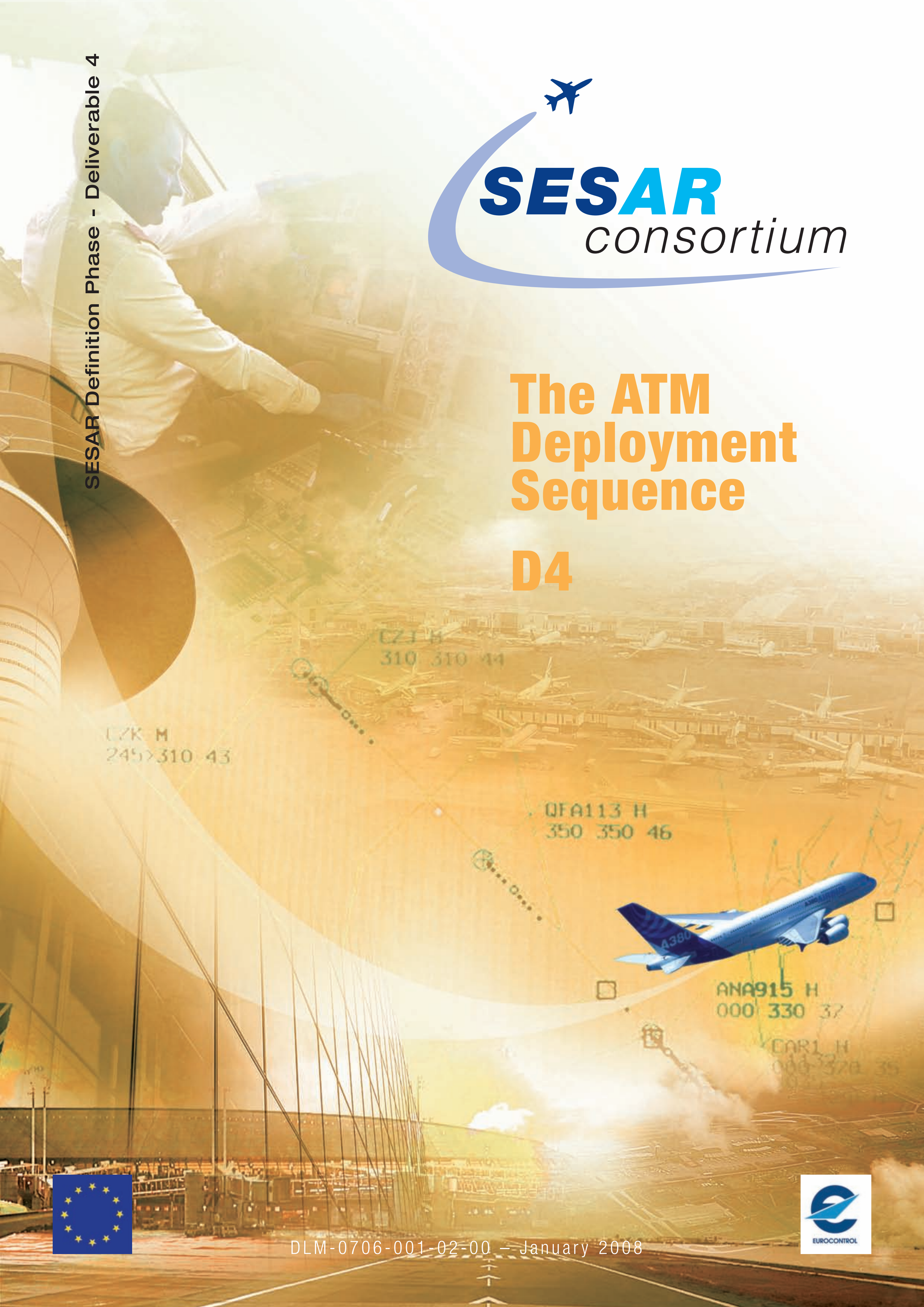
SESAR Definition Phase - Deliverable 4

SESAR consortium

The ATM Deployment Sequence

D4



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SESAR Ex Com
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We, Representatives of the Global Consortium Members within the SESAR Executive Committee, hereby approve the following D4 document for submission to the Purchaser ("EUROCONTROL") by the Project Directorate:

Document D4

Document No: DLM-0706-001-02-00 (accepted document)

Document Title: The ATM Deployment Sequence

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The SESAR Consortium joins the forces and expertise of 29 companies and organisations together with 21 associated partners: from Airspace Users, Air Navigation Service Providers, Airports, Supply Industry and many others, including Safety Regulators, Military, Pilots & Controllers Associations and Research Centres as well as significant expertise from EUROCONTROL.

Preface

The SESAR programme is the European Air Traffic Management (EATM) modernisation programme. It will combine technological, economic and regulatory aspects and will use the Single European Sky (SES) legislation to synchronise the plans and actions of the different stakeholders and federate resources for the development and implementation of the required improvements throughout Europe, in both airborne and ground systems.
The first phase of SESAR, the Definition Phase, is co-funded by EUROCONTROL and the European Commission under Trans European networks. The products of this Definition Phase will be the result of a 2-year study awarded to an industry wide consortium supplemented by EUROCONTROL's expertise. It will ultimately deliver a European ATM Master Plan covering the period up to 2020 and the accompanying Programme of Work for the first 6 years of the subsequent Development Phase.
The SESAR Definition Phase will produce 6 main Milestone Deliverables (DLM) over the 2 years covering all aspects of the future European ATM System, including its supporting institutional framework. The scope of the 6 Deliverables (Dx) are:

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

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

It has to be reminded that the SESAR Definition Phase is a feasibility study, some long term results of which (e.g. technology platform) shall be further validated and consolidated during the next phases (e.g. SESAR Joint Undertaking (SJU) and other Single European Sky (SES) initiatives) before Stakeholder groups could effectively implement its outcome in a concrete way.

This fourth Deliverable, D4, has been produced in accordance with its Milestone Objective Plan (MOP) [Ref 1] and the inputs of the twenty-eight Task deliverables which are providing the substantiating information and which are identified within the SESAR Work Breakdown Structure. D4 is subsequently approved and accepted by all Project Participants.

The SESAR Consortium members:
AEA (Association of European Airlines), ADP (Aéroports de Paris), AENA (Aeropuertos Espanoles y Navegacion Aérea), AIRBUS, Air France, Air Traffic Alliance E.I.G/G.I.E, Amsterdam Airport SCHIPHOL, Austro Control GmbH, BAA Ltd, BAE Systems, DFS Deutsche Flugsicherung GmbH, Deutsche Lufthansa AG, DSNA (Direction des Services de la Navigation Aérienne), EADS (European Aeronautic and Space Company), ENAV S.p.A. (Società Italiana per l'Assistenza al Volo), ERA (European Regions Airline Association), FRAPORT, IAOPA (International Council of Aircraft Owner and Pilot Associations), IATA (International Air Transport Association), Iberia, INDRA Sistemas SA, KLM (KLM Royal Dutch Airlines), LFV (Luftfartsverket), LVNL (Luchtverkeer Nederland), Munich International Airport, NATS (National Air Traffic Services), Navegaçao Aérea de Portugal (NAV), SELEX Sistemi Integrati, THALES Air Systems S.A., THALES AVIONICS.

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

Executive Summary

The Deployment of the SESAR Target Concept is scheduled from today up to 2020!

The ATM Target Concept has been agreed by the SESAR Consortium in the previous Milestone Deliverable D3. It has been analysed and its implementation divided into three successive Implementation Packages (IP). **The main target of this D4 document is to describe and demonstrate the feasibility of this deployment sequence to realise the ATM Target Concept. The SESAR Consortium is committed to the implementation steps proposed for the shorter term and recommends the launch of the development and validation activities according to the proposed transition sequence.** This will allow the modernisation of the ATM System and enable the safe growth of the European air transport industry and thereby the European economy. In addition, a number of the proposed operational ATM enhancements will reduce the environmental effects of aviation. Without SESAR, the increasing system-wide congestion would provoke an intrinsic deterioration in efficiency and environmental impact per flight.

The objective of defining the deployment sequence is to detail the Implementation Packages needed to transition towards the long-term target based upon their feasibility which has been analysed in terms of system enhancement – both at the operations, architecture and Communication Navigation Surveillance (CNS) technology level; the deployment sequence also considers and encompasses the systematic management of all relevant aspects of the ATM network: legal, institutional, safety, human performance, security, environment etc. and provides roadmaps for them. All on-going initiatives which are considered to fit within the scope to reach the 2020 ATM Target Concept and beyond are taken on board and aligned within the deployment sequence. In addition it is recognised that close cooperation with major initiatives such as CleanSky will further enhance the environmental benefits for Society.

For the first and second Implementation Packages, the benefits to be realised, the costs to implement them and their ability to achieve realistic transition steps from today's situation have been determined. For the third Implementation Package, the operational improvements have been identified as well as the remaining issues of their further analysis and validation.

The SESAR Consortium defined the ATM Target Concept in response to the performance objectives and targets defined in D2. The Concept of Operations is organised in terms of Lines of Change (LoC) describing the main areas and directions of essential progress to be made.

The specific and detailed changes required to transition from today's system have been structured in a series of Operational Improvement (OI) Steps, defined along the LoCs. A detailed transition path from today onwards has been developed.

The OI Steps have been allocated to one of the three Implementation Packages (IPs), depending upon their start of operation:

- IP1 from 2008 – up to 2013 – "Creating the Foundations" by building on the current ongoing European ATM initiatives contributing to capacity improvements which are building the basis for and leading to the ATM Target Concept;
- IP2 from 2013 – up to 2020 – "Accelerating ATM to implement the 2020 ATM Target Concept", by timely implementation of all the activities needed to achieve the 2020 targets;
- IP3 from 2020 – onwards – "Achieving the SESAR goals in the long-term" targeting the activities necessary for further performance enhancement of the overall ATM System beyond 2020 to fully realise the ATM Target Concept.

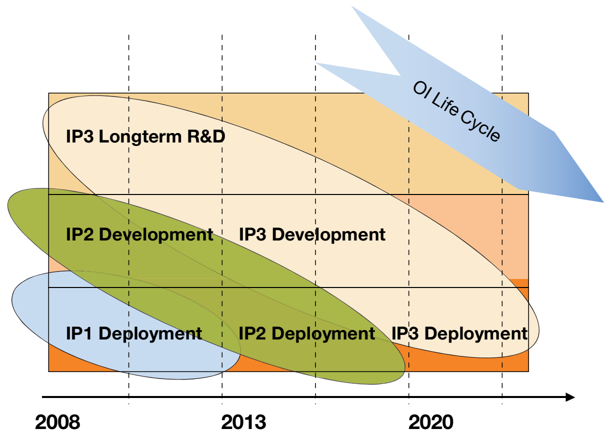


Figure 1: Implementation Package Time-View

Figure 2 presents a general overview of all operational changes defined in direction of the ATM Target Concept; every arrow represents a grouping of activities whose targets and benefits are more detailed in the main body of this document.

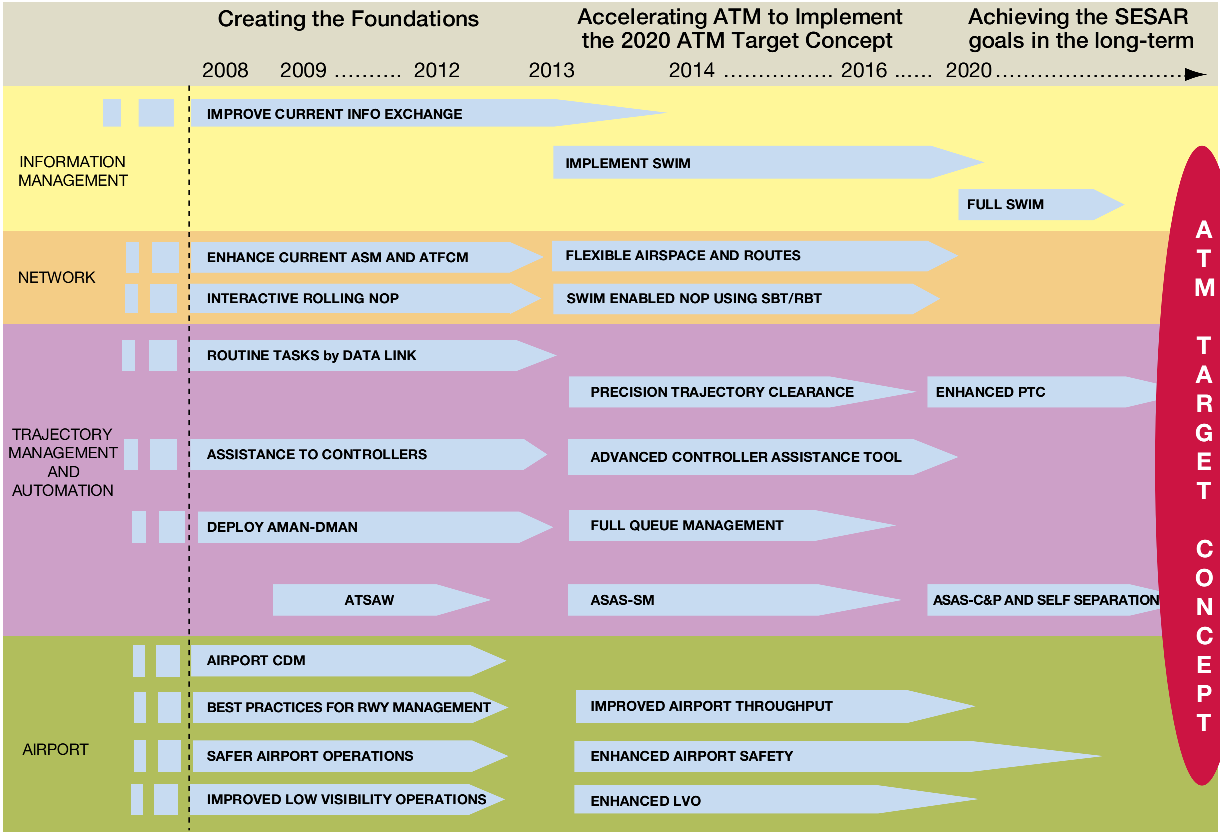


Figure 2: Overview of the ATM Deployment Sequence

IP1 - Creating the Foundations

Implementation Package 1 has the objective to implement short term initiatives and disseminate best practices through a set of Operational Improvement Steps. It has the following 5 main aspects:

- Unlocking latent and generating additional Network Capacity: the Dynamic Management of European Airspace Network (DMEAN) programme will generate additional capacity, lead to less delay and improved network and flight efficiency;
- Information sharing through expeditious deployment of the ground-ground Pan European Network system and Services (PENS), deployment of air-ground datalink in accordance with the datalink Implementation Rule and launch of action to ensure viability for the use of datalink (releasing Very High Frequency (VHF) spectrum for datalink use). Extending flight data sharing will improve predictability with consequent enhancements to safety and capacity;
- Enabling more environmentally sustainable performance-based operations (i.e. Continuous Descent Approach (CDA), Precision Area Navigation (P-RNAV), etc.);
- Airports/Terminal Operations efficiency and capacity gains with a series of measures (e.g. specific procedures for adverse weather conditions including weather hazards like heavy rain, fog and windshear, best practices on the ground to reduce the risk of runway incursions, and improved static wake-vortex classification for runway management), that will, when implemented not only enhance efficiency and capacity, but also safety;
- En-route efficiency and capacity gains with measures based on automated support for traffic management (e.g. conflict detection, flight conformance monitoring, etc.).

Enhancing safety, in particular mitigating the risk of collision, by making all General Aviation aircraft electronically visible, is of critical importance and will be investigated with urgency.

IP1 represents the foundation of the ATM Deployment Sequence on which the following Implementation Packages are built. It can only be achieved if all European ATM stakeholders fully commit to the timely and effective implementation of all activities identified in IP1. It will need to be supported by co-ordinated planning, implementation and business oriented management at European ATM network level with the aim to ensure the best use of European airspace capacity and efficiency resources.

Any delay or failure to implement IP1 will impact the rest of the ATM Deployment Sequence.

IP2 - Accelerating ATM to implement the Target Concept

The Implementation Package 2 will deliver a wider information sharing environment which will be the driver for improved efficiency of the ATM network as a whole. It has the following 5 main aspects:

- Network cost-effectiveness & efficiency gains through further improved Trajectory Management process;
- Extending data sharing; information sharing in a more dynamic sense has to be implemented (System Wide Information Management (SWIM));
- Availability of more precise meteorological data (delivered automatically by individual aircraft) will assist in better planning and management of the business trajectories;
- Augmenting Airports/Terminal Area Operations and En Route capacity benefits through the introduction of more advanced automated tools (e.g. automated surface movement planning and routing) and procedures;
- Operational flexibility for both civil and military users through dynamic information sharing which enables a far better response to military airspace requirements (time and space).

IP2 will deliver the implementation of the 2020 ATM concept. Its definition has identified all the activities required to achieve it and the associated timeframe.

In support, a first analysis of on-going and future R&D activities which have to be tackled by the SESAR Joint Undertaking (SJU) has been conducted.
In particular, the planned application of Automatic Dependent Surveillance Broadcast (ADS-B) by all civil airspace users for air and ground operations, and by aerodrome vehicles necessitates early overall R&D and Business Case studies of all aspects regarding the application of SWIM and ADS-B to ensure its safe and effective use, its interoperability, and to prevent costly re-equipage. Specifically, this R&D activity must reveal acceptable and affordable communication and navigation solutions for all airspace users, including Business Aviation (BA) and General Aviation (GA).
User-specific enabler solutions will have to be considered (e.g. Universal Access Transceiver (UAT) and Space Based Augmentation System (SBAS)) for cost-effective implementation and integration in the Target Concept, such that all airspace users contribute to the efficiency, environmental sustainability and safety of the ATM System.

IP3 - Achieving SESAR Goals

All previously identified benefits achieved with the implementation and deployment of Implementation Packages 1 and 2 will be further enhanced with Implementation Package 3 to meet SESAR long-term goals. Its main aspect is to introduce the most advanced features of the SESAR Concept of Operation (ConOps), aiming to achieve the long term performance goals:

- Full application of Airborne Separation Assistance System (ASAS) Self Separation;
- 4D Trajectory Contract.

Research activities have been identified to define and validate the above features and will have to be launched within the scope of the SJU.

The ATM Performance Improvement view

- **Performance improvements required for the short term**
  The IP1 best practices and short term initiatives were assessed against the defined performance targets [Ref 24] and will result in improved network performance based on the full exploitation of existing latent capacity. The operation of a more integrated European ATM network has the potential to generate savings estimated between €0.7-1.1Bn/year for airspace users and also to meet the other performance requirements. Safety screening with non quantifiable measures has been performed and the requirement for continuous improvement in Safety Management was identified.
  IP1 will accommodate demand by 2013 (see Figure 3) if all initiatives are timely implemented.

- **Towards SESAR Performance Targets**
  The selected IP2 Operational Improvement Steps were assessed against the 2020 Performance Targets. The main findings confirmed the D3 outcome:
  - Capacity issues at constrained airports will have been addressed by the full application of recognised best practices associated to the foreseen SESAR operational improvements steps. Best use of runway capacity will be in place but full traffic demand will not be accommodated unless a part of the traffic makes use of secondary airports to relieve congested airports. By 2020, the bottleneck of capacity increase will be more and more transferred to high density airspace, especially terminal areas;
  - SESAR will contribute to reaching the Cost Effectiveness target which aims at reducing the direct ATM cost per flight by 50%. Additional rationalisation including Functional Airspace Blocks (FAB) and Air Navigation Service Provider (ANSP) consolidation will be required to reach this target.

  Rigorous performance monitoring must apply for the development activities in support of IP2 with the appropriate focus on the achievement of the IP2 performance targets.

Figure 3 provides a synthesis of the different performance assessments for each IP. An assessment trade-off was conducted between the accommodated traffic and the acceptable delay. As a consequence in 2020, with IP1 and IP2 implemented, the ATM system will be able to accommodate 15.8 Million flights with an average delay of 1.2 minutes per flight and greater fuel efficiency (corresponding to a fuel saving of 2.9% compared to the 2007 baseline).

Benefit Component		2007	2012	2020
			IP1	IP1 + IP2
Flight / Traffic	M Fl. per y.			
Demand Accommodated	M Fl. per y.	10	12.6	15.8
QoS - Delays				
Total delays	Min. per fl.	2	1.3	1.2
En Route delays	Min. per fl.	1.1	0.9	0.7
Airport delays	Min. per fl.	0.9	0.4	0.5
QoS - Fuel				
Fuel In-efficiency	% total fuel	11.7 %	10.6 %	8.8 %

Figure 3: SESAR Performance Assessment Synthesis

- **Towards SESAR Performance Goals**
  IP3 performance has been assessed utilizing expert judgement considering the limited maturity level of the defined Operational Improvement Steps and their applicability, and the availability of suitable validation tools. It was concluded that with the deployment of IP3, the further performance enhancement required to accommodate increasing demand will be realised. These results will need to be further analysed and consolidated when better definitions will be available. It shall be considered that these enhancement steps are of fundamental importance for the achievement of the SESAR long term goals.

Estimated Cost and Benefits to trigger Investment Decisions

The Benefits Side

The results of the timely and synchronised implementation of the complementary and efficient ground ATM services and tools exploiting the airborne investments are the main factors influencing the airspace users Cost Benefit Analysis (CBA). The benefits being considered in the CBA are: additional accommodated demand; delay reduction; fuel efficiency; maintaining airport capacity in low visibility conditions, and reduction of flight unit costs for Air Traffic Management Services. The performance assessments were expressed in monetary terms and the cost per flight evaluated; the balance of the benefits is presented in Figure 4 for IP1 and Figure 5 for IP2. Additionally, an initial projection of societal benefits has been performed.

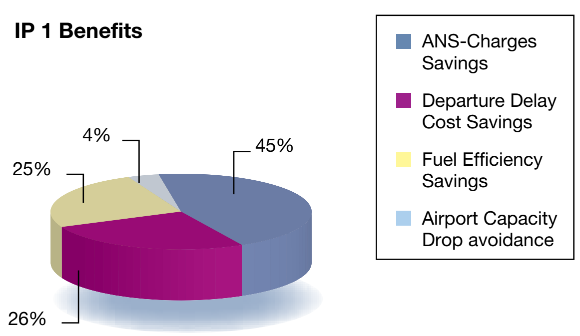


Figure 4: IP1 Benefits in 2020

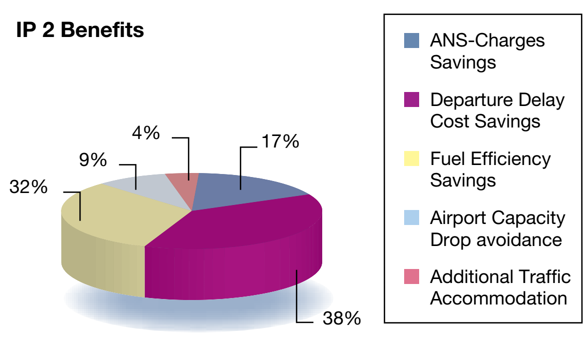


Figure 5: IP2 Benefits in 2020

The unit cost savings have been extracted from the assessment made of the Cost effectiveness by a "financial" model which computes the development of the unit cost from two main inputs: Air Traffic Control (ATCO) productivity and SESAR investment cost for ANSPs. By revisiting the assumptions made during D3 and analysing in more detail the cost associated with the implementation of the ATM Target Concept, the average direct ATM cost per flight has been computed to reach €630/flight by 2020 (while the performance target was to halve the cost from €800/flight to €400/flight).

The Cost Side

Figure 6 illustrates the Stakeholders investment costs assessed for the implementation of IP1 and IP2.
The cost for the equipage of an average large commercial aircraft to implement IP2 capabilities is estimated to be around €1 Million. In the current costs assessments, avionics packages are assumed to become "basic" (part of some standard aircraft) after a certain period of time (approximately 7 years).

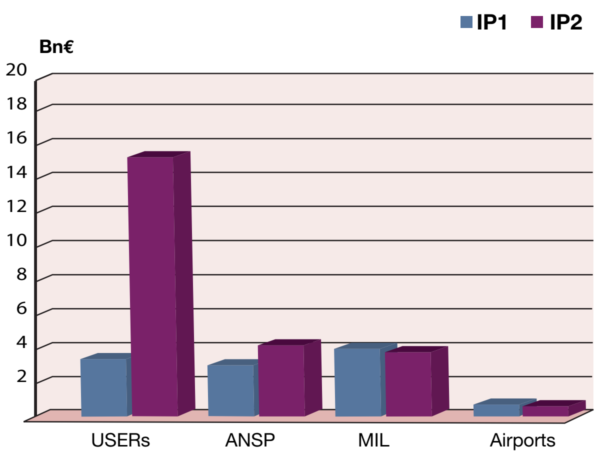


Figure 6: Stakeholder Investment Costs

For all IPs it has been determined that the estimated retrofit costs represent approximately twice the costs of the forward fit. Further analysis of the detailed solutions to deploy the ATM Target Concept should consider the viability of having 2 different solutions for the same function on board commercial aircraft:

- The "nominal" fully scoped solution for forward fit;
- A "minimum" solution at a lower cost (especially for old aircraft for which a limited retrofit might happen in the future).

The Cost Benefit Analysis

The ATM Deployment Sequence is supported by iterations of CBA which identify that the selected IPs tend to be affordable for the schedule airlines[1] only under the following conditions:

- (on the benefits side) if the cost-effectiveness target is met and capacity and quality of service targets are met to their greatest extent;
- (on the cost side) if global interoperability (e.g. with NextGen) is achieved preventing proliferation of technical solutions thus allowing significantly reduced avionics costs.

For the Business Aviation and General Aviation, the overall SESAR improvement analysis and the cases for IP1 and IP2 are likely to be always negative due to the lack of significant benefits (besides safety) and/or difficulty to quantify some. For the military the associated costs to implement IP1 and IP2 were identified.

The overall CBA for IP1 and IP2 shows the following results.

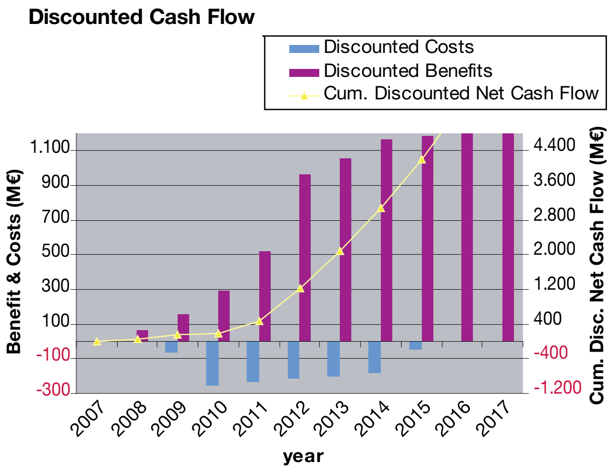


Figure 7: Scheduled Airlines IP1 CBA

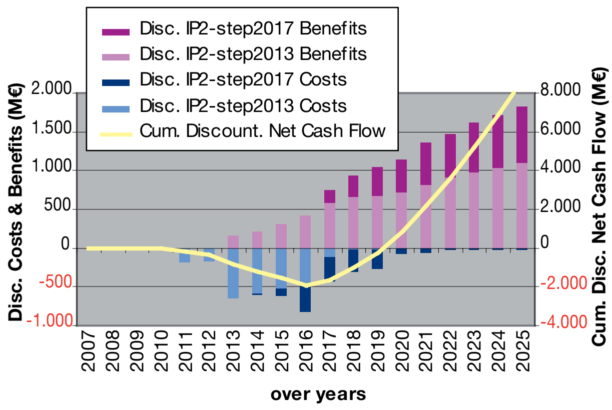


Figure 8: Scheduled Airlines IP2 CBA

The positive benefit to cost ratio and break even point at 2020 are encouraging, however the cumulated discounted net cash flow (around -€2Bn during 2015-2018) identifies the high upfront avionics investment effort required. This highlights, like for existing commitment from SESAR consortium to IP1, the importance to ensure that the expected benefits will be delivered on time.[2]

Risk and Prerequisites for Success

The viability of the D4 ATM Deployment Sequence depends on:

- Decisions to invest and implement are made and sustained by all stakeholders;
- Further analysis during the development phase. The proposed CNS technology roadmap has been established from hypotheses for operational requirements of the ATM Target Concept that remain to be further validated. Corresponding R&D activities have been identified and it is recommended that they are started without delay as part of the SJU work programme;
- The 23 additional runways that are planned to be operational across the European Civil Aviation Conference (ECAC) region are available (it shall be noted that these runways and associated taxiways are outside the scope of SESAR and are not included in the CBA);
- The current development cycles which need to be significantly reduced in order to accelerate implementation. For the military the life cycle of military systems, the constraints of national budgets, the technical limitations for retrofit of aircraft equipment and the achievement of international agreements between Armed Forces constitute an important factor for the future system deployment;
- Follow-up measures of the High Level Group report [Ref 32] which are taken to support the implementation of the ATM Deployment Sequence, especially in the area of Institutional and Regulatory Frameworks. It is recommended that the following aspects be covered:

1 - Since most of two other major stakeholders, ANSPs and Airports are presently operating on a full cost recovery principle, their own CBA (often negative) is less important than the contribution of their investments to the capability to manage the traffic growth. The importance to further improve their cost effectiveness, resulting in lower unit costs per flight, is the key aspect.

2 - The cost of IP 3 has not been defined as more analysis is necessary to assess it.

    - To consolidate this ATM Deployment Sequence, a strong and timely standardisation and institutional framework must be introduced to minimise complexity, avoid duplication and keep the cost of undertaking standardisation activities to the absolute minimum needed. This will ensure the desired high level of ATM interoperability and flexibility will be achieved both globally and throughout Europe;
    - To provide growth, it is essential that the ATM safety regulatory framework will be developed to provide a clear, unambiguous set of regulations across the whole of the air transport industry. It is necessary that in parallel to the SJU establishment, all ATM regulators will join and define all regulatory activities necessary to support this ATM Deployment Sequence and its development;
    - To support all envisaged solutions and their timely implementation, the appropriate legal framework needs to further evolve accordingly. Areas like SWIM and change in separator designator (ASAS) are planned activities which will require appropriate legal framework evolutions.
- FABs and industry consolidation will need to take place to close the performance gap, with special regard to Cost Efficiency for which the CBA has resulted in a shortfall of €230 per flight compared with the target. The FAB scope and objectives - one of the major building blocks of the SES - should be revised and progressed as indicated in the High Level Group Report. The alignment between SESAR and the various FAB initiatives underway is expected to deliver further and additional benefits in terms of de-fragmentation and the creation of economies of scale: it is therefore considered as a critical point for success;
- Innovative incentive and/or penalty mechanisms (such as route charge reduction, operational priorities) are proposed to provide the best opportunity cost for all stakeholders to quickly adopt the system;
- Human Performance aspects have to be properly assessed through the application of the Human Factor methods such as Human Factors case. This will significantly enhance the capability to meet the expected performance improvements in due time;
- Social Dialogue and Participative Management should be enabled to achieve sustainable evolutions. The involvement of social partners (including the professional staff associations) and all ATM staff groups affected by the ATM Target Concept at European, national and local levels is to be achieved, as well as a full integration of them in all relevant working groups;
- Availability and efficient management and exploitation of aeronautical spectrum needs to be ensured as it remains a key issue and potential blocking point for the future;
- Monitoring of all implementation steps to meet the required performance target needs to be ensured considering economic and/or performance regulation;
- Working level arrangements between Europe, USA, the Russian Federation and other regions are further developed in the R&D area, allowing to reinforce dialogue and exchanges to encourage international co-operative ventures in research, implementation and standardisation. These arrangements should be organised to best meet the SESAR development needs. Furthermore, it is strongly recommended that similar arrangements be established with other regions/nations.

If any of these measures fail to happen, then SESAR deployment will be endangered and European ATM may face a deterioration in Efficiency and hence Environmental Sustainability, limiting traffic growth and thereby the growth of the European economy.

Paving the way to the ATM Master Plan

The ATM Deployment Sequence provides the reference to support the decisions to build the European Master Plan and launch the SJU activities, including the development of the 2020 solution and the research needed for the long term ATM Target Concept.

The next SESAR Milestone Deliverable D5 will build upon the previous Milestones Deliverables, including this ATM Deployment Sequence. The ATM Master Plan (D5) will link and align the stakeholders programme activities to meet the agreed performance requirements and pave the way to the associated Work Programme for 2008-2013 (D6).

1 Introduction

This SESAR Milestone 4 Deliverable (D4), entitled "The ATM Deployment Sequence", describes the overall transition sequence to implement the ATM Target Concept[3] that was defined to deliver the ATM Performance Targets[4]. It identifies the operational improvements and enablers to be deployed between 2008 and 2020 as well as the research and development activities needed to support them. In addition it identifies activities needed to develop the more advanced aspects of the Concept that will be implemented beyond 2020.

