration of the civil and military AIS providers to the EAD has already improved the availability, completeness and the harmonisation of the Aeronautical Information including the distribution of the already published eAIP.

The full deployment of CHAIN and the implementation of its deliverables has brought improvement in the quality of Aeronautical Information. The xNOTAM is under validation and development on similar messages (e.g. SNOWTAM) is underway.

Currently Aeronautical Information Publications are monitored on a regular basis for consistency with the ICAO Standards in terms of availability, timeliness, completeness and publication resolution (AMMON project).

**C3.6.2.2 Capability Level 1**

The xNOTAM will be implemented after validation with a wide sample of users, and adoption of the eAIP will continue. Work will continue in order to reach a consensus on the requirements for further implementation of the electronic Terrain and Obstacle (eTOD) database. In parallel to the increasing data generation, the validation, maintenance and refinement of the various information models and information encoding specifications such as: AIXM, AMXM, ANXM, NDBX, ARINC 816, etc. will continue.

EAD data model will, where required, follow-up the models evolutions and the requirements to make available information to allow improved pre-flight briefings and dynamic data exchanges. National and sub-regional AIM systems will adopt agreed interoperability standard in order maintaining interoperability with EAD.

**C3.6.2.3 Capability Levels 2 and 3**

These phases will see full implementation of AIM services using quality assured digital databases for airspace, navigation, terrain and obstacle and aerodrome description.

**C3.6.3 Meteorological Information Domain**

In this sub-section, the word MET represents the Aeronautical Meteorological Information.

The future European Air Traffic Management (ATM) system will continue to be subject to the same vagaries of weather phenomena that affect air transport today. Consequently, detailed knowledge about the past, current and future state of the atmosphere, provided as MET, is required to enable the European ATM Master Plan objectives to be met.

Historically, aviation weather services have mainly addressed safety issues. Now within the context of the future ATM system, the considerable impact of weather on safety, capacity and efficiency and its potential to mitigate some of the environment impact of aviation must be considered as well. In more detail, MET is an important key element for the short and medium term trajectory prediction. MET will be used either in planning the business trajectory or in changing the trajectory in the short term due to several factors including the avoidance of weather hazards.

For the short-term period, MET is potentially available based on ICAO and national requirements. Close coordination in the implementation of and training in the use of MET will suffice at first. However, to really meet the European ATM Master Plan Capability Level 2 and Level 3 objectives the transversal use of MET in the decision making processes throughout all phases of flight will become essential.

This will require improvements to the existing meteorological services, the development of new products and services and the introduction of concepts such as the ‘level of uncertainty’ and the ‘level of confidence’ associated to MET, to be used in decision-making processes. This foreseen evolution requires an approach to Information Management which will ensure the timely, accurate, and complete availability of the aeronautical meteorological information within the concept of system-wide information management for all phases of flight.
In a generic sense, these developments lead to changes in:

- Definitions of scope, content, quality and timeliness of MET to support the key enabling objectives of the ATM System in a cost-effective manner mitigating the environmental impact of air traffic;
- Standards for MET Information provision to ensure:
  - harmonisation of the open exchange of MET, formatted for ATM use;
  - harmonisation of MET systems interfaces supporting ATM;
  - accessibility of MET during all phases of flight.
- Arrangements set-up for institutional, organisational, regulatory, financial and intellectual property issues associated with the provision of MET to ATM.

With respect to the identified changes, it should be recognised that the provision of MET in Europe is diverse and complex. In some States MET is provided by the air traffic services providers whereas in the majority of States the provision of MET is a component of the overall meteorological service of the State; in some cases this responsibility is given to the Military. The variation in R&D capabilities, the multiplicity of international and regional organisations with defined and/or proposed responsibilities for MET providers and the relatively soft link between the MET domain and the ATM Master Plan all add to the diversity of the current and foreseen MET provision. To ensure the harmonised evolution of MET, there is a clear need for pan-European coordination between ATM and multiplicity of civil and military actors within the MET domain.

A more detailed breakdown of the foreseen changes in the Capability Levels is identified:

**C3.6.3.1 Current Situation**

The existing framework for the harmonization of integrated briefing systems (i.e. Full integration representing single office, single terminal, single application, single report) is a typical current activity. For the user, it brings together traditional AIS and MET and could be seen as a first premature step towards the envisaged fusion of data originated in different domains. From an Information Management perspective these are also the first steps in developing common policies and platforms to access data which originates from multiple sources and multiple domains of responsibilities.

**C3.6.3.2 Capability Level 1**

The Capability Level 1 period will be highly dominated by utilising current MET provider capabilities to enable Operational Improvements foreseen till 2013; a first step towards real weather assimilated ATM decision making. Furthermore, the initial requirements, initial transversal Information Management dependencies, initial Cost Benefit Analysis (CBA) and overall feasibility for the required improvement of MET beyond the current or near future capabilities will be set to fully support the concept of the 4-D Business Trajectory.

These foreseen MET developments will focus on:

- Probabilistic weather forecasts in support of making greater use of congested / constrained en route airspace;
- Improved accuracy, timeliness and forecast range of convective weather information (including lightning), turbulence and icing;
- Improved accuracy reliability and lead time of visibility / ceiling forecasts including a measure of uncertainty;
- Provision of high accuracy, high resolution, short range wind forecasts to support:
  - Continuous Descent Approaches (CDA) / Continuous Climb Departures (CCD);
  - Runway specific tail- and crosswind components in connection with runway conditions;
  - Wake Vortex predictions.
- Harmonisation of de-icing and winter operations forecasts;
- Provision of warnings/forecasts for the terminal area on hazardous weather phenomena including low level wind shear and temperature inversions;
- Provision of wind aloft information for approach and departure flight operations and runway selection procedures;
• Provision of meteorological parameters related to the braking action of the movement area of the airport to reduce capacity loss safely.

From the information viewpoint the introduction in the Capability Level 1 time period of the Weather Information Domain Models at a conceptual (WXCM) and logical level (WXXM) will enable both the MET community and ATM community to implement the newly developed MET into the SWIM of ATM. This also requires a first level of understanding and agreement to be established on institutional, legal, financial and liability issues related to MET service provision for ATM beyond the traditional scope of ICAO Annex 3 and national regulation.

C3.6.3.3 Capability Level 2

The framework laid down in the Capability Level 1 period will evolve further and shall be used to really benefit from the initiatives and concrete R&D in the MET domain and ATM started before 2013. A separation of interest will start to be witnessed between the MET providers and the MET users and a fully integrated use of the required meteorological parameters is possible. The use of aircraft derived MET is expected to widen. The MET that will support the long term planning, mid and short term planning and execution phase of the business trajectory will gradually be based on probabilistic forecasts; information on uncertainty and confidence, which are natural attributes for MET, will be used in the ATM decision making chain.

Like in the Capability Level 1 time period, the foreseen developments should be facilitated by changes to the WXCM / WXXM to transparently and seamlessly exchange the MET. Furthermore, the standards, institutional, legal, financial and liability framework should be in place to foster the developments.

C3.6.4 Capacity, Demand & Flow Data Domain

The Capacity, Demand & Flow Data Domain is responsible for the Network Operations Plan (NOP) and its local extension - the Airport Operations Plan (AOP)

The NOP is a dynamic rolling plan for continuous operations providing access to traffic demand, airspace and airport capacity and constraints and scenarios to assist in managing diverse events. As a single portal to ATM information, The NOP is continually available to ATM actors and evolves during the planning and execution phases through iterative and collaborative processes. The aim of the NOP services is to facilitate the processes needed to reach agreement on the balance between demand and capacity.

To provide the best possible picture about capacity and demand, in both the planning and execution phases of the trajectory NOP information management has to provide services in support to Demand and Capacity Balancing, the User Driven Prioritisation Process and others. On the other side it has to
define which services it requires from the ATFCM scenarios and from the AIM Airspace infrastructure. The same is true between e.g. AOP and Airport scenarios / infrastructure. The interface between both planning columns are related to the estimated take-off and touch-down times and the way the network planning will take into account the services related to Airport throughput for departures and/or arrivals, taking into account also exceptional conditions, e.g. planned or unplanned closure of parts of the infrastructure or weather constraints.

For the execution part, updates for each flight need to be taken into account coming from turnaround processes managed through CDM, and which may be supported by Arrival Surface and Departure Management systems.

**Capability Level 1**

To support collaborative decision making, basic information sharing:

- Collaborative planning applications (for example to support the Network Operations Plan);
- At airports automatic data sharing between operators/handlers, ATM-Systems and users (AOC);
- ATC sectors opening/closing and grouping/de-grouping within a centre.

**Capability Level 2**

To support collaborative decision making:

- Integration of queue management into the CDM processes, resulting in the need for additional services for the business trajectory in the NOP.

To support management by trajectory (including queue management and separation):

- CTA/CTO management – improved airborne function for the descent phase, resulting in new services between NOP related planning and AOP related planning.

**C3.6.5 Surveillance Data Domain**

The surveillance data domain handles the provision of surveillance information, in support of en-route, approach and aerodrome ATC, through information modelling and information encoding specifications for:

- Surveillance sensors;
- Surveillance data processing and
- Surveillance data distribution.

The current specification is ASTERIX. The Surveillance data domain is different from the other domains, because surveillance is sampling the continuous movement of a target (aircraft, vehicles) and the validity of the information is short. From an IM perspective it is best seen as a continuous stream of measurements, where each measurement updates the available information related to the target and is used with the previous ones for prediction or extrapolation of the movement. For purposes related to technical tuning or incident analysis, those samples are recorded.

ASTERIX categories currently cover the following of surveillance data types: plots, tracks, Surveillance status messages, coordination messages, weather information and multi-lateration data.

The following table will give a summary of the relevant ASTERIX Categories, related to the type of Surveillance Data to transmit.
<table>
<thead>
<tr>
<th>Transmission of (Surveillance related Data)</th>
<th>From (Data Source)</th>
<th>ASTERIX Category to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monoradar target reports</td>
<td>PSR radar</td>
<td>Cat 048</td>
</tr>
<tr>
<td></td>
<td>SSR radar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M-SSR radar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode-S station</td>
<td></td>
</tr>
<tr>
<td>Monosensor target reports</td>
<td>ADS-B ground station</td>
<td>Cat 021</td>
</tr>
<tr>
<td>Monoradar target reports</td>
<td>Surface movement radar</td>
<td>Cat 010</td>
</tr>
<tr>
<td>Monoradar service messages</td>
<td>PSR radar</td>
<td>Cat 034</td>
</tr>
<tr>
<td></td>
<td>SSR radar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M-SSR radar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode-S station</td>
<td></td>
</tr>
<tr>
<td>Mode S surveillance coordination function messages</td>
<td>Mode-S station</td>
<td>Cat 017</td>
</tr>
<tr>
<td>Mode S datalink function messages</td>
<td>Mode-S station</td>
<td>Cat 018</td>
</tr>
<tr>
<td>Ground station service messages</td>
<td>ADS-B ground station</td>
<td>Cat 023</td>
</tr>
<tr>
<td>Monoradar service messages</td>
<td>Surface movement radar</td>
<td>Cat 010</td>
</tr>
<tr>
<td>Directed Interrogation Messages</td>
<td>Military Mode-S station</td>
<td>Cat 007</td>
</tr>
<tr>
<td>Monoradar weather information</td>
<td>Monoradar</td>
<td>Cat 008</td>
</tr>
<tr>
<td>Multisensor weather picture</td>
<td>Multisensor processed</td>
<td>Cat 009</td>
</tr>
<tr>
<td>TIS-B Management messages</td>
<td>ADS-B ground station</td>
<td>Cat 022</td>
</tr>
<tr>
<td>A-SMGCS data (target report, flight plan data, holdbar status)</td>
<td>SMGCS system</td>
<td>Cat 011</td>
</tr>
<tr>
<td>System track data</td>
<td>SDPS system</td>
<td>Cat 062</td>
</tr>
<tr>
<td>Sensor Status messages</td>
<td>SDPS system</td>
<td>Cat 063</td>
</tr>
<tr>
<td>SDPS Service status messages</td>
<td>SDPS system</td>
<td>Cat 065</td>
</tr>
<tr>
<td>Safety Nets Alarms</td>
<td>Safety Nets Server</td>
<td>Cat 004</td>
</tr>
<tr>
<td>Multilateration data</td>
<td>Multilateration ground stations</td>
<td>Cat 020</td>
</tr>
<tr>
<td>Multilateration System Status Messages</td>
<td>Multilateration ground stations</td>
<td>Cat 019</td>
</tr>
<tr>
<td>ASTERIX Version Information</td>
<td>Any system</td>
<td>Cat 247</td>
</tr>
</tbody>
</table>

As ground operations include identification of vehicles and other obstacles on the airport surface, surveillance data information models should include data from identification systems (e.g. active and passive transponders, satellite).

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Surveillance data is exchanged in most cases via “surveillance networks”, i.e. value added networks on top of communication networks. RADNET, for example, is a value added network for the distribution of surveillance data (sensor, track server and sensor monitoring/control data) in the 4-States/EUROCONTROL area, allowing the use of any available surveillance information by the ATC centres connected. Internally RADNET uses exclusively the ASTERIX format. The system installed as network node for RADNET is the RMCDE (Radar Message Conversion and Distribution Equipment); conversion from and to other formats is done by the RMCDEs. Other surveillance data networks have been developed at the same time.

The communication transport medium used for RADNET is a common backbone X.25 packet switching network called RAPNET (Regional ATS Packet Switched Network), used also for the exchange of other types of aeronautical data (flight plan data, AFTN/CIDIN messages, coordination messages (OLDI)) as well as other applications.
X.25 is going to be replaced by IP based communication. In that respect a new Surveillance Data Distribution System (SDDS) developed by EUROCONTROL will replace the current systems (like RMCDE) and form the new surveillance network(s), which will be using PENS as communication infrastructure.

**C3.6.6 Environment Domain**

Environmental data integrates with SWIM in a two way nature:

- the need to incorporate environmental requirements into operational decision making at strategic, planning and tactical levels;
- the need for operational data to combine with environmental models and algorithms for environmental performance tracking purposes.

The objectives are to support and inform ATM decision making, with relevant, accurate and timely environmental information in order to:

- Minimise adverse environmental impacts;
- Ensure compliance with environmental obligations;
- Underpin environmental R&D;
- Inform environmental performance tracking; and,
- Enable analysis of and reporting on environmental improvements.

Environmental data topics include constraints, mitigation, compliance and performance (impact, KPI and trade-offs) and cover noise, air quality, climate change forcing and potentially others including water-quality/de-icing and third party risk.

An ECAC base-level of environmental KPI-data capability is presently being developed by EUROCONTROL in its PAGODA facility. It has environmental information management requirements on environmental data (CO2, NOX, local air emissions), movements (city-pairs), Continuous Descent Approach, Meteorology, route network, aircraft performance etc. which are not all yet fully data modelled. This will be completed by 2013; and will deliver quick wins at a strategic level of data through integration and analysis of past-recent operational-environmental data.

Within the Capability Levels 2/4 timeframe, changing SWIM-Environment data requirements may arise on the following areas.

**Environmental rule compliance planning**

This will ensure that relevant rules setting out curfews, access restrictions, non-optimal operations, environmental charges and penalties, together with, aircraft compliance, charges levels and exemptions are included in business trajectory decision making. This could for example modify environmental exemptions, budget usage or charges based on variables such as weights or success in achieving a mitigation requirement (e.g. CDA).

Potential Information Management requirements:

- Transparent provision of airport rules and constraints – may require access via SWIM;
- Warnings of risks for limit (predictive)/curfew (imminent) breach – estimated available capacities;
- Notification and acceptance exchange of flight operational parameters for exemptions against rules – or mitigated environmental charges;
- Environment assessment parameters (e.g. trade-off parameters) to determine tactical course of action where competing objectives apply – i.e. curfew exemptions for very early arrivals which would incur significant fuel and human time penalties);
- For airports where noise dispersion applies – scheduled airport/airspace configurations for flight planning purposes.

**Integration of Environmental Parameters into SWIM**

This will ensure that the environmental performance of flights and flight planning options are available to stakeholders to support decision making. This will entail integration of environmental assessment capabilities with operational data (see previous) in a form to aid decision making. This may include for example predictive capabilities (to estimate when a budget type limit will constrain part of the ATM system), trade-off assessment (e.g. to allow a decision on whether a night curfew should be relaxed to
prevent unnecessary emissions from holding an early arrival). This could be used to inform transparent environmental rule assessment (a key SESAR requirement). It would also allow system wide impacts of local decision to be taken into account and pan-European environmental performance tracking.

It could also provide environmental impacts to be used in pre-flight planning (e.g. emissions loading for emissions trading purposes) so that the business trajectory can incorporate consideration of socio-economic and environmental imperatives (and their interdependencies).

Whilst the tools and information production may be external to SWIM – SWIM needs to be able to handle the information to allow decision making to have access to this.

Potential Information Management requirements:

- Potentially – contrail prediction data;
- Emission and environmental economic costs to advise business trajectory development;
- MET derived impact dispersion parameters for airport and potentially en-route – this may allow (in the more distant future) the tailoring of impacts affected by MET (e.g. Noise and air quality emissions);
- MET derived concentration predictions where concentration limit exceed determines airport capacity – to allow an environmentally driven turn-down of an airport available capacity to be absorbed by ATM system.

**Operational data for Environmental Purposes**

Operational data is essential to assess environmental impacts, to decide upon route optimisation, rule compliance, mitigation (practice) adoption, forecasting, environmental budget usage, rule effectiveness and so on. This task would identify such data requirements and ensure that these are stored, available of adequate quality and maintained. This would not just cover aircraft or trajectory capability but influencing factors such as MET (e.g. to select/optimise mitigation procedures like CDA or to allow impact dispersion to be predicted).

Potential Information Management requirements:

- Aircraft specific, Flight planning, profile and accurate radar data to enable local impact assessment, environmental capacity use and capacity predictions etc.;
- Same to allow ATM system target achievement tracking, environmental performance monitoring and KPI population;
- MET data and other operational parameters to allow optimisation of environmental mitigation techniques (e.g. CDA, noise track compliance and continuous climb);
- Operational parameters for trading and charging schemes.

**Uncertainty:** Environment is a rapidly changing topic with the potential for significant constraints on any phase of the ATM system. Whilst it is possible to plan effectively for known aspects (e.g. noise), uncertain issues such as “contrail induced cirrus” may not become a real issue until scientific agreement is reached (possibly in the Capability Levels 2/4 timeframe). Similarly there is uncertainty in the effects that climate change itself will have on ATM (e.g. changing demand patterns, flooding, increasingly severe weather events etc). The uncertainty risk can be mitigated by ensuring that the fundamental ATM requirements required to respond to these potential risks, including potential data requirements, emerging research are mapped out and updated; and, that the developing SWIM related activities are kept informed of emerging change (research).

**C3.6.7 Others**

Airport Operators and Airspace Users require much more than the ATM information provided by the previously listed Domains, for efficient and safe operations. This includes forecasted and historical statistical information, airport slot information, and local disturbances (strike, traffic jam, incidents, etc.). The requirements for the data elements that needs to be standardised and made available along the principles of this IM guidance material will progressively come from advanced versions of CDM, implementation of the Business Trajectory and the User Driven Prioritisation Process (UDPP). This will require that existing and on-going data modelling activities such as Type X are closely followed to ensure alignment.

An example of a data domain that has not been specifically identified by the SESAR Definition phase is the Aircraft domain, though many of its requirements notably in the area of air-ground data
exchange needs have been taken into account. There are currently several aircraft related data (e.g. static / dynamic performance) that are stored at different places and which may benefit from being managed all together by a specific “aircraft domain”

The aircraft data domain covers the information that needs to be made available to ATM about each individual aircraft that participates in ground or flight operations. This includes data on aircraft performance (both generic and specific to a particular airframe), aircraft equipment and operating status of that equipment, trajectory as known by the aircraft, aircraft load, etc.

Currently, the aircraft data that is known by ATM is limited in scope (flight plan, identification, position, speed, altitude, etc.). Some data is simulated based on generic models, such as aircraft performance models used for profile calculations. Most of the aircraft data remains on board the aircraft itself.

The 4D trajectory concepts and the SESAR view of full integration of the Aircraft information with the Ground systems, requires that the aircraft data known by ATM becomes more accurate and more available. This will be achieved initially by connecting the AOC to SWIM, and later through existing or wider band data links between air and ground, through the implementation of enhanced import/export capabilities in the on-board equipments (FMS, EFB, etc.). Communicating through data link information such as digital taxi clearances, 4D trajectory, actual performance data of each individual aircraft, etc. will be enabled.

The on-board systems need to share common data models with the ground system. The first steps are currently being made through the development of new open standards for on-board navigation databases (NDBX), through the refinement of the aircraft performance models (BADA), etc.
D1 Scope

The ATM Infrastructure Guidance specifies how airspace users, airports, ANSPs and other stakeholders are expected to modernise and improve their ATM related systems and infrastructure so as to enable the other strategies. It outlines the transition as a roadmap of Enabler deployments organised around Stakeholder systems, complemented by a suitable deployment Strategic Guidance. Civil-military interoperability aspects are also covered.

D1.1 Glossary

SESAR System Level Architecture

Infrastructure

In the context of this annex the scope of the term “Infrastructure” includes the following:

22 For more information on the definition of the systems – see Appendix 1 -
• **Airspace User systems**, including aircraft systems and Airline Operations Centre (AOC) ATM systems
• **Airport systems**, consisting of Aerodrome ATC system and the Airport Airside Operations system
• **En-Route and TMA systems**
• **ATM Regional systems**, which include the Aeronautical Information Management system, the Network Information Management system, the Advanced Airspace Management system, the Air/Ground Datalink Ground Management system (AGDLGMS) and the SWIM Supervision system, all acting at regional level

The systems are underpinned by Communications, Navigation and Surveillance (CNS) technologies together with availability of radio spectrum.
D2  The Need for Change and Vision

D2.1  The Need for Change

ATM Infrastructure\(^{23}\) is an enabler for the SESAR future operational concept. Proposed changes to the existing Infrastructure are determined by new performance targets\(^{24}\) (see Annex A - Performance), and new operational requirements emerging from future ATM concepts (See Annex B - Network), with their associated information processing and distribution requirements (See Annex C - Information Management). Evolution will also be influenced by technology opportunities (e.g. GNSS, ADS-B, Internet protocols) as well as global interoperability, civil-military co-ordination, transition issues, institutional issues and business considerations.

The SESAR ATM Concept of Operations aims at implementing new operational paradigms, which will drive the evolution of the ATM Infrastructure:

- Trajectory based operations;
- Collaborative planning;
- Integrated airport operations;
- New separation modes;
- System wide information management (SWIM);
- Human in the loop.

The future ATM Infrastructure aims at enabling the CNS/ATM integration, by removing fragmentation and allowing the exchange and sharing of information between the ATM stakeholders.

The objective of an improved infrastructure is therefore to provide a safe, efficient and cost-effective set of interoperable systems which enable, in a globally compatible manner and with due regard for backward compatibility, the required functionality and performance. Cost and RF spectrum considerations will drive a rationalisation process of the current infrastructure requiring legacy systems to be phased out as soon as practicable and new, more efficient technologies to be introduced.

The SESAR Concept of Operations anticipates that it will be difficult to operate State\(^{25}\) aircraft on the basis of segregation and exemptions/derogations in relation to ATM Infrastructure requirements. In the new environment there will be a need to ensure that military systems can interact with the underlying SESAR network centric environment.

To sustain military operations within SESAR ATM structures particular architecture considerations and specific technology options are needed. The concepts enabling the appropriate interaction between civil and military systems include:

- Enhanced levels of civil-military interoperability;
- Identification of longer term technology convergence targets;
- Reduction of exemptions and derogations for mandatory equipage;
- Performance-based requirements enabling the re-utilisation of available military capabilities.

The provisions related to civil-military interoperability needs are an integral part of this guidance material for ATM Infrastructure. They require security assessments and might oblige the adoption of mitigation measures. Military aircraft will be accommodated, in a limited number of cases, on the basis

\(^{23}\) For the purpose of this document, "infrastructure" includes both airborne and ground or satellite based elements.

\(^{24}\) The European ATM system in 2020+ should achieve compared to 2005 baseline: 3-fold increase in capacity, factor 10 in improvement of safety, 10% reduction in environmental impact, 50% less cost to the Users

\(^{25}\) Military, customs and police
of equivalent performance where military systems will be re-utilised to support an equivalent ATM function. Adoption of ATM requirements by the military might require a certain lead time to overcome lengthy procurement cycles and huge fleets with multiple aircraft variants.

**Navigation**

As the ATM Network develops, the operational requirements for safety, capacity, efficiency and flexibility will drive a transition from the current RNAV operations through Advanced RNP to ultimately 4D trajectory Navigation. Additionally, the guidance material for ATM Network also requires to enhance airport access and to improve safety during approaches.

To respond to the more demanding operational needs, advanced GNSS technologies will become essential to enable the SESAR operational concept. The progressive development of a global multi-constellation GNSS will offer higher positioning performance and robustness.

The transition to GNSS will allow the rationalisation of conventional navigation aids enabling cost savings and a more efficient use of the spectrum.

**Surveillance**

From the current situation, where mainly Monopulse SSR, SSR Mode-S and Primary Surveillance Radar (PSR) are widely in operational use, the Surveillance infrastructure will evolve and be rationalised to achieve a higher performance, cost-efficiency and spectrum efficiency.

It will be driven not only by the operational requirements but also the availability of new techniques and systems, such as Wide Area Multilateration, Automatic Dependent Surveillance etc. which will enable rationalisation of the ground infrastructure and development of new applications such as Airborne Surveillance.

**Communications**

A key driver for communications is the transition from analogue techniques to fully utilise digital technologies. This will facilitate a greater use of automation in communication exchanges and a move away from voice to data as the prime means of air traffic control.

The new operational paradigms will identify new requirements for the Communications Infrastructure which will be fulfilled by the introduction of new air-ground data links. The volumes of information and the level of automation will continue to increase in an environment where Air Traffic Control, Airline Operational Control and Airport systems are integrated. The SESAR Concept of Operations calls for the sharing of Trajectory and ATM information between partners and for a net-centric operation based on System Wide Information Management (SWIM).

**ATM systems**

The changes to the ATM systems are driven by two main factors:

- New operational paradigms, which require the systems to provide additional functionality and enable greater collaboration between the ATM Stakeholders; and
- Recognition of the need to move away from the current fragmented design to an architecture that considers the whole ATM, with its different Stakeholders, as one “Enterprise” and in which the business and operational needs for each part of the system are clearly established.

Individual solutions developed for local needs are limiting collaborative action across the stakeholder domains and cannot always accommodate network requirements. The full integration and connection of stakeholder systems to the network will be implemented via solutions, such as internet access to the SWIM systems. This requires a modular approach, enabling all stakeholders to achieve a common picture of the respective traffic situation and contribute according to their specific needs and the overall network performance.

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26 The GNSS infrastructure includes global satellite constellations (e.g. GPS, GLONASS and Galileo) and 3 types of augmentations: on-board augmentations like RAIM (Receiver Autonomous Integrity Monitoring), SBAS (satellite based regional augmentations) like EGNOS in Europe, and GBAS (Ground Based Augmentation systems).

27 Today GPS is the only GNSS constellation that is fully operational. GPS offers a very efficient service and is widely used in aviation. However, GPS has some deficiencies impeding its comprehensive use in aviation (e.g. number of satellites, single frequency, low power signal and single operator). The expected GNSS developments, including Galileo, will overcome most of the current GNSS deficiencies.
Enhanced decision support tools are also required. The more the planning and execution of a flight is transiting towards 4D-trajectories the more information on impact at the entire network needs to be taken into account from the individual actor.

Impact on human factors needs to be taken into account, as well as the need to facilitate the required change in working culture.

**Spectrum**

It must be stated at the outset that the viability of the ATM Infrastructure as described in this guidance material is totally reliant on the availability of sufficient RF Spectrum. Since the 1990's with the deregulation of telecommunications and the emergence of mass media public communication, the demand for spectrum is exponentially increasing for day-to-day life. Heavy pressure is on the so called aviation bands to make them more spectrally efficient and to share them.

No new spectrum will be made available, by States, for aviation usage. The only way for aviation to continue its safe and economic operation is to optimise spectrum usage in support of new or additional requirements.