The detailed objectives of D4 [Ref 1] are:

- To define implementation packages (IPs) needed to realise the long-term target (incorporating any on-going initiatives as appropriate) based upon their feasibility, the benefits to be realised, their costs to implement, their geographic dispositions and the ability to make realistic transition steps;
- To identify the changes needed to the institutional, legislative, organisational, regulatory and standardisation aspects resulting from the implementation packages;
- To assess the current plans and on-going initiatives against the mid-term and long-term performance targets in order to identify:
  - Those which are aligned to these targets;
  - Those which are not aligned, and therefore require a modification of their scope;
  - Any gaps for which new activities should be scoped.
- To define, where appropriate, any short-term local improvements to address existing gaps and issues, and provide early local benefits based upon technologies already available and aligned with the general transition path.

The ATM Deployment Sequence covers the period from 2008 to 2020 and beyond. However, in order to allow for potential changes in expectations and needs of the air transport industry over such a long period, 3 periods have been defined for performance assessment and planning, namely: 2008-2013, 2013-2020 and 2020+ (corresponding to D2 SESAR Performance goals).

Selecting these dates enables a stepped approach to be taken to the evolution of the European ATM System based upon a number of important factors as follows:

- Each of these time periods contributes to an evolution step of the European ATM System which have been classified as ATM Capability Levels during D3 and further refined during D4;
- Airspace users may have at any one time different performance capabilities. However, they will be required to evolve their fleet in accordance with the appropriate ATM capability level of each evolution period. This will occur at different rates and be driven primarily by the business/mission imperatives of each airspace user category. The overall aim must be to deliver the performance from the Future ATM System where and when it is needed by its users;
- In order to achieve a better rationalisation of resources and to optimise cost/benefits, the geographical scope of the ATM Deployment Sequence embraces the ECAC area but needs to consider further segmentation into the following operational environments – Network; En-Route Airspace; Terminal Airspace and Airports.

1.1 Consideration of D1, D2 and D3 Findings

An initial analysis of current European ATM System was delivered in D1. It recommended among other things that:

- The future European ATM System must be able to cope with the expected growth in traffic;
- The design & management of the future European ATM System should be based upon:
  - A consistent and explicit framework linking the economic, commercial and operational priorities of stakeholders within the ATM System be established;
  - A comprehensive performance framework be applied across the European ATM System (EATMS) as a whole;
  - The use of the notion of a "Network Operation Plan";
  - The principles of asset management explicitly linking the strategic planning of new investments with the in-service support of operational systems.
- The future applied Research & Development (R&D) must focus upon the applications needed to achieve ATM System performance and then identify the technological solutions to deliver them. R&D activities, in general, have been conducted in a fragmented manner without addressing an identifiable need, while lacking robust user requirements to support the work and sufficient business planning analyses and/or safety case work;
- A simpler, more coherent framework of legislation and regulation, matched to ATM's business model, should be created;
- As the role of the human in the ATM System starts to change, a proactive approach to change management should be established which involves staff at all levels, considering resource planning from a greater forward looking perspective;
- A single functional architecture should form the basis of the future ATM System, with the airborne and ground-based systems being treated as one.

3 -The SESAR ATM Target Concept was defined in SESAR Milestone Deliverable 3 (D3) [Ref 2].
4 - The SESAR Performance Target was defined in SESAR Milestone Deliverable 2 (D2) [Ref 3], and further updated in Performance Booklet [Ref 24]

Based upon the conclusions and recommendations made in D1, an initial set of performance targets were established for the future European ATM System in D2 with the following particular recommendations:

- Distinct business & regulatory management frameworks be created which work to a common performance framework based upon that developed by ICAO (International Civil Aviation Organisation), and which have a "dynamic working relationship" between them to ensure the best outcome is achieved for the ATM industry as a whole;
- The ICAO global ATM operational concept [Ref 5] be used as the reference for the development of the ATM system;
- Stakeholders have to establish an ATM Performance Partnership (ATMPP) that will define roles and responsibilities based on a shared set of values, priorities and network interactions.

Using D1 and D2 as the basis, the ATM Target Concept was developed in D3. The principle features of the Target Concept are:

- Trajectory Management that is introducing a new approach to airspace design and management;
- Collaborative planning continuously reflected in the Network Operations Plan;
- Integrated Airport operations contributing to capacity gains;
- New separation modes to allow for increased safety, capacity, and efficiency;
- System Wide Information Management integrating all ATM business related data;
- Humans who will be central in the future European ATM system while their role is evolving to managing and decision-making.

D4 has been developed based on the results of 28 Task deliverables and a full analysis and consolidation of the conclusions and recommendations developed within the D1, D2 and D3 Deliverables. It is important to note that a basic decision made for the development of D4 was to take the performance, growth and cost figures used at the time D1 and D2 were produced. Although during the development of D3 and D4 actual 2006 figures became available, the previous figures have been maintained as the baseline for purposes of continuity since the potential error margin is negligible in comparison to the assumptions and predictions made for the long-term.

1.2 Relationship with ICAO and ECIP/LCIP

This ATM Deployment Sequence document considers the Global Air Navigation Plan for Communication Navigation Surveillance/Air Traffic Management (CNS/ATM) Systems (Global Plan, Doc 9750), which was developed by ICAO as a strategic document to provide reference for the implementation of CNS/ATM systems.

The Global Plan contains near and medium term guidance on air navigation system improvements necessary to support a uniform transition to the ATM system envisioned in the Global ATM Operational Concept (Doc 9854).

In accordance with the Global Plan, planning shall be focused on specific performance objectives, supported by a set of "Global Plan Initiatives". These initiatives are options for air navigation system improvements that when implemented, result in direct performance enhancements. States and regions will choose initiatives that meet performance objectives, identified through an analytical process, specific to the particular needs of a State, region, homogeneous ATM area or major traffic flow. The terminology and methodology used in this document are consistent with ICAO use.

At European level whilst the European Convergence and Implementation Plan (ECIP) and the Local Convergence and Implementation Plans (LCIP) processes have become widely recognized by the ATM Community , they are still suffering from a lack of commitment for implementation from stakeholders, the association of an increasing number of ECIP Objectives to European Commission (EC) Implementing Rules is expected to re-enforce their implementation.

The approach and methodology used in this document builds upon and expands on ECIP/LCIP practice.

1.3 Document Organisation

This document is organised as follows:

- Chapter 1 provides a brief introduction to the foundations upon which D4 has been built;
- Chapter 2 describes the overall approach taken to build the ATM Deployment Sequence, giving a description of the considerations made and the rationale regarding the content of the Implementation Package;
- Chapter 3, 4 and 5 describe the Implementation Packages 1, 2 and 3 respectively, each starting from their particular performance targets;
- Chapter 6 proposes an overview of the roadmaps for each of the main enablers, namely:
  - System Architecture;
  - CNS Technology;
  - Human Performance;
  - Legislation Aspects;
  - Safety;
  - Security;
  - Environment;
  - Standardisation;
  - Financing Aspects;
  - Research and Development Considerations.

2 Building the ATM Deployment Sequence

The transition from today's system to the ATM Target Concept is formulated through a sequence of "Implementation Packages (IPs)". This chapter provides a high level introduction of the methodology for the building and assessment of the IP sequence and resulting recommended ATM Deployment Sequence. A full description of the process is given in Annex III.

2.1 From the Concept of Operations Lines of Change to Implementation Packages

Milestone Deliverable D3 [Ref 2] presented a ConOps able to meet future demand.

To ensure that the evolution to this ConOps will meet the required performance over time, the IPs have been considered through the main operational areas that describe the evolution of the ATM environment (so called Line of Changes - LoC). Each IP is made up of a set of Operational Improvements Steps (OI Steps). OI Steps describe a change to a specific area of the ConOps, which can be implemented in a given period of time, and results in a direct performance enhancement. Implementing an OI Step implies that a number of conditions are met, and actions are performed. These are the enablers of the OI Steps. One or more enablers usually support an OI Step.

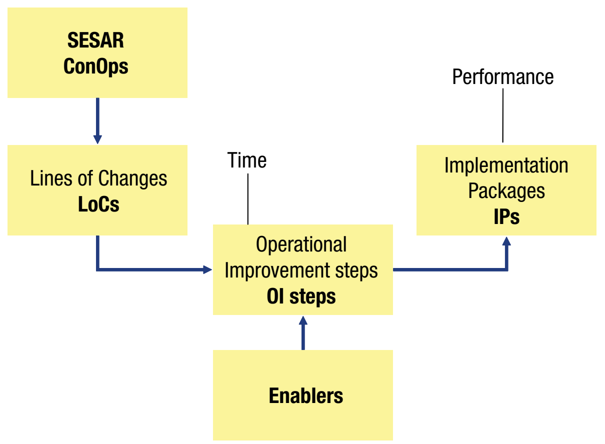


Figure 9: The Information Model

Figure 9 shows the process and the related information model. The applied methodology has, as its objective, to establish a transition path which:
- Identifies the change steps;
- Defines their timing, starting from today's system;
- Enables flexible adaptation to changing requirements and technological developments;
- Assesses the costs involved and the benefits to be gained by all stakeholders, including the rate at which these will be incurred and realised respectively.

After the assessment of all influencing factors within the scope of the SESAR feasibility study, a transition strategy has been developed. This is contained in three distinct Implementation Packages addressing three time frames characterised as follows:
- IP1 – Creating the foundations: to meet 2013 performance by deployment of ongoing and planned operational improvements covering the period 2008-2013;
- IP2 – Accelerating ATM to implement the 2020 Target Concept: to meet 2020 performance by deployment of identified and feasible operational improvements between 2013-2020, and;
- IP3 – Achieving the SESAR goals in the long term: to collect operational improvements, of which the feasibility still needs to be proven, for deployment from 2020 onwards.

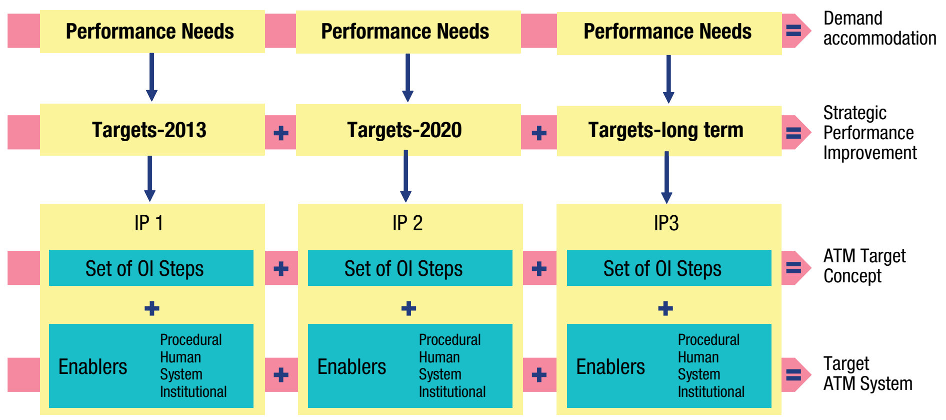


Figure 10: IP Sequence Approach

Figure 10 represents the overall view of the IP sequence; the content and the targets to satisfy the performance needs over time. A detailed description of each IP can be found in chapters 3, 4 and 5.

All information on OI Steps and availability dates of the enablers have been captured in a database that is described in Annex III.

2.2 Basic Constituents for Implementation Package Definition

2.2.1 Performance Targets

While the ATM Target Concept has "design performance goals" on the basis of a long-term forecast, its evolution has to ensure that the performance of the ATM network matches the actual needs over time. For the purposes of the SESAR Definition Phase, performance targets have been set for three specific periods: the short term (up to 2013), the mid term (up to 2020), and the long term (beyond 2020). These targets shall be considered as guidelines during the SESAR Definition Phase since:

- Only a limited number of targets are expressed in quantifiable parameters;
- There is a limited availability of suitable validation tools to perform an objective quantitative assessment whether the global targets are met;
- There is a need to evolve the present ATM system performance measurement towards the SESAR Performance Framework [Ref 24];
- The validation framework needs to be applied to each of the major performance areas, starting with significant up-front work to provide the infrastructure in order to design, develop, and validate these changes.

2.2.2 Implementation Package Milestones

The timing of the IPs is crucial to reach the performance goals and targets within the foreseeable SESAR horizon. Each IP needs to provide a quick return on individual stakeholders' investment and encourage early implementation of the change, advancing the time of positive payback to bring benefits to the network as a whole. To reduce investment risk for all stakeholders a solid business case for each IP is required.

IPs and their timing will have to be revised in a cyclic process based on a performance ATM partnership, which needs to take into account changing forecasts, up-to-date information on performance and the need to plan on a global, regional and local level. A continuous monitoring of the performance and initiating needed adjustments could provide the most cost-effective service. However, to synchronise the planning and investment cycles between the stakeholders, the optimal cycle to adjust the OI Steps will be around 5 years, with the possibility for an interim update if deemed to be required.

Moving from the definition of an IP to its actual deployment requires a number of activities to be performed in a synchronised manner. Notably the life cycle of each OI Step (see Figure 11) needs to be synchronised between all stakeholders.

Synchronisation points are identified, each of them corresponding to the occurrence date of a significant event in relation to the deployment and operation of an OI Step.

To build the IPs the following synchronisation points have been established:

- Initial Operational Capability (IOC) date: This is the date when a

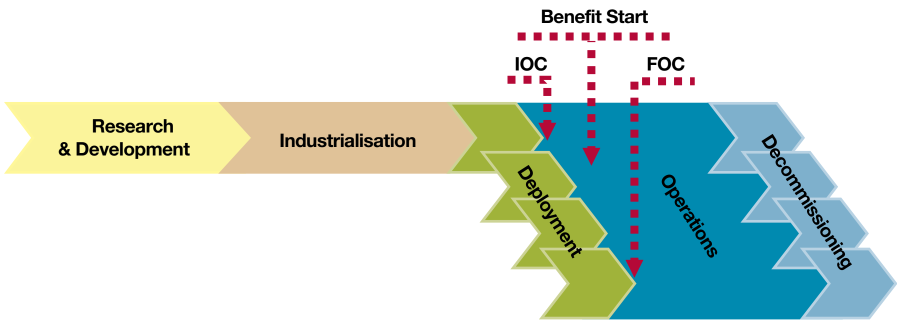


Figure 11: OI Step Life Cycle Model

given OI Step is first implemented. This means all enablers are developed and sufficiently deployed to enable initial operation. According to the operational specification of the OI Step, this deployment may be initially limited to one airport, one Area Control Centre (ACC), one aircraft or requires deployment on several sites;
- Full Operational Capability (FOC) date: This is the date when all required enablers are deployed as planned (geographical deployment for ground enablers, fleet equipage for airborne enablers), and that operations are performed with the full-expected coverage;
- Benefit Start date: This is the date when the deployment is sufficient for the OI Step to start producing benefits. It largely depends on the operational characteristics of the OI Step. It may be depending on a certain level of fleet equipage, on a number of sites equipped, level of staff trained or impact on overall network performance.

2.2.3 Enablers

Enablers are - in terms of systems, procedures, institutional and human aspects - needed in order to facilitate the desired OI Step, i.e. their implementation and deployment. They are not necessarily specific to a given OI Step, i.e. they may “enable” a range of OI Steps.

For the institutional and human enablers there are some general aspects which are not directly related to a specific IP and are addressed in this chapter. A potential failure to establish and maintain stakeholders commitment at the institutional level is a high risk for the successful implementation of any ATM deployment sequence. In particular the past experience of the slippage of timescales requires to strengthen the decision making process in the following areas:
- The level of commitment at stakeholder level;
- The elimination of the uncertainty surrounding the evolution towards a new institutional/governance framework;
- The ability of high level decision-makers to bind stakeholders to implementation.

2.2.3.1 Human Factors

To increase capacity and efficiency, advanced automation will support or even take over specific human tasks resulting in a continuously evolving role for the human in the ATM system. It will be essential to consider the cumulative impact on human performance and by implication on safety and efficiency.

To ensure that all human performance aspects are properly covered it is recommended to set up a transversal co-ordination function for SESAR.

In addition ATM functions will be more distributed between ground and airborne systems, a distribution that can even change dynamically over time. To properly deal with the change, the legal and social framework as well as a regulatory process will have to be re-defined with a special focus on Human Factors, noting already available standards and identified best practices. The development of such a new framework historically takes at least 7 years, however as early as possible, an adequate training programme and licensing strategy needs to be established to prevent a delay of the deployment of the needed OI Steps.

If human performance aspects are not properly dealt within each OI Step, there will be a significant risk that the expected OI performance (in efficiency, capacity or safety) cannot be realised in due time.

2.2.3.2 Legal Aspects

Legislation is primarily a tool to achieve political objectives. As such, achieving the necessary legislative enablers to support the implementation of the ATM Target Concept will require them to be given the necessary priority within the relevant political and legislative processes. It is prudent only to develop legislation when it is clearly the only/best way to achieve the desired outcome.

Legislation may be developed at European (e.g. EC, EUROCONTROL) or National level. In many cases, relevant European or National legislation already exists and it may be more appropriate to amend this rather than developing new legislation from scratch.

It is anticipated that as most of SESAR's predicted legislative needs cover technical matters at a relatively low level (relating to implementation issues rather than matters of high-level policy) they could be addressed by Implementing Rules to be developed under the SES Interoperability Regulation No 552/2004 of 10 March 2004. Implementing Rules are adopted through the comitology process (in the SES context, by the European Commission assisted by the Single Sky Committee) and do not therefore need to go through the European Parliament and the Council of the European Union co-decision process, potentially saving several months (if not years) in elapsed time. All Interoperability Implementing Rules falling within the remit of EUROCONTROL are developed by EUROCONTROL upon a mandate from the European Commission.

However, some aspects of SESAR may be not classifiable as Interoperability issues and thus may require the adoption of regulations/directives by the European Parliament and the Council of the European Union (e.g. the Security requirements for SWIM – [Ref 6]).

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.

National legislation, in some cases, will still be the relevant form of law, although where changes are necessary they should be co-ordinated among States to ensure harmonised and compatible applicability dates (and hereby considering the complex issue of national security and defence requirements).

The legislative development process takes time (typically a minimum of 3 years within the European Union (EU) but longer for complex issues); in addition, timescales must plan, for example, to allow for the implementation period. Considering that SESAR's timescales are already challenging, it is essential to have an appropriate level of certainty over any performance/design/technical requirements needing legislation before commencing discussion, as well as to have the necessary political backing.

EUROCONTROL also produces Rules which are binding on its whole membership, and issues Specifications and Guidelines. The 38 States members of the Organisation have obligations stemming from their membership in EUROCONTROL and 25 States thereof are also members of the EC. It is generally accepted that double regulation should be avoided and any current discrepancies between EUROCONTROL law and EC law are being reviewed.

The currently drafted EC report on the progress of SES implementation is expected to review issues that include (but are not limited to) the following: charging mandate, performance review mandate, separation of service provision and regulation, FABs, question of Community regulator and role of NSAs, and EASA's role. In conjunction with the report, the Commission will be proposing a second SES legislation package during mid-2008, concentrating on fragmentation and reduction of costs; SESAR developments will be taken into account to determine the appropriate regulatory needs.

2.2.3.3 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 along the ATM deployment sequence through consistent and efficient standardisation scenarios.

The standardisation process time duration is dependant on the commitment of the stakeholders' participation. Optimisation may be envisaged for strategic & relevant standardisation activities by setting an appropriate management process to support those activities and to improve the level of effectiveness.

2.2.3.4 Safety

The overall Safety framework consists of 5 major elements that build upon each other: Legislation, Regulation, Standardisation, Certification and Safety Management.

Within the SES, the link between Legislation and Regulation is built via Essential Requirements that anchor the regulatory material in the legislation while the link between Regulation and Standardisation is built with several means of Community Specification that are accepted by the regulator to fulfil regulatory requirements.

As the interdependencies between the different stakeholders in ATM will increase with the more advanced developments for IP2 and IP3, an assessment of the similarities and differences between the stakeholders' use of certification and safety management will be needed prior to the commencement of IP2. It is the expectation that the identification of these needs and pragmatic resolutions towards a common approach (to include plans for cross-domain, pan-European certification, interoperability and oversight mechanisms) will result from the proposed safety regulatory coordination function during the development work.

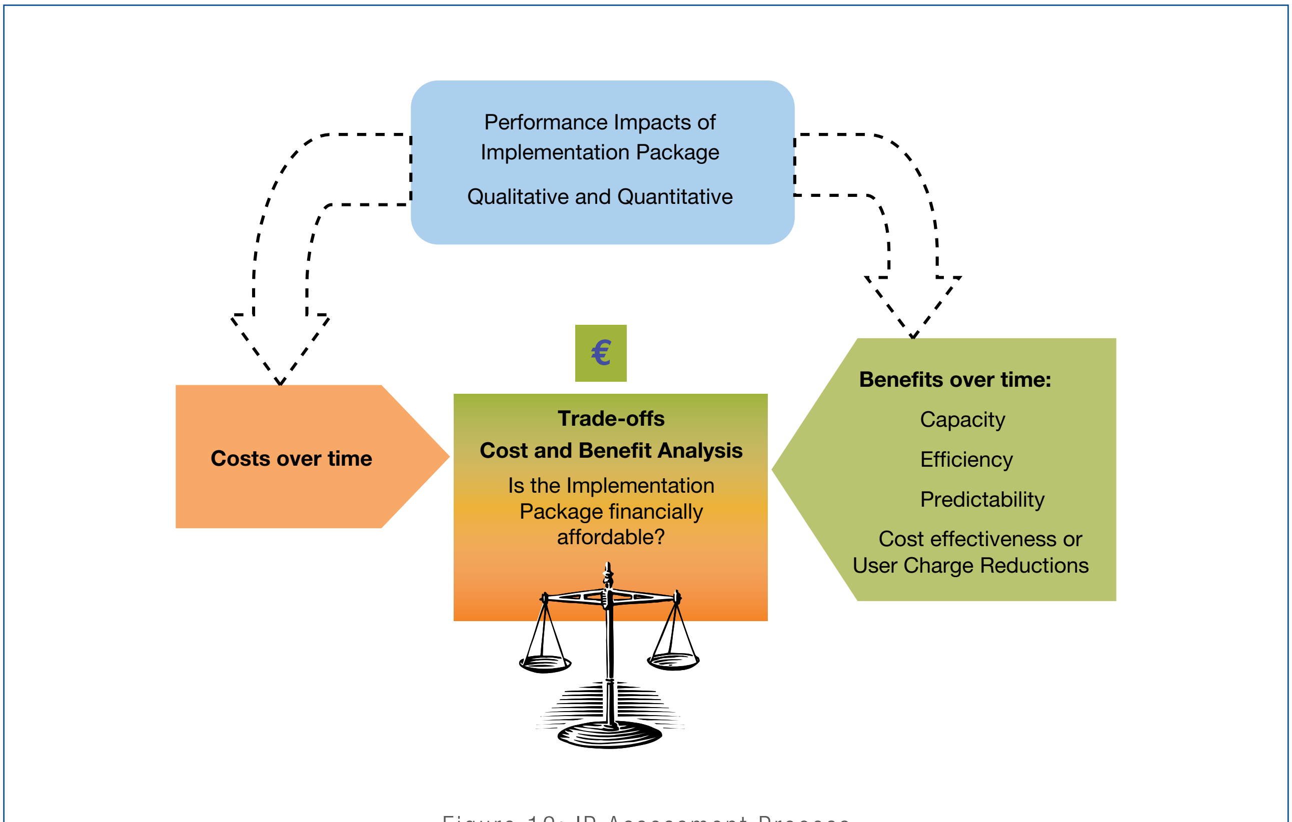


Figure 12: IP Assessment Process

2.2.4 Assessment

For each IP, a performance assessment has been conducted with the aim of:

- Assessing to the extent possible in the Definition Phase, whether the targets in terms of Capacity, Efficiency, Environment and Cost-effectiveness could be met over time;
- Identifying benefits, gaps and potential effect on the overall Performance Areas to allow mitigations to be developed;
- Evaluating the financial viability through an assessment of the Net Present Value (NPV) of the IP, the cash flow and the financing needs;
- Providing each stakeholder with a better insight into their required involvement and ensuring that the transition sequence meets their expectations.

For the enabling performance areas, “Participation” and “Interoperability”, the assessment consisted entirely of the identification of the necessary enablers in these areas for the transition.

The results of the qualitative assessment in terms of Safety, Security, Environment, Access & Equity and in other performance areas were used to complement the transition sequence, identify possible benefits in these areas and ensure that potential negative impacts were identified and mitigated. The costs of implementing the OI Steps over time were compared against the benefits from additional capacity, fuel efficiency, predictability and improved cost-effectiveness.

Figure 12 shows the assessment and the different performance criteria, which were taken into account to support the Cost and Benefit Analysis (CBA) to assess the affordability of the proposed sequence. Further analysis is required for the identification and comparison of adjustment options in terms of when and whether to implement certain OI Steps and associated enablers.

2.2.5 Benefits to the Community

To ensure a commercially sustainable high quality air transport service to the European community, the SESAR project improvements are considered beneficial for the European environment, economic growth, and competitiveness.

Cost Benefit Analysis have been used in the SESAR Definition Phase for deciding whether the cost to make a change was balanced by tangible benefits but not all the appropriate tools are available to quantify the intangible costs and benefits for the community.

Nevertheless SESAR provides benefits to the community in the following areas:

- Environment: SESAR’s contribution to the airline industry goals of achieving a neutral carbon growth is in the order of an annual reduction of 12 million tonnes of CO_2;
- Economic contribution: Additional flight services benefit not only the end users of air transport but also the community through the supply chain of air transport and the spending of the people

2.3 The Recommended Sequence

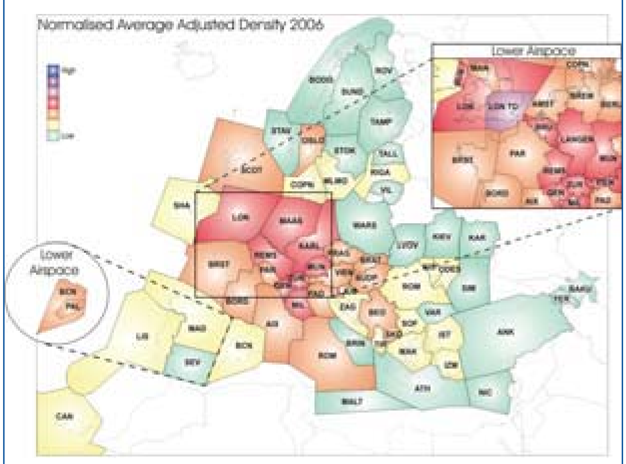


Figure 13: 2006 Forecasted Traffic Density

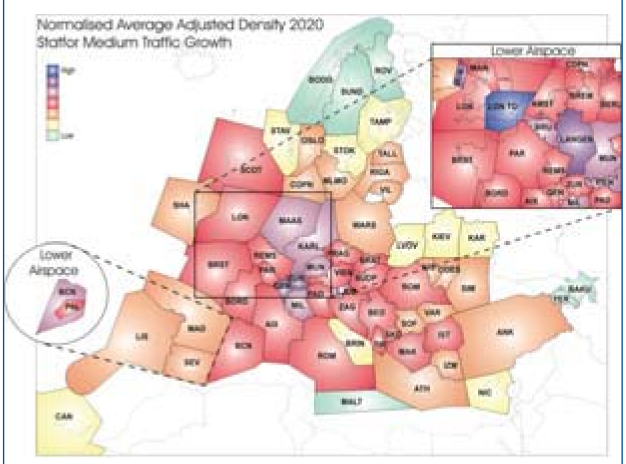


Figure 14: 2020 Forecasted Traffic Density

working directly and indirectly for air transport. It has been estimated that, depending on the extent of unused resources in the European economy, accommodating an additional 3.7 million flights per annum could add up to 90 billion Euro to annual European GDP and create an additional 1.7 million jobs;

- Additional revenues collected by States from this economic growth will by far offset the necessary investment in military equipage to accomplish the military missions to discharge national defence and security responsibilities;
- Catalytic Benefits: Air transport has also a wide range of catalytic and dynamic effects in the European economy and society. It enables other activities and industries to exist, to grow and to perform more efficiently. Air transport impacts business investment as more flights encourage more businesses to locate or expand in a region, increases labour mobility, widens markets and increases competition. It also provides the fast accessibility and mobility to enable more research synergies, innovation and transfer of technology. Air transport growth in the past decade is estimated to have provided the opportunity to add 4% each year to the Gross Domestic Product (GDP) of Europe in the long run through its impact on business investment and productivity. This amounts to 410 Billion per year in 2004 Euros;
- Improved quality of air transport services to the community. The increase in capacity and efficiency providing a safe service with less disruptions and reduced travel times;
- An high safety level of the European Air Transport service through a clear safety regulatory framework and a consistent management of safety by all contributors to the aviation processes.

The process as described in the previous chapter resulted in a recommended sequence of OI Steps, which have been mainly focussed to accommodate traffic demand forecast and improving the quality of operational services. Figure 13 and Figure 14 show the increase in traffic density in Europe from 2006 to 2020 resulting from the EUROCONTROL Future ATM Profile (FAP) study. It shows that most of European Airspace will be classified as high or medium-high density by 2020.

Notwithstanding potential airspace organisation changes, all stakeholders need to implement the ATM Deployment Sequence in a timely controlled way. Airspace Users and Service Providers (ANSPs, Airports) will have to take into account the traffic density forecast when defining their respective plans for evolution in the deployment of each IP. While the IPs and their OI Steps will have to be tailored to the specific needs, there is an overall requirement for the Pan-European ATM network to increase harmonisation and to increase the overall throughput.

2.3.1 Overview of Major Changes – The Recommended Sequence

Figure 15 (page 22) is a high level view of the major changes induced by the three IPs.

2.3.2 Key Message and Risks

The key message from the assessment is that deployment of the recommended IP sequence has the potential to provide a cost effective transition toward the future ATM Target Concept.

However to reduce programme and investment risk the following conditions need to be fulfilled:

- Further validation of the feasibility of the IOC dates;
- Further development of the appropriate validation tools;

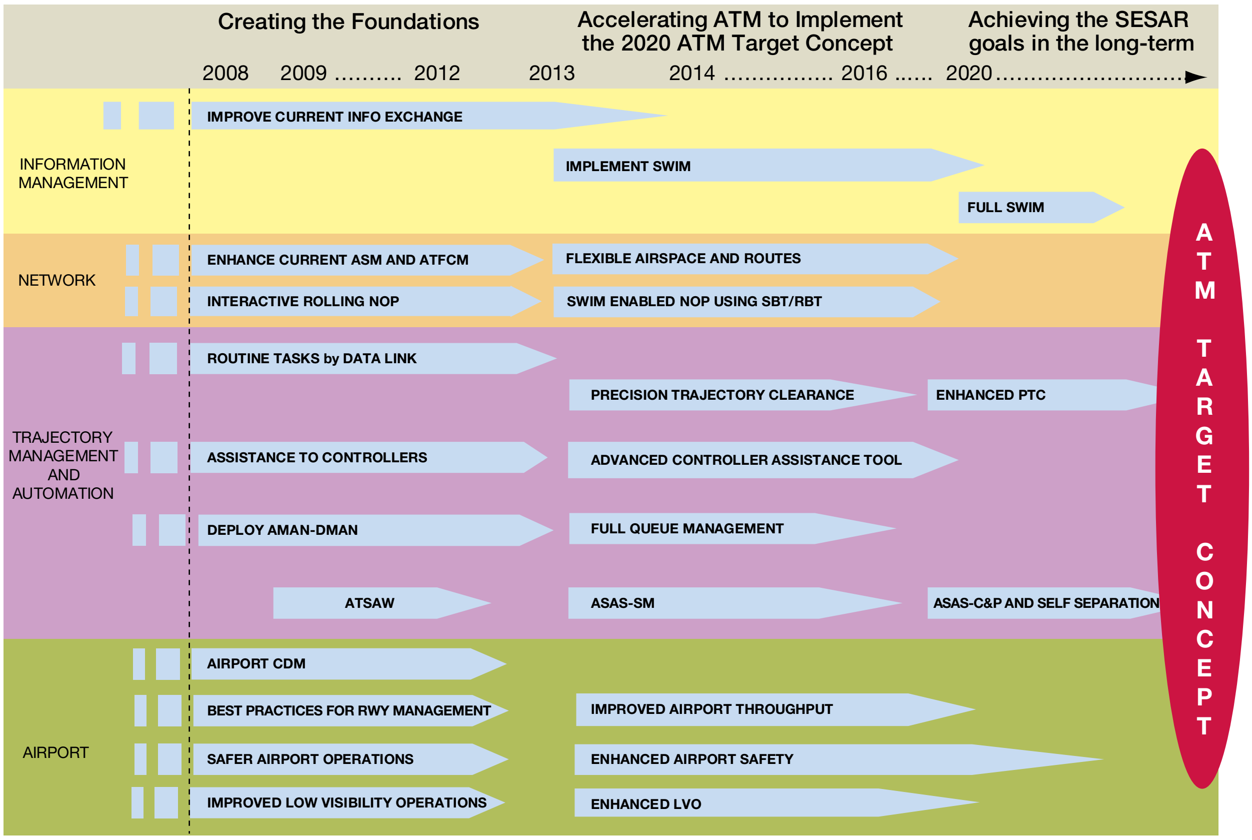


Figure 15: ATM Deployment Sequence

- Evolutionary path to a full performance based concept with measurable indicators for decision-making;
- Tight synchronisation of all stakeholders' transition planning including but not limited to Resource planning (Finance and Human); R&D plans, regulation and standardisation plans;
- Continuous development of new OI Steps to optimise overall performance;
- Major reduction of the time span between concept adoption and deployment;
- Progressive rationalisation of the European ATM ground infrastructure taking the benefit of the technological opportunities provided by the SESAR concept;
- A political solution to fund military participation must be identified.