SESAR foresees the introduction of new technologies to address the shortcomings of the current systems, for this new spectrum needs to be made available to allow the new systems to be developed and deployed prior to removing the current systems from service. This guidance material highlights the considerations and actions that are necessary to allow the smooth and efficient implementation of the new technologies and thus facilitate the SESAR Concept of future operations. The inability of aviation to achieve the recommended actions will ultimately prevent the deployment of some of the planned CNS elements because of insufficient radio spectrum.

Unless aviation as an industry can continue to demonstrate the need for the currently allocated spectrum, the International Telecommunications Union (ITU) will seek to share the aviation bands with other non-aviation users. Finally the idea of pricing the spectrum used will force rationalisation and development of more spectrally efficient technologies. A more efficient use of spectrum is essential to the development of the ATM infrastructure, so all Stakeholders are encouraged to embrace this need.

**D2.2 ATM Infrastructure Vision**

An integrated, performance and service driven approach for new developments of the ATM Infrastructure is needed. This applies not only to the various technical domains (Communications, Navigation, Surveillance, ATM systems, spectrum etc.), but also to the stakeholder systems (both in the aircraft, and on the ground) and the human factors.

In order to support this integration, a paradigm shift in system architecture and a new approach to system development will be used, based on an Enterprise Architecture comprising different views of ATM from Strategic and Business, through Operational to System and Technology. All of this will be addressed using a service-oriented approach.

The SESAR deliverables provide the roadmaps describing how and when legacy and new elements of the ATM Infrastructure will operate together. New air-ground data link technologies will use spectrum efficient technologies and, where applicable, basic components already defined for the mass market. At the same time, the definition of data elements to be exchanged over the air-ground link should minimise the required data bandwidth to take account of spectrum constraints.

**Navigation**

In the period covered by this guidance material, the vision of Navigation is the deployment of 4D trajectory capabilities. The Navigation infrastructure vision is based on a gradual increase in reliance on GNSS for positioning and timing; the final goal being a satellite based sole navigation service, to the extent that this can be shown to be safe and cost beneficial.

The continued availability of a network of ILS and DME is needed for the full period, to address remaining GNSS signal vulnerabilities, independent surveillance could be the main backup following loss of navigation capability.

The transition to GNSS will allow cost savings and spectrum availability coming from the removal of VORs and NDBs.

28 These are related with solar activity and interferences. They will be addressed by security studies regarding jamming of GNSS frequencies and a workplan related with the impact of solar activity on the GNSS signals.
For approach and landing operations, advanced GNSS technologies such as SBAS\textsuperscript{29} (Satellite Based Augmentation Systems) and GBAS (Ground Based Augmentation System) will allow provision of vertical guidance based on satellites and will become progressively more cost efficient alternatives to ILS.

All aircraft will need to have a GNSS sensor capable of supporting not only Navigation but also ADS-B and Datalink applications. The airborne equipage requirements for dual RNAV/FMS (Flight Management System) will increase to support advanced RNP and 4D trajectory based operations.

**Surveillance**

The vision for ground Surveillance in en-route and terminal areas is the combination of ADS-B with independent Surveillance, the latter provided by MSSR or Mode S or Wide Area Multilateration. Where there is still a need for Primary Surveillance radars, it could be fulfilled by the spectrum efficient Multistatic PSR (MSPSR).

Airborne ADS-B systems will be available as enablers of the new separation modes (from airborne traffic situational awareness through spacing and separation to ultimately self-separation). These airborne applications will require changes in the avionics ("ADS-B out"\textsuperscript{30} and "ADS-B in"\textsuperscript{31}) to process and display the air situation picture to the pilot.

For airports, a locally optimised mix of the available technologies, i.e. airport Multilateration, Surface Movement Radars and ADS-B, will enable A-SMGCS systems and integrated airport operations. This includes the availability of Surveillance information on a moving map, using an HMI in the cockpit and in surface vehicles.

A rationalised (i.e. cost-efficient and spectrum efficient) ground surveillance infrastructure can be foreseen to be gradually deployed, using the opportunities offered by the new technologies.

**Communications**

For air/ground communications, the instantaneous voice communications between pilots and controllers for the communication of safety-critical messages will remain a key requirement. These Air traffic Control operations will continue to use the allocated VHF spectrum (118-137 MHz) for voice communications. In order to service continued demand for additional voice channels and mitigate against frequency congestion problems, 8.33 kHz channel spacing has been implemented in the VHF band above FL195, and further implementation below FL195 is foreseen.

For air/ground en-route data communications, the use of datalink applications (such as CPDLC) will initially complement voice communications between pilots and controllers based on the use of ATN/OSI and VDL2 technologies in the VHF band. In support of the SESAR ATM Concept of Operations, data link communications will become the prime means of communications with voice being used for non-routine and emergency communications only (in designated airspace), thus the requirements for voice channels will diminish. The combination of a new terrestrial data link technology in L-band and a satellite link will provide the necessary performance to meet the availability, continuity and integrity requirements of the most demanding data link services in addition to the CPDLC services in the VHF band.

For the airport environment, a new aviation airport surface data link system will be introduced, supporting both Air Traffic Services (ATS) and Airline Operations Centre (AOC) data exchanges. This will support surface routing and guidance functions (SMAN) as part of an overall A-SMGCS, as well as the transmission of 4D trajectory data for the ground segment of the flight.

For ground/ground data and voice communications and in order to meet existing and new requirements derived from data sharing and SWIM, a Pan European Network Service (PENS) is being implemented. The existing national networks, initially linked together within PENS using the Internet Protocol (IP), will migrate towards full IP networks in the PENS environment. The network will also support ground Voice over IP (VoIP) services including the ground segment of the air ground link.

**ATM systems**

The European ATM systems architecture that needs to be developed for the future will be different to that currently deployed. It will form part of the service-oriented Enterprise Architecture and its

\textsuperscript{29} The SBAS implementation in Europe is called EGNOS (European Geostationary Navigation Overlay Service)

\textsuperscript{30} ADS-B transmission capability and related systems, applications

\textsuperscript{31} ADS-B reception capability on board and related systems, applications
development will require contributions from and collaborations between all Stakeholders involved in European ATM.

In order to support increased collaboration between ATM Stakeholders, the systems will be more integrated, with a transition from point-to-point connections and interfaces to an environment where information can be shared between all ATM Stakeholders including the Aircraft, with System Wide Information Management (SWIM) supported by a common ATM information Reference Model and infrastructure. The development of standardised, interoperable ATM components, based on service interfaces, is foreseen. A higher automation and enhanced functionality/performance will be deployed.

**Spectrum**

Regarding spectrum, the goal is to establish processes and working arrangements to ensure optimal use of this scarce resource by the stakeholders. This includes the following:

- Rationalised use of infrastructure: the spectrum requirement is related to the number of ground and airborne transmitters which need to be optimised, taking into account performance requirements and with a regional (instead of local) perspective;
- Co-ordinated CNS & Spectrum approach (instead of a fragmented approach) in addressing the spectrum needs of current and future technologies;
- Implementation of spectrum efficient technologies;
- Monitoring the use of the spectrum;
- Auditing the frequency assignment tables.
D3 ATM Infrastructure Strategic Guidance

D3.1 Approach

The evolution of the Infrastructure to meet the SESAR performance requirements and new operational features is driven by the following interrelated strategic processes:

- Integration
- Deployment of new technological capabilities
- Rationalisation

These are presented in more detail in the following Sections

Integration

The integration is a consequence of the needs of the “ATM Network”, the new operational paradigms as well as the technological advancements. It includes the following components which need to be taken into account for the realisation of the new ATM Infrastructure:

- Holistic “end-to-end” (ATM Network) approach, driven by performance and “interfacing” with the operational domains and Information Management

The future ATM Network as enabled by SESAR requires the removal of all operational and technical fragmentations in order to meet the performance objectives in general and enable efficiency in particular. The Infrastructure developments have to be performed in an integrated approach with the operational domains, having as main driver the needs of the ATM Network as reflected by the SESAR objectives.

All the new operational features which are introduced by SESAR, i.e. the trajectory based operations, SWIM, the new separation modes, the collaborative planning and the integrated airport operations have as a main prerequisite the integration between the CNS/ATM stakeholder systems (including the Infrastructure), i.e. they simply cannot be realised without such integration.

- Integration between COM, NAV, SUR, ATM systems and ATM network components, as well as between the human operators and the systems

The integrated approach towards implementation of the ATM Infrastructure is also driven by the technological advancements which are introduced in the ATM Infrastructure.

A typical example is related to the increased role of GNSS, which provides positioning and timing information to support many aviation applications. In fact, GNSS provides positioning data to support Navigation and Surveillance (such as ADS-B) in the civil and military domains and in all phases of flight including airport operations. It also provides common and accurate timing information that is used to synchronise systems (e.g. 4D FMS, communication and ATC) and ATM operations. Additionally, the long term option of broadcasting GNSS related data (e.g. satellite orbit corrections) using aviation COM systems has to be explored.
Use of GNSS in aviation applications

Civil domain

Surveillance (ADS-B) | Navigation | Timing in communications (e.g. Datalink)

Positioning | GNSS receiver on-board | Timing

Positioning and Time (4D NAV)

Figure 62 Use of GNSS in ATM applications

The deployment of 4D trajectory capabilities require advanced harmonised avionics, such as 4D capable FMS, performant data links, integrated ATC ground support tools etc. This will permit an optimal integration of user preferred trajectories into the network. An integrated approach is, therefore, necessary to synchronise the requirement definition process with the infrastructure development Strategic Guidance, to enable delivery based on a rather ambitious plan, considering the airborne, ground and datalink systems affected.

The deployment of ADS-B as an enabler of new separation modes (spacing, separation, self-separation), which leads gradually to a new balance of separation responsibilities between controllers and aircrew also requires an integrated approach for Navigation, Communications, Surveillance, ATM systems, spectrum etc.

Similar remarks can be made for the systems enabling SWIM, collaborative planning and integrated airport operations (which by definition aim at realising the integrated perspective).

The integrated approach for infrastructure is also illustrated by the spectrum resources which are commonly used by different domains and Users. So far the approach was rather fragmented, but this will unavoidably change in the future in order to meet the SESAR requirements. Spectrum should be viewed as a common resource subject to a continuous rationalisation process to allow the new applications to be served.

- Integration between airborne domain, En-Route/TMA, Airports and Regional systems

The full integration of the airborne domain in the system is one (key) feature of the transition to the SESAR target infrastructure. This includes the transmission of aircraft derived data such as position, velocity, 4D trajectory to other Users and the provision of data available on the ground systems to the airborne domain, via data links.

- Interoperability between civil and military

- Integration at geographical level (regional, e.g. Functional Airspace Blocks and global, e.g. Europe/other continents/ICAO)

An important aspect of integration which will happen in the period covered by this guidance material is the creation of the Functional Airspace Blocks. Several initiatives are ongoing throughout Europe and they include plans co-ordinated by the involved Service providers for the ATM Infrastructure. There are various levels of possible co-operation envisaged at the technical level of FAB, such as:

- Common Specifications (joint study, specifications and validation) for a technical system
- Common technical systems (as above plus common procurement and development)

In SESAR documentation a distinction is made between “core” technologies (affecting most of the Users) and “non-core (incidental)” technologies having a local applicability and lower impact at the Network level.
Common technical service (as above plus common training and maintenance)

**Figure 63 Illustration of the FAB co-operation options in ATM Infrastructure**

This new environment will lead to a greater “integration” between neighbouring Service providers, which in turn will enable cost efficiencies and other benefits to be realised.

Similarly, the changes which will be introduced in the period covered by this guidance material have (to a large extent) to be co-ordinated at international level, i.e. with other continents and with ICAO fora.

As a consequence of the above, the working culture, methodologies and arrangements used in the ATM Infrastructure lifecycle have to be restructured drastically in order to allow as a standard practice the required cross-domain, cross-border co-ordination to take place efficiently. Safety, performance, interoperability, human factors and security have to be assessed in an end-to-end perspective based on proven methodologies and corresponding mitigation measures have to be implemented, where necessary. Institutional and legal aspects have to be addressed, as appropriate.

**Deployment of new technological capabilities**

The future ATM Infrastructure will prepare for operational use and deployment of new techniques, technologies and automation which are necessary to meet the defined objectives. These include:

- Space based navigation (GNSS), including GBAS and SBAS (EGNOS)
- 4D trajectory capable avionics (FMS)
- Multilateration
- Automatic Dependent Surveillance (ADS-B)
- Digital technologies and Internet protocols (IP)
- New datalinks (e.g. terrestrial, satellite)
- New and improved ATM system functionality etc.

The number and magnitude of these new developments in the period until 2025 is so large compared with previous implementations, that it poses a big challenge to the aviation community in general and SESAR working arrangements in particular.

A major issue is the transversal impact of these developments to many domains and stakeholder systems, as presented above. A fragmented approach in addressing these developments is clearly a non-option. Strong partnership/collaboration is necessary between the relevant parties and domains involved (operational, technical, ground, airborne, national, international etc.) and proven methodologies have to be selected/used, in order to make best practices used in the past or new best practices the rule for the future.

The implementation oriented work of Capability Level 1 will establish the baseline for the following (R&D oriented) Capability Levels. It is necessary to build efficient interfaces between the Programmes and projects of these two periods and ensure the required smooth transition.

**Rationalisation**

Rationalisation is a key strategic process in the development of the new ATM Infrastructure. It aims at the most cost-efficient and spectrum-efficient mix of systems meeting the requirements. This is wider than decommissioning and reflects the objective of “optimisation” (i.e. best use) of the resources from the ATM Network perspective.

The whole ATM infrastructure must be thoroughly examined to identify where rationalisation can occur. So far, new systems were added to the ATM Infrastructure portfolio, but none seem to be removed and decommissioned.

The pressure on cost and spectrum efficiency gets higher and decommissioning of part of the legacy systems must be concretely planned, in order to ensure that resources are freed for the new technologies. Having decommissioned some systems, their replacements must be cost and spectrum efficient. Maximum use must be made of modern techniques and systems (e.g. modulation
maximising throughput whilst minimising operational bandwidth, dependent surveillance, GBAS which provides a service to all runways in an airport etc.).

Wherever possible the time between development and full deployment into an operational environment must be reduced to a minimum, in order to maximise the benefits. This should be taken into account in the decision between voluntary equipage and mandates.

The realisation of the ATM Infrastructure requires a strategic (as opposed to ad-hoc) approach to rationalisation. The rationalisation process has to be based on the “ATM Network” perspective and driven by performance/operational objectives, reflected in specific criteria (indicators). It has to lead to a rationalisation plan, which clarifies the concrete milestones for system decommissioning and synergies, in order to maximise cost and spectrum efficiency. As for the deployment of new capabilities described above, the rationalisation process also has to take an “integrated perspective” and address the interdependent character of the used resources.

The current guidance material identifies rationalisation milestones during the various phases. This includes:

- Decommissioning of systems
  - PSR/SSR, NDB, ADF, VOR etc.
- Cost and spectrum efficient use of existing and new systems
  - Regional co-operation
  - VHF band
  - 1090 MHz datalink
  - Use of DME/TACAN
  - Independent surveillance as backup in the case of Navigation failure in an end-to-end system perspective
  - Multistatic PSR etc.

The overall Rationalisation Plan has to be agreed by the stakeholders in the context of SESAR. It has to use the results of projects already foreseen within the SESAR Workplan and other to be defined, in order to build the required “big picture”.

A successful implementation of the new Infrastructure will require the realisation of the above approach and strategic processes at planning, development, deployment and institutional levels.

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**Figure 64 ATM Infrastructure Streams**
The strategic steps are presented below in more detail as a function of time, i.e. the SESAR Capability Levels. The time scale which corresponds to the Capability Levels in the European ATM Master Plan is given below:

![Figure 65 European ATM Master Plan Capability Levels](image-url)
D3.2 Capability Level 1

An overview of the strategic steps for Capability Level 1 is presented in Figure 66:

The following sections identify the infrastructure systems applicable to Capability Level 1 and how they are envisaged to transition during the period related to this Capability Level.
D3.2.1 Airspace User systems

Navigation

To support *en-route and TMA operations*, all aircraft operating IFR in European airspace, including a very large proportion of military transport-type aircraft, carry as a minimum a single RNAV/FMS compliant with B-RNAV requirements, mandatory in ECAC since 1998.

A sub-set of them carry an RNAV/FMS with better capability, i.e. P-RNAV\(^33\) capability. This optional capability allows RNAV operations on some TMAs. An increasing number of new aircraft are equipped with dual RNAV/FMS installations.

Nearly all RNAV/FMS have multi-sensors (e.g. GNSS, DME/DME, Inertial, etc.), and a few of them have only GPS as a sensor. Aircraft carrying older RNAV/FMS still using just VOR/DME sensors are expected to cease operations in ECAC towards the end of Capability Level 1. All GNSS RNAV systems have integrity monitoring capability (Receiver Autonomous Integrity Monitoring - RAIM).

Almost all aircraft operating IFR in European airspace carry VOR and Automatic Direction Finder (ADF\(^34\)) in addition to the B-RNAV or P-RNAV unit. VOR and ADF support conventional operations as backup to RNAV operations, and are necessary where only GPS and/or a single RNAV/FMS fit is carried. VOR and ADF also support operations in lower en-route airspace (below applicable RNAV flight levels) and in TMAs (SID, STAR, NPA, missed approach), which are essentially conventional (point to point) operations\(^35\). Few countries have VOR requirements for navigation equipment on VFR operating aircraft.

During the CL1 timeframe, a decision has to be made about the mandate related to the Advanced RNP requirements\(^36\) applicable for the Capability Level 3 timeframe.

For *approach and landing operations*, all IFR aircraft are equipped with ILS for precision approach with some also carrying MLS for Cat III operations or GBAS Cat I equipment, in addition to ILS.

An increasing number of new aircraft carry RNAV/FMS compliant with the more advanced PBN performance and functionality including RNP Approach (APV baro VNAV with barometric input), or RNP AR Approach procedures. The latter normally requires dual FMS. Such capability and corresponding operations are optional, but are increasingly implemented in ECAC to increase safety and local accessibility.

For State aircraft special measures to accommodate the absence of advanced avionics might be required for some fleets. Modern transport-type military aircraft will more and more be equipped in accordance with civil requirements. Combat aircraft, as weapons platforms, will have to be accommodated on the basis of re-utilising available military avionics capable of offering an equivalent level of performance.

Appropriate consideration will be required for military aircraft equipped with different NAV configurations including TACAN, GPS/Precision Positioning Service (PPS), INS/IRS. Multi-Mode Receivers (MMR) and FMS-like on-board Mission Computers.

Surveillance

All aircraft flying within ECAC controlled airspace are currently required to be equipped with a pressure altitude reporting device, in accordance with ICAO requirements. To fulfil this requirement, the majority of aircraft are fitted with an SSR Mode-S transponder. In the European Core Area Mode-S airspace, aircraft are required to be equipped with a Mode S transponder with Elementary and Enhanced Surveillance capability, including the Surveillance Identifier (SI) capability. In addition, about 70% of Mode S equipped aircraft currently have the 1090 MHz Extended Squitter capability, (currently most are not yet certified for operational use).

In 2008, EASA started the airworthiness approval of aircraft installations to support the ADS-B ground based surveillance for Non Radar Airspace (NRA)\(^37\). This will be the basis of initial implementations of ADS B NRA in ECAC sites.

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33 Compliant to JAA TGL-10
34 The airborne receiver of the ground Non-Direction Beacon, NDB.
35 Some countries do not require ADF if it is not needed to support the intended operations.
36 The Advanced RNP specification that will be required is being consolidated.
37 EASA Acceptable Means of Compliance AMC 20-24
The consultation to mandate the carriage of a transponder with SSR, Mode S Elementary and Enhanced Surveillance and 1090 Extended Squitter capability for GAT in the European FIR started in November 2008 through the Surveillance Performance and Interoperability Implementing Rule. The proposed dates for civil aircraft equipage in the Rule are 2012 for forward fit and 2015 for retrofit. For state aircraft, transitional arrangements including different dates of application are proposed. The Implementing Rules for Navigation (expected for Advanced RNP) and Surveillance (in consultation) need to be co-ordinated, so that the corresponding GNSS functionality will be sufficient to support ADS-B positioning requirements.

Global interoperability for ADS-B implementation will be based on the use of 1090 Mhz Extended Squitter. In local sites such as Sweden, ADS-B using VDL Mode 4 is currently being implemented.

In Capability Level 1, aircraft will start using airborne Surveillance applications and be equipped with “ADS-B in” capabilities, including receiver and airborne Surveillance Data Processing System to present the air situation picture to the aircrew on an airborne graphical display. These capabilities will provide the aircrew with a complete and reliable situation picture in support of Airborne Traffic Situational Awareness (ATSAW). Certified “ADS-B in” equipment for the first ATSAW applications will be available in 2009. The use of some airborne (“ADS-B in”) applications by one aircraft will require carriage of a certified “ADS-B out” system by the surrounding aircraft. The SPI IR mentioned above as well as earlier mandates in other parts of the world (e.g. Hudson Bay in Canada) will accelerate the implementation of the initial “ADS-B out” applications and establish the basis for deployment of the first “ADS-B in” applications.

Regarding State aircraft, Mode S and ADS-B capabilities are to be implemented, as necessary, taking advantage of increasing equipage with Mode S transponders where 1090 MHz Extended Squitter is available and possibly considering specific equipage of the military aircraft.

**Communications**

At the start of the Capability Level 1 period the technology for aeronautical voice communications, in airspace below FL195, is the VHF 25 kHz channel spacing system whilst in airspace above FL195 in the ICAO EUR Region, it is the 8.33 kHz channel spacing system.

The operational use of 8.33 kHz below FL195 within designated airspace is foreseen to start by the end of this Capability Level. This use will likely take place in a phased way and with a transition to cope with procurement and technical constraints of military aircraft.

In the context of the DLS (Data Link Services) Implementing Rule, aircraft with an individual certificate of airworthiness first issued on or after 1 January 2011 and operating above FL285, shall be equipped with ATN/OSI protocols and VDL2 technology. Specific provisions for State aircraft are included in the IR.

For the majority of aircraft, a software upgrade of the data link avionics and possibly wiring will suffice to execute Initial 4D trajectory services.

**ATM systems**

For the Airspace Users, there will be enhanced assistance, before departure, for flight planning, including route finding and optimisation tools; for military users, there will be the possibility to harmonise OAT flight plans with the ICAO format as the basis. In addition, the availability of new data models for exchanging Aeronautical Information Management (AIM) information will permit an automation of AIM updates such as digital NOTAM and will allow better sharing of information via the existing means of communication, supporting participation in local CDM, for instance at individual airports.

In the cockpit, there will be upgrades (including HMI) to enable initial ATSAW applications (in-trail procedures, visual separation on approach). ACAS will be linked to the autopilot or flight director, providing automatic downlinks of alerts and automatic guidance according to ACAS resolution advisories.

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38 SPI IR - ENPRM/08-009
39 For aircraft fulfilling defined weight or speed related criteria
40 Non equipped state aircraft have to be accommodated, provided that they can be safely handled within the capacity limits of the Air Traffic Management system on UHF or 25 kHz VHF assignments.
Aircraft shall be equipped with the necessary avionics HMI and end systems to realise the requirements of the DLS Implementing Rule in applicable airspace. Initial uplink of aeronautical information is foreseen.

**D3.2.2 Airport systems**

**Navigation**

Connectivity between the TMA and the airport is ensured through a variety of approach operations with different decision heights. This diversity is mainly due to different operational needs and local business decisions. *Non-precision approaches* (NPA) are widely spread. The large majority are conventional (based on VOR or NDB) and are increasingly being supplemented by RNAV (based on GNSS). In ECAC most NPA are flown as Continuous Descent Final Approach (CDFA) providing increased safety through the use of a stabilised approach.

For further safety improvements, they will be gradually replaced by *Approaches with Vertical Guidance* (APV) either based on SBAS or airborne Barometric altitude for vertical VNAV, the latter being flown by aircraft approved for RNP approaches. The replacement of NPA with APV procedures is in accordance with the decisions of the 36th ICAO Assembly which agreed a target date of 2016 for the provision of APV to all IFR runway ends. APV/SBAS are dependant on SBAS certification in Europe (EGNOS). This evolution of approach types will allow the reduction of NDB and VOR which will no longer be required to support NPA and missed approaches.

RNAV operations in terrain-constrained areas are being introduced, based on a special PBN specification (RNP Authorisation Required, i.e. RNP AR), and normally requiring dual equipage.

*Precision approach operations* are available to most runway ends at all major airports, and to at least one runway end at a large majority of medium airports, to support operations in low visibility conditions (Cat I/II/III). ILS will remain the prime source of guidance for such operations. Where necessary and once agreed by ICAO, ILS may be modified to overcome multipath problems and maintain Cat II/III capability at some runway ends.

For runways presently not equipped with precision approach systems or when ILSs are at the end of their operational life, it will be considered introducing SBAS or Cat I GBAS systems, along with airport lighting as needed. Business cases for such changes will be dependent on the nature of the traffic and availability of aircraft with certified GNSS based approach and landing systems\(^\text{41}\).

Similarly, where a local business case can be made (e.g. improved capacity in low visibility procedures (LVP) or where the ILS modifications cannot overcome multipath) MLS CAT III may be used as an alternative or replacement to ILS. In addition, towards the end of the period, depending on research and development results, there may be a limited availability of GBAS Cat II/III as a back up to ILS to enable operational benefits or to cater for maintenance/system failures. The interoperability with military differential GPS will need to be studied.

**Surveillance**

At the start of the Capability Level 1 period, surveillance capabilities for detecting the position and identification of all aircraft and surface vehicles have been progressively introduced. A-SMGCS, using a combination of Surface Movement Radar and Multilateration techniques, has been widely implemented at many of the larger airports. Airport Surveillance Data Processing has been implemented, mainly using a stand alone data fusion tracker, providing ground controllers with an improved airport situation picture.

In Capability Level 1, Multilateration systems will be deployed on a wider scale in European airports to support initial A-SMGCS. Initial use of ADS-B is expected in support of enhanced ground and airborne traffic situational awareness. Although many Airport Multilateration systems are configured with their own data fusion trackers as standard, a possible upgrade to existing TMA SDPDs to support Aerodrome operations will be required.

**Communications**

At the start of the Capability Level 1 period Air Traffic Control units providing ATC voice services to general air traffic, are equipped with 25 kHz channel spacing capable radio equipment.

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\(^\text{41}\) A limited number of special CAT I GBAS installations are available in Northern Europe to address the operational needs of demanding regional operations where the previous approach capability was limited to VOR based Non-Precision approaches.
The Departure Clearance (DCL) and the Digital Automatic Terminal Information Service (D-ATIS) are operational at many European airports using ACARS (Aircraft Communications Addressing and Reporting System), as the communication exchange mechanism. The D OTIS service, also using ACARS, is expected to be operational by the end of this Capability Level period at key airports, based on individual airport decision processes driven by performance needs.

In Capability Level 1, additional airport services for Data Link Taxi Support (D-TAXI), Data Link Operational Terminal Information (D-OTIS), Data Link Flight Update Service (D-FLUP) and Data Link Runway Visual Range (D-RVR) are developed using ATN/OSI and VDL2. An implementation decision is needed during this Capability Level period, if the operational use of these services is to be achieved by the Capability Level 3 timeframe.

In order to accommodate the forecast traffic on the airport surface (resulting in increased data throughput demand) and alleviate use of valuable VHF spectrum, it is proposed by ICAO Aeronautical Communications Panel (ACP) to use the IEEE 802.16e technology (in the C band) to build an aviation airport surface data link system supporting both AOC and ATS data exchanges. It will be interconnected with the airport fixed data network infrastructures in order to provide a seamless data transport network at airports. It is anticipated that test and trials activities be completed by the end of this Capability Level period, so that ICAO provisions, technical standards, and initial deployment of AOC and ATS services using the 802.16e Aero infrastructure be completed by 2016, at some airports.

**ATM systems**

The major change for Airports will be the implementation of Airport-CDM, which will impact different sub-systems depending on what each individual Airport needs to achieve. Generally, cooperation between sub-systems will be increased, and in some cases, new sub-systems will be introduced (i.e. the Aerodrome ATC or Airport Demand and Capacity sub-systems).