Notwithstanding the need for these conditions to be met, the most important condition is a full, unconditional commitment from all stakeholders in the spirit of the ATM Performance Partnership.

3 Implementation Package 1 Creating the Foundations

Implementation Package (IP) 1 aims at providing the infrastructure and processes for efficient collaborative planning as well as timely decision making across the network (incl. more responsive airspace management). This IP will also implement the required interoperability between ATM partners to enable a smooth migration to trajectory-based operations, and will implement more advanced procedures and systems to raise the safety and throughput of airports/sectors to the performance targets for the period. This will be carried out in compliance with the societal need for further environmental protection, and will build on conventional modes of separation while paving the way for new methods of control. IP1 also looks at generating additional network capacity by unlocking the current latent network capacity, and will ensure that ATM operations will support sustainable growth.

The on-going ECIP/LCIP objectives support the delivery of IP1. They show that improvements can be made in a short timeframe and especially in the area of route network improvements and will contribute to the transition to the ATM Target Concept.

The supporting initiatives (e.g. DMEAN, LINK 2000+, etc.) have been already highlighted in the previous Deliverables. See Annex VII for the links between the Operational Improvements and the supporting Initiatives.

3.1 IP1 - Required Performance

The transition to the SESAR Performance framework is part of the SESAR Development phase. The novelty of many SESAR indicators and the lack of accurate baseline and prediction means lead to express IP1 indicators and targets in the current Performance Review Commission (PRC) terms.

The following quantitative targets (agreed at PRC level) are retained for the short-term period (starting from the 2006 baseline):

- Cost-effectiveness: Reduce European average En-Route real unit cost by 3% per year until 2010 and by 5% from 2011;

- Capacity:
  - En-Route – ensure by 2013, a European ATM network En-Route capacity increase between 33-38%, depending on the traffic growth;
  - Airports – for airports with 1 or 2 runways, align on best in class in each airport category[5], when demand needs it. Complex airports (with 3 or more runways) should be considered individually.

- Efficiency:
  - Average En-Route Air Traffic Flow Management (ATFM) delay/flight for the European ATM network of 1 minute/flight for the Summer season (May-October) for a period until at least 2013;
  - Average airport ATFM delay/flight for the European ATM network of 0.7 minutes/flight for the Summer season (May-October) for a period until at least 2013;
  - Reduction of the European average route extension per flight of two kilometres per year (4% of the route extension) for a period until at least 2013.

- Environmental sustainability:
  - Reduce overall emissions (e.g. CO_2, CO, HC, NO_x, SO_2 and PM10) and minimise noise nuisance; ensure that the top 50 airports in Europe have operational CDA procedures (according to internationally agreed definition and applied when traffic conditions allow), and monitor adherence to noise preferential routings.

Furthermore, for all Key Performance Areas (KPAs), IP1 improvements shall be checked against the qualitative objectives expressed in the D2 DLM [Ref 3].

5 - Best in class BIC is expressed in number of movements par busy hour. The baseline for BIC is: single runway: 60, two parallel dependent runways: 90, complex airports (more than 2 runways) are clustered in two groups: complex 1: 125 and complex 2: 100.

3.2 IP1 - Operational Improvements, Initiatives and Enablers

3.2.1 Operational Improvements and System Enablers

Figure 17 shows the main changes that will be introduced to the operations during IP1, and the supporting evolutions to the EATM architecture and technologies.

- **Group of OI steps** compatible in terms of nature of the change and their IOC date, are shown in the form of milestones (♦ **diamonds**) corresponding to their IOC date. They are presented along the Lines of Change describing the Concept of Operations (please refer to Annex III). An explanation of these groupings of OI steps is given in Annex III.
- For IP1, the implementation of some operational changes has already started in some context. They are represented with a **dotted shape**, before the start of the IP1 timeline.
- The main **system enablers** (changes to the architecture and supporting CNS technologies), contributing to the operational changes are shown in the form of **triangles** (▲) corresponding to their IOC date. **Arrows** (⟶) represent their contribution to the realisation of the operational changes. More details on system and technology enablers can be found in Chapter 6 and the full list in Annex VI. Whilst recognising the fact that one enabler can contribute to many operational improvements, only the main enablers and links are displayed. Important enablers other than system enablers are not displayed for readability.

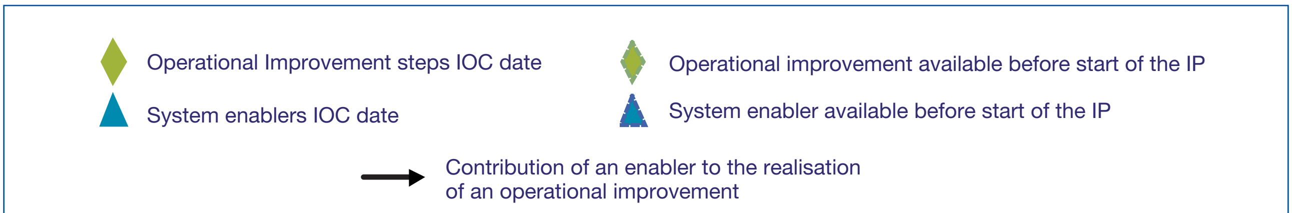
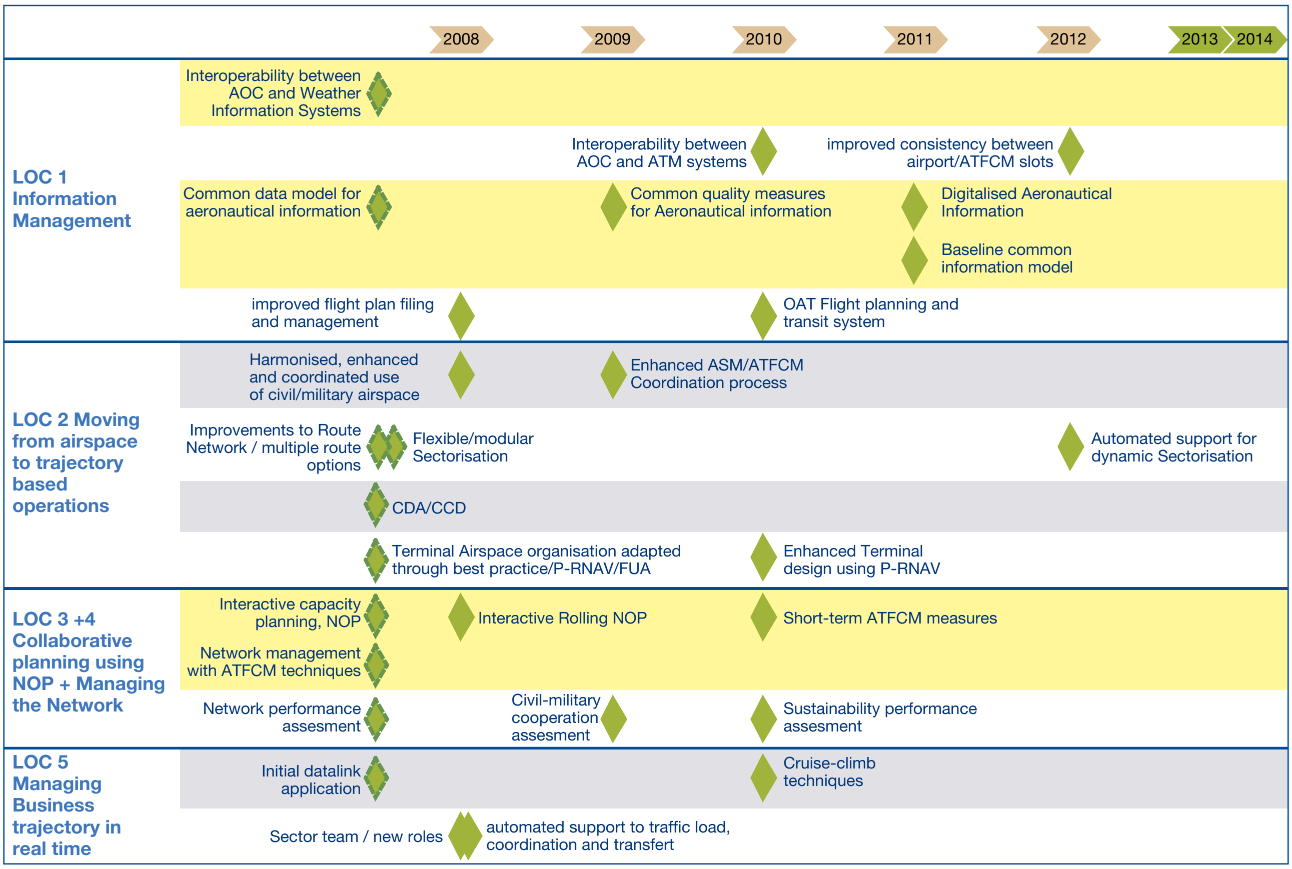


Figure 16: Legend for the IP1 Timeline Diagrams



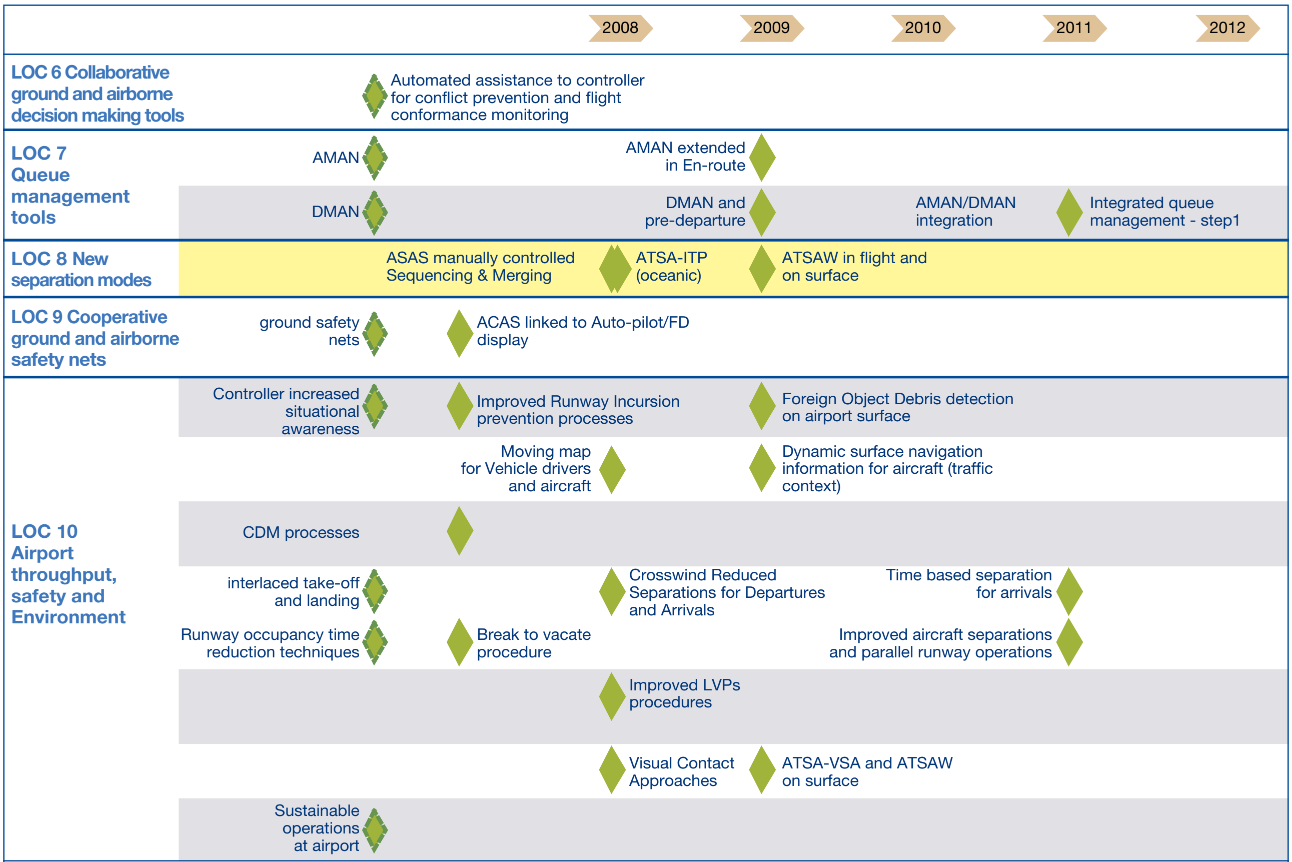


Figure 17: The IP1 Main Changes

The following sections describe the operational and associated technical enabler changes per Line of Change.

Information Management

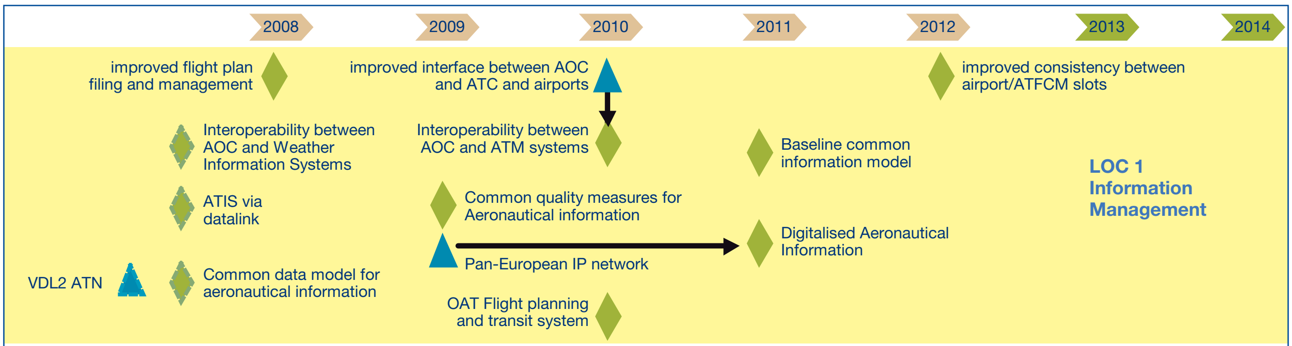


Figure 18: Information Management in IP1

The two main drivers to the evolution of Information management in IP1 are to overcome the constraints currently placed on accessibility and availability of information (e.g. the paper-based distribution of aeronautical information), and to expedite all initial improvements to prepare the introduction of SWIM in IP2.

The scope of Aeronautical Information Management (AIM) is enlarged to airport mapping and limited terrain information. Steps are taken towards the electronic distribution by the information providers of **digitalised aeronautical information** (e.g. meteorological information, eAIP), supported by common quality measures throughout the distribution chain. Around 2011, dynamic aeronautical information are disseminated in electronic form (Electronic Notice to Airmen (XNOTAM)).

The implementation of Pre-SWIM systems still using point-to-point message information exchanges improves the interoperability and the data accuracy between EATMS domains, in particular between Airline Operational Control (AOC) and other ATM partners (**Improved flight plan filling and management and Interoperability between AOC and ATM systems**). The two main initiatives are the implementation of enhanced Flight Data Processing System (FDPS) programs and the data sharing between Airspace Data Repository and AOC to support the building of flight plans.

The better alignment of CFMU slots and airport slots with flight plans improves the slot adherence and the stakeholders slot effect information (**Improved consistency between airport/ATFCM slots**).

In the interim, SWIM is being prepared through the definition of a consistent set of information models for all ATM data (**Baseline common information model**) and of the role and responsibilities of the different domains. Some unique Data Repositories (Airspace data, Air Traffic Flow and Capacity Management (ATFCM) scenarios, Demand & Capacity, static and dynamic Aeronautical and meteorological information) are made accessible through dedicated portals.

To support the pre-SWIM evolutions and to prepare the SWIM implementation, the Ground-Ground Data communication (including ground voice communication through initial Voice over Internet Protocol (VoIP)) get benefits from the deployment of the cost-effective Pan-European IP communications network backbone (PENS) and the progressive integration of national networks.

A VDL2/ATN (Aeronautical Telecommunication Network) infrastructure has already started to be deployed in continental airspace to support the IP1 data link services (e.g. Controller Pilot Data Link Communication (CPDLC)) with the mandatory equipage proposed to start in 2011 for airborne systems (forward fit) and 2013 for ground systems. To relieve the VHF communication band (118-137 MHz) congestion and to support the increase of data exchange two venues are open:

- Public telecom technology (IEEE 802.16) that can be deployed for AOC services at the aircraft parking stand. Even though other public telecom technologies may be locally used as agreed between the airspace users and airports;

- A new process for ensuring a better integrity to frequency assignment is introduced. This is a basic requirement to optimise the management of the current aviation spectrum and in particular the recent allocation to aeronautical mobile (R) services of the 112-117.95 MHz. Of particular concern is the VHF band, which in addition to supporting the air-ground datalink service, will be required to support the Ground Based Augmentation System (GBAS) services.

At the end of IP1, European ATM is ready for the more fundamental changes in Information Management to be introduced early in IP2.

Moving from Airspace to Trajectory based Operations

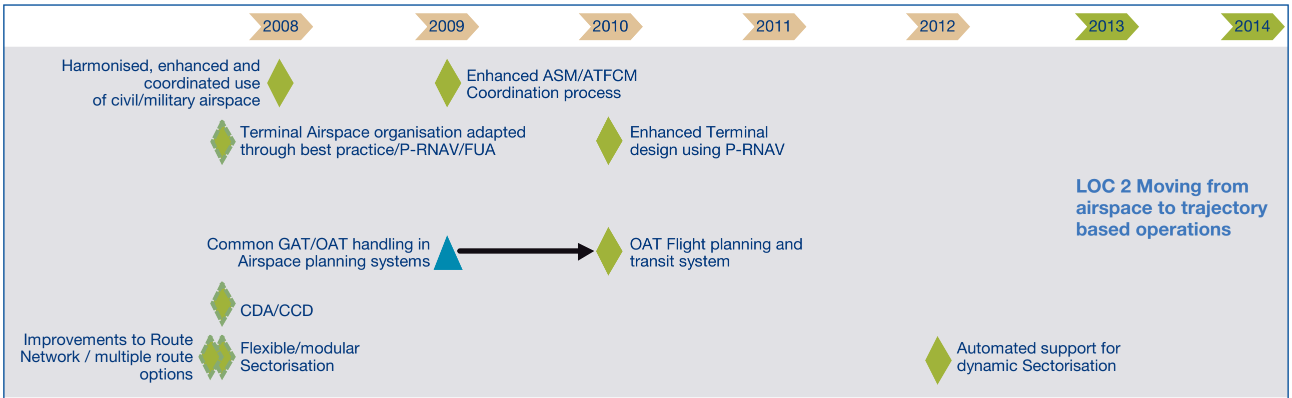


Figure 19: Moving from Airspace to Trajectory based Operations in IP1

The organisation of the European lower airspace is harmonised and its management is done on the day of Operation. Temporary Airspace Structures and Reserved Areas become more modular.

Civil/military Airspace Management Cell operations includes now Cross-Border Collaborative Airspace Planning and Enhanced Real-time Civil-Military Coordination of Airspace Utilisation with full implementation of Flexible Use of Airspace (FUA) and first application of advanced FUA (AFUA) (**Harmonised, enhanced and coordinated use of civil/military airspace**).

Collaborative processes between Civil and Military Airspace Managers and Network Management Functions continuously assess the network impact of the expected airspace allocations within the planning and execution phases (**Enhanced ASM/ATFCM coordination process**). ATFCM tools building upon more precise trajectory information allows for a more dynamic sectorisation, moving from static constraints to more dynamic constraints on the trajectories.

Continuous Descent Approach and Continuous Climb Departure (**CDA/CCD**) procedures are put in place in low traffic density situations while considering military departure/arrival procedures with their specific characteristics. Terminal Area design is improved according to the best practices and to get benefits of P-RNAV and ultimately allowing steep and curved approaches.

Military Wing Operations Centres (WOC), Military AIS offices and ANSPs apply commonly agreed procedures through harmonisation of Operational Air Traffic (OAT) rules and OAT Flight Planning. Advanced Airspace Management System (AAMS) improvements support the new tasks of Airspace Designers.

These improvements are supported by DMEAN and other coordinated ongoing initiatives.

Collaborative Planning using NOP and Managing the Network

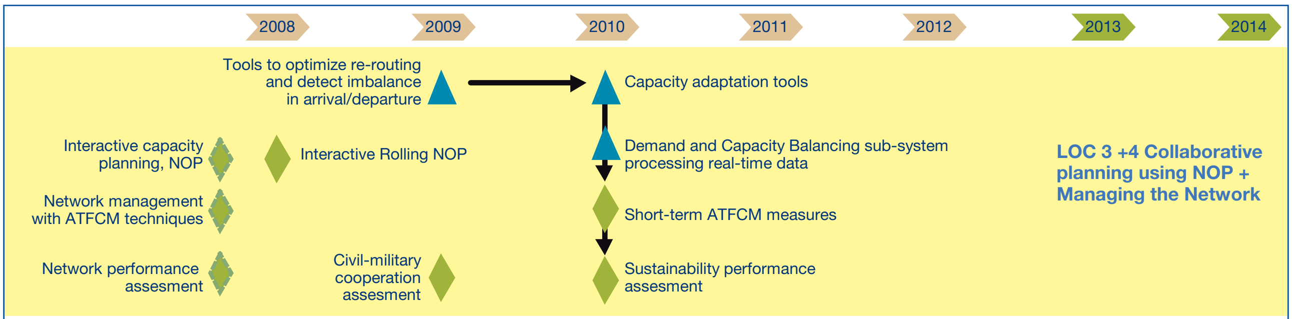


Figure 20: Collaborative Planning using NOP and Managing the Network in IP1

The Network Operation Plan (NOP) is improved in 2 steps: first the Enhanced Seasonal NOP and the **Interactive Capacity Planning** are implemented. Then an **interactive rolling NOP** is implemented which provides online information on the demand and the capacity from T0-6 months to the day of operations to all the stakeholders.

Network performance assessment is implemented in several steps including **civil/military cooperation** and **sustainability performance assessment**. It is supported by post-operation analysis tools assessing the use of Demand and Capacity Balancing (DCB) measures, monitoring abuses of the system and the performances of the NOP and the Network.

Network Information Management System (NIMS) systems in regional and sub-regional Network Units, AOC, Airports and ANSP systems are enhanced to support Collaborative Decision Making (CDM) processes such as ATFM Slot Swapping, execution when required of the predefined ATFCM Scenarios on the day of operation, in particular in cases of significant changes to airport capacity. The system improvements include new what-if, decision-making and optimisation tools, especially taking into account coordinated airports, flight schedules and airport capacity (**Network management with ATFCM techniques and Short Term ATFCM measures**).

DMEAN, ATFCM and enhanced FDPS are the main initiatives supporting these changes.

Managing Business Trajectories in real Time

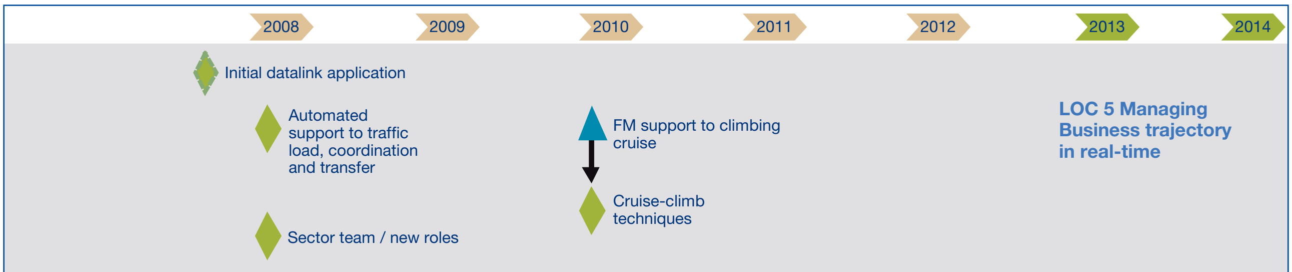


Figure 21: Managing Business Trajectories in real Time in IP1

Initial data link applications (CPDLC) are implemented through the LINK 2000+ initiative to decrease the controller and pilot routine communication tasks.

Tools are implemented or enhanced to manage **traffic load** on network nodes and to ensure **automated assistance to Controllers for Seamless Coordination** (including civil/military).

New sector team operations are defined to alleviate or smooth the task load of the Tactical Controllers benefiting from automation support tools and longer planning horizons.

Flight trajectories apply **cruise-climb techniques** supported by flight management evolution.

Collaborative Ground and Airborne Decision making Tools

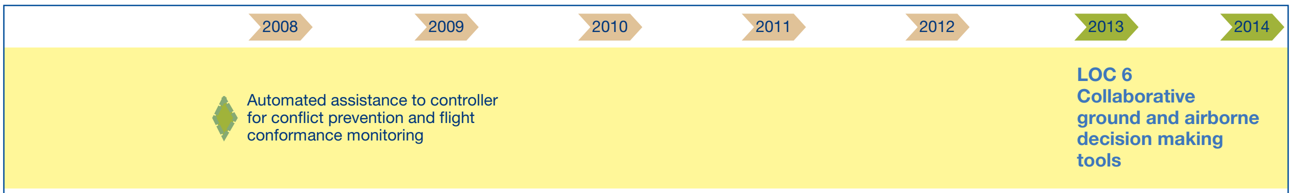


Figure 22: Collaborative Ground and Airborne Decision making Tools in IP1

Through the First ATC Support Tool Implementation (FASTI) programme, the enhanced FDPS and other initiatives, the implementation of automated **flight conformance monitoring, conflict detection** and a first level of **conflict resolution** tools provides more automation assistance to the controller.

Queue Management Tools

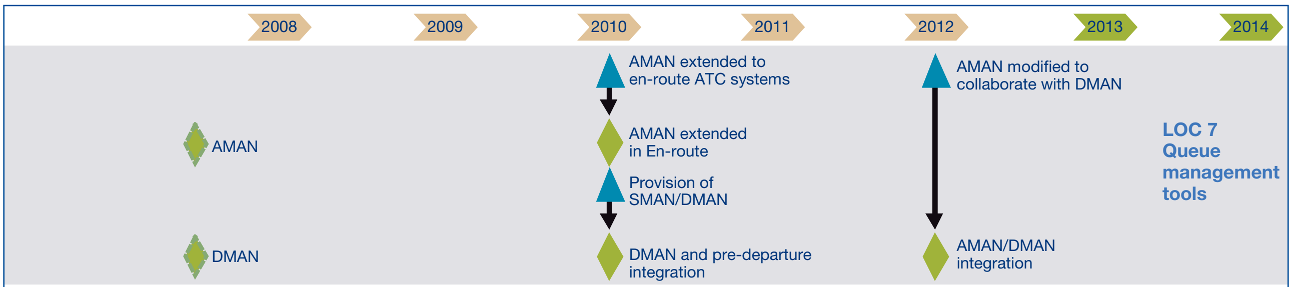


Figure 23: Queue Management Tools in IP1

Arrival Management (AMAN) tools continue to be implemented and they integrate the En-Route part of the flight (**AMAN extended in En-route**). Departure Management (DMAN) tools are implemented in airports and are then synchronised with the pre-departure sequence (**DMAN and Pre-departure**) and with AMAN (if it has been implemented on the airport) to manage mixed mode runway operations, and identify and resolve complex interacting traffic flows (**AMAN/DMAN integration**).

New Separation Modes

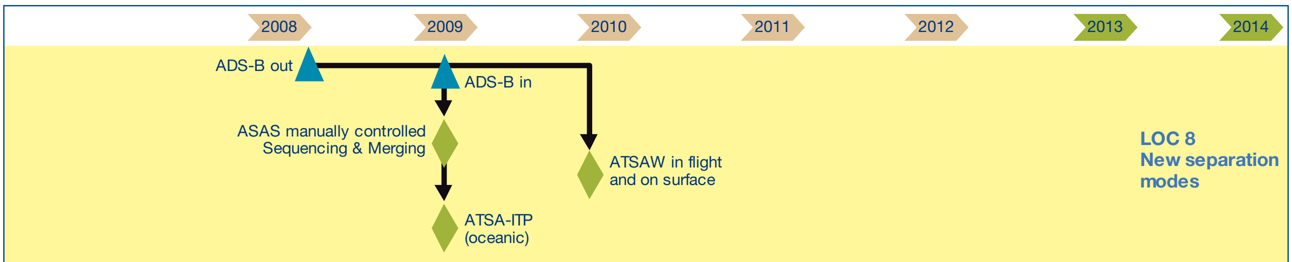


Figure 24: New Separation Modes in IP1

While the separation provision in continental En-Route airspace does not evolve, progressive implementation of the Airborne Traffic Situation Awareness (**ATSAW**) in the cockpit improves the pilot situation awareness in flight and on the ground, by displaying surrounding traffic position.

The ATM Deployment Sequence

ASAS Manually Controlled Sequencing & Merging operations start to be implemented in some TMAs, for aircraft equipped with non–integrated ASAS equipment requiring the pilot to follow the speed command manually and based upon voice exchanges between ATCO and pilots.

In-trail Procedures are implemented in Oceanic Airspace (Airborne Traffic Separation Assurance – In Trail Procedure (**ATSA-ITP**)) as another step to the deployment of ASAS applications.

1090 Extended Squitter (ES) ADS-B In/Out starts to be deployed (using the updated standard) and can be used to support Airborne Traffic Situation Awareness and manual ASAS Sequencing and Merging. Adaptation of 1090 low power GA Secondary Surveillance Radar (SSR) transponders (LPST) making light GA aircraft electronically visible is being investigated.

Airborne navigation is relying more and more upon Global Navigation Satellite System (GNSS) (Global Position System (GPS)/Aircraft Based Augmentation System (ABAS) or SBAS).

Cooperative Ground and Airborne Safety Nets

Figure 25: Cooperative Ground and Airborne Safety Nets in IP1

Ground safety nets (Short Term Conflict Alert (STCA), Area Proximity Warning (APW), Minimum Safe Altitude Warning (MSAW) and Approach Path Monitor (APM)) are improved and homogenised.

Airborne Collision Avoidance System (ACAS) is combined with Auto Pilot or Flight Director display in order to provide a vertical speed guidance using ACAS resolution advisory (automatic manoeuvre if the autopilot is on or a manual manoeuvre through flight director cues if autopilot is off).

Airport throughput Safety and Environment

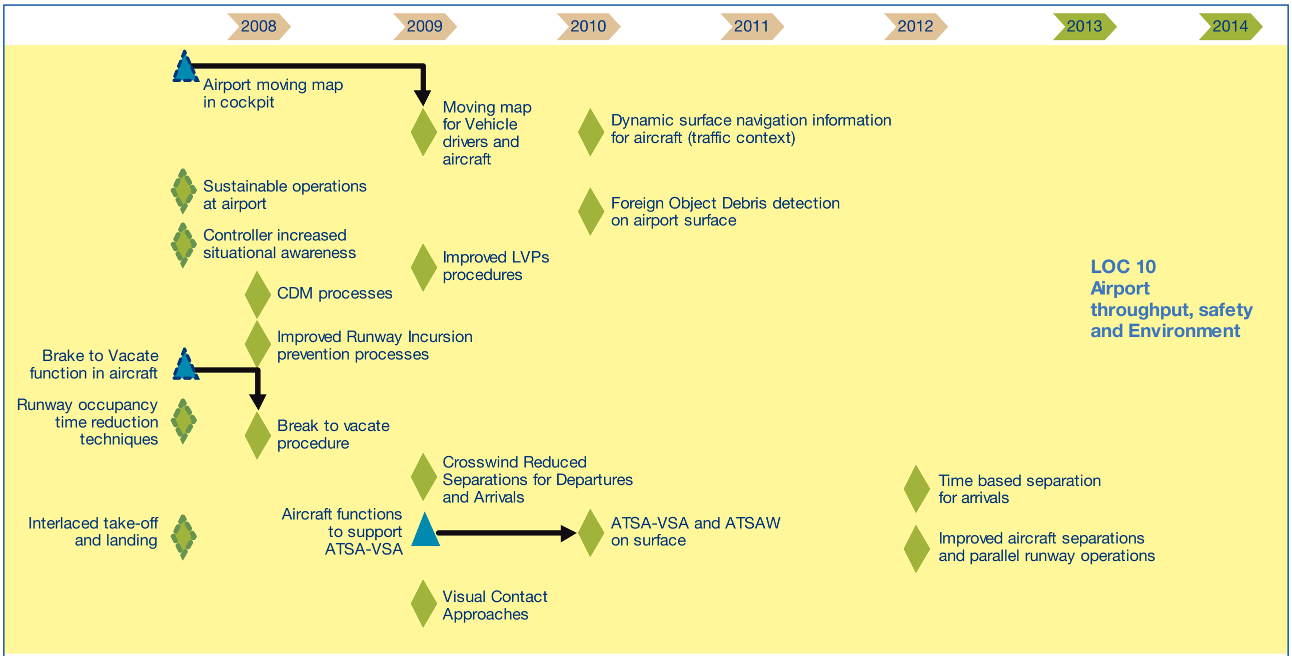


Figure 26: Airport Throughput Safety and Environment in IP1

In IP1 the efficiency and safety of Airport operations are improved by the wide implementation of current best practices. Building on the initial CDM initiatives, airport **CDM processes** are implemented and developed to increase the efficiency of airport resources. The CDM processes aim to a better management of Operations in Adverse Conditions, the Turn-Around Process, Collaborative Pre-departure Sequencing and the De-icing operations. CDM processes are also extended to integrate the Regional Airports. Aerodrome ATC sub-systems and Airport Operation Centres (APOC) are enhanced to support basic Airport CDM exchanges (Stand and Gate information). Environmental management systems and procedures are put in place in co-operation with the ATM stakeholders and the local community to ensure sustainable operations at airport.