Airport-CDM is divided into four levels. Airport-CDM levels 1 to 3 are already implemented at some airports in Europe but will see further deployments. Airport-CDM level 4 (moving from event-driven CDM to service-driven CDM with direct connections into the ATM network as a whole) is new for Capability Level 1. The Airport-CDM processes will be supported by the provision and access to commonly shared data through SWIM. Both the Aerodrome ATC and Airport Airside Operations systems will start evolving towards the common information models required by the SWIM environment (i.e. the Common ATM Information Reference Model).

In the pre-SWIM phase, changes in the airport domain will consist mainly of the provision of airport tools for sequencing aircraft and tools to support turnaround management with progressive integration which will support closer co-operation between Aerodrome Operations, Terminal Area Operations and AOCs. At some airports initial integration of DMAN solutions into Airport-CDM turnaround management processes will be available. Introduction of cooperative DMAN and SMAN capabilities in the local airport environment will be prepared, in order to provide the first generation of integrated airport operations controller tools in support of:

- Optimisation of departure sequences;
- Enhanced surface safety nets: Runway incursion detection and alerting services (A-SMGCS level 2);
- Enhanced surface routing: Storage and dissemination of surface routes (A-SMGCS level 3).

The introduction of runway usage management will allow additional runway usage improvement through dynamic adjustment of separations based on wind shear monitoring and static wake-vortex information.

For Airport Operators, there will be the start of the evolution of airport vehicle equipment for high/medium density/complexity airports. Airport vehicles will become equipped with static (airport maps) and dynamic situation displays helping reduce navigation risks (especially in low visibility conditions).

All types of airports will start to introduce sub-systems for environment monitoring purposes.

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42 Level 1: Airport CDM Information Sharing & CDM Turn-around Process
   Level 2: Collaborative Management of Flight Updates & Variable Taxi Time Calculation
   Level 3: Collaborative Pre-departure Sequence & CDM in Adverse Condition
D3.2.3 En-Route and TMA systems

Navigation

GNSS is becoming increasingly important, initially for positioning and later for timing. For this Capability Level, GNSS will be based on GPS with a single frequency and SBAS augmentation upon its certification for aeronautical operations in Europe (EGNOS).

Using GNSS positioning requires RNAV/FMS with GNSS sensors on the aircraft. This will be the catalyst for a faster transition to a total RNAV environment. The extension of RNAV to lower flight levels and for terminal operations will enable a reduction and eventual removal of conventional routes and terminal procedures.

A progressive reduction of conventional routes and procedures will enable a limited reduction of NDB and VOR, while leaving a sufficient backbone of NAVAIDS to continue supporting a reducing non-RNAV GAT route structure at lower flight levels. It will support remaining conventional operations (e.g. SIDs, STARs, NPAs and missed approaches) and enable ATC to re-route aircraft in the event of individual aircraft RNAV failure. The progressive reduction of NDBs and VORs will enable an increase of ANSP cost efficiency.

However, the availability of only single frequency GPS necessitates a backup in the event of single channel GPS failure. The required backup capability will depend upon the local operational environment. For commercial Air transport operations, backup is expected to be to DME as this capability is provided in all existing FMS and many RNAV systems. This will require the enhancement of DME coverage to improve the quality of service for en route and terminal operations (removal of coverage gaps). This will be achieved mainly by deploying additional DMEs and in some cases by repositioning some of the existing facilities, as enabled by some decommissioning of VOR. In areas of radio spectrum congestion, the DME coverage optimisation may depend on VOR reduction. DME coverage redundancy may be enhanced by the availability of military TACANS, provided these are maintained and operated to meet the ICAO SARPS requirements.

Surveillance

At the start of this Capability Level period, the principal technical solution for En-route and TMA ground based surveillance is SSR (Monopulse and Mode S). The Surveillance Standard foresees double SSR coverage (plus PSR coverage in major TMA) for 5 Nm en-route separation and 3 Nm TMA separation. Mode S Enhanced Surveillance is implemented in the core area of Europe.

In addition, pockets of Wide Area Multilateration (WAM) have already been implemented and are in operational use as a cost effective alternative to SSR/SSR Mode-S. The capability for processing of WAM data is being developed and is planned to be available for this Capability Level.

Surveillance Data Processing and Distribution (SDPD) systems based on server technology are widely implemented in ECAC. The SDPD is capable of using multi-sensor position information from SSR (Mode-S) and ADS-B. Where required, the SDPD uses Airborne Derived Data/Downlink Aircraft Parameters (ADD/DAP) to improve track quality and also distributes ADD with the track message.

The surveillance data is used to support ATM applications including operational tools like ground based Safety Nets, Automatic Flight Conformance Monitoring and Continuous Descent Approach and Continuous Climb Departure.

Ground Surveillance for Oceanic En-Route is provided either by ADS-Contract or procedurally. ADS-Contract is used to supply surveillance information over the oceanic regions via satellite datalink. In most cases, ADS-C & CPDLC are implemented simultaneously with FANS 1/A.

In the course of Capability Level 1, more Wide Area Multilateration (WAM) will be implemented as a cost effective alternative to SSR (Mode-S).

Local pockets of ADS-B in Non Radar Areas (ADS-B NRA) will be implemented based on SSR Mode-S Extended Squitter.

43 This includes the expected traffic density, route spacing and potential for ATM and aircraft systems to provide support for continued operation of all aircraft in the event of GNSS outage.

44 In support of (amongst others) precision and parallel approaches.
The first “ADS-B in” applications will be implemented locally (e.g. ATSAW In-Trail Procedure in the North Atlantic), where local benefits justify the cost.

As a cost reduction measure, the development of Multi Static Primary Surveillance Radar (MSPSR) will start as an alternative replacing legacy PSR. MSPSR will be more cost efficient than current PSR and in addition will have a greater spectral efficiency, offering the possibility of releasing spectrum in the future. MSPSR offers also the chance of better detection (such as in areas around wind farms or of small UAV like targets). The SDPD and other Surveillance products (network nodes, interfaces, tools) will have to be updated to accommodate this additional sensor type.

Surveillance data sharing between civil and military organisations and internationally across borders is based on Surveillance networks and will be widely implemented. Upgrade of the ground Surveillance distribution infrastructure to distribute additional surveillance information might be required, as well as new ASTERIX formats e.g. for MSPSR once ready for implementation.

A study to support a surveillance rationalisation plan is foreseen to be conducted through the SESAR working arrangements.

**Communications**

At the start of this Capability Level period Air Traffic Control units providing ATC voice services to general air traffic, below FL195, shall be equipped with 25 kHz channel spacing capable radio equipment whilst those providing services to general air traffic, above FL195, shall be equipped with 8.33 kHz channel spacing capable radio equipment. The implementation of 8.33 kHz below FL195 is foreseen.

The European Commission has adopted the Implementing Rule (IR) for the coordinated introduction of Controller-Pilot-Data-Link-Communication (CPDLC) services above FL 285 and with mandatory dates from 2011, 2013 and 2015 depending on the type of Users and area of implementation.\(^{45}\)

Whilst the provisions in the IR are performance based, the protocols defined by ICAO based on the Aeronautical Telecommunication Network/Open Systems Interconnection (ATN/OSI) and the Very High Frequency digital link Mode 2 (VDL 2) are currently the only validated means of compliance meeting the requirements.

In the DLS IR it is stated that Member States which decide to equip new transport type State aircraft entering into service after 1 January 2014 with data link capability relying upon standards which are not specific to military operational requirements, shall ensure that these aircraft have the ICAO ATN-compliant VDL2.

For combat aircraft equipped with military data link, interoperability solutions with the European ATM Network (EATMN) have to be studied in SESAR possibly on the basis of a ground-based gateway.

Ground voice communication services which use analogue signalling protocols\(^{46}\) will progressively evolve towards digital interfaces.\(^{47}\) This transition is driven by the communications industry where support for the analogue systems is diminishing rapidly.

Ground data communication services\(^ {48}\) based on X25 are phased out and progressively replaced by the IP network technology.

Distribution of flight plans and meteorological data will move from the Aeronautical Fixed Telecommunications Network (AFTN), used for the last 30 years, to the Aeronautical Message Handling Service (AMHS) specified by ICAO for future message handling applications. ANSPs are

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\(^{45}\) 1 Jan 2011 – Mandatory equipage of new aircraft
7 Feb 2013 – Data link services provided by ground equipment in the core area
5 Feb 2015 – Mandatory equipage of existing aircraft (with some exceptions like transport-type State aircraft and FANS equipped aircraft)
5 Feb 2015 – Data link services provided ground equipment in the extended area (almost all Europe)

\(^{46}\) such as Multi Frequency Compelled R2 (MFC/R2)

\(^{47}\) ATS Q-Interface Signalling Protocols (ATS QSIG)

\(^{48}\) They cover inter-centre communications either between ATC Centres or with regional units, airports, and AOCs; Information Distribution Services; safety-critical data services such as surveillance data distribution, CFMU, EAD; Meteorological services; and Administrative and none-safety-critical services such as CRCO. Ground communications interconnection with military ATC and Command and Control/Air Defence support the exchange of flight data, aeronautical information, radar data sharing and airspace management coordination. This includes the need to ensure that the NATO Air Command and Control System (ACCS) can exchange information with ATM networks and requires particular security measures to be put in place.
already deploying AMHS technology for international messaging applications. AMHS is being deployed over IP in the European region. The migration in the long term, to other information-sharing and data distribution mechanisms such as SWIM is expected.

For Oceanic and remote areas, starting from the end of this Capability Level period, SATCOM voice will be used, with High Frequency (HF) voice as backup. This will provide increased throughput and transmission quality. To meet this date, the reliability and security issues should be assessed and the procedures and business case be developed.

ATS data link communication in oceanic and remote airspace is provided using FANS-1/A systems to achieve a number of ATS operational benefits such as separation assurance at 30/30 NM (RNP4) lateral/longitudinal, route and flight level conformance monitoring, facilitation of in-flight rerouting and weather avoidance, and tailored arrival procedures.

Military aircraft (especially fighters) could benefit from the implementation of a ground interface to convert information received from military data links as a means to comply with the ATS data link services requirements. The main objective is to avoid retrofit to military aircraft that already have military data link technology. This approach requires further investigation to ensure the feasibility of a technical solution that has no negative impact on the civil L band systems and safeguards military security and operational requirements. A decision needs to be taken in the time period for this Capability Level 1 for initial operations starting in Capability Level 2.

Higher performance (e.g. predictability, security, latency, availability, integrity and throughput) data links will be required to support transition to 4D trajectory based operational services. A dual link system operating in different spectrum bands is likely to be necessary to cope with the higher availability requirements. New terrestrial mobile communication technologies and satellite technologies can provide the advantage to offer complementarities in terms of infrastructure and radio spectrum diversity and coverage.

For the terrestrial link, a number of candidate technologies operating in the L band (960-1215 MHz) have been proposed, but the final choice requires further design work and validation, taking into account aircraft equipment cohabitation and spectrum availability, which are the major constraints. A final decision on technology is needed in this Capability Level period. This decision can only be taken given the timely availability of the detailed system performance requirements and a clear and agreed spectrum policy.

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. This can provide the necessary levels of availability for the more advanced concept elements, and reduce the spectrum used by terrestrial systems for the less (time) critical data communication. An important 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.

The transport layer protocol which satisfies the full 4D requirements of the SESAR concept, needs to be selected from the candidate ATN/OSI and ATN/IP solutions, together with the Quality of service mechanisms for the transport, network and physical layers.

Future communications data link technologies are seen by the military as the longer term opportunity for technology convergence for common solutions to be available for integration in military aircraft.

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. Accurate requirements for advanced ASAS and point-to-point applications need to be available during the Capability Level 1 period.

It is essential that the new data link technologies activities better consider the constraints of General Aviation, whilst maintaining interoperability with other Airspace users.

An Internet Protocol (IP) based ground communications network will become operational in this period. This Pan European Network Service (PENS), based on a combination of national networks and an international backbone, will support all ground data distribution requirements including the ground segment of the air-ground link.

Ground installations for ATS ground voice services will be connected using a fixed ground-ground IP based network, enabling the implementation of Voice over IP (VoIP) for ground segments including the ground segment of the air ground voice link.
**ATM Systems**

For En-route and Approach, before the introduction of SWIM, there will be more information sharing, but still using existing methods.

New generation Flight Data Processing (FDP) sub-systems will be introduced which will improve sharing of flight data between adjacent centres, enabling improved centre-to-centre transfer of flights, to match internal sector-to-sector transfer capabilities. These sub-systems will also make increasing use of aircraft derived data to supplement, or replace, generic or local estimations.

The En-route Controllers will make use of greater automation and tool support enabled by this better trajectory information, such as: initial use of precision trajectory clearances; improvement to local AMAN abilities including the provision of sequencing information into the local en-route environment.

ATC will be performed with awareness of adjacent sectors’ air traffic situations; typically a Multi-sector Planning Controller would have a responsibility and authority to optimise trajectories within the area of operation and within the constraints coordinated with the adjacent Multi-sector Planners or ATC Sector Planners. The typical environment to support them in this would include System Supported Co-ordination (SYSCO), Monitoring Aids (MONA), Medium Term Conflict Detection (MTCD) (with 20 minute prediction horizon), en-route sequencing assistance with limited required time of arrival management, Conflict and Resolution Advisor (CORA) (with multi-sector resolution capability), traffic complexity prediction tools and air-ground datalink.

ATM Systems need to implement the requirements of the following CPDLC services, in support of the DLS IR:

- ATC communications management (ACM): to handle repetitive frequency changes;
- ATC clearances: to provide standard clearances (ACL)\(^49\);
- ATC microphone check (AMC) to enable communication in case of blocked frequencies.

During Capability Level 1, the designated ATS providers, in the core area, will take the necessary actions to ensure that flight data processing systems, the human machine interface and air-ground communication systems support the provisions of the ACM, ACL and AMC services above FL 285. The end-to-end exchange of data between ground and aircraft systems shall be based on the ATN/OSI communication protocols together with VDL Mode 2 as the data link technology.

Development activities are on-going to extend CPDLC with the Initial 4D services, which will be implemented using the same technologies i.e. ATN/OSI and VDL2. This approach aims to deliver quick-wins and benefits whilst facilitating the transition towards the SESAR target concept. A decision needs to be taken in 2009/2010 for initial operations starting in Capability Level 2.

**D3.2.4 Regional systems**

During Capability Level 1, the first steps of the migration towards information sharing, using current methods is expected. There will be the introduction of a SWIM foundation and initial SWIM services based on new and legacy systems, contributing to improved CDM.

All ATM partners will adapt to take advantage of better information sharing to benefit the overall ATMS.

The European ATM Master Plan has defined the Air/Ground Data link Ground Management System (AGDLGMS) as the interface between the ground SWIM infrastructure and the aircraft data link system for the exchange of flight data. After validation of the AGDLGMS principles, a decision is needed in the time period of this Capability Level to use the AGDLMS operationally from Capability Level 3 onwards. The possible impact on aircraft and ground systems equipage needs to be determined in the same time period.

The Pan-European Network Service (PENS) is foreseen as the strategic ground telecommunications infrastructure for voice and data transmission and switching for the aeronautical community, providing the core supporting infrastructure for System Wide Information Management (SWIM). It will be an IP network service supporting new and legacy applications using IP technologies resulting in efficiency improvements by enabling sharing of voice and data on the same network. In 2009, PENS will be operational as an international ground-ground IP communications backbone, supporting the connectivity requirements of the EAD and CFMU applications as well as ANSPs interconnections. Integration of national networks towards PENS has started.

\(^{49}\) e.g. “Climb to level 350”
The initial Information Management services in ACCs and the Network Information Management System (NIMS) will support the sharing of meteorological, aeronautical and Surveillance information as well as the first set of flight information (trajectory related information and aircraft derived data). In particular, in Capability Level 1, the Airspace Data Repository (ADR) and the Demand Data Repository (DDR) will be implemented.

A Network Operations Plan (NOP) portal will be created. Local, sub-regional and regional planning sub-systems (including newly introduced Aerodrome ATC and Airport Demand and Capacity sub-systems) will closely cooperate around the NOP supporting new CDM processes and taking into account airline & airports schedule data. The NOP will also be the kernel around which a new Network Performance Management sub-system will provide applications for operational performance assessment of the network. NOP-related information provision and use will initially be from existing local sub-systems and information exchange mechanisms.

In airspace management and airspace design, there will be increased co-ordination in order to optimise the use of airspace and the overall network. Systems will be available to support sectorisation design and management.

The scope of the Aeronautical Information Management System (AIMS) will be broadened to cover airport mapping and meteorological information.

New generation systems based on COTS\(^50\) hardware platforms and operating systems (which include computer industry standard monitoring and control facilities) will:

- provide integrated supervision for all technical assets that support service delivery;
- provide the Internet Protocol-based ground to ground interoperability foundations required for SWIM exchanges (and to support its governance through application of operation-related rules); and
- enable the introduction and use of ‘standard functionality’ components.

During this period there will be the first benefits from the rationalisation of infrastructure and use of common systems by the Functional Airspace Block (FAB) projects in Europe.

**D3.2.5 Spectrum**

The continued expansion of aviation is putting considerable pressure on all spectrum allocations, but the most severe short term problem is the near saturation of the VHF COM band 118-137 MHz. This band is currently organised using 25 kHz channels for analogue voice. Pressure for new sectors creates pressure for new frequency assignments and not all requests can be accommodated. Consequently a programme to introduce 8.33 kHz channels for aircraft above FL195 has been introduced and is supported by a European Commission Implementing Rule\(^51\) enforcing carriage of suitable receivers. Unfortunately not all 25 kHz channels can be reorganised and hence, to keep pace with demand, there is a need to introduce VHF 8.33 kHz channels below FL195\(^52\).

High power, rotating Primary Surveillance Radar Systems are expensive to procure, install and maintain. It is also predicted that pressure on the spectrum used by PSR will grow and consequently pricing could become a spectrum management technique to facilitate the introduction of commercial radio systems. Where the retention of PSR is essential for several safety and security related functions, work is in progress to develop a cheaper and more spectrum efficient possible alternative. Current R&D on Multi Static Primary Surveillance Radar (MSPSR) indicates that a replacement system with similar performance criteria could be designed and the overall spectrum required would be significantly less than the current spectrum allocated to Primary Surveillance Radar. Once again the problem of finding spectrum to move into remains and needs to be addressed.

The occupancy and RF interference levels (FRUIT) of 1030/1090 MHz frequencies are regularly monitored and simulated. Rationalisation of its use will start. An updated assessment of the 1090 MHz datalink capacity should be performed in support of future applications enabled by ADS-B.

Furthermore and as part of a spectrum policy, a decision is required, to specify the necessary spectrum in L band for the future terrestrial communications technology and in C band for the 802.16e Aero link. Furthermore, the band 1.5/1.6 GHz is foreseen for the satellite segment of the future

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\(^{50}\) ‘Commercial off the Shelf’

\(^{51}\) Commission Regulation (EC) 1265/2007

\(^{52}\) Supported by the amendment of the Commission Regulation
communication system. This band is presently used by INMARSAT. Due to the very high commercial value of this band, the access for new ATC services will be difficult. Careful business planning and selection of a spectrum efficient technology supported by the aviation community and the European Commission is necessary.

An efficient and regular monitoring system for the 1164-1215 MHz used by GNSS is required, in order to remove quickly interference sources and thus address the system vulnerability to unintentional or malevolent radio frequency interference.

The possible future use of the MLS band has to be also analysed.

Civil-military coordination is needed in the area of spectrum management to ensure synergies when deciding the best options to support future systems deployment and to safeguard aviation interests when competing with other frequency users.
**D3.3 Capability Levels 2 and 3**

An overview of the strategic steps for Capability Levels 2 and 3 is provided in Figure 67:

The following sections identify the infrastructure systems applicable to Capability Level 2&3 and how they are envisaged to transition during the period related to the Capability Levels.
D3.3.1 Airspace User systems

Navigation

For *en-route and TMA operations*, multi-sensor RNAV/FMS with GNSS being the main Navigation sensor becomes the predominant capability. The requirement for a GNSS sensor coming from the mandate for Datalink and Surveillance/ADS-B (proposed for 2012 in forward fit and 2015 in retrofit) will ensure it is available on all aircraft for navigation and timing operations.

During these Capability Periods a new set of RNAV/FMS functionality and performance (corresponding to A-RNP\(^{53}\) PBN specification) will become mandatory for IFR aircraft. All Commercial Air Transport aircraft, business aviation and high-end General Aviation aircraft will carry, as a minimum, dual A-RNP/FMS equipment with multi-sensors (GNSS and DME).

The low-end General Aviation and Air work aircraft with only single GNSS based A-RNP equipment will be allowed, but it is expected that most of this fleet will be progressively equipped with dual A-RNP equipment.

Inertial sensors will provide a backup capability to cater for short periods of GNSS outage but accuracy is unlikely to be able to cater for more than a few minutes of outage for A-RNP and higher accuracy operations. However, their cost is likely to decrease and thereby be available for a greater range of aircraft.

For *approach and landing*, more aircraft will carry RNAV/FMS with APV functionality.

ILS Cat II/III remains largely available on Air Transport Aircraft. In addition, more aircraft will have GBAS Cat I capability, while a limited number of aircraft will carry MLS or GBAS Cat II/III equipment based on single frequency GPS. Multi constellation, multi frequency GBAS Cat II/III capability will become available towards the end of the Capability Level 3 period, provided Galileo constellations and the enhanced GPS\(^{54}\) are available and validated for operational use.

Military aircraft are expected to be able to meet advanced civil navigation requirements mainly based on GNSS. Tactical aircraft with airborne architecture such as TACAN, GPS PPS, Galileo PRS, Multimode receivers (MMR), Inertial and Military Mission Systems might have to be handled by accepting the equivalence of military systems performances.

Surveillance

Infrastructure enhancements for the aircraft component will be:

- To continue to provide SSR, Mode-S Elementary and Enhanced Surveillance and to provide “ADS-B out” (1090 Extended Squitter) functionality supported by the mandate foreseen in the SPI IR.
- To continue to implement “ADS-B in” capability and supporting systems to provide the aircrew with a complete and reliable situation picture in support of new spacing and separation modes (ASAS applications), in particular Spacing - Sequencing & Merging (ASPA S&M) and Initial Separation - In Trail Procedure (ASEP-ITP) and to support the Airport higher level A-SMGCS applications. This includes adaptations to the avionics suite.
- To start to deploy the capability for processing of intent information (e.g. in the form of 4D trajectory data, Trajectory Change Points etc). The required airborne data could be delivered by the surveillance system or another air-ground datalink taking regard of the potential impact on the surveillance performance.

Communications

A requirement for 8.33 kHz below FL195, is anticipated\(^{55}\) (in a phased implementation). However, due to the size of fleets, known procurement and technical constraints, State aircraft still not equipped with 8.33 kHz radios might need to continue to be supported by UHF and/or remaining 25 kHz channels for a longer period.

For airspace above FL285 and in the context of the DLS IR civil aircraft with an individual certificate of airworthiness first issued before 1 January 2011 and operating above FL285 in the extended area

\(^{53}\) The Advanced RNP specification that will be required will be consolidated during CL1.

\(^{54}\) GPS broadcasting in L1 and L5

\(^{55}\) Subject to ICAO conclusions and subject to further revision of the Air-Ground Voice Channel Spacing (VCS) IR,
Air-ground datalink services will be introduced to enable aircraft to receive uplinked meteo and aeronautical information.

**ATM systems**

For the Airspace Users, SWIM will allow sharing of far more information with continuous update, but will need modifications of communications systems and new definitions of roles and responsibilities on the information processes. SWIM will also permit a global view of the traffic and will support a negotiation process to address big issues involving UDPP (User Driven Prioritisation Process), allowing the Airspace Users to find the best outcome from the system. This process will need improved CDM (Collaborative Decision Making) systems, either direct (for SWIM-connected Airspace Users) or via other means.

The Airline Operations Centre (AOC) systems will be modified to manage the shared business trajectory: firstly to handle the continuous update of the constraints given by the other parties; and secondly to meet the quality of service requirements requested by the NOP (Network Operations Plan). With the new types of 3D and 4D constraints (e.g. multiple CTO, 3D precision trajectories in TMA, 4D contracts) permitted by the improved accuracy of the aircraft systems, the AOC’s Trajectory Management sub-system will need to be updated to provide the same accuracy. This applies primarily to civil AOC ATM systems but at least some military Wing Ops or other command and control centres will also be equipped with new Military Mission Trajectory management capabilities. For scheduled airlines, a continuous link with the Schedule Management sub-system will be created to take into account the modifications of the trajectory.

The air ground datalink will be co-ordinated at sub-regional or regional level to optimise data exchanges between air and ground based systems using AGDLMS and provide connectivity to the SWIM infrastructure. The aircraft will be progressively integrated into the SWIM infrastructure to enable greater information sharing with ground systems and other aircraft, in particular basic trajectory data (ATC constraints/clearances/areas, small speed adjustments, runway incursion alerts, safety net alert) and aircraft derived meteo data.

The aircraft navigation architecture will support new flight management and flight guidance evolutions for enhanced altitude and time constraint management, multiple time constraints and auto brake/taxi. New generation systems will be developed supporting enhanced and later, synthetic vision. The aircraft architecture will include the evolution of ASAS Spacing and Separation and on-board equipment for wake-vortex detection. ACAS will be adapted to be consistent with new separation modes (spacing and separation) and other applications.

For airspace above FL285 and in the context of the DLS IR aircraft with an individual certificate of airworthiness first issued before 1 January 2011 and operating above FL285 in the extended area (almost all Europe), shall be equipped with the necessary avionics HMI and End Systems to realize the requirements of the ACM, ACL and AMC services for operational use from 5 February 2015.

**D3.3.2 Airport systems**

**Navigation**

In accordance with the decisions of the 36th ICAO Assembly, non Precision Approaches will be replaced for all IFR runway ends by RNAV approaches with vertical guidance (APV). APV approaches can be achieved either through the use of SBAS or through Barometric VNAV or through RNP Approaches (RNP APCH). APVs operations will increase airports accessibility and safety. This evolution will allow a reduction/removal of NDB and VOR that are used for Non precision Approaches.

ILS remains the prime source of guidance for precision approach and landing in ECAC. Where necessary ILS could be modified to overcome multipath problems and maintain Cat II/III capability at some runway ends. Such modification will be an ICAO standard.

GBAS Cat I and SBAS (EGNOS)\(^{56}\) operations will be installed in an increasing number of airports, as alternative to ILS Cat I.

For Cat II/III operations, MLS may be introduced at more runway ends, as an alternative option to ILS, where required.

\(^{56}\) LPV 200 which is an SBAS based operation equivalent to Cat I.
GBAS CAT II/III will be employed initially in addition to ILS in order to enable operational benefits (capacity, cost). While limited numbers of GPS/GBAS-based on single GPS-frequency (L1) are possible, the full GBAS CATII/III will become available when the full GPS and Galileo constellations will be available.

**Surveillance**

Infrastructure enhancements for the aircraft will be dependent on local conditions and will comprise:

- The continued development of A-SMGCS enabled by SMR, Airport Multilateration and ADS-B;
- The continued implementation of an ADS-B sensor infrastructure (alone or combined with Multilateration) for airport Surveillance applications (ADS-B-APT and ATSAW SURF) in support of controllers and pilots;
- The upgrade of the Airport Surveillance Data Processing to deal with multi sensor data and to store and forward additional ADD/DAP (in particular to the Flight Data Processing and Safety Nets) and to support Automated Surface Movement Planning and Routing.

**Communications**

Air traffic control units providing ATC voice services to general air traffic, are anticipated to be equipped with 8.33 kHz channel spacing capable radio equipment.

In early Capability Level 2, D-OTIS, using ACARS, is expected to be operational at key airports, based on individual airport decision processes driven by performance needs. At a later stage, (during Capability Level 3), D-TAXI, D-OTIS, D-FLUP and D-RVR are planned to be operational, at airports, using ATN/OSI and VDL2.

In Capability Level 3, initial deployment of AOC and ATS services using the 802.16e Aero infrastructure will be completed, at some airports. Large scale deployment is expected to be completed in later phases (Capability Level 4 and beyond).