Surface Management systems are enhanced to support detection of all mobiles and obstacles on the runway coupled to surface movement routing and alerting/resolution functions thereby resulting in an increased safety (**controller increased situation awareness**). A display in aircraft and airport vehicles shows the pilot/vehicle position (**Moving map for vehicle driver and aircraft**). The display is further enhanced in the aircraft with dynamic traffic context information including status of runways and taxiways, obstacles, route to runway or stand (**Dynamic surface navigation information to aircraft**). These improvements increase the safety of airport operations in all weather conditions. Surveillance information is provided by a combination of Multi-lateration (MLAT), ADS-B Out, and/or Surface Movement Radar (SMR) based on the safety and business case of the airport operations.

In the mean time, the Airborne Traffic Separation Assurance-enhanced Visual Separation on Approach (**ATSA-VSA**) application helps crew to maintain visual separation from the preceding aircraft, while **Air-Traffic (pilot) Situational Awareness on the surface** is improved with the implementation of moving map technologies to enhance safety and airport throughput.
Runway Management is improved by integration of improved static wake-vortex classification, decreased wake-vortex in case of cross-wind (**crosswind reduced separations of departure and arrivals**) and wind shear monitoring. This is supported by the integration of technologies developed for military applications in airport ground weather radar improving their cost effectiveness. The implementation of **time-based separation** adjusted to improved Wake-Vortex minima and **Visual contact approaches** when appropriate visual conditions are also increasing the runway throughput. The Runway Occupancy Time becomes more predictable by enhancements to operating practices of airlines and pilots (**ROT reduction techniques**) the implementation of **Brake to Vacate procedures** and wider deployment of **interlaced take-off and landings**. The implementation of specific procedures, accurate surveillance techniques and controller tools supports dependent **parallel runway operations.**

Improved Low Visibility Procedures (LVP) are collaboratively developed and are implemented at applicable airports involving in particular an harmonised application across airports and the use of optimised separation criteria.

Runway safety is improved by **Foreign Object Debris detection and runway incursion detection** procedures and tools.

To support the aforementioned improvements, Instrument Landing System (ILS) Cat 1/2/3 remains the standard for precision approach at most primary airports. Microwave Landing System (MLS) is an option for Cat 2/3 operations to be deployed on a local basis as agreed between the airspace users and airport. Depending on local needs, GBAS Cat 1 is deployed as precursor to GBAS Cat 2/3 and to support validation of precision approaches using this technology. Area Navigation (RNAV) approach procedures are based on Required Navigation Performance (RNP) APCH, APV BARO and/or APV/SBAS. Except in high latitude areas, Space/Satellite Based Augmentation System (SBAS) enables Approach with Vertical Guidance APV, and steep and curved approach operations. It is particularly interesting for some user communities (GA, rotorcraft, Business aircraft, military aircraft and some regional airlines) as it provides them access to a wider number of airports.

The biggest cost in providing precision landing is associated with the lighting. Airport surface lighting using new energy efficient Light Emitting Diode (LED) technology starts to replace incandescent lamps to complement the new landing technologies and improve environmental performance.

3.2.2 Human and Institutional Enablers

3.2.2.1 Human

3.2.2.1.1 Human Factor Enablers

Available human performance best practices have not (yet) been systematically implemented throughout all the ECAC member states, negatively impacting the achievement of the related benefits (e.g. in terms of efficiency, participation and safety). These best practices must also be extended in a balanced way to other safety related jobs and workforces (e.g. technical staff, AOC/Mil Ops planning staff, airport staff).

This quick win - which could be achieved within 5 years - requires a comprehensive communication campaign, encouraging the attendance of training courses (e.g. in human factors) and the allocation of appropriate resources to facilitate the transition and implementation of the available human performance processes, methods and tools.

It is of essence that high political commitment by individual states will be ensured to fully deploy the available products in the spirit of the SES legislation in a timely manner and to develop a common legislative and regulatory baseline. Examples of current best practices are: human machine interaction guidelines, team/crew resource management, Normal Operation Safety Survey, Human Factors Case, Critical Incident Stress Management and SENSE (EUROCONTROL Human Factor Work Programme); a comprehensive list can be found in the Work Package 1.7 DLT/D1.

Colour coding: red > 50%; orange ≤ 50% and ≥ 40%; light orange < 40% — Recruitment, Training, Competence and Staffing Enabler area (for details, see SESAR 1.7 D4 DLW)	Level of impact (Percentage of the OIs affected in IP1)	*Minimum* years timeline to start activities before IOC
Competence requirements of operational staff	32%	2
Regulations and standards	22%	5
Verification of competence	28%	7
Training	95%	2
Recruitment and Selection	9%	4
Staffing	16%	4
System design encompassing training feasibility	54%	3

Table 1: Level of impact on Recruitment, Training, Competence and Staffing Enablers in IP1

The human factors enablers considered as applicable to SESAR are reported in Annex VI.

3.2.2.1.2 Recruitment, Training, Competence and Staffing Enablers

An analysis of the impacts of IP1 for Recruitment, Training, Competence and Staffing is summarised in Table 1.

The analysis reveals that the provision of training and the development of suitable technical training infrastructure (e.g. simulation) are the key enabling activities. As IP1 mainly relates on existing or emerging initiatives, the impact of concrete OI Steps on regulations, recruitment and staffing is minor compared to IP2 & 3.

Therefore the IP1 timeline must be used to further enhance harmonisation of competence of operational ATM staff (e.g. through the implementation of ATCO regulations and finalising the emerging standards for Air Traffic Service Electronic Personnel (ATSEP) on a comparable level) across Europe. IP1 will produce a solid competence baseline to implement the more and more harmonised and interlinked systems and procedures in IP2&3. Relevant activities have already started but need to be carefully followed to ensure that eventual critical elements are managed according to the IP1 timeline.
Training development for SESAR related systems and procedures will be ideally developed in proven trans-national arrangements to provide harmonised standards and produce economical synergies. The same is valid for development and implementation of related simulation tools. For staffing implications it was found that if staffing is supposed to be affected, it is rather an increase in staffing needs for specific roles (e.g. new Environment Institutional and Procedural enablers need to be supported by appropriate competences).
In terms of resources, training delivery for all groups of affected staff across the aviation industry (i.e. 500.000 staff) is expected to consume around 11M working days (bottom up estimate assuming all staff affected by an OI Step is to be trained). However, the biggest proportion should be covered by training activities already planned. The highest training amount will result for ANSPs.

Chapter 6.3 outlines the human performance roadmap showing the high-level steps that will enable the timely implementation of all SESAR operational improvements steps.

3.2.2.1.3 Social Factors and Change Management Enablers

Social Dialogue and Participative Management are the main enablers to achieve sustainable evolutions in the SESAR Vision, as well as to reach and optimise the KPAs through various SESAR Implementation Packages. The recognition of social partners and all ATM staff groups affected by the ATM Target Concept at European Regional and National levels is to be achieved, as well as a full integration of them in all relevant working groups.
A structured change management programme, including participation and involvement of social partners and affected employees, must be in place to establish processes and procedures for the key change enablers (for details refer to WP1.7 D4-DLW [Ref 13]).
Management and staff at regional, national and local levels should reflect their specific needs and ensure a structured and coordinated participative management approach at their level.
An initial Social Dialogue and Participative Management enablers screening of OI Steps in IP1 revealed the requirement for intensifying dialogue with, and participation by, specific staff groups (APOC, ATFCM and ATCO staff), especially when moving from airspace to trajectory based operations.

3.2.2.1.4 Social Factors and Change Management Enabler Initiatives

More advanced approaches and methods for social dialogue at European, national and local levels are to be applied as soon as is possible. The following recommendations are proposed:
- It should be ensured that Social Partners (including professional associations) are involved to adequately represent all affected parties/staff achieving their full participation and contribution;
- Social Partners should create awareness, understanding and introduce a functioning Social Dialogue culture, structure and processes at all levels including local working levels;

- Social Partners at sub-regional, national and local levels should establish appropriate Social Dialogue agreements and consultation arrangements (i.e. rules of procedures) to achieve early involvement, participation and contribution of staff;
- Social Partners should promote the introduction of effective best practices in conducting the Social Dialogue for Management and staff.

In the frame of an established, well-managed and structured change management programme to oversee and drive forward the IP1 implementation:
- The EC and EUROCONTROL should engage European Social Partners and professional staff in the change programme;
- The EUROCONTROL Agency should develop harmonised advisory material to support the effective implementation of changes in compliance with existing European Civil Aviation legislation and safety regulatory requirements for change management ensuring commonality.

3.2.2.2 Institutional

3.2.2.2.1 Standardisation

The activities related to the development of standards for IP1 are of two categories:
- Global or regional implementation for which formal standards are required;
- Local improvements (for which no technical standards may be required). These will serve as a learning & collection process out of which stakeholders can draw material to initiate the development of global and/or regional standards.

The majority of operational improvements targeted for IP1 deployment rely on currently available and recognized aviation standards and procedures. The completion of the remaining standards for IP1 must be further expedited by standardisation bodies in particular through enhanced coordination between EUROCAE and RTCA working group (such as the ones set up in the Datalink and/or ADS-B areas).

Details of all the standardisation activities can be found in [Ref 21] and main aspects are captured in chapter 6.8.

3.2.2.2.2 Environment

The operational improvements identified for IP1 have to be supported by an evolution of the institutional framework in the area of Environmental Sustainability. The institutional enablers required in the short-term are:
- Monitoring of environmental performance, enabling the assessment of the effectiveness of the management strategies implemented;
- Guidance for stakeholder environmental management/quality systems: ATM stakeholders shall adopt a sustainability policy supported by an appropriate environmental management system to facilitate standard setting, monitoring and continuous improvement;
- Routine application of commonly agreed and transparent impact assessment methods with a socio-enviro-economic scope: A framework detailing commonly agreed assessment methods is required to support unbiased monitoring and assessment of sustainability impacts (including indicators and metrics).

3.2.2.2.3 Security

During IP1, consideration of the security aspects related to the OIs and their enablers will draw on and build upon on-going activities that are considered to be “best practice”. Current initiatives related to security measures for Information and Communications Technology, Risk Assessment Methodology and for Threat Assessment are fully supported. Initiatives to develop a Security Management plan and to support all relevant stakeholders in meeting recent regulations (e.g. EC Regulation 2096/2005). Pragmatic approaches taken in the context of on-going activities and working groups (e.g. the recently established ATM Security Team, EUROCAE WG72 and NATO/EUROCONTROL ATM Security Coordinating Group (NEASCOG)) are supported.

However, to fulfil the aim of creating an effective security management system for the future, the following specific improvements need to be progressed in the short-term:
- Creation of a Trusted Security Partnership Framework and accompanying Regulations:
  - International Security Regulations shall be specified at European Level by 2012;
  - The specification of a Security Management System and associated Management Plan, supported by today’s on-going initiatives, shall be mature by 2010 and used thereafter, evolving as necessary based upon experience gained;
  - The specification of a Security Incident Information Exchange regime shall be mature by 2010 and ready for deployment by 2012;
  - A Risk Assessment Methodology, already being addressed by on-going initiatives, shall be complete by 2010;
  - A standardised Identity Access Management & Staff Vetting regime shall be specified for the Identification Access Management by 2010 and ready for implementation by 2012.

- Implementation of a Security Service for ATM:
  - A Collaborative Decision Making process for Security shall be specified by 2010 and ready for implementation by 2012;
  - Collaborative Security Support for ATM Incidents shall be specified by 2012.

By implementing the above a sound basis will be laid for what will be needed during IP2. Chapter 6.6 provides a summary overview of these activities in the form of a security evolution roadmap.

3.2.2.2.4 Decision-Making

Although SESAR has previously highlighted the need for changes in the institutional decision-making process, particularly in terms of the length of time it can take for decisions to be taken, it must be accepted that there is no prospect of any significant process change happening in time to apply to IP1. IP1 will therefore have to be implemented using the current process model which can include several or all of ATM stakeholders.

It is clear that in many areas the timescales to implement the IP1 improvements are already tight. It is therefore essential that the SESAR Master Plan be endorsed at the highest political level as soon as possible following its publication in early 2008. This is anticipated as being at the June or September Transport Council meeting.

3.2.2.2.5 Legislation

The proposals made for the future SESAR ATM Target Concept to treat the airborne and ground-based systems as one and to take a service-oriented approach to the design of the future ATM System's Architecture impact Annex 1 of the SES Interoperability Regulation 552/2004 as currently written. It currently divides the ATM System into distinct sub-systems for legal purposes and will need to be aligned with the SESAR Reference Architecture once this is available. This will then allow optimal development of implementing rules & technical systems and facilitate the verification of compliance with the regulatory requirements.

All IP1 target elements must be in place before 2013 if the SESAR timescales are to be met. Taking a pragmatic view, any legislation required to compel compliance with SESAR's proposed developments should be in place several years before the end of this period to allow time for implementation. As it takes at least 3 years to develop EU legislation such as Implementing Rules, work must start on any necessary additional legislation by early 2009 at the latest.

In addition to the above, European-level legislative activity will need to focus on supporting the early requirements of SWIM. Information supply and management is so fundamental to SESAR that stakeholders' compliance cannot be left to a voluntary basis, since harmonised implementation timescales must be achieved to realise the anticipated network-wide benefits which rely on it. However, it seems unlikely that all the longer-term issues will have been identified and resolved during the IP1 timeframe. Thus, the legislation necessary to successfully implement the information management improvements will have to be put in place on a phased basis across IP1 to IP3; assumed to be through a series of Implementing Rules. (Note that legislation covering requirements for Information Management is expected to deal with information provision, transfer and access, not simply the technical interoperability issues of the SWIM physical network.).

Past experience suggests that the proposed harmonisation of Airspace Classifications below FL195 will involve both European and National legislation.

Finally, documents with legal standing which will need to be developed during IP1 (though not strictly legislation) are the inter-State agreements necessary to permit cross-border airspace planning on a formal basis and will be further reviewed in the context of European airspace regulation developments.

3.2.2.2.6 Safety Regulation

In order to ensure that the global ATM system is acceptably safe, a range of organisations and institutions has been set up to develop legislation, regulation, common standards and procedures for ATM. These organisations function (amongst other things) as the current safety regulatory framework for ATM. Whilst the deficiencies (including fragmentation and inconsistent applications) identified in D1 [Ref 4] and the HLG report [Ref 32] are being addressed, this safety regulatory framework provides a workable basis for the changes envisaged to be implemented in the time-frame of IP1.

No drastic changes in the level of implementation are expected in the timeframe of IP1 within the current understanding of ATM, but the following activities are fully supported:

- European Safety Programme;
- European Action Plan for the Prevention of Runway Incursions (EAPPRI);
- European Action Plan for the Prevention of Level Bust (EAPPLB).

3.3 IP1 - Assessments

The scope of the ATM changes arising in IP2 and IP3 require the SJU to have both clear processes for safety management and for an appropriate safety regulatory interface to be established. These activities must be initiated in the IP1 time frame in order to reduce project risk.

3.3.1 Performance Assessment

The IP1 initiatives were assessed as responding to the performance targets retained for the short term (Capacity, Efficiency, Flexibility, Predictability and Environmental Sustainability) provided that all of these initiatives are fully implemented:

Initiatives	Estimated capacity improvement (%)	Reference
DMEAN (incl. capacity planning, improved FUA, airspace design improvements, data sharing, ASM/ATFCM processes, traffic forecast, OAT Harmonisation, airport integration into the network, etc).	18-20	SAAM studies based on the AAS deployment contribution DMEAN implementation required for full AAS benefits DMEAN MUAC Case Study ATFM Independent Study
ATFCM	5-10	
LINK 2000+	4 (25% flights equipped in 2013)	Link 2000+ CBA Local capacity plans
Advanced FDPS/FASTI/Mode S	4-6	Local capacity plans

Table 2: Network Level Capacity Improvements provided by the Initiatives

- **Airspace performance**
  The table below indicates the individual contributions of various initiatives (estimated prior to launching the initiatives[6]) to this capacity growth requirement. The contributions are consolidated at the network level on the basis of the local plans and the full implementation of the network initiatives.

The capacity estimations above are based on simulations at network level (in what concerns the contributions of DMEAN-related projects and the ATFCM Evolution Plan) and on input from ANSPs, through their local capacity plans, in what concerns technology improvements.

The evaluations above indicate that the full implementation of the initiatives selected for the short-term has the potential to increase the En-Route capacity of the European ATM system by 31-40%, between 2006-2013. This capacity increase is in line with the target (i.e. 33-38%).

The airspace development plans have the potential to further improve the flight efficiency performance of the European ATM network, if fully implemented, as follows:

- o Air Traffic System (ATS) Route Network ARN V5 – Savings in the order of 110,000 km/day (source ARN V5 Report);
- o ATS Route Network ARN V6 – Savings in the order of 75,000 km/day (source ARN V6 Catalogue);
- o Full AAS deployment – Savings in the order of 55,000 km/day (source RNDSG Material);
- o Flight efficiency scenarios – (depending on scenarios agreed) Savings in the order of 30,000-35,000 km/day (source EUROCONTROL Route Network Development Sub-Group (RNDSG) Material).

The improvement expected represents a flight inefficiency reduction of approximately 25% over 5 years.

- **Airport performance**
  With respect to airport initiatives, the Airport airside Capacity Enhancement (ACE) exercises (collection of best practices) already conducted at a number of medium/large airports have the potential to improve runway utilisation, thereby unlocking latent capacity, eventually increasing runway throughput (up to +20%, depending upon infrastructure configuration). An appropriate implementation of ACE initiatives offer the possibility to gain approximately 4,500 to 5,000 minutes per day (while the daily airport ATFM delay/day could reach by 2013 approximately 35,000-40,000 minutes) which in conjunction with other initiatives (such as Airport CDM, TMA2000+ or RNAV in Terminal Manoeuvring Area (TMA) should be considered as major airport capacity enhancement enabler. Airports operating close to their "best-in-class" capacities will not benefit of similar capacity increases.

This shows that the measures envisaged at the European airports could accommodate the expected traffic growth within the targets set.

- **Environmental sustainability**
  Significant environmental savings have been achieved to date. They continue through the daily operations of the European ATM network. The Reduced Vertical Surveillance Minima (RVSM) operations save up to 310 KTonnes of fuel annually. The Flexible Use of Airspace concept already saves about 120 KTonnes of fuel every year. Air Traffic Flow Management principles and measures avoid the unnecessary consumption of a further 300 KTonnes of fuel every year.

The total environmental benefits generated as a result of the new actions foreseen in IP1 to improve flight efficiency could incrementally further reduce fuel consumption by 40-50 KTonnes per year, equivalent to almost 125-155 KTonnes of CO_2.

6 - The reference material can be found in the T323 DLT [Ref 21].

In addition, the impact of the SESAR improved processes will also reduce ground delays, and at a typical major hub airport this could ideally remove 44% of ground emissions. Assuming that the average ground idle fuel burn was 35kg per aircraft, this amounts to a reduction of approximately 30 KTonnes of CO_2 on the sample of 35,700 departures that were analysed. While the specific saving would be dependent on the fleet mix and local characteristics of the airport, the overall Airport benefits are considerable and of the same order of magnitude, Europe wide, as the potential en-route savings.

It should also be noted that the development of curved and steep approaches will allow a drastic reduction of noise nuisance to airport local communities.

- **Cost-effectiveness**

  IP1 cost effectiveness was assessed from two views:

  - "gate to gate ATM ANS cost effectiveness" Key Performance Indicator (KPI) (CEF-2)[7], defined in D2.

    The assessment of this KPI was done for IP1 using the generic cost effectiveness analysis model developed during D4 for the financial planning (see also Annex V).

    This model uses mainly the historical dependencies identified between, on one side the "ATCO on duty" costs and the "investment costs", and on the other side the other cost categories (other staff costs, operating costs, depreciation…). It derives these costs through a set of iterations starting from a "business as usual" scenario, and then adding the costs of the SESAR improvements (R&D, validation, training, operations…) and deducting associated benefits. Main benefit contributor is the "ATCO productivity" developments for ACC and Approach/Tower (APP/TWR), which are assessed together with the capacity improvements in these areas.

    The "business as usual scenario" has been prepared by expert judgment plus diverse sources like ACE reports. It shows a development as forecasted by Performance Review Unit (PRU) until 2010 with a turn up afterwards due to increase complexity in (inter) sectors management[8].

    IP1 ATCO productivity for "En-Route" and "TMA/APP" improvements were assessed in relation with associated capacities developments (note: methodology is described in detail in chapter 4.3.3).

    IP1 ANSP costs elements (investment, operation, etc.) were assessed on the basis of OI steps and the associated enablers. Assessments results are shown below:

  - En-Route cost effectiveness per PRC/PRU KPI[9]

    At this stage, based on the forecast provided by the ECAC States and ANSPs to EUROCONTROL Central Route Charge Office (CRCO), the consolidation of the cost-effectiveness trends at European ATM network level indicates that the real En-Route unit cost per kilometre at European level is forecast to reach 0.64 EUR_{2005}/km in 2011 (from 0.76 EUR_{2005}/km in 2005), representing a decrease of 15% compared to 2005 (or 2.7% on yearly average). The gradual implementation of Functional Airspace Blocks, the exploitation of synergies between ANSPs and the co-ordination of initiatives at European level have the potential to bring further cost-effectiveness improvements and to close the gap between the forecast and the target set.

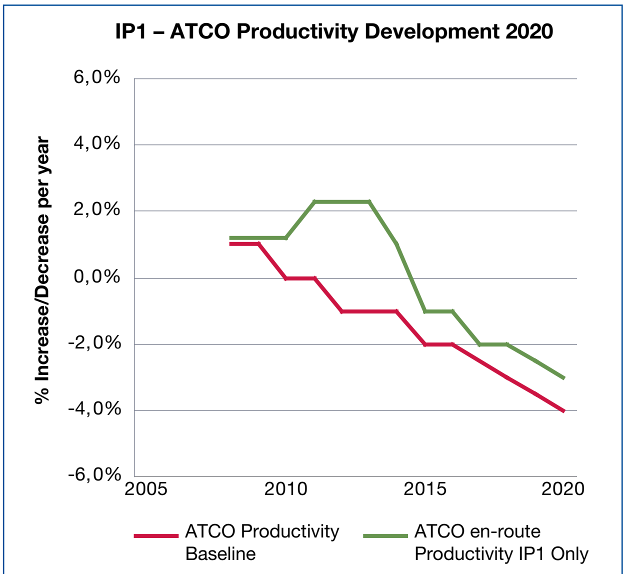


Figure 27: ATCO Productivity Development IP1

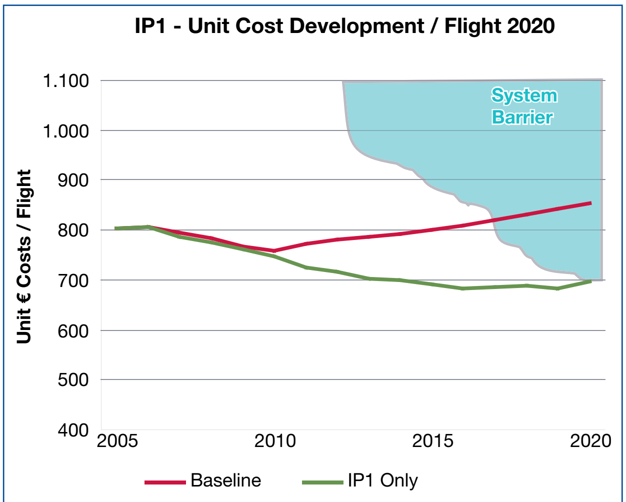


Figure 28: Unit Costs Development/Flight IP1

7 - Detailed analysis of OI steps and IP made during D4 confirmed the D3 statement that CEF-1 KPI assessment was not necessary, since in CEF-1 « Airspace users and Airport costs are considered only to the extent of any increased role in ATM with respect to the 2004 reference ».

8 - This extrapolation of the development of the 2010 baseline might become theoretical when the barrier of the current system is reached.

9 - Note: these Cost Effectiveness improvements are only for En-Route while the SESAR CEF KPI is for Gate to Gate and cannot be easily compared.

3.3.2 Financial Affordability Assessment

- **Benefit** – Figure 29 displays the division of the quantified monetary benefits resulting from the performance assessment on an IP1 deployment presented in chapter 3.3.1. This total of €7.7Bn is the result of the potential to significantly increase the QOS (reduction of delays and fuel-inefficiency, improved predictability[10]) and reduction in Air Navigation Service (ANS) charges. Together with these improvements capacity will still grow to fully accommodate the 2012 traffic.

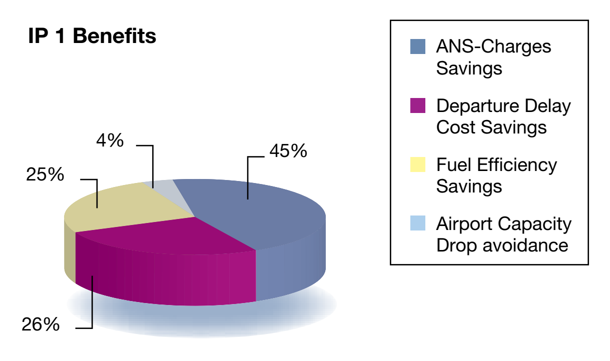


Figure 29 : Summary of IP1 Operational Benefits

ANSP cost savings are computed from the Gate-to-Gate ANSP cost effectiveness development (CEF2 KPI) for IP1 as shown in chapter 3.3.1, complemented by an assessment of how it would develop after 2013 if no further improvements were made.

- **Costs** – IP1 unit cost development includes the necessary investment costs in ANSP[11] systems, which amount in total to €2.6Bn (see Table 3). The Airports airside investments of around €0.3Bn are not considered as a major factor to influence the total user charges (note: they exclude Runway and associated infrastructure costs).

IP1 investments	Pre-implementation Bn€	Implementation Bn€
ANSP	0.2	2.4
Airports	0.04	0.26

Table 3: IP1 ANSP & Airport Investment Cost

Avionics civil airlines investments for IP1 have been split in two sets; the so called "structural" avionics package is the one which is necessary to equip the full (100%) fleet (for scheduled airlines the number of aircraft considered is: 9500) for meeting the performance targets, while the "incidental package" is tailored to the specific needs for a specific category of airspace users or a specific operational local environment.

IP1 "Structural" avionics package includes:
- Navigation (Runway incursion);
- Communications (ADS-B in/out, CPDLC).

IP1 Avionics investments	Structural Bn€	Incidental Bn€
Scheduled Legacy Low Fares Regionals Charters	1.76	0.3
BA	0.5	0.13
GA	0	0
MIL Transports Lights Fighters	2.22	2.48

Table 4: IP1 Avionics Investment Cost

IP1 "Incidental" avionics package includes (retrofit%/forward-fit%):
- SBAS: Major (10%/30%), Regional/Low fares (0%/50%), Business (60%/100%);
- GBAS Cat1: Major (10%/20%), Regional/Low fares (20%), Business (0%/20%).

Annex V provides a detailed description of cost synthesis.

- **Cost Benefit Analysis**
  A Cost Benefit Analysis (CBA) is generally made to support the decision-making. For IP1, CBAs have already been performed at the level of the individual improvements (i.e. Data link Implementing Rules, CDM, DMEAN, Cascade, etc.), nevertheless a CBA at the level of the whole IP1 was performed for the civil "scheduled airlines" to provide a consolidated result.

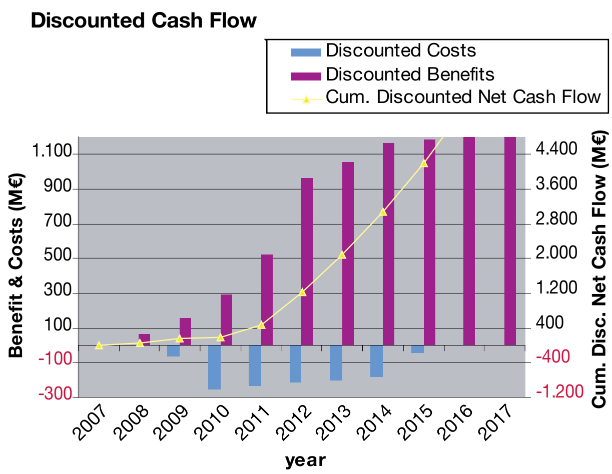


Figure 30: IP1 CBA

10 - Regarding the predictability only the potential to reduce the airport capacity drop under low visibility conditions has been assessed.
11 - ANSP and Airport costs represent the total investment costs for implementation of the enablers associated to the IP.

The CBA, performed using the methodology described in Annex V, indicates a benefit to cost ratio (6.7) and a NPV[12] (€6.6Bn) computed over a 11 years period. While this is encouraging for the airlines, the influence of their investment is rather marginal.

The most significant contributor to the benefits being the ANS unit cost savings, reinforces the need for the ANSP's to pursue the cost effectiveness and to commit to the investment to synchronise the supporting associated operational improvement steps.

3.4 IP1 - Conclusions & Risks

IP1 is mainly characterised by the current ongoing European ATM initiatives that contribute to the ATM Target Concept defined in D3. The performance assessment of IP1 implementation has led to the preliminary results (in comparison to the year 2005) of approximately:

- 31- 40% increase of En-Route capacity;
- 20% increase in the overall runway capacity;
- Additional 125-155 KTonnes per year less CO_2;
- Significant cost savings of 0.7 - 1.1 Billion €/year for scheduled airlines.

Along with the **SESAR Consortium**, all European ATM stakeholders must fully commit to the timely and effective implementation of activities identified in IP1 to ensure the expected improvements. It will also ensure the baseline for IP2 deployment.

The major risks associated with IP1 are therefore considered to be:

- Failure to implement the selected Operational Improvement steps due to lack of implementation commitment/time/management – the initiatives selected represent a clear step towards improving the performance of the European ATM network; this cohesive package of initiatives must be deployed in a co-ordinated way to deliver the expected benefits;

  - o Mitigation actions (pre-requisites):
    - – All European ATM stakeholders must fully commit to the timely and effective implementation. Strong management and coordinated planning at European ATM network level with the aim to deliver and ensure the best use of European airspace capacity and resource effectiveness;
    - – Decisions must be made to avoid divergent implementation, where separate initiatives address common aspects, which impact the overall expected network benefit, provide just limited short term benefits or represent a duplication of effort;
    - – Have a consolidated and coherent management of the initiatives, to ensure a coordinated delivery of common and consistent benefits. It is vital that all European ATM actors receive timely and relevant training to ensure that they have the required skills and competencies to implement IP1;
    - – Appropriate and effective enforcement mechanisms e.g. IRs or directives under the framework of the SES regulation package.

- Failure to implement the SESAR Performance Framework due to inconsistent performance monitoring – the production of all the additional data needed for performance monitoring should be designed in as an integral part of the future Trajectory Management function. It is stressed that this is essential for the transition from the current performance framework to the full SESAR D2 performance framework;
  - o Mitigation action: Definition and integration of SESAR performance framework requirements while developing the future Trajectory Management function.

- Risk that maximising benefits of individual short term initiatives might prevent most direct transition towards the Target Concept;
  - o Mitigation action: Ensure that the initiatives remain focused to the SESAR Target Concept.

IP1 will still require R&D work; however, this will largely be final validation and development of previous R&D work. Nevertheless focus must remain on completing these items during the early stage of the SJU work so as to ensure the timely success of IP1.