**ATM systems**

The integration of local AMAN/SMAN/DMAN will provide improvements in queue management in relation to both inbound and outbound flows to constrained runways, leading to a full integration of local airport sub-systems and “total airport management”. Further improvements will be derived from the provision of the new Environment Management sub-system as well as from an enhanced turnaround management supporting the “En-route to En-route” concept.

Runway usage will be improved through dynamic adjustment of separations based on real-time detection of wake-vortices. In parallel, a new generation of TWR Controller HMI functionality will be introduced to benefit from the improvements brought by the integration of these tools (AMAN/SMAN/DMAN). Later on, in high density/complexity airports, DMAN will be enhanced to handle departures from multiple airports within the same TMA and to collaborate with non-local SMANs and AMANs.

Airport ground equipment will be enhanced to allow provision of advanced guidance assistance to aircraft and airport vehicles, combined with routing (either through automated switch of ground signals or virtual guidance by visualising routing information in the cockpit).

A transitioning to SWIM takes place. For example, Airport Mapping information will be published via the SWIM network. However, until the Aircraft is fully integrated into SWIM, existing datalink services will be used to uplink aeronautical information to aircraft (e.g. D-ATIS).

The ATM Systems need to support the requirements of the DCL, D-TAXI, D-OTIS, D-FLUP, and D-RVR services.

**D3.3.3 En-Route and TMA**

**Navigation**

Transition to a total RNAV environment will be marked by the mandates for GNSS and FMS with A-RNP functionality. DME/DME remains the main backup to GNSS, resulting in the need to enhance the coverage. Where suitable DME coverage cannot be achieved, such as low flight levels in terrain constrained areas, the backup to GNSS, in the event of GNSS failure, will be inertial.
Galileo and enhanced GPS will start to become available in the period of these Capability Levels allowing increased reliance on GNSS once multi-constellation multi-frequency equipment is installed in aircraft and experience is built up on Galileo operation.

For aircraft where DME based RNAV is not available the lack of backup to GNSS will result in need for an alternative reversion, in case of GNSS failure. ATC workload, security and safety case considerations may result in a need to retain some VORs. Some aircraft may rely on Inertial to cover short outages of GNSS. Nevertheless, the cost of Inertial and other backups will result in the primary reversion being ATC surveillance for many GA aircraft. This limitation will need to be considered within the context of overall safety and business cases for the transition to RNAV. NDB will cease to be required to support operations, and its decommissioning will be completed.

A performance based approach is required to take into account State aircraft equipped with avionics which do not comply with civil requirements but which might be able to support an equivalent function (e.g., GPS/PPS, Galileo/PRS, TACAN, Military Mission Systems, Joint Precision Approach and Landing system (JPALS) etc.).

**Surveillance**

In addition to the systems for Capability Level 1, Multi Static Primary Surveillance Radar (MSPSR), a new alternative to support Independent Non Cooperative Surveillance, will be considered for operational deployment, if proven to be a cost and spectrum efficient technology.

It is predicted that by 2015 some SSR and SSR Mode-S systems may be approaching the end of their operational life and a surveillance rationalisation plan could be envisaged.

The WAM implementations will be extended. Implementations of ADS-B RAD (Radar Area) are expected to start after the 2015 SPI IR 1090 ES mandate, which will also accelerate the implementation of ADS-B NRA which started in the period of Capability Level 1, where necessary.

Compatibility between ground and airborne Safety Nets must further be secured.

Implementation of ADS-B in support of ATSAW, spacing and initial separation applications will be extended.

ADS-B options for State aircraft will be investigated in the context of the SPI IR and SESAR.

**Communications**

Air traffic control units providing ATC voice services to general air traffic, are anticipated to be equipped with 8.33 kHz channel spacing capable radio equipment.

For ATC data link services provided above FL285, in the context of the DLS IR, the following is applicable: by February 2015, the designated ATS providers in the extended area (almost all Europe), shall support the provisions for the ACM, ACL and AMC based on the ATN/OSI communication protocols and VDL Mode 2.

The new air-ground datalinks, i.e. terrestrial and satellite will be developed by the end of this period.

Operational use of VoIP for ground/ground voice communications will be gradually extended replacing the previous protocols. VoIP will also be implemented for the ground segment of the air ground voice link. Operational use of VOIP for the ground segment of the A/G voice communications will be provided for Capability level 2.

The Aeronautical Message Handling Service (AMHS), the Flight Message Transfer Protocol (FMTP), VoIP, and possibly radar data exchange will gradually be deployed as ‘PENS’ applications. All national ANSP network infrastructures will be fully integrated within the European IP network and managed as a seamless network. Traditional store and forward messaging (AMHS) for aeronautical information may gradually be replaced by other forms of information-sharing and data distribution mechanisms such as SWIM, from the end of Capability Level 3 onwards.

In oceanic and remote areas, the operational use of SATCOM voice is further increased.

**ATM Systems**

In En-route and Approach, we see the transitioning to SWIM and use of Common ATM Information Reference Model definitions, accompanied by further ATM system automation and tool support, including:

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57 MFCR/2 and ATS QSIG
- Flexible re-deployment of human resources;
- Flexible adjustments to ATC sector boundaries;
- Redistribution of individual Reference Business Trajectories within the multi-sector ATCO team;
- Re-direction of air traffic flows to ensure that high levels of efficiency are sustained;
- Adjustments to Reference Business Trajectory parameters (target times and/or levels).

Increased AMAN functionality will be deployed including collaboration with DMANs (for pre-departure aircraft, where the departure airport is within the destination airport's AMAN flight-time horizon).

Additional local dynamic airspace management processes will provide support to local, sub-regional, and regional traffic demand and capacity management facilities, with collaborative flow management benefits being supported through the provision and use of airspace, and traffic demand related SWIM information services. Thus, local and regional demand and capacity views will now be aligned.

Each flight will receive a "trajectory clearance" which may be quite different in function of aircraft capabilities. For non-equipped aircraft the trajectory clearance may simply result in a sequence of standard route/level/speed clearances provided to the controller by automation and to be relayed to the pilot by voice, whereas for fully equipped aircraft it may be a 4D trajectory contract for a given look ahead time with tolerances in the constraint matching process.

This will enable layered ATM planning that will include complexity, queue and conflict management capability over a large airspace consisting of several multi-sector areas. Typical functionality will include multi-sector and complexity management tools with capabilities to share trajectory data with aircraft, assign targets for airborne separation (pairs of aircraft) and balance aircraft operator preferences and Controller workload with automated assistance.

In the transition to Capability Level 3, as more and more aircraft are able to connect to SWIM, the ground modelling of aircraft trajectories within the FDP sub-systems will be replaced by use of the aircraft's own trajectory information. This will support the continuing evolution of traffic planning and Controller co-ordination tools to support provision of precision trajectory clearances across multi-sector segments within ACCs and with adjacent ACCs, in alignment with Aircraft Operator preferences for direct/free-routing (Reference Business Trajectory driven) across FAB's and multiple Areas of Responsibility.

For ATC data link services provided above FL285, in the context of the DLS IR, by February 2015, the designated ATS providers in the extended area (almost all Europe), shall ensure that flight data processing systems, human machine interface systems, air-ground communication systems support the provisions of the ACM, ACL and AMC services.

Specific ground-based gateways will allow, by 2015, military aircraft (especially fighters) to start using ACM, ACL and AMC data link services.

The legislative provisions to mandate the implementation of the Air/Ground Data link Ground Management System (AGDLGMS) need to be approved early in the period of this Capability Level in order to start operational use by the end of the Capability Level 3 period. The transition from the existing data link infrastructure, meeting the DLS IR requirements, to the SWIM infrastructure (including AGDLGMS) needs to be addressed.

Some ANSPs, plan to provide Initial 4D services to suitably equipped aircraft as part of an aircraft pioneering scheme. Based on the results, the dates for mandatory aircraft and ground systems equipage will be set in a future revision of the DLS IR.

### D3.3.4 Regional systems

The regional systems will be enhanced to support free-routing and Advanced Flexible Use of Airspace (AFUA) concepts, starting from dynamic airspace allocation up to more advanced features, such as dynamic sector shapes and variable profiles.

The NIMS will be updated to support the new role of arbitrator for demand and capacity balancing, continuously monitoring the network situation watching for network impact of local decisions and taking account of Airspace Users' priorities. The initial NOP portal will be replaced by a set of services accessible for local/sub-regional applications through SWIM.

Traditional store and forward messaging (AMHS) for aeronautical information will gradually be replaced by SWIM. In this environment, the scope of the AIMS will be broadened to cover terrain and obstacle data and the management of dynamic airspace data.
There will be an increased rationalisation in the various FABs in Europe leading to an increased efficiency.

**D3.3.5 Spectrum**

The portion 978-1164 MHz of the 960 to 1215 MHz L-band where DME operate remains heavily used. Some channels in the lowest part of this band might become unavailable due to the introduction of new UMTS services just below 960 MHz. Access to channels in the upper part might be also difficult due the necessity to operate simultaneously GNSS and DME equipments on the same aircraft. This pressure would be increased by the gradual introduction of the new terrestrial air-ground data link system into parts of the 960-1164 MHz and the proposals from other regions of the world for a possible introduction of the command and control of the unmanned aircraft. Significant spectrum would then be needed. However, there are discussions in the ATM community and strong positions by some stakeholders to oppose its allocation to UAS. An agreed position which is satisfactory for the aviation community is necessary. JTIDS/MIDS is another user of this band. As many systems will operate in this band, this band might become a single point of failure for the ATM infrastructure and a cautious safety analysis of these systems must be conducted.

In parallel to the safety case, measures to ensure cohabitation of these systems in the same band must be investigated:

- Examine the need to optimise the DME infrastructure and to supplement it by TACAN stations
- Examine the current DME radio parameters, to offer additional spectrum capacity, whilst, of course, not compromising safety
- Audit the current DME assignment tables and monitor the RF spectrum to identify unused frequencies or assignments. This too could release channels for reallocation.

Navigation has no short term spectrum problems. However this is just an “illusion” due to the pressure for spectrum from its Communications and Surveillance Users. The future of Navigation foresees the demise of NDBs and VORs.

Therefore the VHF spectrum 112-118 MHz could be depopulated. The new systems required for GBAS could be installed in this band as the VORs are removed. However if the pressure for VHF voice continues the top end, close to 118 MHz, could perhaps be requested by COM to give precious breathing space prior to the Future Communications Infrastructure (FCI) being implemented circa 2020.

GNSS backup in case of failure, jamming or solar storm service interruption needs to be addressed; however the back up system is likely to be based on today's DME infrastructure. In fact extra DMEs may be required to provide the level of service provided by GNSS. These extra DMEs will have to be housed in the DME allocation in L Band (960-1215 MHz)58.

Communications is looking to the use of the L Band to house the new terrestrial data link component. Following the AM(R)S allocation in the L Band in WRC2007, there are two candidate systems with rather different spectrum requirements. One is looking for operation in the lower part of the L band (below the DME allocations) band and the other is considering an inlay approach with frequencies between the existing DME allocations. The spectrum compatibility of these candidate systems and the feasibility of operations in the considered bands still need to be demonstrated. If however, clean spectrum would be required to ensure feasibility of operations in the upper part of the AM(R)S band, previous studies have indicated that a clean 15 MHz space (1141 – 1156 MHz) could become available if some 39 DME assignments would be reallocated. Such a reallocation could be eased if the rigid VOR/DME pairing could be abolished. Given the removal of VORs, such pairing changes could commence almost immediately. In addition to 1141-1156 MHz, the band 960-977 MHz, not presently used by DME is also being studied for the new terrestrial datalink component.

The Secondary Surveillance Radar frequencies 1030/1090 MHz are heavily utilised. The 1090 MHz frequency in particular is used for several surveillance applications, including several military modes, Mode A/C SSR, SSR Mode S, ACAS and ADS-B Out. The occupancy and RF interference levels (FRUIT) are regularly monitored and simulated. Rationalisation of the use will continue in the period covered by this guidance material. As rationalisation continues and new applications are introduced, the need for link enhancement (or second link) for such applications will be examined. Decisions can

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58 except in the upper part coallocated with GNSS (1164-1215 MHz)
be made following the definition of the spacing and separation applications, expected by the end of Capability Level 1.

Civil-military coordination in terms of spectrum management should be continued.
D3.4 Capability Levels 4 and 5

An overview of the strategic steps for Capability Levels 4 and 5 added on the achievements of the previous Capability Levels is provided in Figure 68:

The description of the transition of the Infrastructure systems during this period is provided in the next Sections.
D3.4.1 Airspace User systems

Navigation

In this timeframe, an increasing number of IFR aircraft (Air Transport and General Aviation fleets) will carry dual 4D RNAV/FMS systems, with multi-sensors: GNSS with inertial or DME/DME. Those aircraft will also have a GNSS based capability for approach and landing in Cat II/III conditions, in addition to ILS.

Remaining aircraft (e.g. low end General Aviation, legacy lower capability State aircraft) will carry single RNAV/FMS (A-RNP functionality) with GNSS sensors. These will not have an RNAV back-up, and will need a reversion support that can be managed by ATC.

GNSS multi-constellation receivers will combine different GNSS signals and augmentations.

The 4D RNP systems will include RNP APCH and RNP AR APCH capability and/or LPV capability and providing RNAV approach capability for runways not equipped with precision approach and landing capability.

There will be new Flight Management and Flight Guidance evolutions giving capabilities to execute 3D Precision Trajectory Clearance (PTC) with vertical navigational performance requirement and later to execute 4D PTC (4D contract) on a segment of the reference trajectory and ASAS self-separation in a mixed environment.

State aircraft will carry Navigation equipment with performance and functionality equivalent to 4D RNAV/FMS systems, including GNSS sensors, on-board inertial and TACAN.

Surveillance

Aircraft systems have to be prepared and made capable to implement ASAS Separation and Self Separation applications, envisaged by Capability Level 5, that are being developed and validated before.

However, depending on the datalink requirements for ASAS Self Separation applications by 2025, ADS-B link enhancement might have to be implemented.

If ASAS Separation or Self-Separation will require additional automated tools in the cockpit it is likely that the aircraft systems will require an upgrade to existing ADS-B infrastructure to provide a system of higher integrity and additional functionality.