12 - Discounted to year 2007

4 Implementation Package 2 Accelerating ATM to Implement the 2020 Target Concept

The Implementation Package 2 aims to implement the fundamental changes of the SESAR ATM Target Concept with the introduction of an information rich and information sharing environment with SWIM and of the trajectory management while improving network management and Airports/Terminal Area Operations. These changes will deliver the necessary improved efficiency of the ATM network as a whole.

4.1 IP2 - Required Performance

The targets for 2020 have been initially defined in D2 [Ref 3]. They are expressed with indicators defined in D2. During D3, clarification and assessment activities have led to improve D2 definitions and to refine and better explain some targets. The current status is given in [Ref 24]. The objectives and targets can be summarised as follows:

- Cost-effectiveness: half the European average direct ATM gate-to-gate cost to from the year 2005 reference value (800€/flight);

- Capacity:
  - o The European ATM network to accommodate by 2020 a 73% increase in traffic, based on the Long term Forecast high scenario established in 2004 [Ref 27], while improving the Quality of Service (QoS) (efficiency, predictability and flexibility);
  - o Airport capacity – For airports with 1 or 2 runways, uplift the best in class performance to the D2 targets (hourly rates in Visual Meteorological Conditions and Instrument Meteorological Conditions), when demand needs it. Complex airports (with 3 or more runways) should be looked at individually.

- Quality of Service:
  - o Efficiency:
    - – Fuel efficiency: remove the current inefficiencies as much as possible, seeking to meeting the D2 targets, considering the trade-off with capacity and other QoS indicators;
    - – Time efficiency: ensure on-time operations, seeking to meet the D2 targets, considering the trade-off with capacity and other QoS indicators.
  - o Predictability:
    - – Ensure on time arrival;
    - – Reduce variability of operation times;
    - – Reduce the impact of disruption in the ATM network.
  - o Flexibility: accept short notice change made to the demand in controlled circumstances (frequency, notification delay, military operational circumstances).
    - – Environmental Sustainability target for CO_2 is linked to the efficiency target. All objectives related to the Environment Management process are still applicable, even if quantitative targets for 2020 are not set in D2;
    - – Safety level has to be kept commensurate with the improvement made in operational performance, to ensure that no degradation occurs.

Furthermore, for all KPA, IP2 improvements shall be checked against the qualitative objectives expressed in the SESAR Performance Objectives and Targets [Ref 24].

4.2 IP2 - Operational Improvements and Enablers

4.2.1 Operational Improvements and System Enablers

Figure 32 shows the main changes that will be introduced to the operations during IP2, and the supporting evolutions to the EATM architecture and technologies.

- **Group of OI steps** compatible in terms of nature of the change and their IOC date, are shown in the form of milestones (♦ **diamonds**) corresponding to their IOC date. They are presented along the Lines of Change describing the Concept of Operations (Please refer to Annex III). An explanation of these groupings of OI steps is given in Annex III.
- The main **system enablers** (changes to the architecture and supporting CNS technologies), contributing to the operational changes are shown in the form of **triangles** (▲) corresponding to their IOC date. **Arrows** (⟶) represent their contribution to the realisation of the operational changes. More details on system and technology enablers can be found in Chapter 6 and the full list in Annex VI. Whilst recognising the fact that one enabler can contribute to many operational improvements, only the main enablers and links are displayed. Important enablers other than system enablers are not displayed for readability.
- Some system enablers are already implemented to support IP1. They are represented with a **dotted shape**, before the start of the IP2 timeline. On the other hand, some system enabler are first introduced during the IP1 period, but support only IP2 OI steps and are presented with the solid shape.

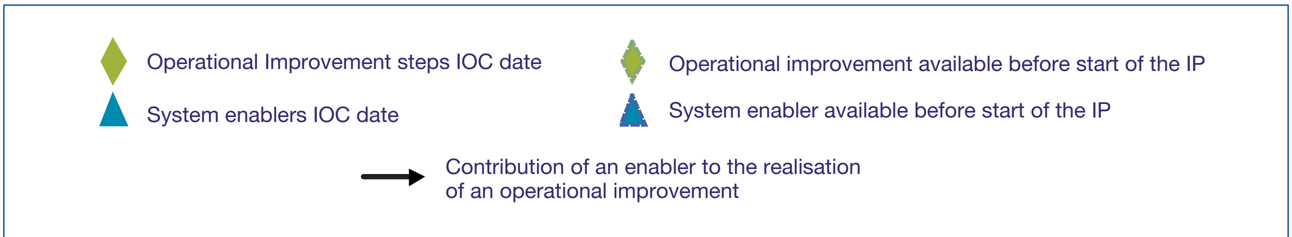
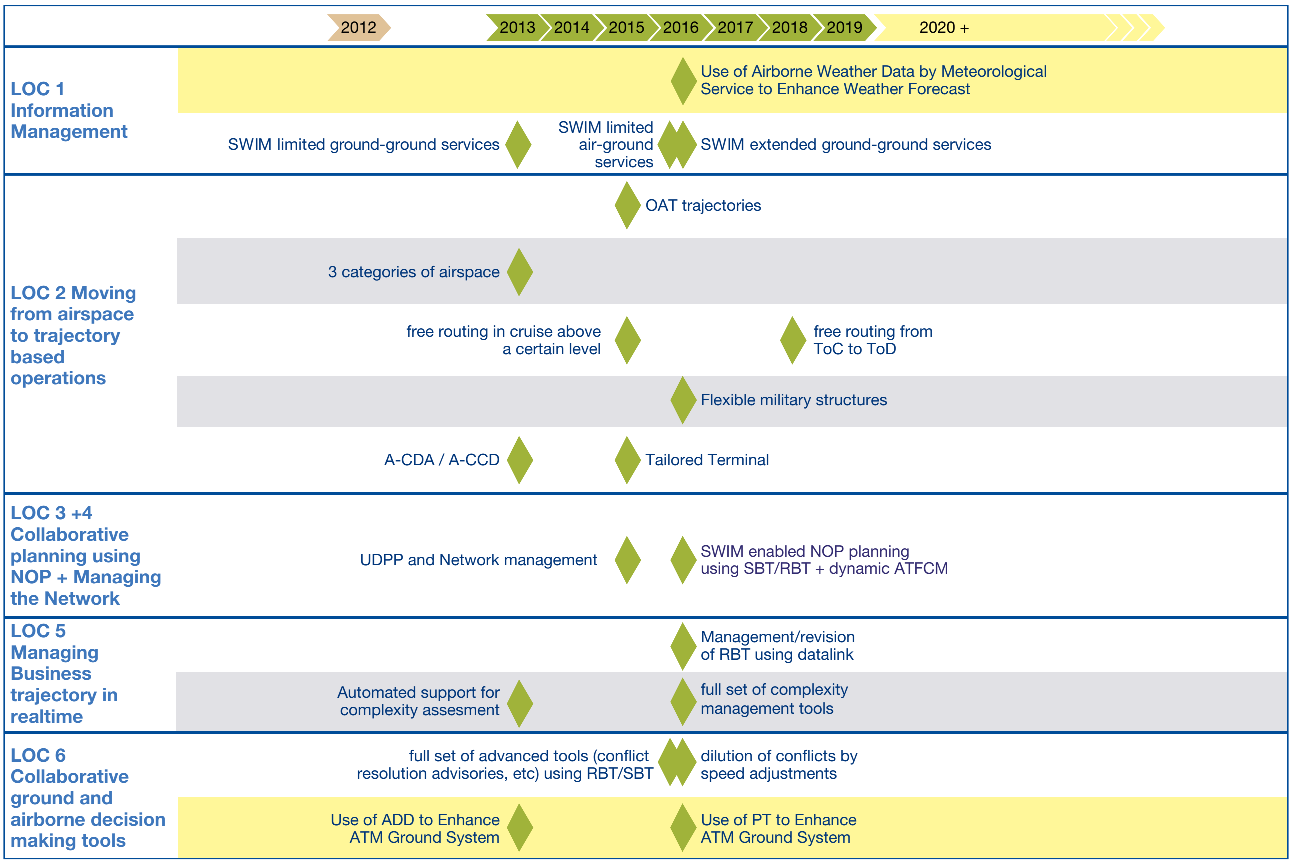


Figure 31: Legend for the IP2 Timeline Diagrams



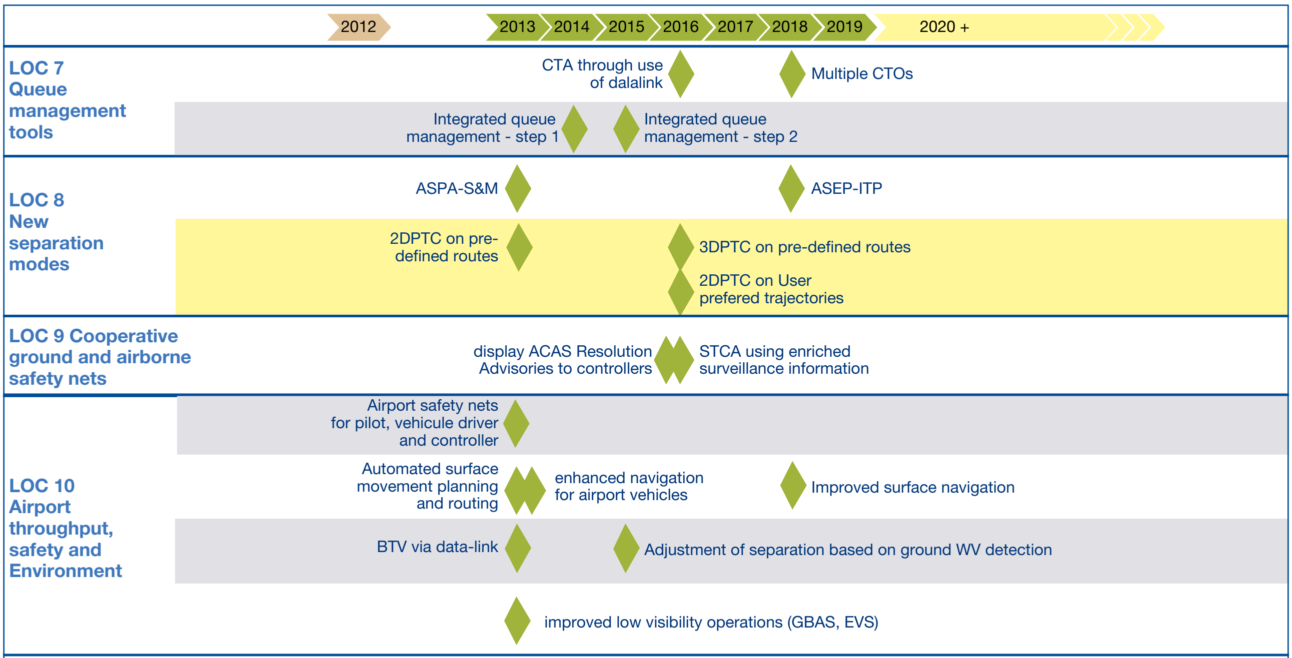


Figure 32: IP2 Main Changes

The following sections describe the operational and associated technical enabler changes per Line of Change.

Information Management

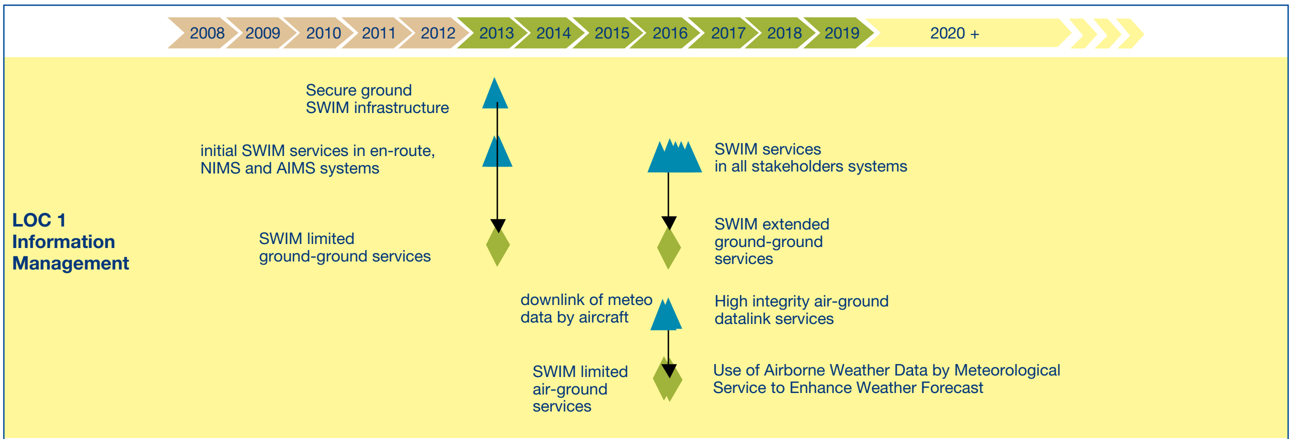


Figure 33: Information Management in IP2

The goal of the Information Management improvements in IP2 is to implement System Wide Information Management (SWIM), both from an infrastructure point of view and from a service point of view, as SWIM is the key enabler to trajectory management.

SWIM is implemented along the following steps:

- **SWIM – Limited Ground-Ground services** (2013). The initial SWIM services in ACCs and Network (NIMS) support the sharing of meteorological, aeronautical and surveillance information and first set of flight information (planned and executed trajectories information and aircraft derived information in their current implementation);

  Basic SWIM services provided through an Interoperability (IOP) middleware are made available and integrated within each existing EATMS system. New roles for SWIM technical and operational management (including security requirements like access management) are defined at local, sub-regional and regional levels and at stakeholders system level. SWIM uses the Ground-Ground European IP based data transport network deployed through the Pan-European Network (PENS) initiative;

- **SWIM – Extended Ground-Ground services** (2016). The second stage of SWIM Ground-Ground services implementation supports information sharing for the planning services related to the NOP, flight information services supporting exchanges of Shared Business Trajectory (SBT) and Referenced Business/Mission Trajectory (RBT), Airspace data (Terrain and Obstacle data, Airspace static and dynamic data). All systems migrate over time to using the SWIM mechanisms to access or to provide information, and new services are added as required. In consequence, all SESAR partners have access to the most up-to-date information according to their requirements;

- **SWIM – Limited Air-Ground services** (2016). With this step, the aircraft is connected to the SWIM infrastructure through an Air Ground Data Link (AGDL) ground dedicated system (one single or one per FAB) that interfaces with the various data-link network infrastructures. It allows to uplink the appropriate up-to-date information (trajectory revisions and constraints) and to publish 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). The Air-Ground data links supporting the Air-Ground limited services are:
  - o The VDL2/ATN to support continental ATS services. The use of the limited VDL2 resources by these services and by other services need to be managed carefully (see Chapter 6.2);
  - o Link 16 (or any other future military data link) for equipped military aircraft, to exchange information with ATM systems using ground based military gateways/interfaces[13];
  - o New WIMAX[14] air ground mobile links for airport surface operations providing ATS and AOC Services (reducing the use of VHF Digital Link (VDL) Mode 2 and Aircraft Communications Addressing and Reporting System (ACARS) VHF resources).

Moving from Airspace to Trajectory based Operations

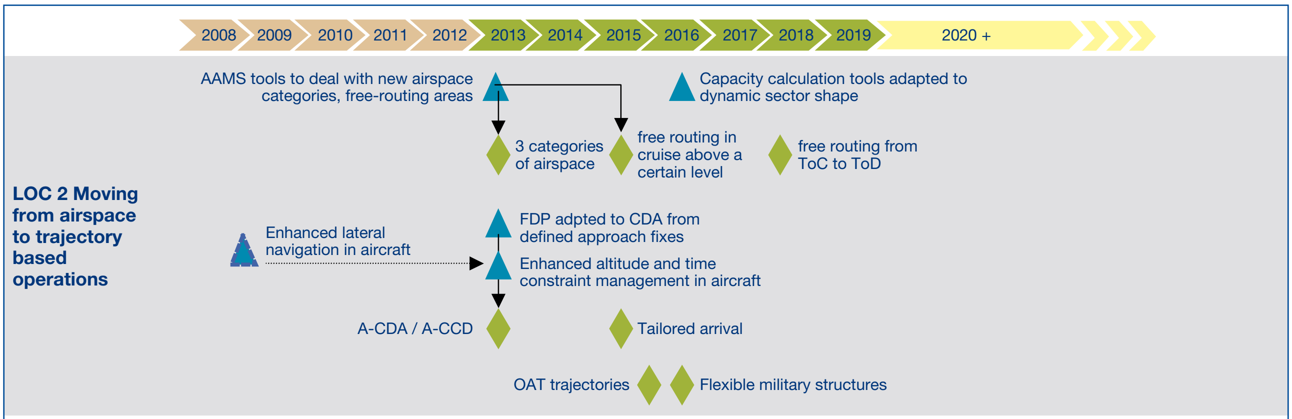


Figure 34: Moving from Airspace to Trajectory based Operations in IP2

The European airspace organisation is simplified into only **three categories**[15]. Free routing is made available for Airspace users in 2 steps (flight in **cruise above a certain level** in large airspace areas – typically FAB, and then **from Top Of Climb to Top Of Descent**). **Flexible military structures** give airspace designers the ability to delineate ad-hoc structures at short notice to respond to short-term airspace users' requirements. Flight Data Processing (FDP) systems are updated to support dynamically configurable airspace.

Civil/military Airspace Management Cells are organised at sub-regional level improving co-ordination with Network Management Units. AAMS integrates new airspace design and management tools supporting flexible military structures and the impact of free routing. NIMS sub-systems (in charge of flight planning, capacity planning, scenario management, demand & capacity balancing) are also adapted to allow further flexible adaptation of capacity to the traffic demand.

Advanced CDA and Advanced CCD (**A-CDA/A-CCD**) allow CDA and CCD operations to be used in higher density TMAs, with the introduction of 3D trajectory management and new controller tools. As a result of the trials performed in IP1, **tailored arrival** are then implemented allowing aircrafts to follow an efficient path. The constraints are defined and uplinked by the ANSP based on the aircraft parameters and the traffic situation and the fine trajectory is computed by the aircraft.

13 - Subject to further studies proving that ATM requirements can be met without compromising the security of the highly sensitive military data.
14 - A form of long range WiFI, based on IEEE 802.16
15 - The current airspace categories are replaced by a new model consisting of 3 airspace categories (N, K and U) where: N (standing for iNtendend traffic environment) and U are the ConOps finaL categories (N being the ConOps Managed and U the Unmanaged) and K is a category, which will then disappear. K stands for Known Traffic Environment within which all traffic is known to ATS either with position only or with flight intentions as well.

Collaborative Planning using NOP and Managing the Network

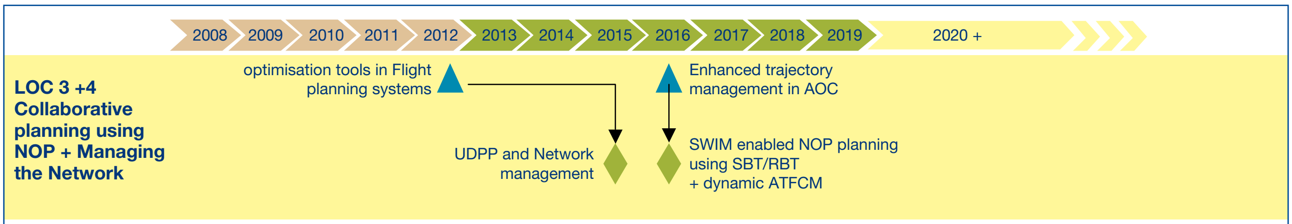


Figure 35: Collaborative Planning using NOP and Managing the Network in IP2

The planning process occurs in a collaborative manner among all the ATM partners. The conventional flight planning process and tools are complemented by the development and publication by airspace users of a Shared Business/Mission Trajectory (SBT) made widely available for ATM planning purposes to authorised users subject to appropriate subscription mechanisms.

Through holistic view of the **Network Operations Plan, Network users access and update via SWIM** the capacity, the demand on the system and the strategy taken by Network Management to maintain its stability and efficiency. The airspace user is able to define the Reference Business/Mission Trajectory 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.

Airspace users can use flight-planning tools to define and optimise route including assessment of the network impact. Pre-defined scenarios (including military scenarios) or scenario elaborated/adapted on short-notice are supported by collaborative computer-aided tools to ensure a high level of flexibility and responsiveness in adapting the capacity to the civil and military business needs.

Sub-regional Network Management Units are in charge of sub-regional network capacity planning measures to take advantage of capacity opportunities or to mitigate capacity shortfalls through dynamic ATFCM. In the event of insufficient capacity, **User Driven Prioritisation Process (UDPP)** can now be applied defining prioritisation as the result of a collaborative process involving all partners. Regional Network Management Unit is responsible of the overall network stability.

Managing Business/Mission Trajectory in Real Time

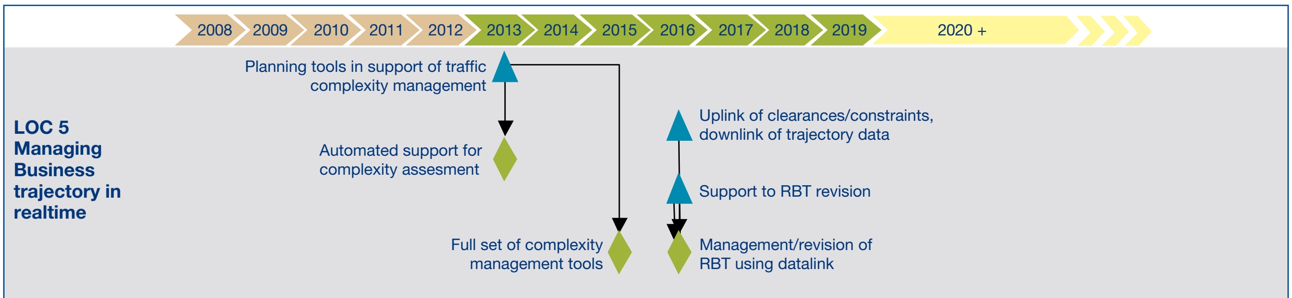


Figure 36: Managing Business/Mission Trajectory in Real Time in IP2

Central to the improvements in IP2, longer term planning and the greater use of tools assist the controllers in identifying needed changes of Business/Mission trajectory before they become time critical, at least in the En-Route. The current tactical actions in TMA evolve with the introduction of 3 Dimensional-Precision Trajectory Clearance (3D-PTC) techniques (see also the section "New separation modes" on the next pages of this document).

The **management of the Reference Business/Mission Trajectory** during the flight allows for more innovative ways of handling traffic as it is shared and kept up to date by all stakeholders. Controller's clearances are sent to the pilot by data-link for the successive segments of the Reference Business/Mission Trajectory along the flight progress (including taxi route).

The SESAR ConOps is based on the notion of user trajectory ownership and the operating principle of managing flights using constraints where necessary, the basis of which is that ATC issues ATM constraints and the individual airspace user is responsible for the way in which compliance is managed.

The airspace user (and pilot) is automatically informed of ATM constraints so that the pilot can alter the trajectory to conform. In some circumstances (e.g. taxi route instructions) these may take the form of trajectory change proposals. Flight Crew/aircraft system flies the agreed RBT. Aircraft, Aircraft operators and control centres systems' architecture is adapted to support the management of RBT.

Thanks to the improvement of the traffic information and to the availability of improved weather information, the **traffic complexity is assessed** in real-time with greater accuracy informing controller about forthcoming complex situation. In a second step, new tools support the Controller to solve complex situations, enabling tailored actions to be taken provide greater smoothing and traffic balancing even across several sectors or centres (**full set of complexity management tools**).

Collaborative Ground and Airborne Decision-making Tools

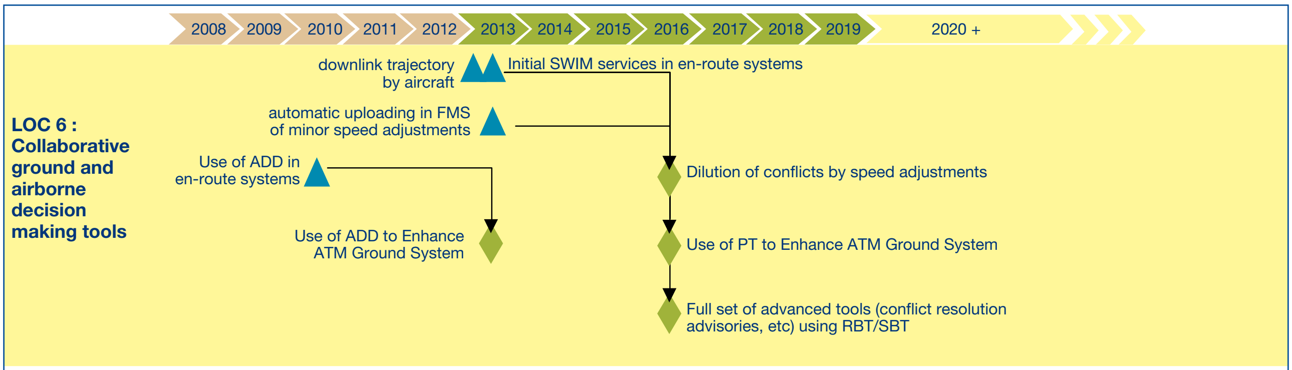


Figure 37: Collaborative Ground and Airborne Decision-making Tools in IP2

The trajectory information accuracy is augmented in 2 steps: initially by increased use of the Aircraft Derived Data (**Use of ADD to enhance ATM ground system**) and then by direct use of the aircraft predicted trajectory (**Use of PT to enhance ATM ground system**).

Based on this improved prediction and extensive use of the RBT, **a full set of advanced tools** is deployed contributing to the task load reduction at sector level but still keeping the controller in the decision-making loop. The tools encompass conflict resolution providing resolution advisories, intent and improved conformance monitoring and support coordination free transfer of control. These tools are common to En-Route and TMA. In TMA, automated controller tools play an increasing role in the provision of conflict-free routes, based on the use of available trajectory data. The role of the Executive Controller develops from high tactical content towards conformance monitoring, except for military controllers due to the specific nature of the military air operations.

In En-Route, Cooperative air/ground tools and new data link services enable minor adjustments to be made to an aircraft's speed in order to "dissolve" potential conflicts (**dilution of conflicts by speed adjustment**).

Queue Management Tools

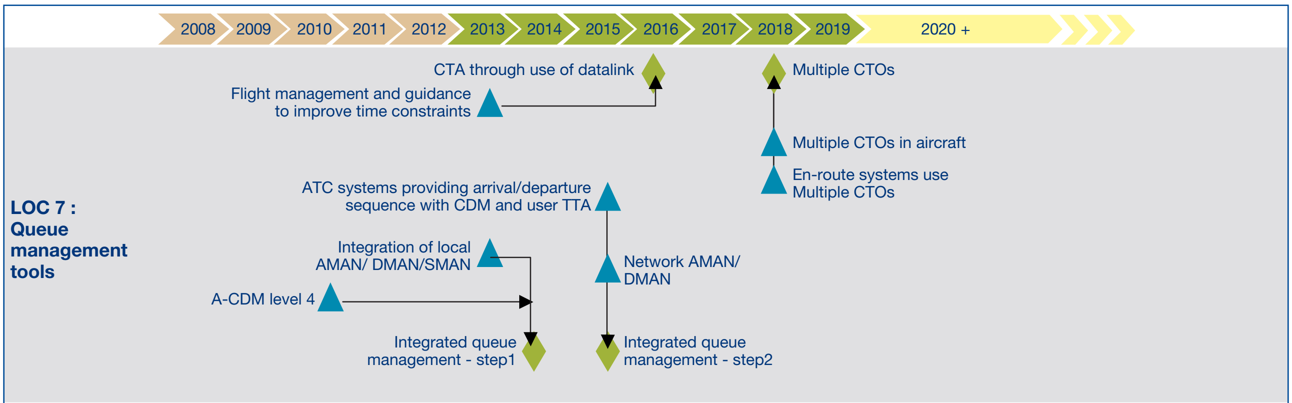


Figure 38: Queue Management Tools in IP2

The integration of arrival management, departure management and airport surface management systems produces a more stable arrival sequence through the identification of surface constraints. The management of surface constraints is performed through a CDM processes between airport operator, aircraft operators and air traffic service provider at the same airport (integrated queue management step 1). In a second step, integrated AMAN and DMAN are adapted to take into account the flows to/from multiple airports in high traffic density areas (integrated queue management step 2).

Time constraints on specific points (En-Route – CTOs, arrival – CTAs) are computed if required by the ground systems on the basis of the estimated times provided by the airspace users and transmitted to the aircraft which then automatically will manage them (CTA through use of data link and Multiple CTOs).

New Separation Modes

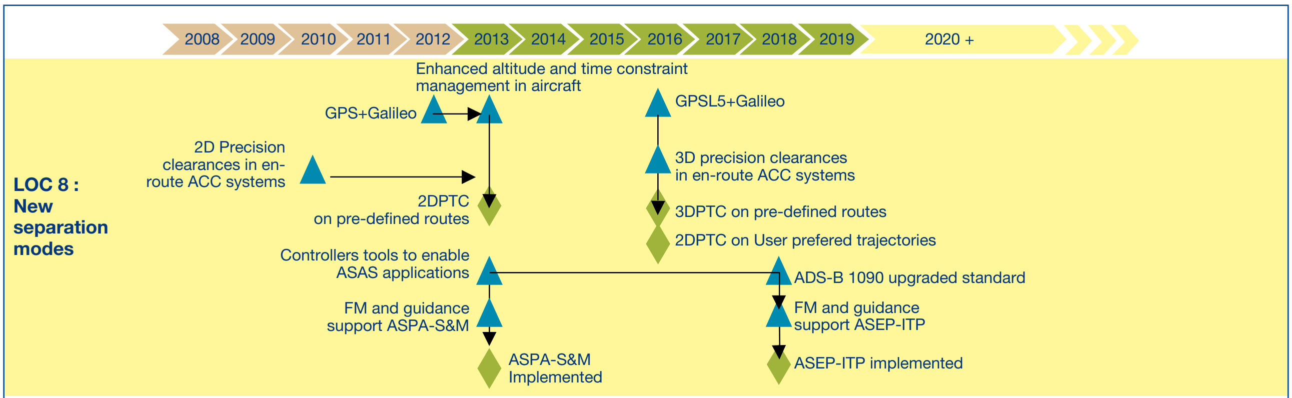


Figure 39: New Separation Modes in IP2

Although managing all trajectories in 4D, Flight Data Processing systems and architecture and Controller tools enhancement are gradually implemented to manage the clearances and the constraints to aircraft systems, in order to handle:

- Precision Trajectory Clearances on 2 Dimensions: **2D-PTC based on pre-defined 2D Routes** in a first step and then **2D-PTC on User preferred trajectories**;
- Precision Trajectory Clearances on 3 Dimensions: **3D-PTC on pre-defined 3D Routes only**.

Enhancements to arrival sequencing are introduced through the use of ASAS in its Sequencing and Merging application (Airborne Spacing Sequencing and Merging (**ASPA-S&M**)) with a full Flight Management System (FMS) integrated solution assisting the pilot. The flight crew ensures a time or distance based spacing from designated aircraft as stipulated in new controller instructions for aircraft spacing. The separation application In-Trail Procedure (**ASEP-ITP**) is implemented for use En-Route in an oceanic environment as a further step toward ASAS application deployment.

1090 ES ADS-B In/Out is now deployed to support the introduction of these ASAS applications. An upgrade to the standards may be required to support initial separation applications such as ITP. ADS-B out is mandated in Europe.

GNSS becomes the principal navigation enabler to support the navigation performance required by the Precision Trajectory Clearance.

Independent cooperative Ground and Airborne Safety Nets

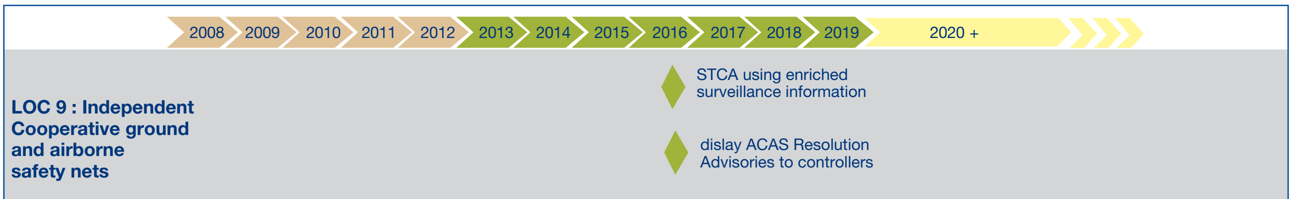


Figure 40: Independent cooperative Ground and Airborne Safety Nets in IP2

If necessary, the Airborne Collision Avoidance function is adapted to the new separation mode.

Controllers are automatically informed when Airborne Collision Avoidance System (ACAS) generates a Resolution Advisory (RA) to complement the voice report. Aircraft systems architecture and dedicated controllers tools (workstation) are adapted to take advantage of all available information to improve the performance of safety nets but remaining robust against missing or erroneous information (SCTA using enriched surveillance information).

Airport Throughput, Safety and Environment

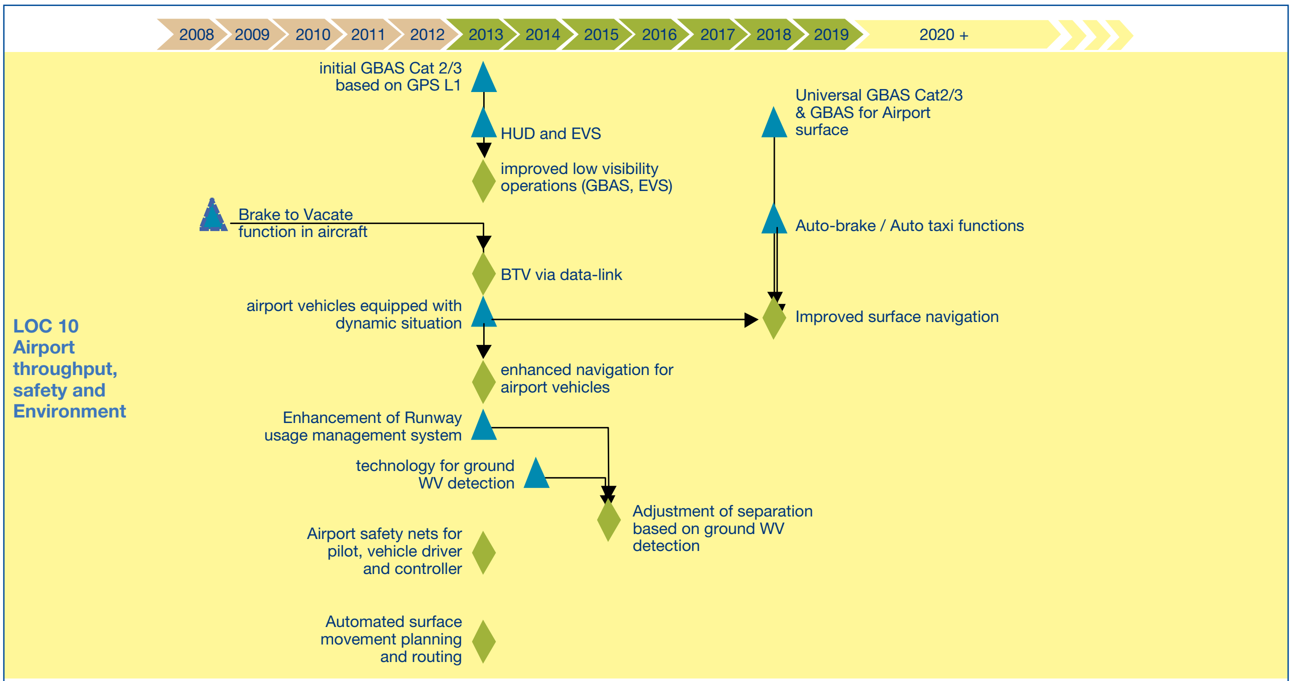


Figure 41: Airport Throughput, Safety and Environment in IP2

Automated Assistance to Controller for **Surface Movement Planning and Routing** is implemented and decreases the uncertainties on taxi-times. Combined with Queue management tools and airport CDM processes, this improves the efficiency and predictability of the sequence.

Enhanced navigation for airport vehicles: The system displays in airport vehicles dynamic traffic context information including status of runways and taxiways, obstacles, and an airport moving map, as well as traffic information, contributing to safety in particular in low visibility conditions.

Airport safety nets: The airport safety nets detect potential conflicts and 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 (depending on the complexity of resolution possibilities). The systems also alert the controller in case of unauthorised/unidentified traffic. These systems combined with ad hoc operational procedures are essential to enhance safety of airport surface operations.

Improved Low Visibility Operations: With the combined use of signals from different constellations (e.g. Galileo and GPS), GNSS allows large aircraft and most GA aircraft to achieve APV (LPV) or reach reduced RNP 0.x approach capability (at least RNP 0.1). In low visibility conditions, the introduction of satellite-based precision approaches supported by initial GBAS Cat 2/3 avoids the existing constraints associated with the ILS protection areas and could increase the runway throughput. Obstacle clearance rules need to be revised to ensure that the full capacity increase is achieved. These operations are first based on GPS L1. Dual constellation GNSS receivers bringing further navigation performance (accuracy, continuity and integrity) enable more universal deployment of GBAS Cat 2/3.

Surface navigation based on GBAS (using enhanced positioning based on Galileo/GPS L5) enables the aircraft to navigate autonomously on the ground to the gate **(Improved surface navigation**).

Positional awareness is improved through the application of visual enhancement technologies (new sensors such as infrared camera on Head Up Displays) thereby reducing the difficulties of transition from instrument to visual flight operations.

New airport lighting based on LED technology is deployed. In addition to the environmental contribution, the dynamic colour control capabilities can be used to support enhancements to surface movement safety.

The introduction of a negotiated contract for use of a specific runway exit (e.g. **brake to vacate via data-link** at a pre-selected runway exit coordinated with ground ATC through data-link) contributes to increase runway throughput and support full 4D ground trajectory management.

Adjustment of separation based on Wake Vortex detection: Runway throughput is further enhanced with the introduction of such techniques as separation based on real-time wake vortex detection.

4.2.2 Human and Institutional Enablers

4.2.2.1 Human

4.2.2.1.1 Human Factors Enablers

Also for IP2 it is strongly recommended to carry out a Human Factors Case for each OI-step. For IP2 the same 7 human factors enablers have been defined as for IP1 (see also Chapter 3.2.2.1.1). The following process ought to be added for IP2:

Human Performance Certification of integrated Air-Ground Systems

To increase capacity and efficiency, advanced automation will support or may even take over specific human tasks. Therefore the situational awareness of controllers, ATSEPs and pilots is very likely to change. As a consequence, human operators need to be supported by back-up functions and procedures (e.g. secondary automation) in case primary automation is degraded or fails completely. In addition, in SESAR ATM functions will be more distributed between ground and airborne systems, and this distribution can even change dynamically over time (e.g. ASAS). Airborne and ground systems will therefore become more interdependent than they are now. In order to properly deal with the subsequent legal liability issues, the current certification process for airborne systems should be extended to include ground systems with a special emphasis on air/ground integration. Human Performance aspects should be explicitly addressed in the certification process as crucial topics for the realisation of benefits. Relevant activities should start in 2008 to be completed by 2015.

4.2.2.1.2 Recruitment, Training, Competence and Staffing Enablers

An analysis of the impacts of IP2 for Recruitment, Training, Competence and Staffing (RCTS) is summarised in Table 5.

The analysis reveals that the provision of training and the development of system design, encompassing training feasibility, are essential activities. In addition, analysis reveals that, compared to IP1, more OIs require intense enabling activities in the RCTS area.

IP2 will already result in completely new roles and responsibilities. A concentration of activities will be around the establishment of the comprehensive SWIM and CDM network, resulting in a high requirement for interdisciplinary training and an enhancement of competence verification due to the sensitivity and safety criticality of the information shared and exchanged. Additionally the increased automation support of the core ATC roles will result in many training and competence verification requirements and enhanced simulation facilities. The more automation tools will be implemented for ground roles, the higher the need for refresher and degraded mode training will be. The increased need to certify ground systems will have high impacts on competence and staffing requirements for technical staff throughout the system. The staffing needs for specifically ATCOs is expected to no longer increase in the IP2 timeline, for technical and planning staff, an increase due to new roles could result from the implementation.

Training delivery for all groups of affected staff is expected to consume around 9 millions working days in IP2 (bottom up estimate assuming all staff affected by an OIs is to be trained). Also in IP2 the highest training amount will result for ANSPs staff.

Colour coding	Percentage of affected OIs
(red)	> 50%
(orange)	≤ 50% and ≥ 40%
(light orange)	< 40%

Recruitment, Training, Competence and Staffing Enabler area (for details, see SESAR 1.7 D4 DLW)	Level of impact (Percentage of the OIs affected in IP2)	***Minimum*** years timeline to start activities before IOC
Competence requirements of operational staff	48%	2
Regulations and standards	44%	7
Verification of competence	59%	7
Training	100%	2
Recruitment and Selection	13%	5
Staffing	27%	5
System design encompassing training feasibility	86%	4

Table 5: Level of impact on Recruitment, Training, Competence and Staffing (RTCS) Enablers in IP2

Chapter 6.3 outlines how an aligned, OIs related Training management enabling a timely and harmonised implementation will be set up.

4.2.2.1.3 Social Factors and Change Management Enablers

The evolution towards the SESAR Vision in IP2 requires a successful transition towards a strategic and regulatory framework for change management. The impacts on social issues to be examined and resolved and change management initiatives to be established and resolved remain to play a key role. They should become a fundamental part for each of LoC foreseen in IP2.

Impacts on social issues to be resolved and Change management initiatives to be established are relevant to the same areas described in IP1 (Ref chapter 3.2.2.1.3).

4.2.2.1.4 Social Factors and Change Management Enabler Initiatives

The effectiveness and impacts of established Social Dialogue cultures, practices and participative processes should be further investigated, with a view to enable their monitoring and their contribution to KPAs as well as to the overall performance and safety.

Cultural differences in the area of Social Dialogue, the implementation of Changes and their structures exist. The complexity and wide variety of working practices, differences between ATM systems, infrastructures, organisational structures and cultures are pertinent. They need to be addressed through strategic initiatives including R&D with the aim to overcome and find manageable solutions for successful implementation of the ATM Target Concept.

The effectiveness of enhanced leadership styles and management procedures together with a new "co-workership" relationship needs to be established. Participative processes and social dialogue structures for mitigating and resolving social risks and problems need to be further developed in the following areas:
- Effective communication;
- Employee involvement;
- Leadership and commitment from senior management;
- Evidence that management is leading the change.

The SJU work programme should include to develop a roadmap, create a detailed change programme plan for the SESAR implementation Phase and define the responsibilities for the delivery of the milestones.

The EUROCONTROL Agency should be tasked to further develop and refine existing advisory material in support to social factors and change management.

4.2.2.2 Institutional

4.2.2.2.1 Standardisation

To meet the IP2 objectives, the main critical standardisation activities that require to be started as soon as possible are:
- IOP and safety performance requirements (SPR) standards to support the full 4D Trajectory Management concept;
- Standards for Advanced Surface Movement Guidance and Control System (A-SMGCS) level 3 and 4, including Surface Manager (SMAN) concept of operation;
- Clear description of global SWIM architecture and the development of standards to support the Airport mapping services and Air-Ground interoperability;
- Standards supporting the Wake Vortex detection (with Ground Doppler X-band radar and/or Ground based Doppler Lidar) performances and associated ground Safety net alert services;
- Standards related to Airport Surface Operations using GBAS Cat 2/3.

Even if standardisation activities are not considered as a time critical issue with respect to the IOC dates for the enablers[16], specific emphasis has to be given to the urgent development of standards covering datalink standards as datalink services are seen as one of the most important pillars of the SESAR concept.

As a global issue, most of these critical activities need urgent prerequisite activities, especially for the 4D Trajectory Management, to fix detailed concept definition before any standardisation.

The development of these standards should be conducted with the objective of ensuring global consistency of Datalink IOP and SPR standards.

Also in this period civil-military interoperability requirements should be supported by the development of standards taking into account military requirements.

A full roadmap of the standardisation activities needed can be found in Chapter 6.8.

4.2.2.2.2 Environment

The Operational Improvements identified for IP2 have to be supported by evolution, including institutional, in the Environmental Sustainability area.

The enablers requested in the medium period are:
- Collaborative Environmental Management guidance and standards, providing a shared framework supporting different needs of ATM stakeholders;
- Guidance for community relations at airports: a sound 2-way understanding and communication link between ATM stakeholders

16 - Major evolutions in the standardisation process are necessary to support the timely implementation of all enablers (e.g. sufficient prototyping, interoperability demonstrations and validation activities can contribute to the acceleration and cost-reduction of the standardisation process).

and the local community about real disturbance and environmental impact shall be achieved;
- Central environmental guidance web-portal: delivering a comprehensive and updated source for guidance and best practices;
- Environmental regulation: covering all regulatory instruments, rules and provisions that apply any segment(s) of the air transport industry and may impact on ATM service provision. It will include noise, air quality, chemical emissions by aircraft in all phases of flight as well as any legislation that could have an impact (e.g. Kyoto protocol to the United Nations on climate changes, which expires in 2012).

4.2.2.2.3 Security

Building upon the "Trusted Security Partnership Framework" and the regulations created during the IP1 timeframe, further developments will be needed in IP2 to underpin the partnership and roll-out the proposals made to achieve a homogeneous approach across all stakeholders. Thus, during the medium-term, the following are needed:
- Trusted Security Partnership Framework and Regulations:
  - International Security Regulations shall be implemented at EU level and, where necessary, at ICAO level by 2020;
  - The Security Management System, supported by the Security Management Plan, shall be fully implemented by 2015, supported by the Security Incident Information Exchange mechanism and the Risk Assessment Methodology;
  - The standardised Identity Access Management & Staff Vetting shall be implemented by Identification Access Management (excluding Air-Ground) by 2015.

- Implementation of Security Service for ATM:
  - SWIM Network Security shall be specified by 2013 and be implemented by 2016;
  - Collaborative Security Support for ATM Incidents shall be implemented by 2016;
  - The System Design for Response & Recover shall be specified by 2015;
  - The Automated Trajectory secured function shall be specified by 2020.

Chapter 6.6 provides a summary overview of these activities in the relevant section of the security evolution roadmap.

4.2.2.2.4 Decision-Making

SESAR anticipates an improved and quicker institutional decision-making process as being a key enabler to shortening the time between concept development and operational implementation. However, it has already been noted in Chapter 3 that the institutional processes necessary to effect such a change will not permit it to happen in time to assist the implementation of IP1.
ICAO is often cited as an institution where discussion and consultation processes take an appreciable amount of time. Any proposals to reduce the consultation periods for State Letters, amendments to the Annexes, etc., would require discussion and approval at the highest levels within ICAO. The next opportunity to speed-up the consultation and decision process is in 2010 during the next session of the Assembly (i.e. the highest-level meeting within ICAO).

Changes are anticipated within the European Institutional Framework which would have an impact by 2013 to speed-up the decision making process.

Regardless of the above, it is critical that the necessary points at which the various decisions in the project lifecycle must be taken are identified and met. Formal decision plans should be used to ensure that all involved understand the potential knock-on implications of missing even a relatively low-level decision point.

4.2.2.2.5 Legislation

As IP2 assumes that IP1 has been completed to achieve the 2013 targets, it is taken as a starting point that all the legislative/regulatory changes identified in Chapter 3 have been implemented. Further, it is also taken as a given that these changes have been implemented on time (i.e. around the end of 2011) as some legislation to support IP2 will need to be based on that developed for IP1. Timing is particularly important as it is expected that many of the IP2 improvements will be implemented during the early part of the period, meaning that many of the legislative changes to support IP2 must be initiated during the IP1 timeframe.

From a legal (as opposed to operational or architectural) perspective, the majority of the IP2 improvements likely to require legislation relate to the improved provision, dissemination and use of information. The major European legislative effort to support IP2 is therefore expected to be further development of/a follow-up to the anticipated Implementing Rule on Information Management (as noted in Chapter 3, it is highly unlikely that all the SWIM technical details for the next 20 years can be worked out in time to be included in a single piece of legislation which also meets IP1's timescales). It will be crucial that the SWIM legislative requirements are established as early as possible so that implementation is still possible during IP2.

IP2 includes a proposal to move from the current 7 classes of airspace to 3 categories. As for other subjects, this will require changes at National and possibly European regulatory level to ensure that implementation happens within the desired timescales.

Various changes anticipated during IP2 involve the use of new/modified airborne equipment (e.g. ACAS, ASAS, datalink services); this will require further legal assessment of the responsibility and liability issues.

Finally, documents with legal standing which will need to be developed during IP2 (though not strictly legislation) are the inter-State agreements necessary to permit European-wide shared use of military training areas.

Clearly, the time criticality for IP2 legislative change is not as stringent as for IP1. The key deadlines will be driven by the length of the implementation period required to achieve Full Operational Capability. As with IP1, the legislative process should start at least 3 years before the legislation is required.

4.2.2.2.6 Safety Regulation

In order to put in-place appropriate structures and processes necessary to fulfil safety regulatory needs to support the Future ATM Target Concept implementation in IP2 and IP3, the following are required to be established in the IP1 timeframe:

- The SJU needs to have both clear processes for safety management applicable to its role throughout the project lifecycle and an effective interface with those currently responsible for safety regulation in order that, where benefits can be realised, changes to the safety regulatory requirements (baseline) and the safety regulatory framework (arrangements) can be pursued. This will rely on existing best practices for both SMS/safety assessment and safety regulation as its baseline. A SESAR Safety Regulatory Coordination Function (SSR-CF) is proposed. A detailed description of this is provided in the Task 1.6.2 DLT [Ref 12] as an input to set up such a function;

- As part of the SJU's approach to managing safety throughout the development phase, it is essential that personnel with organisational responsibilities are appointed to coordinate activities and maintain coherence of safety assessments and arguments across all contributors to the work being performed. It is recommended that the SJU's approach to managing safety should, as a minimum, contain the following key elements:
  - o A Safety Policy – A hierarchal structure of safety policy statements linked to the organisation's safety objectives which define the fundamental approach to managing safety through the SJU, its Members and its contractors;
  - o Accountabilities and Responsibilities – The allocation of clear accountabilities and responsibilities for safety in SESAR at all appropriate levels of the SJU organisation and within contractual agreements for external services and support. This shall include accountability and responsibility for the final safety arguments being produced at the end of the development phase;
  - o Safety Processes – Appropriate safety assessment and monitoring methods must be devised which can adequately identify safety performance and safety regulatory impact across all domains.

- Co-ordination of Safety Regulation is envisaged to be undertaken by a SESAR Safety Regulation Coordination Function (SSR-CF) which will be composed of representatives from all safety regulatory authorities to ensure that:
  - o The SJU and those delivering to it are able to demonstrate compliance to the relevant Safety Regulations;
  - o Any request made by the SJU to pursue a change to either safety regulation or the safety regulatory arrangements is credible and of net benefit;
  - o The relevant regulatory authorities are represented when discussing a change to the ATM System, the regulatory baseline and/or the regulatory arrangements;
  - o Changes to the regulatory baseline or the regulatory arrangements are tracked and any likely adverse impact on the ATM Master Plan reported;
  - o It is envisaged that the main output from the SSR-CF, as an enabling platform facilitating future implementation of the SESAR OI steps is as follows:
    - – A safety regulatory baseline – this is the set of appropriate safety regulatory requirements that will have to be met by respective aviation stakeholders in order to secure approval of implementation by the regulatory authority ultimately responsible. The baseline will ensure a harmonised pan-European approach starting from the existing safety regulatory requirements captured in ICAO SARPs, SES legislation, EASA system and ESARRs. European and national regulatory authorities, through the mechanism of the SSR-CF, will be assisted in ensuring that the regulatory baseline for SESAR is current and can meet stakeholders' safety needs. This includes augmenting the baseline to cater for new operational improvements as they are identified within the development process. In this context, an important input to the SSR-CF's work will be the information received from the safety management processes within the SJU regarding planned changes to the ATM System. The appropriate level of cooperation and coordination with the relevant military authorities will also be crucial for the success of this process;

    - – Safety Regulatory arrangements – this is the description of those arrangements considered appropriate for the initial approval and ongoing oversight of the safety performance of specific implementations. These arrangements will take into account the nature of each implementation and the allocation of safety responsibilities. Currently Member States carry the ultimate responsibility for approving the implementation of SESAR OI steps, either through their national or international arrangements as needed, in accordance with the safety regulatory baseline and applicable European and national legislation. It is, however, possible that the responsibility for approval of certain OI steps may change, particularly in IP2 and IP3 based on their specific pan-European nature. The evidence required to show compliance with safety regulatory requirements will be in line with the safety criticality of the implementation.

In order to put the above arrangements in place in time for the implementation of the contents of IP2, it is recommended that the allocation of the functions to the appropriate institutional bodies proceeds now in accordance with the principles established in the 1.6.2.Task Deliverable (DLT), these being in line with the conclusions and recommendations of the High Level Group [Ref 32].

4.3 IP2 - Assessments

4.3.1 Performance Assessments

Capacity and Quality of Service KPAs

The IP2 performance qualitative assessment was performed on the following performance areas: Capacity, Efficiency, Flexibility and Predictability. The results are presented in [Ref 15].
For the Airspace, Airport Capacity, Low visibility Capacity and Fuel Efficiency[17] performance focus areas, quantitative assessments were also produced. These quantitative assessment are used to:

- Estimate order of magnitude of some performance indicators by 2020, including the potential gaps against the 2020 targets;
- Contribute to the assessment of Cost-Effectiveness through ATCO productivity, which is a by-product of Capacity assessment for deriving the direct operational cost factor;
- Produce benefit input data for CBA as described in the Financial Affordability Assessment section.

Figure 41a below illustrates the assessment processes and their dependencies.

The assessment process is presented in Annex IV.

In the following subsections, the quantitative results only are presented for Capacity, Fuel Efficiency and Low visibility capacity degradation, while qualitative results are presented for all other KPA.

For quantitative assessment, it is assumed that aircraft are 100% equipped when applicable (e.g. for flying 3D RNP routes or using low visibility landing aids).

Airspace Capacity and Control Productivity

Objective of the Assessment

The D2 target for Airspace Capacity is derived from the Network Capacity target expressed by the annual traffic demand in 2020, according to the LTF2004 unconstrained A scenario. The 2020 target is 18 Million Instrument Flight Rule (IFR) flights.

However, the airspace capacity assessment does not attempt to answer directly the question of whether or not this target is met. The objective is to estimate the airspace capacity increase provided by the IP2 OI steps, and the associated ATCO staffing level for Cost-Effectiveness assessment and CBA. The network consolidation of the local airspace capacity improvement, together with airport capacity improvement is performed at a later stage, using the FAP tool. This consolidation is presented in the Performance Gap section 4.3.2.

Assumptions

The assessment of Airspace Capacity has been carried out separately for En-Route airspace and TMA airspace. The quantification is based on a combination of workload and capacity judgements

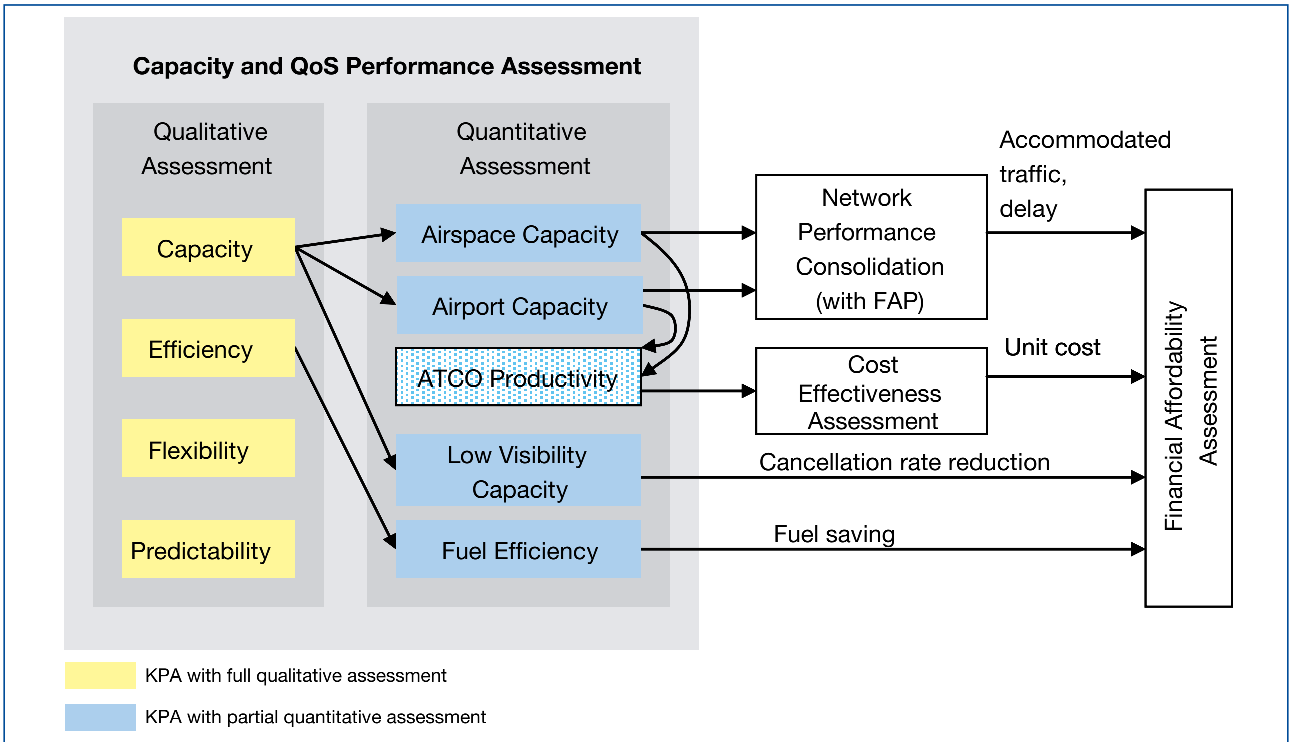


Figure 41a: Assessment Processes and Dependencies

17 - Time efficiency is no assessed directly. It is expressed in the form of the delay indicator generated by FAP from traffic demand and capacity figures.

made across the performance improvement factors. The Influence diagram for airspace capacity is given in Annex IV. The quantification of elementary factors differs and leads to different values. Several assumptions are made for estimating the workload reduction of tactical control. These assumptions are fully documented in Task 2.3.1 DLT [Ref 15].

The main assumptions related to the quantification are as follows:

- Controller workload per flight will remain an important factor in determining capacity;
- The assessment relates to high-density airspace, i.e. a "most challenging environment", where new Operational Improvement Steps will be most needed;
- The Controller Task Load factors are characterised as Decision-making, Monitoring, and Execution/Co-ordination;
- These factors and judgements pertain to "Tactical Controller" workload as this is most often the constraint to capacity in current operations. The "Planner" function is however considered for ATCO Productivity quantification;
- Theoretical task load reductions do not translate linearly into capacity increase when traffic demand increases, but rather according to a quadratic law (see [Ref 15] for further details).

To derive potential ATCO Productivity gains, a set of coefficients have been applied to the capacity benefits according to improvement factor. This is on the basis that an increase in capacity will not automatically translate into a commensurate (lower) staffing level. In general, a coefficient of 75% is assumed to be the maximum achievable due to various overheads. The coefficients that have been applied to each type of improvement factor are detailed in [Ref 15].

Results

The overall results for Capacity and Productivity for IP2 are depicted in Figure 42. The increase percentages refer to the capacity and productivity baseline obtained by deploying IP1.

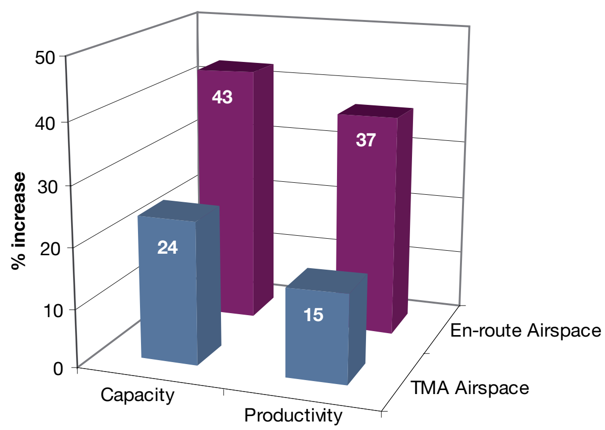


Figure 42: Airspace Capacity and Control Productivity Increase attributed to IP2

These improvements represent the estimated capacity effect of IP2 deployment, on top of IP1.

In En-Route Airspace, the main sources of Capacity and Productivity are thought to be from Automation tools for controllers and from significant improvements in the quality of planned traffic demand information through the SBT refinement and agreement process.

In TMA Airspace, Capacity enhancement is assessed as coming mainly from automation tools and the use of 3D high-precision routes.

Airport Capacity

The purpose of this assessment is to assess the extent to which SESAR can raise airport capacities and the effect that this is likely to have across the network in accommodating traffic demand. The assessment is based on a "busy-hour" analysis of the extent to which the forecast **unconstrained** demand can be accommodated. This forecast demand is assumed to grow by approximately a factor of 2.1 in 2020 vs. 2003 (as per the Long Term Forecast 2004 Scenario A) and varies from airport to airport. In this section a runway system is a set of runways (from 1 to many) that are operated together at a particular airport. Runway throughput or capacity is a short cut for runway system throughput or capacity.

It is worth remembering that Airport capacity declarations are derived by selecting the weakest link of the airport capacity chain – Runway throughput, Environment, Terminal Infrastructure, TMA/Approach serving the airport, Airport Airside throughput. In the quantitative Airport capacity assessments, the runway throughput has been used as the reference for the analysis since no data are available for other variables. It is recognised that the Best-in-Class (BIC) approach is not the ultimate way of assessing capacity and that local conditions may have a significant impact on the need to reach the BIC performance or not for a given airport.

The Airport Capacity assessment focuses on the following three aspects:

A) Contribution to capacity from currently planned Airport Runway Infrastructure expansion;

B) The scope to accommodate forecast future demand within current hourly Best-in Class (BIC) Airport capacities;

C) An assessment of the potential for IP1 and IP2 OI Steps to raise the BIC capacity values for the different Airport types.

The assessment of the first two aspects (A+B) is based on a detailed analysis of the Top 100 ECAC Airports in the Challenges to Growth 2004 Report (accounting for ~85% of all European Airport air traffic movements). The third aspect (C) also uses the CTG-2004 Airport sample, with capacity enhancement judgments derived from "expert judgement" based on the Influence Diagram approach to assess OI Steps. Figure 43 below summarises the key figures (the values have not been rounded, but they shall be considered as representing order of magnitudes only).

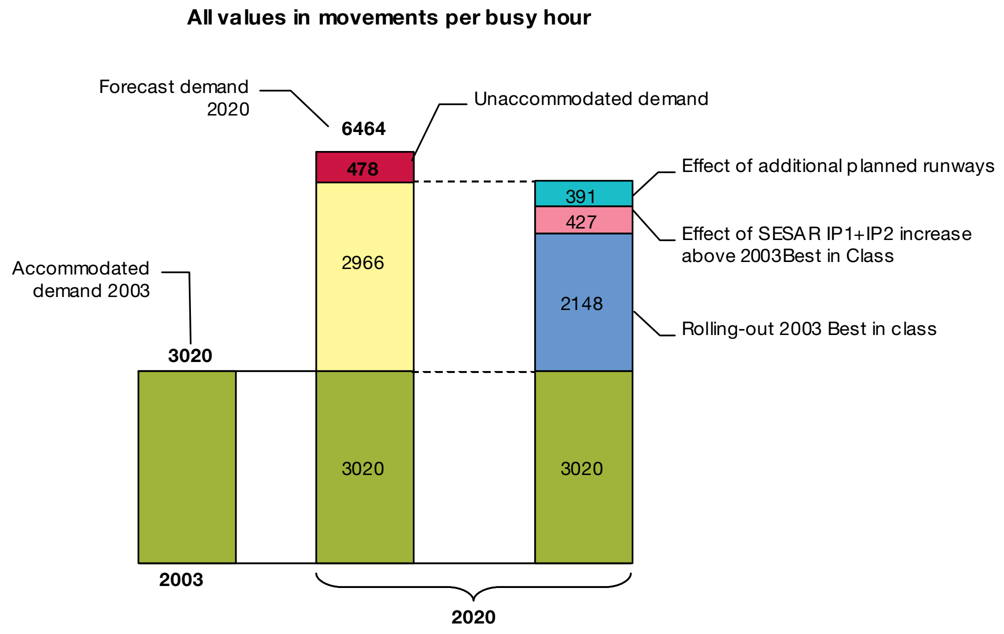


Figure 43: Airport Capacity Assessment

"Unconstrained" growth generates an additional "busy hour" demand to be accommodated in 2020 of 3444 movements. The figures derived for A, B, and C all assume full utilisation of Best In Class (BIC) where demand exists – effectively declaring capacity in the busy hour as high as possible, e.g. at 50 movements per hour currently at single runway airports.

- 23 additional Runways are planned to be operational (against the 2003 baseline employed by CTG-2004) across the ECAC region. Due to only 16 of these being at the more severely capacity constrained airports, the additional runways only add an unexpectedly low 391 movements per busy hour;

- The full use of current capacities and the roll-out of BIC capacities across the network contributed the bulk (62%) of potential capacity enhancement. This ignores local constraints, which leads to an optimistic value. This capacity enhancement includes several IP1 OI Steps which are already partially deployed across the Airport network, e.g. Rapid Exit Taxiways, Runway Occupancy Reduction techniques, etc. The assessments of aspects A+B are broadly consistent with the findings of CTG-2004 which forms the basis for the Constrained demand forecast for Long Term Scenario A. This is equivalent to growth of 89% by 2020 (over 2003) and represents 16M annual flights;

- Enhancements to the current BIC have been estimated from analysis of the planned OI Steps for IP1 and IP2. The capacity uplift ranges from 8% to 30% depending on the runway system category. Overall, this translates into a Capacity contribution of 427 movements per busy hour. This is equivalent to approximately an additional 1.0 M movements per year, or half the "gap" between LTF Scenario A Unconstrained and Constrained demand.