Communications

The operational use of the SESAR Concept of Operations will start, based on the exchange of Reference Business Trajectory (RBT) data over the new terrestrial and satellite link. By 2025 the exchange of Reference Business Trajectory data using these links is completed in all identified ECAC airspace. Data link has become the prime means of communications with voice only used for emergency and non-routine communications. The aircraft equipage shall meet the requirements of the terrestrial/satellite radio communications, shall implement the functionality to exchange RBT data, and shall be equipped with the appropriate HMI.

For oceanic and remote areas, the use of Satcom data has become the primary means of communications with Satcom voice as a back-up.

ATM Systems

Aircraft data communications will be fully integrated into the SWIM infrastructure and will be enhanced to downlink the predicted trajectory in case of delta versus the reference trajectory (according to trajectory management requirements TMR) and to receive meteorological data provided by the ground system.

New capabilities will be made available onboard the aircraft to enable wake-vortex spacing and performance of wake-vortex free approaches.

D3.4.2 Airport systems

Navigation

The availability of a multi-constellation and multi frequency GNSS environment and corresponding increase in equipage of aircraft with multi-sensor GNSS will enable advanced operations at and around airports.
GNSS will be increasingly used to support APV and Cat I approach and landing operations at most runway ends, due to increased equipage of aircraft with multi-sensor GNSS. This is expected to be accompanied by the decommissioning of ILS Cat I systems, where the business and safety cases can be established.

For Cat II/III approach and landing operations, ILS will remain the main navigation aid. Increasingly, alternative options based on MLS and in particular GBAS will be provided by ANSPs according to their business case. The role of ILS Cat II/III will evolve gradually to providing backup to GBAS Cat II/III, to address remaining GNSS vulnerabilities.

**Surveillance**

At airports a wider deployment of ADS-B is expected both for ground (ADS-B APT) and airborne Surveillance (ATS SURF) driven by the improved positioning quality of GNSS.

**Communications**

Large scale deployment of AOC and ATS services using the 802.16e Aero Communications infrastructure at major ECAC airports is expected to be completed.

**ATM systems**

A-SMGCS levels 3 and 4 will be implemented and automated guidance, control, and routing functions will be established, feeding fully integrated systems (AMAN/SMAN/DMAN) within CDM processes.

**D3.4.3 En-Rout and TMA systems**

**Navigation**

In this time frame, it is expected to have a multi-constellation and multi-frequency GNSS environment, consisting in Galileo, enhanced GPS, and possibly full GLONASS constellations, available and operationally validated. This environment with more than 80-90 satellites, with 3 independent control systems and two frequency bands will provide an adequate level of GNSS service in terms of robustness and performance, at least as secure as today’s environment and, in a number of aspects, having greater security and redundancy.

The GNSS enhancements will reduce significantly the probability of having a GNSS failure and would reduce the extent of an alternative reversion, allowing for reductions in DME (and TACAN) network that support the back-up requirements. The existence of a total RNAV environment will allow discontinuation of all conventional departure and arrival operations, thus increasing ANSPs’ cost efficiency. For those remaining aircraft with single RNAV/FMS equipment the mitigations to RNAV failure (either GNSS signal in space or RNAV equipment) will have to be addressed taking account of surveillance environment, ATC workload, security etc. Failure mitigations will need to address operation below Minimum Radar Altitude and lost communication requirements.

Independent surveillance will be the main reversion following loss of navigation capability.

**Surveillance**

Capability Level 4 and 5 requirements are based on the continued need for the ground system to monitor targets and the need for aircrew to have a traffic situation picture in the cockpit.

It is predicted that a large number of the SSR and SSR Mode-S systems currently installed will reach the end of their operational life and a surveillance rationalisation plan could further be envisaged mainly based on Wide Area Multilateration (Independent Cooperative Surveillance) and ADS-B (Dependent Cooperative Surveillance).

Compatibility between ground and airborne Safety Nets must further be secured.

In summary, the ground surveillance requirements for En-Route and TMA for Capability Level 5 will be:

- At least one layer of Independent Cooperative surveillance (preferably WAM otherwise SSR Mode S);
- Dependent Cooperative surveillance (ADS-B);
- Independent Non Cooperative surveillance (PSR or MSPSR), if required.

Implementation of ADS-B in support of separation and self-separation applications will be extended.
Communications
The new air-ground data links (terrestrial and satellite) will be deployed.

Air-ground digital voice Communications for ATM remains a desirable requirement for implementation and operational use during the period of Capability Level 5. Cost/benefit evaluations for ATS use of digital air-ground voice technology, and its associated security features are required.

For ground-ground voice communications, VoIP is used in the whole of ECAC, completely replacing the current protocols (with the possible exception of facilities at the ECAC borders).

ATM Systems
Air Traffic Controllers will make use of ATM systems, tools and automation to move towards full 4D trajectory control. This will include planning tools and 4D trajectory management capability, including management of self-separating aircraft and 4D trajectory contracts. Safety Nets will be adapted to use SWIM-available information to reduce distraction from false alerting and provide focused alerting etc.

The En-route and Approach ATC system will be enhanced to support the dynamic transfer of sectors between ACCs enabling management of local resources to reflect daily variations in traffic patterns and providing support for contingency situations.

In En-route and Approach, the generalised use of SWIM information services will replace the specific, direct sub-system to sub-system linkages and provide wider information sharing abilities (both within the ground environment and with the aircraft).

Aircraft parameters, such as State vector, intent, ETA or RTA, and meteorological data will be down-linked by Data Link, enhancing ATC tools such as Arrival Managers. The cost benefit of these initial 4D operations, both from the ground and airborne perspective, has still to be quantified.

The designated ATS providers shall ensure that flight data processing systems, human machine interface systems, air-ground communication systems support the provisions of the SESAR Reference Business Trajectory services. The data exchange mechanism between ground and aircraft systems shall be based on the appropriate SWIM based technologies and possibly the AGDLMS.

AMAN/SMAN/DMAN systems are fully integrated, linking airports, airspace, and network management to support the full 4D-trajectory. HMIs have evolved to intelligent decision support tools condensing extended information from SWIM and proposing solutions in support of the trajectory for the best benefit of the network.

D3.4.4 Regional systems
NIMS and Advanced Airspace Management systems (AAMS) will adapt their architecture to SWIM. NIMS keeps its role of an entry point for airspace Users and external entities which are connected to SWIM and are not equipped with local optimisation tools.

All SWIM services will be using the European IP network resulting in cost efficiencies. Military units and systems should be able to exchange information with SWIM structures with the right level of security in place.

There are significant activities taking place to establish the procedures and requirements for safe and routine operation of unmanned aircraft systems (UAS) in European airspace. While UAS will be considered as manned aircraft for the purposes of Air Traffic Management, the UAS control communications links will likely be required to operate in protected spectrum, just as ATC communications links are, because they relate to “safety and regularity of flight”.

The scope of the AIMS will be broadened to include information about aircraft (e.g. equipage, performance).

The rationalisation effects from FABs in terms of infrastructure “optimisation” and commonalities will further increase.

D3.4.5 Spectrum
The congestion in the VHF COM band is such that investigations for location of the new air-ground terrestrial data link, deemed to be required by 2020, have concentrated on L band thus easing the pressure on the VHF band in the interim period.

59 MFCR/2 and ATS QSIG
It is likely that the pricing of the PSR band in 2700-3100 MHz will have started and some commercial applications will be introduced in this band. Aviation will be firmly invited by governments and the European Commission to revisit the PSR frequency assignments and optimise their bandwidth in order to free spectrum for new applications. It would be judicious to investigate how to introduce new aviation technologies in this band.

Rationalisation of the spectrum use will continue.
D4  Concluding Remarks

i. The future ATM Infrastructure, as required by SESAR, has to enable the biggest paradigm shift in ATM:
   - Establish the “ATM Network”, interconnecting the human operators and ATM systems on board and on the ground
   - Deploy the “best mix” of current and future systems and technologies in order to enable:
     - Trajectory based operations
     - Collaborative planning
     - Integrated airport operations
     - New separation modes
     - SWIM
     - Human in the loop
   in a cost and spectrum efficient way and all that by 2025.

ii. In order to achieve this ambitious target, three equally important strategic processes have to be put in place:
   - Integration
   - Deployment of new technological capabilities
   - Rationalisation

iii. A fully integrated (and not hierarchical) approach should be established and maintained, for all the lifecycle phases of the ATM Infrastructure. This includes the deployment of new technologies (safety, performance, interoperability requirement definition, standardisation, development, validation, implementing rules etc.) and the rationalisation process (spectrum use optimisation, synergies between domains and with military etc.).

iv. The future ATM Infrastructure will exploit, in a structured way, the new technological capabilities, such as GNSS, ADS-B, digital technologies and internet protocols, new performant, spectrum efficient datalinks, improved ATM system functions etc.
   The number and magnitude of these new developments poses a big challenge to the aviation community in general and SESAR working arrangements in particular.
   A major issue is the transversal impact of these developments to many domains and stakeholder systems. A fragmented approach in addressing these developments is clearly a non-option. Strong partnership/collaboration is necessary between the relevant parties and domains involved (operational, technical, ground, airborne, national, international etc.) and proven methodologies/best practices have to be selected/used.

v. Realisation of the ATM Infrastructure requires a strategic (as opposed to ad-hoc) approach to rationalisation. This applies to all Infrastructure components and includes Spectrum as a key issue. This strategic approach should be based on an “ATM Network” perspective and establish clear criteria (such as performance indicators) driving the rationalisation process. It should lead to a rationalisation plan which clarifies the concrete milestones for system decommissioning and synergies, in order to maximise cost and spectrum efficiency.

vi. In summary, the successful realisation of the new ATM Infrastructure requires a big change on the working culture, methodologies and arrangements. A fragmented (“silto”) approach is simply incapable to address challenges of such magnitude and will introduce high risks of not meeting the target objectives. Multidomain and multinational arrangements are necessary and regional/global partnerships have to be established.
Appendix 1 - ATM Systems

The **Airline Operations Centre (AOC)** ATM system is responsible for publishing all relevant trajectory information and contributing to the Demand and Capacity Balancing process. It also has responsibility for the management of aircraft de-icing to optimise the intra-fleet sequence.

The level of functionality will potentially be reduced for on-demand operators.

It comprises the following subsystems:

- De-Icing management
- Ground-Ground Interoperability (IOP)/SWIM Management
- Schedule Management
- Technical Supervision
- Trajectory Management
- UDPP

The **Aircraft** system responsibilities cover 3 main areas that are specialized depending on the category of aircraft (Commercial aircraft / Military Transport aircraft / Combat aircraft / UAS / General Aviation (Non-commercial)):

- Communication: Air-Ground IOP/SWIM Management and Air-Air Information Exchange;
- Surveillance: Traffic Awareness and Avoidance, Terrain Awareness and Avoidance and Weather Awareness and Avoidance.

The **Aerodrome ATC** system supports the Tower Ground Controllers, Tower Runway Controllers and Tower Supervisors for the surveillance, control, planning and guidance of aircraft and vehicle movements on the aerodrome surface (manoeuvring and traffic areas).

It comprises the following subsystems:

- Aerodrome ATC Demand and Capacity
The **Airport Airside Operations** system is responsible for aerodrome operations such as the management of aircraft de-icing, the management of the turnaround phase (stand/gate allocation, ground handling…).

It comprises the following subsystems:

- Airport Demand and Capacity
- Airport Mapping
- De-icing
- Environment Management
- Ground-Ground IOP/SWIM Management
- Performance Management
- Stand and Gate Management
- Stand Turn around
- Technical Supervision
- Turn around Management

The **En-Route and Approach ATC** system assists the planning and executive controllers in different tasks, such as in maintaining safe aircraft separation, keeping track of the association between flight and surveillance information, keeping track of potential deviations from planned routes and reminding the controllers of activities to be performed. It also supports the Demand and Capacity Balancing process.

It comprises the following subsystems:

- Arrival Management
- Code Management
- Conflict tools
- Controller Workstation
- Correlation
- Flight Data Operator Workstation
- Flight Data Processing
- Ground-Ground IOP/SWIM Management
- Local/Sub-regional Resource Management
- Local/Sub-regional Traffic Demand and Capacity Balancing
- Local/Sub-regional Traffic Flow
- Operational Supervision
- Recording
- Safety Nets
- Surveillance
- Technical Supervision

There are several systems that act at regional level: the Aeronautical Information Management system, the Network Information Management system, the Advanced Airspace Management system, the A/G Datalink Ground Management system and the SWIM Supervision system.

The **Aeronautical Information Management** system (AIMS) is responsible for managing both static and dynamic Aeronautical Information and including new shared information such as terrain information, airport layouts and static information about aircraft.

It comprises the following subsystems:

- Aeronautical Information
- Aircraft Information
- Terrain Information
- Airport Mapping
- Technical Supervision
• Ground-Ground IOP/SWIM Management

The **Network Information Management** system (NIMS) provides regional level support 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 by ensuring a stable and balanced network in all phases, from business development phase up to post-flight analysis phase.

It comprises the following subsystems:

• ATFCM scenario management
• Capacity Planning management
• Demand data Management
• Flight Planning Management
• Ground-Ground IOP/SWIM Management
• Network demand & capacity balancing
• Network Performance Management
• Technical Supervision

The **Advanced Airspace Management** system (AAMS) supports the European Airspace Design and Management. Corresponding systems for Airspace Management will exist in support of civil-military Airspace Management Cells at sub-regional level.

It comprises the following subsystems:

• Airspace Design
• Airspace Organisation long-term planning
• ASM scenario management
• Ground-Ground IOP/SWIM Management
• Technical Supervision

The **A/G Datalink Ground Management** system is a new type of system that will be introduced either at sub-regional or regional level to provide the connectivity to the aircraft and to limit the Air-Ground exchanges between EATMS ground systems and aircraft. It will provide the connection between the aircraft and the ground SWIM network.

It comprises the following subsystems:

• Air-Ground IOP/SWIM Management
• Ground-Ground IOP/SWIM Management
• Technical Supervision

The **SWIM Supervision** system will monitor the performance of the SWIM network as a whole. It will maintain a record of all the systems providing SWIM services and will also log all transactions on the SWIM network allowing monitoring and later analysis of the quality of services provided by each stakeholder.

It comprises the following subsystems:

• Recording
• SWIM Supervision
Notes
Notes