Having allocated unconstrained demand to the resulting capacity, this leaves some 478 movements un-accommodated (14% of the additional demand) in the busy hour. This needs to be displaced to a less busy time or to a nearby – less busy – regional airport. Where neither is possible, the demand will remain un-accommodated. This assessment has not attempted to establish the scope for such displaced demand to be accommodated. In particular, the potential runway capacity provided by military airports has not been assessed.

It must be noted that all this assumes a widespread capacity declaration at 100% of BIC capacity. For example, in 2003, 4 Top 30 airports were declaring capacity at BIC. In 2020, this will have grown to 19 Airports, with the average utilisation rising to 92% from 71%. Across the Top 100 Airports, some 42% of movements would be operating at a very congested airport – compared to 13% in 2003. The consequences for Quality of Service performance (all KPAs) have not been assessed, but it is difficult to imagine that they remain "neutral".

Low Visibility Capacity

The D2 Predictability KPA includes a Service Disruption Effect focus area, where targets are expressed as reducing the cancellation rate and the diversion rate by 50% compared to the 2005 baseline. In D4, Disrupted service has been analysed qualitatively from two perspectives: Airport capacity and Predictability.

The current Capacity drop between low visibility and good visibility is assessed at 50%. This assessment is based on observations of current operations on very busy airports (e.g. London-Heathrow). The current number of cancelled flights per year is estimated at 16800 for the whole European airspace.

However, analytical judgements of the potential for improvement have not been possible. At this stage the judgements simply reflect what IP1 and IP2 would need to deliver to reach the Target gap of 20% between good and low visibility arrival rates at busy airports. Figure 44 shows the results of this impact assessment.

Some improvement is already expected from IP1 OI Steps, related to the management of arrival flows; these steps aim at improving low visibility procedures and ILS operations taking into account a better prediction of the Runway Occupancy Time.

Most improvements are expected from new landing aid systems (such as MLS, and GBAS for Category-3 operations), envisioned for the first half of the IP2 deployment period. No judgement has been made as to the relative benefits of either system.

OI Steps concerning the ground operations (on taxiways and aprons) are thought to be useful mostly for safety. In addition it needs to be considered that further ad hoc separation criteria for low visibility operations on airport surface will need to be developed to support the TMA capacity improvement steps. Therefore it is expected that ground operations will not be the limiting factor for capacity owing to appropriate OI steps (further investigation needed).

No attempt was made to assess the proportion of flights undergoing diversions and no existing diversion model nor baseline was available. No attempt was made to assess the delay imposed on remaining flights.

Time horizon	% of available low visibility capacity compared to good visibility situation
2007 (current)	50%
2013 (IP1)	55%
2020 (IP2)	80%

Figure 44: Assumed low Visibility Capacity Targets

Fuel Efficiency

A quantitative Fuel Efficiency assessment has been carried out based on judgements of how OI Steps contribute to improving fuel efficiency across 4 main flight phases:

- Ground operations – covering excess fuel due to deviations from fuel-optimum taxi path;
- TMA operations – covering excess fuel due to lateral and vertical deviation from optimum climb-out and descent profiles;
- Air queuing – covering excess fuel due to queuing in the air at busy arrival airports;
- En-Route operations – covering excess fuel due to lateral and vertical deviation in En-Route airspace.

A baseline had to be constructed, starting from today, because IP1 targets and assessment are only addressing a subset of inefficiency.

- For the En-Route phase, a baseline value for lateral deviation is available as part of the PRR2006 report [Ref 26]. The average figure of 4% lateral deviation given there for ECAC-wide En-Route phase is widely thought to be consistent with results of more local lateral deviation studies;
- No suitable baseline exists for En-Route vertical deviation. Its magnitude was assessed by judgement, taking as reference certain fast time simulation results obtained for SESAR Milestone Deliverable 3 [Ref 2];
- For the TMA phase, no such baseline was found. An judgemental estimate of 15% for the current baseline lateral deviation for TMAs has been made. Details are given in Task 2.3.1 DLT [Ref 15];
- For ground queuing, the baseline is an average time based judgement value, informed by known values of ground queuing at major, complex airports (which provide an upper value).

Finally, a weighting of the respective contributions of flight phases to fuel burn is proposed taking into account *(actual)* fuel flow and time spent in each phase.

The preceding discussion allows a baseline for each phase to be created, which characterises the current situation in 2006. Figure 45 shows the evolution of fuel inefficiency/flight (i.e. excess fuel burnt) between 2006 and 2020.

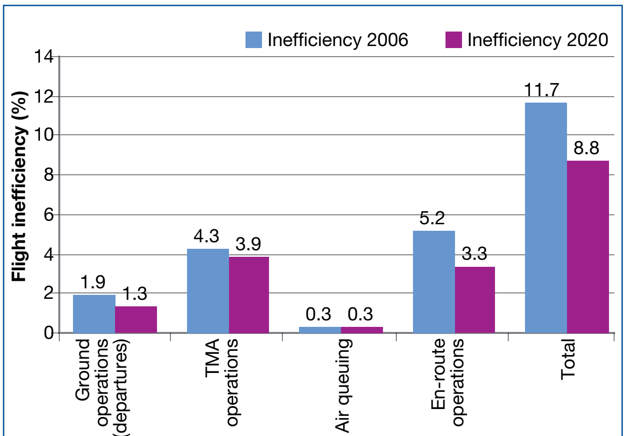


Figure 45: Inefficiency Improvement due to IP1 and IP2

The main fuel efficiency gain is expected in the En-Route flight phase where more direct routes are expected to be enabled. The TMA is unlikely to become significantly more fuel efficient due to the benefits of "better" 3D routes being nearly outweighed by the impact of traffic growth on currently less dense TMAs. Ground operations improve as a result of a greater proportion of departure queuing at the gate with engines off – enabled by integrated airport traffic management tools.

Among the 2% of En Route gains about 1.5% is provided by IP1 [Ref 21].

The overall improvement is a reduction of flight inefficiencies from 12% to 9% between years 2006 and 2020.

However, the “do nothing” (i.e. without IP1 nor IP2) scenario has been assessed for providing base-cases to cost-benefit analysis per IP. It shows that inefficiencies would not stay at the level of 2006. They would reach a value of 16% by 2020, owing to the additional ATM constraints that would be needed to accommodate the traffic increase. The inefficiencies after IP1 and IP2 deployment together with the “business as usual» case are depicted by Figure 46.

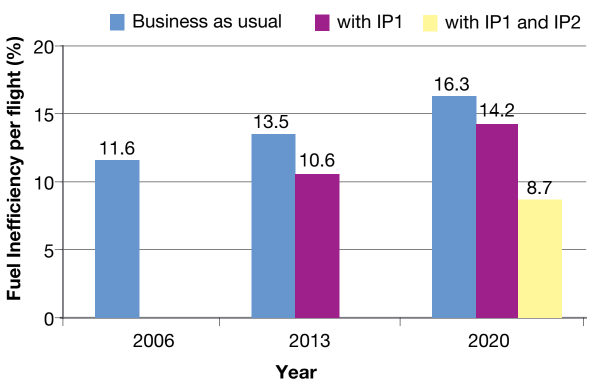


Figure 46: Estimated Inefficiency Profile

It is worth noting that ATM contribution cannot increase beyond a theoretical maximum defined by fuel optimal trajectories for each individual aircraft flying alone in airspace. The major improvement in fuel consumption reduction and related emission reduction is expected to come from new jet engines on modern aircraft and in the longer terms new aircraft design.

Safety

Apart from the initial D3 Safety screening results, an overall detailed assessment of the safety impact is not possible at this early stage of SESAR. Further investigation is needed in the next phases to assess the extent of the potential safety benefits and potential negative impact. This is expected to be possible through a well-structured and coordinated safety management approach.

Safety assurance activities will be based on the SESAR Safety Screening results generated during the SESAR Definition Phase, which identified principal requirements for safety regulation, safety management and performance. Safety requirements will be developed during rigorous end-to-end ATM safety studies as critical ingredients of the SESAR ConOps to keep future Air Traffic Management operations acceptably safe.

Those requirements will address both the need for ATM to maximise its contribution to aviation safety and the need for ATM to minimise its contribution to the risk of an accident. The safety assessment processes will be iterative and linked to the further development of the detailed operational descriptions (OIs).

The need to broaden the safety assessment approach for SESAR is acknowledged and techniques will be further developed to keep pace with SESAR developments and to meet stakeholders' safety needs now and in the future. This approach will therefore have to keep the overall safety assurance process and activities manageable and coherent, while at the same time retaining some flexibility to take advantage of improvements in safety theory and practice delivered by Safety Research.

Security

IP2 is considered to be an opportunity to set up a resilient and robust security framework to support ATM operations and allow security to be implemented as the threat situation evolves. The new technologies will also allow ATM to better support state authorities relating security incident situations and allow security means to be implemented and provisions to be established at an early stage as the threat situation evolves.

The OI steps will need to address the security risks that the new technologies and architectures could pose. Security needs to be explicitly addressed during implementation, as the extent of potential benefits and negative aspects depends on it.

Environment

The potential environmental impacts of the IP2 OI steps include:

- Increased efficiency and associated reduced fuel resource use;
- Reduced CO_2 and reduced NO_x emissions;
- Noise reductions;
- Improved Air Quality.

The level of potential environmental benefits and potential negative impacts depends on the implementation of the OI steps.

To enable the environmental benefits of IP2 the following additional measures were proposed:

- Integrating environmental and operational information systems;
- Developing assessment tools and predictive capabilities;
- Developing the skills and resources needed to meet the growing environmental challenge;
- Coordinating ATM environmental sustainability research and support of environmental elements in SWIM;
- Integrated airport planning;
- Environmental good practice, support tools provision, performance management.

Access and Equity

IP2 is considered to have a potential benefit to Access and Equity, as it will increase the capacity of the ATM system. However, some capacity increases will require new airborne functionality and increasing need to access SWIM. This could add to the cost of flying. Important factors for access and equity are polices for equipage requirements and supporting services for various ATM capabilities. For airspace users who cannot support these costs through the achieved benefits, special mechanisms/solutions will need to be found.

Cost effectivenesss

As for IP1, the assessment of the Gate to Gate (G2G) ATM ANS cost effectiveness (CEF-2) of IP2 was done with the cost effectiveness analysis model.

For this iteration, the reference on which are added the benefits and the costs of IP2 is the "baseline scenario of business with IP1 only" (see sections 3.3.1 and 3.3.2) which has been assessed by experts. Combination of IP1 and IP2 gives the following results where the 2020 unit cost is around €630 per flight (ECAC averaged value).

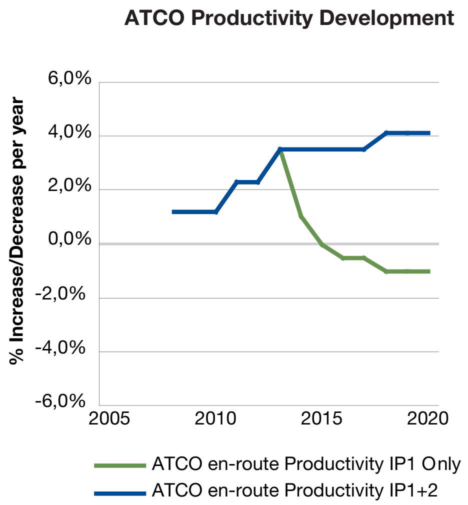


Figure 47: ATCO Productivity Development IP1 – IP1/2

In preparation for the IP2 activities legal and training costs will be occurred which cannot be amortised later. Therefore the IP1 + IP2 unit cost development as depicted in Figure 48 shows a stagnation of the decreasing unit costs for 2010 – 2013 period. However, it will be compensated when the higher productivity from IP2 will emerge.

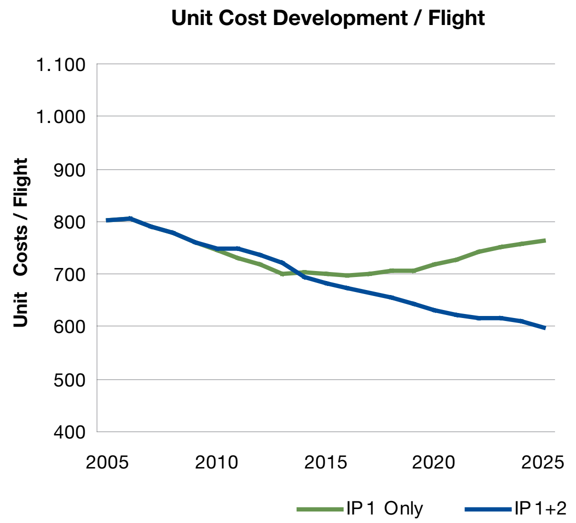


Figure 48: Unit Costs Development/ Flight IP1 – IP1/2

4.3.2 Performance Gaps Analysis

Compared to the D2 targets, the quantitative assessment has allowed to estimate the gaps for some indicators related to capacity and cost-effectiveness.

Other quantifications are not directly mapped to D2 targets, because indicators are current PRC indicators or D4 ad-hoc indicators. However, it is still interesting at this stage to present the values obtained so far.

The summary is given in Figure 49.

(a) Long Term Forecast Unconstrained Scenario A: traffic demand in 2020. See Annex IV for details.

(b) As computed by FAP, generating the associated delay of 1.2 min per flight. This point is not a direct result of performance assessment, but is retained by Airspace users for running the Airline CBA, consi-

KPI	Reference definition	Baseline 2006 value	2020 Target	2020 IP1+IP2
Airport capacity: Accommodated traffic (Million flights)	PRC and SESAR D2	9.6M	18M(a)	17M(c)
Network capacity: Accommodated traffic (Million flights)	PRC and SESAR D2	9.6M	15.8M(d)	15.8M(b)
Average delay (min)	PRC and SESAR D2	2.0 (PRC)	0.2 (SESAR D2)	1.2 (e)
Fuel inefficiency index	SESAR D4	12%	Not defined	9%
Average direct cost per flight	SESAR D2	800€	400€	630€ (f)

Figure 49: Performance Achievements as estimated in D4

dering that the delay is acceptable and that further delay cannot compensate for additional flight accommodation.

(c) Maximum throughput handled by airports, accepting a degraded QoS (i.e. higher delay) due to airspace contention.

(d) Long Term Forecast Constrained Scenario A: traffic demand in 2020. See Annex IV for details.

(e) Results from FAP with SESAR D4 capacity increase estimates [Ref 15], and a 15.8M flights demand by 2020 for ensuring acceptable QoS with IP1 and IP2.

(f) Values based on cost and staffing levels for a 15.8M flights demand by 2020.

Some general assessment feed-back are presented below.

From the airport operator experts viewpoint:

- On the one hand, the increase in Best-in-Class performance (about 15%) is deemed very conservative;
- On the other hand, this is compounded by the fact that the runway system throughput has been considered as the driver of performance, although many large airports are limited by other factors, especially operation restrictions and/or surrounding TMA capacity.

From the network capacity viewpoint:

- Many of the top 100 airports shall declare a capacity at or close to the Best-in-Class of 2003 for minimising the unaccommodated traffic by 2020. This leads to an significant increase in the average utilisation;
- Going beyond the Best-in-Class with IP1 and IP2 improvements is more costly at the network level than deploying the current best practices, and seems limited in range, even if possibly underestimated. However, the number of congested airports that require improved Best-in-Class performance will increase in any case;
- The effect of average higher airport utilisation on the D2 quality of service indicators is unknown, although estimates of ATFM delay have been produced by the FAP tool. It is likely that the potential capacity increase at many airports in the network will be limited by the generation of higher delay or variability of operation time, due to airports themselves and congestion in airspace;
- In the D4 process, the FAP tool has been used to consolidate the capacity increase at the network level. It appears that the unconstrained A scenario from CTG04 cannot be accommodated because it generates unrealistic delays. Therefore for Cost Effectiveness and Financial affordability assessments, the Constrained A scenario has been used instead. This means that the benefit of airport capacity increase is offset to some extent by the effect on quality of service;
- To reduce this uncertainty, there is a need to build accurate network models incorporating IP1 and IP2 improvements so as to estimate the actual accommodated traffic for given QoS targets and the required capacity at each network node. Exploring various combinations of values for delay targets should help determine an acceptable balance between benefits in terms of accommodated traffic with QoS and the associated capacity requirements that translate into cost.

From the cost effectiveness viewpoint:

- The Cost Effectiveness target unit cost of €400/flight [Ref 3] will not be achieved by the ATM Target Concept implementation alone. Current calculations indicate a reduction in the unit cost to a level of €630/flight on average by 2020 (a reduction in 2020 of approximately 21% in comparison to 2005);
- Acknowledging that the costs effectiveness target has not been met, a sensitivity analysis has been conducted on the costs factors which have been taken into account to establish the cost effectiveness for the 2020 unit costs with the following results:
  - +/-1% higher/lower productivity ATCO staff after 2015 **+/- 40 €/flight**;
  - Cost over inflation increase ATCO/Support staff 50% lower than current assumption (current: +1 – 1.5% p.a.) **- 30 €/flight**;
  - Higher cost development ATCO/Support staff with 3% p.a. (according years 200-2005 ACE report) until 2020 **+ 50 €/flight**;
  - Development of technical support & administrative staff with a traffic dependency factor **+ 15 €/flight**;
  - Usage of financing tools (coordinated procurement & special financing entity) **- 4 €/flight**.

  This sensitivity analysis confirms that the number of operational staff assumptions have the biggest impact on the computed cost figures and therefore the unit cost.

- In order to achieve the Cost Effectiveness target of €400/flight, the SESAR community is expecting the gradual efficiencies of Functional Airspace Blocks implementation, the exploitation of synergies between ANSPs, plus more ambitious consolidation plans, and the co-ordination of initiatives at European level further to contribute the remaining portion of the Cost Effectiveness target which must deliver a unit cost reduction of €230/flight. A major driver for this additional reduction will be the technical ability of SESAR to support the necessary evolution in overall staff costs in conjunction with FAB implementation and technical de-fragmentation. In addition the financing recommendations will deliver further reductions if applied beyond SESAR investments to cover all ANSP investments. Further, a cheaper SESAR unit rate could be recommended as an incentive for early adopters of SESAR technologies as long as the ATM system cost remains revenue neutral.

- A limited role has been agreed for a future SESAR financing entity [Ref 3], for all stakeholders, with goals to facilitate the cost reduction opportunities included in the analysis. It should also explore mechanisms for stakeholders with limited benefits. It can also provide access to SESAR financing solutions at preferred interest rates. Finally it will provide the best opportunity cost for all stakeholders to quickly adopt the system by proposing practical incentives and/or penalties.

4.3.3 Financial Affordability Assessment

- **Benefits** – The Figure 22 displays the division of the quantified monetary benefits resulting from the performance assessment on an IP2 deployment presented in chapter 4.3.1. This total of 9.0Bn€ is the result of the potential to further increase the Quality of Service (QoS) (reduction of delays and fuel-inefficiency, improved predictability[18]) and reduction in ANS charges. In addition to the capacity growth resulting from IP1, the IP2 introduction will accommodate an additional 300.000 flights in 2020 with a significantly better quality of service.

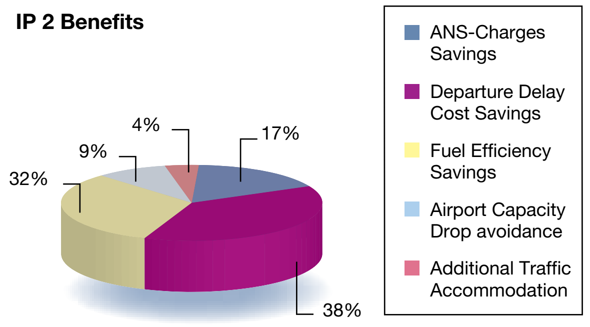


Figure 50: Summary of IP2 Operational Benefits

- **Costs** – The ANS unit cost development has been assessed, like for the IP1 CBA on the basis of the "ATCO productivity" evolution and of the additional costs of the ANS investment for IP2 until 2020. The IP2 investment will temporarily trim down the effect of the IP1 unit cost reduction. However it will be compensated when the higher productivity from IP2 will emerge.

Figure 51 captures the ANSP & Airport investment Cost.

IP2 investments	Pre-implementation Bn€	Implementation Bn€
ANSP	1.1	2.7
Airports	0.06	0.19

Figure 51: IP2 ANSP & Airport Investment Cost

Figure 52 shows that avionics civil airlines investments for IP2 were divided in two packages together providing the following capabilities:

"Structural" avionics packages:
- Navigation (3D Vert., Airport Moving Map, GBAS Cat 2/3, 4D Trajectory);

IP2 Avionics investments	Structural Bn€	Incidental Bn€
Scheduled Legacy Low Fares Regionals Charters	7.94	1.3
BA	1.95	0.76
GA	0.78	0.17
MIL Transports Lights Fighters	1.08	1.37

Figure 52: IP2 Avionics Investment Costs

- Communications (new A/G data-links, New 802.16, ADS-B in) - 100% of a/c;
- Surveillance (Air Traffic Situation Awareness, ASAS Spacing (ASPA) and Separation (ASEP), Runway incursion).

"Incidental" avionics packages
- Navigation capabilities (HUD/EVS, Brake to Vacate Galileo / GPS L5);
- % of a/c to be equipped (Retrofit/Forward fit):
  - o Head Up Display (HUD)/Enhanced Visual System (EVS): Major (0%/10%), Regional/Low fares (20%/50%), Business (20%/50%);
  - o Brake To Vacate (BTV): Major (50%/60%), Regional/Low fares (50%/60%), Business (20%);
  - o Galileo/GPS L5: Major (100%), Regional/Low fares (100%), Business (100%) NB: Assuming the constellation is not funded by the Airspace Users.

Annex V provides a detailed description of the cost synthesis.

In the current costs assessments, forward fit costs for both structural or incidental packages are included only during a certain period (approximately 7 years), then it is assumed that the packages will become "basic". Airspace Users expect the forward fit costs to decrease if global interoperability (e.g. with NextGen) is achieved preventing proliferation of technical solutions thus allowing significantly reduced avionics costs.

For all IPs it has been determined that the estimated retrofit costs represent twice the costs of the forward fit. Further analysis of the detailed solutions to deploy the ATM Target Concept could have to consider whether it is valuable to have 2 different solutions for the same function on board commercial aircraft:
- The "nominal" fully scoped solution for forward fit;
- A "minimum" solution at a lower cost (especially for old aircraft for which a limited retrofit will happen in the future).

18 - Regarding the predictability only the potential to reduce the airport capacity drop under low visibility conditions has been assessed.

• **Cost Benefit Analysis** – The affordability assessment of IP2 was made on the basis of a scheduled airlines CBA in which it was considered that the avionics improvements would be done in two steps: a first upgrade of the fleet from 2013, complemented by another upgrade from 2017. The positive benefit to cost ratio and the break even point at 2020 are encouraging, however the cumulated discounted net cash flow (around 2 Bn€ during 2015-2017) identifies the high upfront avionics investment effort required.

This highlights, like for IP1, the importance to ensure that the expected benefits will be delivered on time.

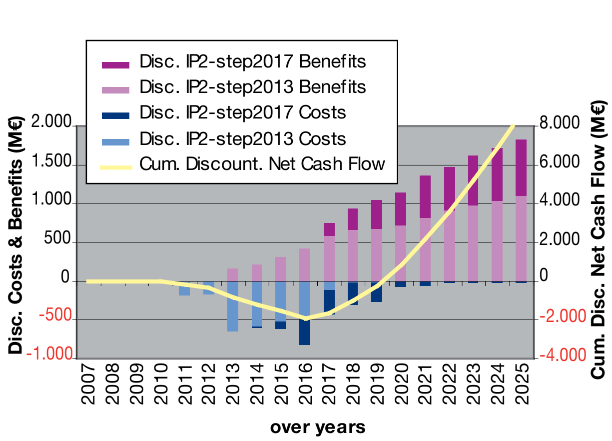


Figure 53: Overall Costs & Benefits of IP2

4.4 IP2 - Research & Development

This section covers two aspects. The first gives an overview of the key R&D needs, which must be done prior to implementing the 2020 Target Concept. The second provides a summary of the assessment of the on-going R&D initiatives/programmes to determine if work is already being done to cover the R&D needs.

4.4.1 R&D Needs

In order to de-risk the implementation of the 2020 Target Concept, a number of key R&D activities must be pursued. These are summarised below (Note: Full details can be found in [Ref 13, 14, 17, 18] and Chapter 6):

- **Development of a secure SWIM network infrastructure, together with how it will be governed and supervised**. The structure of the Enterprise Architecture to define the ATM services which the technical infrastructure will support needs to be defined. Information exchange services between Ground-Ground and Air-Ground entities must be covered, in particular defining the datalink services which will be needed to support them;
- **Definition of the User Driven Prioritisation Process (UDPP)**. The roles of the “AOC” and the “Network Arbitrator” need to be developed;
- **Detailed definition of the Business/Mission Trajectory, its management and the Trajectory Management Requirements (TMR) aspects**. The amount and nature of the information needed to define the Business/Mission Trajectory through its different states, together with the triggers needed to move from one state to the other, must be defined coherently through the Future ATM System;
- **Definition of Airspace Users Agent**. On-demand, airspace users will not be required necessarily to have their own trajectory management capabilities. They may use an external agent to provide the necessary services, but this role needs to be developed;
- **Responsibilities between Regional, Sub-regional and Local levels**. The balance of what is done and the specific details of the ATM services provided at what level needs to be clearly defined;
- **CDM process efficiency**. Supporting CDM processes need to be developed, tested and validated in order to ensure efficiency of the processes and benefits for the network as a whole;
- **Weather**. Improved information provision of the current and forecast weather will play an important role for achieving trajectory accuracies, safety and flow management performance. Requirements for the quality of service of the weather data and their provision need to be specified and checked with respect to that which can be achieved in practice;
- **New separation modes applicable to IP2**, such as dynamic allocation of clearances, airborne spacing and initial separation applications. The feasibility of the dynamic allocation of pre-deconflicted 3D-PTC needs to be investigated;
- **Traffic complexity management**. The System functionality required to support the management of traffic complexity needs to be defined;
- **Airport operation with mixed aerial vehicles**. The Simultaneous Non-interfering (SNI) operations by for example rotorcraft at busy airports needs to be studied;
- **Coupling AMAN, DMAN & SMAN**. The level of integration required between these services needs to be carefully studied;
- **Wake vortex warning system**. There is a need for further R&D on the ability of a wake vortex warning system and/or airborne detection system to significantly increase runway throughput;
- **Air and Ground Safety Nets**. The potential for providing complimentary warnings from the two independent/separate safety nets in a coherent manner needs to be carefully studied;
- **Air and Ground Monitoring tools**. The potential for providing complimentary warnings from the ground and air conformance monitoring tools in a coherent manner needs to be carefully studied;

- **HMI Controller tools**. The assessment of new controller decision support tools and the impact their integration has on existing tools in terms of quantity and clarity of the overall information presented to the controller needs to be made;
- **New management of airspace**. How military systems will be used to support 4D trajectory management and the ability to implement dynamically definable airspace volumes within operational FDP systems are of particular interest to support this subject area;
- **Use of Aircraft Derived Data**. Exploiting the information available from the aircraft needs to be studied across a wide range of applications concerned with trajectory management, safety nets and developing controller support tools;
- **Consideration of military aspects**. Civil-military interoperability needs to be studied, with particular consideration given to the validation of military operations, the development of civil-military datalink services and how Unmanned Aircraft Systems (UAS) will be handled;
- **Adaptation of ADS-B transponders for GA aircraft due to their specific requirements**. Comprehensive R&D shall be launched, including CBA, satisfying the requirements of the Operational Improvements these technologies are to enable, taking into account similar development in NextGen. Development of ADS-B (out/in) transponder technology for GA aircraft due to their specific requirements, including access to SWIM, traffic/weather information and SBAS. The comprehensive R&D shall consider all possible technologies (e.g. UAT) and the interoperability with 1090 ES ADS-B equipped aircraft and ground functions, as well taking also into account similar development of ADS-B functions in NextGen.

In terms of the research needed to develop supporting tools and methods to complement the operational and technical subjects, the following concerning the study of Human Factors are worthy of note:

- Development of a Toolbox of Generic Human Performance methods/techniques. This will help to ensure consistency is achieved across the variety of different subject areas and solutions being developed;
- Development of an analysis method and classification scheme to support the top-down functional analysis of the Future ATM Target Concept to decide how ATM functions need to be clustered and how these will be assigned to human actors and automated systems (including system redundancy and fallback automation).

4.4.2 Related R&D Programmes

An analysis of the on-going R&D programmes and initiatives has been carried out to assess how well the subjects being studied are aligned with meeting the objectives of the OIs in IP2. Over 170 European R&D activities were analysed with respect to the KPAs, the main aspects within the ConOps and the R&D needs identified by the ConOps, Architecture, Technology and Human Aspects as expressed in D3. Full details of the analysis can be found in Work Package 3.1 DLT [Ref 20]. A summary of the results is provided as follows.

Management Framework

Although most existing projects address the objectives of the OIs in IP2, they do not appear to do it along a set of agreed targets and steps. In the current context, the IP2 related initiatives, although significantly funded, do not appear to produce results that are planned for implementation in a clear and understandable manner. In addition, overlaps exist and no management tools are in place to address it.

Alignment of Programmes

The analysis performed demonstrated that the vast majority of initiatives considered contribute to implementation of the OIs and relate directly to the R&D needs established in D3 [Ref 2], but 6 projects were mapped to neither an OI, nor an R&D need. However, the analysis has identified areas where several initiatives contribute to the same OI or R&D need. In these cases the recommendation is that these be either re-orientated or co-ordinated depending upon the level of change introduced by SESAR with respect to the original aims of the project. Consequently, it may be more beneficial to stop some of these contributing initiatives and re-direct the associated budget and resources to addressing those needs which require new R&D activities to be set up.

Identification of Gaps

Gaps have been identified with respect to aspects of the ConOps, Architecture, Technology and Human Factors/Human Resource (HF/HR) Research needs.

Analysis of the content of IP2 and related OIs suggests further gaps in terms of ongoing initiatives in support of:

- Datalink based auto-brake/brake to vacate (no on-going initiative);
- OAT trajectory (reported deployment of ongoing initiatives too late for IP2).

Note: In fact the number of initiatives delivering too late for IP2 may be larger due to the fact reported under "Deployment Timescales" below.

Analysis of IP2 with respect to R&D needs shows that 107 of the 158 R&D needs include elements to support IP2. Of these, 28 are new requirements[19] for R&D and 34 are areas where the current initiatives would require significant re-orientation to fulfil SESAR R&D needs. Areas of particular concern were found to be:

- Definition of the UDPP in both operational and architectural terms, including R&D on the negotiation and arbitration processes;
- Re-orientation of all architecture activities to the SESAR architecture principle. This requires early action to define architecture principles and associated methodology for the definition of services;
- Assessment of all technology enablers against the operational requirements derived from the SESAR Concept of Operations to support re-orientation of technology development projects;
- Studies on improving the quality and use of meteorological information for ATM purposes.

19 - No ongoing R&D initiative/programme was identified covering the specific topic.

Other gaps identified concern the transition from R&D into deployment actions. Those can be considered as very significant as very little of the so-called research results convert into implementation. The gaps appear to be the actions required to bridge development work and implementation activities. Putting research projects in an R&D Management Framework will help address these gaps. To do so, a set of activities of pre-operational nature, which adapt the developments to their operational context in a wide and committing manner are required. From there, deployment actions can be initiated and supporting regulations prepared as necessary.

Need to coordinate with other Activities Indirectly related to ATM

It is expected that other non-ATM programmes (e.g. Clean Sky (FP7) or Meteorology studies) will address topics which are relevant to the SESAR Target Concept. Adequate coordination will be required to ensure that ATM requirements are taken into account and conversely that ATM can adapt to, and exploit relevant developments in these areas. Specifically, adaptation should take place to existing standards or to standards which will become available during the SESAR timeframe in order to achieve the highest levels of interoperability possible. Therefore, the SESAR ATM Master Plan should include activities to monitor relevant non-ATM developments to ensure that aviation is able to benefit accordingly.

Deployment Timescales of On-going R&D Projects

The existing initiatives are perceived to be overly ambitious in their assessment of maturity and declared objective deployment timescales. In this respect they need to be carefully re-assessed as, at present, there is no appropriate mechanism identified to lead those initiatives towards actual deployment. Consequently, the SJU should assess the maturity and value of existing ATM projects in detail.

European System Developments

A number of large on-going system developments are at the moment based on up-to-date technologies, including CFMU and e-FDPS developments. These developments should be further considered as to their potential for reusability.

The current ATM System's architecture, including the use of proprietary interfaces and ATM-specific solutions, does not facilitate interoperability and integration of different systems; this results in fragmentation. The ATM System needs to move to the use of an open architecture and associated standards. The gaps identified in the Architecture R&D, need to be addressed for creating the Service-Oriented Approach (SOA) as further expressed in section 6.1. Thus, the R&D plan should include early actions to establish the required architectural framework.

4.5 IP2 - Conclusions & Risks

IP2 is targeting the implementation of the 2020 ATM Target Concept as defined in D3. The activities necessary to achieve it and the timeframe in which they need to be conducted have, in the main, been identified. The necessary R&D activities and the implementation of their results is well structured and timely monitored, and the right level of information to enable the necessary investment decisions has been analysed.

Successful implementation of IP1 is a pre-requisite; the major risks associated with IP2 are therefore considered to be:

- Unfeasibility of some Operational Improvement steps:
  - Mitigation: The analysis of current initiatives indicates that there is significant high quality R&D in Europe that supports a transition to the SESAR ConOps. However, significant re-direction of this R&D is required to support the novel aspects including some completely new research topics. Work Package 3.1 DLT [Ref 20] contains the risk identified and the proposed mitigation actions. The likelihood of each risk occurring has not been assessed; however it is recommended that the SJU consider each mitigation measure.

- Late migration to SWIM:
  - Mitigation: consolidate early SWIM migration by appropriate R&D support to limit predominance of existing sub-system to sub-system flight information message exchanges for en-route, approach and airport systems; speed-up the associated Global and Regional institutional issues (e.g. data provision and ownership).

- Failure to anticipate the migration (timely) to SWIM since institutional issues related to information management should be resolved before implementation of SWIM:
  - Mitigation action: Issues to be addressed at States level amongst others are liability, intellectual property rights, ownership of information in general, originating and authorized source issues. Without these issues addressed and solved SWIM can not “operate” as it is intended.

- Failure to migrate (timely) to SWIM since the “behaviour” of External Systems within the SWIM concept can not be directly influenced and managed by the ATM stakeholder involved and addressed directly within the SESAR SWIM scope. Only interfaces between SWIM and the External Systems are within the scope whilst the ATM Target Concept and ConOps could have consequences for the Information Management component of the External System itself. The owners of these External Systems could adhere to other business principals or have set other priorities for change for their business than needed for SWIM and ultimately the Target Concept goals:

  - Mitigation action: Involve External Systems owners in the development of SWIM during next SESAR phases (e.g. weather offices).
- Inconsistent air & ground deployment:
  - Mitigation: consolidate synchronised deployment by early coordinated R&D activities, innovative system design and supporting legal instruments, when necessary.
- Unable to deploy effective civil-military interoperability:
  - Mitigation: include processes to develop standards taking into account military requirements based upon taking a performance-based approach.
- Lack of timely and adequate training of ATM staff to support the implementation of IP2:
  - Mitigation: follow lines of activity outlined in chapter 4.2.2.1.2 and 6.3 Human Performance roadmap.
- Lack of ATM regulators structure to define all regulatory activities necessary to support the ATM Deployment Sequence:
  - Mitigation: a vital mitigation of the risk is to establish a regulatory interface with the SJU early, i.e. during 2008 timescales in order to assist decision making, gain commitment and ensure required implementation timescales, including those for IP2, are met. The regulatory interface should include provision for safety, airspace and economic regulatory functions.

5 Implementation Package 3 Achieving SESAR Goals in the Long-term

All previously identified benefits achieved with the implementation and deployment of the 2 previous Implementation Packages are now further enhanced with Implementation Package 3 to meet SESAR long-term goals. In addition to further improvements to existing operations, new concepts are introduced such as other new separation modes using more advanced ASAS Separation and Self Separation applications.

The IOC dates of the IP3 OI steps starts in 2020 and goes beyond. These OI steps need a lot of Research and Development to reach the maturity level necessary to confirm their validity and decide on their implementation, and their IOC dates may be modified. Some new OI steps may be identified in the next phases of the SESAR project as part of the Master Plan maintenance process or as a result of innovative research.

It has to be noted that some Line of Changes of the ConOps have been completely implemented in IP2. This is the case for Collaborative Planning using NOP, Managing the Network, Managing the Business/Mission Trajectory in real time, Collaborative ground and airborne decision-making tools and Queue management. Nevertheless, the operations in these domains will have to adapt to the Operational Improvement brought by the other OI steps (e.g. the introduction of mixed mode of operations) and the enabling system and technologies will continue their improvements (improved use of SWIM services). These changes have not been considered as OI steps.

A performance assessment has not been carried out on IP3 as the long-term performance goals have no associated dates and as the OIs are not sufficiently defined and the necessary performance assessment/validation tools are not mature enough to assess accurately their performance benefits. It is therefore suggested that a performance assessment will be performed in the next phases of the SESAR project.

5.1 IP3 – Required Performance

The long-term targets have been defined in D2 [Ref 3] as the political vision and goals for the design of the future ATM System, as EC objectives of the SESAR programme announced by EC Vice President Jacques Barrot. They are to achieve a future European Air Traffic Management (ATM) System for 2020 and beyond which can, relative to today's 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;
- Provide ATM services at a cost to the airspace users which is at least 50% less.

5.2 IP3 – Operational Improvements and Enablers

5.2.1 Operational Improvements and System Enablers

Figure 55 shows the main changes that will be introduced to the operations during IP3, and the supporting evolutions to the EATM architecture and technologies.

- **Group of OI steps** compatible in terms of nature of the change and their IOC date, are shown in the form of milestones (♦ **diamonds**) corresponding to their IOC date. They are presented along the Lines of Change describing the Concept of Operations (Please refer to Annex III). An explanation of these groupings of OI steps is given in Annex III.

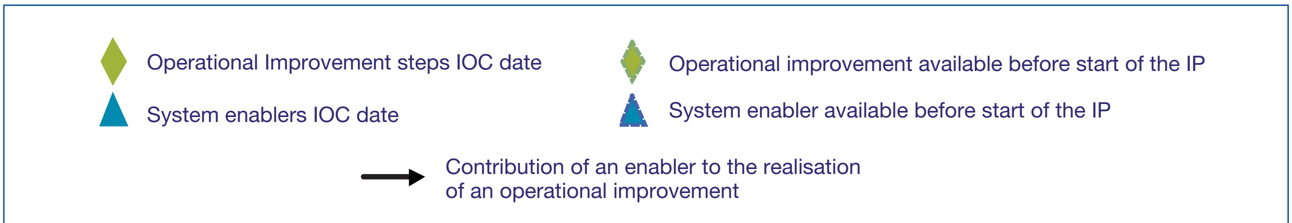


Figure 54: Legend for the IP2 Timeline Diagrams

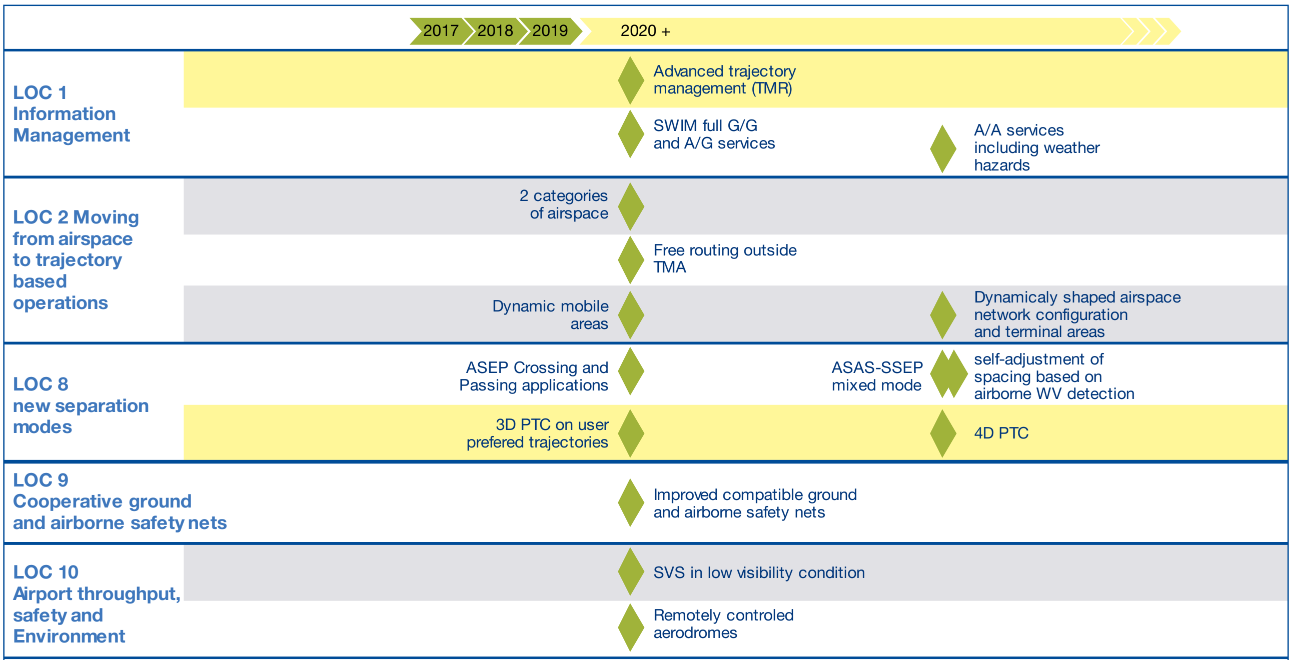


Figure 55: IP3 Main Changes

- The main system enablers (changes to the architecture and supporting CNS technologies), contributing to the operational changes are shown in the form of **triangles** (▲) corresponding to their IOC date. **Arrows** (⟶) represent their contribution to the realisation of the operational changes. More details on system and technology enablers can be found in Chapter 6 and the full list in Annex VI. Whilst recognising the fact that one enabler can contribute to many operational improvements, only the main enablers and links are displayed. Important enablers other than system enablers are not displayed for readability.
- Some system enablers are already implemented to support IP1&2. They are represented with a **dotted shape**, before the start of the IP3 timeline. On the other hand, some system enabler are first introduced during the IP1&2 period, but support only IP3 OI steps and are presented with the solid shape.

The following sections describe the operational and associated technical enabler changes per Line of Change.

Information Management

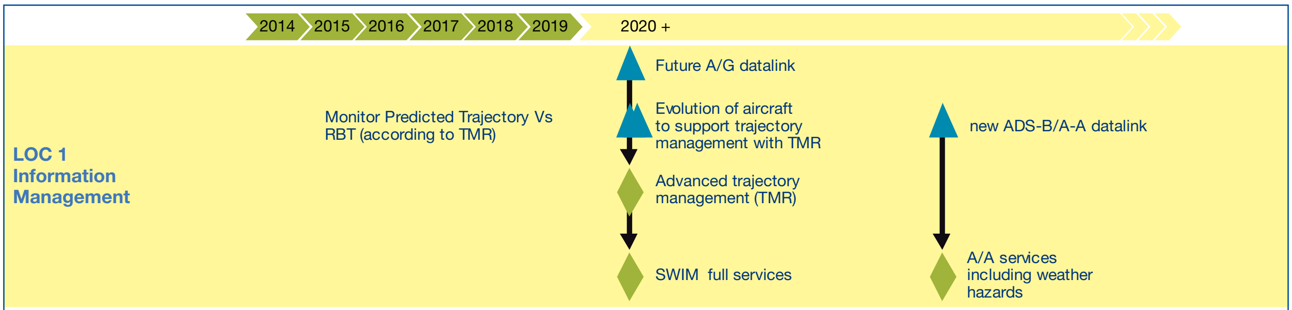


Figure 56: Information Management in IP3

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 **SWIM full service** composed of Ground-Ground full SWIM services (including exchange 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. Stakeholder systems and in particular NIMS and AAMS systems, focus now on adapting their architecture to SWIM in the framework of a continuous improvement process. NIMS keeps supporting its role of being an entry point for airspace users and external entities that are not connected to SWIM and/or not equipped with local optimisation tools. Air-Ground extended serviced is 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.

Finally the implementation of **Air-Air services** allows the introduction of Self-separation (based upon meteorology, wake vortices and trajectory information aircraft data sharing). These services require the implementation of the Air-Air data link in L-Band and the development of the associated airborne transceivers.

Moving from Airspace to Trajectory based Operations

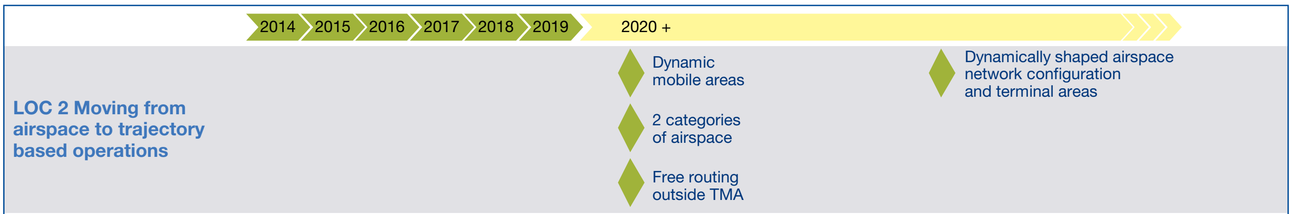


Figure 57: Moving from Airspace to Trajectory based Operations in IP3

The rationalisation and harmonisation of the airspace now reaches maturity. Only **2 categories of airspace** exist: managed and unmanaged.

Airspace reservations are now considered in the context of temporary mobile volumes optimised in time and size besides geographical fixed Temporary Restricted Area/Temporary Segregated Area (TRA/TSA) and defined Military Variable Profile Areas (MVPA) to meet the user's needs while minimising the impact on other airspace users (**dynamic mobile areas**).

Free routing is now in place except in ETMAs/TMAs, whilst respecting the requirement for airspace reservations and the need to suspend free routing due to military operations (e.g. around busy military airfields under certain circumstances or for major military exercises).

Airspace users select the most appropriate route based upon TTA, EOBT, METEO and other operational conditions including airspace and traffic constraints, drawing from a continuously updated NOP. The quality of the NOP information benefits from the implementation of the full set of SWIM services and allows all involved stakeholders to be aware on time of all the latest network events.

ATC sectors shape and volumes are adapted in real-time to respond to dynamic changes in traffic patterns and/or short term changes in users' intentions. TMA configuration is adapted dynamically in order to respond in real time to changing situations in traffic patterns and/or runway(s) in use (**dynamically shaped airspace and terminal area**).

New Separation Modes

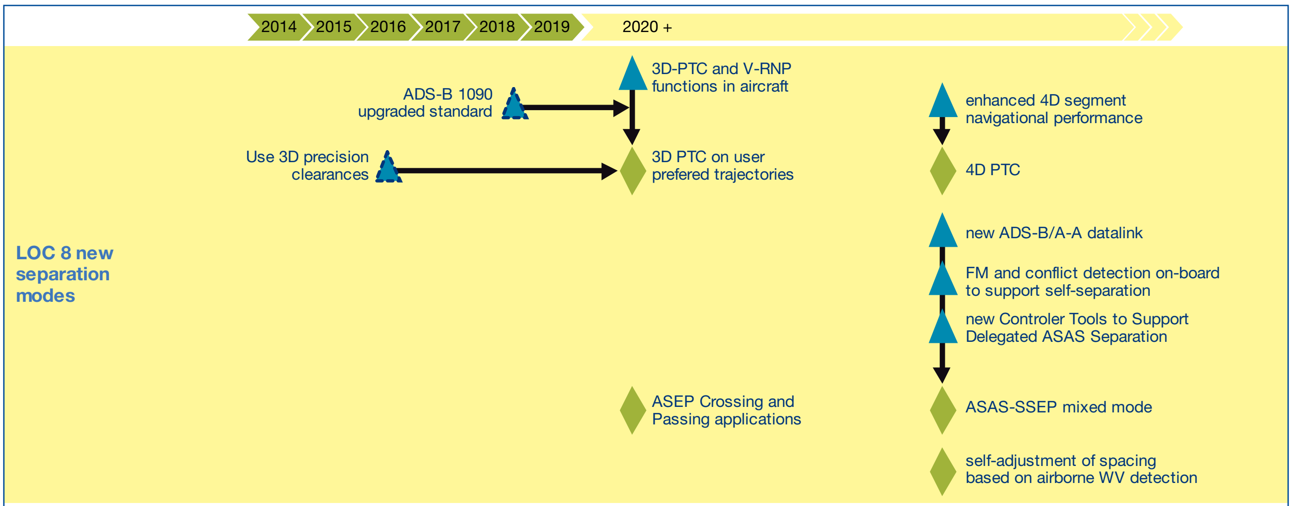


Figure 58: New Separation Modes in IP3

3D Precision Trajectory Clearances (3D-PTC) is implemented for Aircraft flying User Preferred Trajectories (Dynamically applied 3D routes/profiles) and later, the **4D-PTC** is implemented using longitudinal navigation performance management from the aircraft.

The new airborne separation modes are implemented: first step being the delegation of the separation by the controller to an aircraft for crossing and passing manoeuvres relative to designated target aircraft (**ASEP-Crossing & Passing applications**) and then the delegation of the separation to an aircraft to all the other aircrafts by the controller in mixed-mode environment (**ASAS–SSEP mixed mode**). The implementation of either a second new ADS-B link or a significant enhancement of the existing one and significant enhancement of on-board systems (Communication functions, Flight management and guidance and Onboard conflict detection and resolution) is required to support ASAS self-separation application. Ground systems, like controller workstation, FDP and Flight path monitor tools are modified to allow management of all aspects of 4D trajectories (including clearances, RBT update proposal, constraints, pilot request, TMR, etc.). Ground traffic planning tools identify the aircraft able to accept delegated separation (aircraft self-separated) and show the overall potential and real impact of aircraft being removed from the controller responsibilities on the concerned sector's capacity level.

Aircraft can determine the wake vortex characteristic they generate and broadcast this information by data link to neighbouring aircraft. As a consequence, the spacing between aircraft is adjusted dynamically by the pilot based on the actual strength of the vortex of the predecessor (**adjustment of spacing based on airborne WV detection**).

Cooperative Ground and Airborne Safety Nets

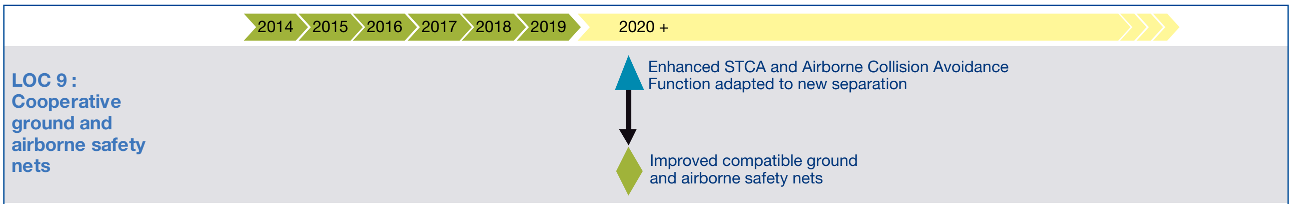


Figure 59: Cooperative Ground and Airborne Safety Nets in IP3

Onboard Airborne Collision Avoidance Function and ground STCA still perform the required safety function in the context of new separation modes. Better coordination between the Airborne Collision Avoidance function and STCA is also introduced. They need to stay independent at functional level. There is however a need for better procedures in order to avoid inconsistent collision detection and solution. Also, information sharing is to be considered to avoid common mode of failure.

Airport throughput Safety and Environment

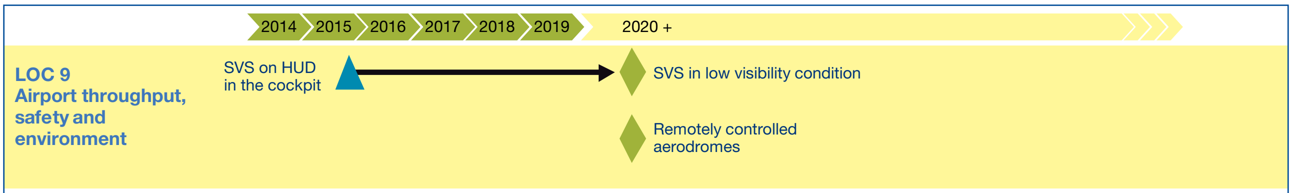


Figure 60: Airport throughput Safety and Environment in IP3

The cockpit systems provide the pilot with a synthetic/graphical view (Synthetic Vision System - SVS) of the environment using terrain imagery and position/attitude information on HUD to facilitate approach and ground operations, in particular in Low Visibility Conditions. New operational procedures will be developed to obtain the full benefits from the use of this SVS evolution.

Remote tower operations are introduced allowing controllers to use remote sensors to provide real-time services in a cost effective way.

5.2.2 Human and Institutional Enablers

5.2.2.1 Human

5.2.2.1.1 Human Factors Enablers

Also for IP3 it is strongly recommended to carry out a Human Factors Case for each OI Step.

5.2.2.1.2 Recruitment, Training, Competence and Staffing Enablers

An analysis of the impacts of IP3 for Recruitment, Training, Competence and Staffing (RCTS) is summarised in Table 6.

The analysis reveals that, compared to IP1&2, IP3 will have enormous implications for the management of operational competence. Especially the new role and responsibility distribution in the area of separation provision (self separation, 4D PTC management, Precision Trajectory Clearances, high degree of automation) is expected to require changes in international regulations and standards, as well as an increased need for continuation training to prepare for non standard situations. The expectations, the continued central role of the Human, especially in non standard situations, will require a selection profile for ground roles and flight crew similar to today.
Critical enablers for IP3 implementations will therefore be:

- Systematic assessment of competence and ability requirements impacts in the IP3 related R&D (starting during IP1);
- Early assessment of international and national regulations and standards for their need to be adapted;
- Early provision of suitable training simulation equipment and harmonised training objectives and standards (enabling harmonised procedures);
- Provision of active staff for involvement in R&D activities during IP1&2 timeline and provision of staff to cater for increased need of refresher training in a highly automated environment;
- Clarification of responsibilities of operators and technical staff including their clear reflection in relevant competence standards.

Colour coding / Percentage of affected OIs: (red) > 50%; (orange) ≤ 50% and ≥ 40%; (light orange) < 40%	***Recruitment, Training, Competence and Staffing Enabler area*** (for details, see SESAR 1.7 D4 DLW)	***Level of impact (Percentage of the OIs affected in IP3)***	***Minimum** years timeline to start activities before IOC*
Competence requirements of operational staff		91%	2
Regulations and standards		86%	7
Verification of competence-		91%	7
Training		100%	2
Recruitment and Selection		14%	5
Staffing		29%	5
System design encompassing training feasibility		100%	4

Table 6 Level of impact on Recruitment, Training, Competence and Staffing Enablers in IP3

Concerning staffing, a decrease in staffing needs for ATCOs becomes likely only from IP3 on, provided that the envisaged features are implemented in a stable and efficient way. Training delivery for all groups of affected staff is expected to consume around 8 millions working days in IP3 (bottom up estimate assuming all staff affected by an OIs is to be trained).

More detailed implications from IP3 are to be determined in the related R&D during the next years.

Chapter 6.3 outlines how an aligned, OIs related Training management enabling a timely and harmonised implementation will be set up.

5.2.2.1.3 Social Factors and Change Management Enablers

There will be a shift of focus towards broader perspectives in Social Policy in Europe due to:

- Changes in the age structure (demographic factors) of European Population for the period 2015 to 2030;
- The need for an effective framework for transferability and mobility of civil aviation staff;
- The need for common objectives in European Social Policies;
- The need for Social Partners to invest in their workforce to ensure employability.

The Social Dialogue will be privileged to find solutions to those common challenges by the European and National legislators once a legislated Social Dialogue structure is in place. New items related to these challenges (ageing productivity, mobility, new work organisation etc.) should be on the agenda for a more elaborated European Social Dialogue. Social Partners have a key role to play and greater responsibilities to bear in finding solutions between themselves. An important aspect is to establish collective agreements at European level going beyond the classical topics of wage and working time.

The dependency of the ATM industry on highly skilled and professional groups of staff having a significant impact upon service provision is a critical factor and requires specific measures to be taken to increase flexibility and productivity in a change process.

The most important factors for making sustainable changes are to create understanding and acceptance, achieve commitment and motivation and to reduce the level of uncertainty related to implementing changes. In addition, a proactive contribution and a positive attitude towards to change management by Social Partners will be the norm.

A pan-European regulatory framework for change management setting up stable procedures and participative processes will support and ensure a successful implementation of the ATM Target Concept. A safety regulatory authority at European level acting also as the regulatory interface for change management will, where appropriate, propose amendments to European Civil Aviation legislation and existing safety regulatory requirements and arrangements.

5.2.2.2 Institutional

5.2.2.2.1 Standardisation

For IP3, no critical standardisation issues have been identified to date. Nevertheless, it is necessary to start, in the IP1 timeframe, some initial activities to investigate those standardisation aspects of the new technologies proposed for deployment in IP3 (e.g. new datalink technologies, new datalink services and ASAS applications) since most of the immature technologies have an R&D completion date around 2014-2016; this makes them compatible with the starting date for IP3.

Notwithstanding the above, the need to achieve interoperability with military systems still requires specific attention. There is still a need to identify those aspects which require standards to be agreed to achieve this.
The full standardisation roadmap can be found in Chapter 6.8.

5.2.2.2.2 Environment

The enablers required and planned for IP1 and IP2 need to be continuously updated after 2020, depending on R&D results activities. Formerly any new enabler is required on long terms, but a refinement of those already identified for IP1 and IP2 is a key point to be addressed.

5.2.2.2.3 Security

By the start of IP3 it is expected that the proposals made for IP2 will be mature and used in “everyday activities”. Thus, for IP3 it is anticipated that the processes, procedures and regulations in-place will be subject to continuous review, improvement and update. This will be done to ensure they keep pace with and remain relevant to the development of the longer-term aspects of the Target Concept which will be implemented beyond 2020. In particular:

- Trusted Security Partnership Framework and Regulations:
  - International Security Regulations shall be implemented at the ICAO level by 2025;
  - The standardised Identity Access Management & Staff Vetting regime shall be fully implemented by 2025.
- Implementation of Security Service in the ATM:
  - The Automated Trajectory secured function shall be implemented by 2025.

The full security evolution roadmap can be found in Chapter 6.6.

5.2.2.2.4 Decision-Making

By IP3 it may be hoped that the anticipated institutional improvements have been implemented. In this case, the IP3 processes should simply be “more of the same”.

5.2.2.2.5 Legislation

It is again taken as the starting point for this assessment that all identified legislative requirements for IP1 and IP2 have been implemented.

The full implementation of the Information Management strategy will take many years and the last elements of SWIM are anticipated during the IP3 timeframe. There will therefore still be some issues which need to be addressed at European level even at this stage. The proposed move to 2 categories of airspace will require the evolution of both European and National legislation. However, it might be possible for this to be included within the same set of amendments which enables the move to 3 categories made as part of IP2. In this case, no further legislation would be necessary.

The majority of the proposed changes within IP3 requiring legislative support appear to relate to improved aircraft and ground equipage and the adoption of new procedures to obtain benefits from this (e.g. ASAS, new datalink technologies). As such, this should mainly be achievable through adjustments to existing requirements for avionics equipage and related operational procedures.

Finally, the assumption that a trajectory management approach will involve increased "out of area of responsibility" working will require improved and more formalised arrangements at State level to ensure the necessary legal clarity is in place over issues such as responsibility and liability.

5.2.2.2.6 Safety Regulation

By the start of IP3 it is expected that the proposals made for IP2 will be mature and used in "everyday activities". Thus, for IP3 it is anticipated that the roles and responsibilities, processes, procedures and regulations in-place will be subjected to continuous review, improvement and update. This will be done to ensure they keep pace with and remain relevant to the development of the longer-term aspects of the Target Concept which will be implemented beyond 2020.

5.3 IP3 – R&D Needs and Related Programmes

This section covers two aspects. The first gives an overview of the key R&D needs which must be done prior to implementing the Target Concept in the long-term. The second provides a summary of the assessment of the on-going R&D initiatives/programmes to determine if work is already being done to cover the R&D needs.

5.3.1 R&D Needs

The R&D activities summarised below are the main subjects associated with achieving trajectory monitoring and providing Air-Ground and Air-Air extended services to allow Precision Trajectory Clearances (PTC) with Trajectory Management Requirements (TMR) and ASAS Self Separation. Specific focus will be given to the role of the human (Note : Full details can be found in [Ref 13, 14, 17, 18] and Chapter 6).

- Wake vortex spacing;
- Further development of Air-Ground extended services;
- 3D PTC (user preferred trajectory) and V-RNP, 4D PTC and 4D RNP;
- Future Communications system;
- Air-Air exchange services in support of the ASAS-ASEP and ASAS-SSEP applications;
- On-board ACAS is evaluated to ensure that it still performs the required safety function with the new separation modes;
- ASAS separation and self-separation;
- Air and Ground Safety Nets. Continued study of the potential for providing complimentary warnings from the two independent/separate safety nets in a coherent manner;
- Delegate aircraft separation in a mixed mode control environment, including appropriate mechanisms for task delegation and authority sharing;
- Dynamic transfer of sectors between ACCs;
- R&D activities need to determine how to support military aircraft flying 4D trajectories using military mission systems or ultimately ground support systems.

5.3.2 Related R&D Programmes

An analysis of the on-going R&D programmes and initiatives has been carried out to assess how well the subjects being studied are aligned with meeting the objectives of the OIs in IP3 by analysing over 170 European R&D activities with respect to the KPAs, ConOps, IPs and R&D Needs for ConOps, Architecture, Technology and HF/HR as expressed in D3. The analysis can be found in Work Package 3.1 DLT [Ref 20] and a summary of the results is provided below.
The study has highlighted the low level of investment today for the longer term (in particular covering the contents of IP3). The Long-Term work programme identified within SESAR is expected to cover specific elements identified as part of the SESAR operating environment, but which are not attainable in the 2020 timeframe. However, these activities will be constrained to the operating environment envisaged for SESAR.

Fundamental, innovative research addressing time horizons beyond the SESAR vision will not be addressed or identified in the ATM Master Plan. Due to the very long cycles required to implement improvements in air transport, it is very important to stimulate creativity and innovation which will develop the scientific knowledge for the long-term and beyond, establishing the foundation upon which Europe's ATM System will cope with future challenges and European industries will remain competitive in the global marketplace. There is a concern that the pressure for more immediate return of research in the context of the SJU could lead to neglect this more fundamental, innovative research.

The Advisory Council for Aeronautics Research in Europe (ACARE) has established its Strategic Research Agenda II. This has formed the framework which guided much of the aeronautical research performed in Europe over the last decade aimed towards the political performance targets exploited by SESAR. The developments resulting from the SESAR initiative should be assessed against ACARE SRA II, and vice-versa, to facilitate the development of an eventual SRA III, building upon and looking beyond SESAR. SESAR must actively participate in this effort and exploit ideas developed in this context for its longer term developments.

There is a necessity to develop the relationships with academia who are, to some extent, absent from the ATM domain in the vast majority of ongoing initiatives. Inspiration could be taken from the US example of Nextor, which is an organisation formed by the partnership between several universities, NASA and Federal Aviation Administration (FAA), to promote ATM research within the academic community.

Taking the example from the PHARE programme and other industrial sectors, it would appear a reasonable target of 5% to 10% of the overall investments of R&D should be preserved and dedicated to innovative research activities. The magnitude of the investments should be modulated to reflect increasing levels of maturity and progress.

5.4 IP3 – Conclusions & Risks

IP3 is targeting the activities necessary for further capacity enhancement of the overall ATM System beyond 2020. In addition there is a need for continued regulatory interface across the disciplines and resolution of governance. All the necessary R&D needs for this period have been identified and need to be launched in a coordinated and rationalised way.

Analysis of R&D initiatives supporting IP3 concluded that the following areas need to be initiated and/or accelerated to deliver their results to meet implementation timescales:

- Use of Free Routing from Terminal Area Operations exit to Terminal Area operations entry and the use of pre-defined ATS routes only when and where required;
- Synthetic Vision for the pilot in low visibility conditions;
- Self adjustment of Spacing Depending Upon Wake Vortices;
- ACAS adapted to new separation modes;
- STCA adapted to new separation modes;
- Improved Compatibility between ground and airborne safety nets;
- Optimised use of ASAS/Trajectory management to maximise capacity;
- Developing mitigation strategies for equipment failure during self-separation;
- Assessment of the need for Air-Air datalink;
- Assessment of cost-effective replacement technology for primary radar;
- Use of virtual towers and low-cost airport weather radar to support airport capacity in all weather conditions.

It has also been observed that few of the R&D needs elaborated so far relate to the participation of UAS in the ATM System, despite the fact that UAS operations are likely to be frequent by 2020 and that the technologies developed for UAVs (including datalink and "sense & avoid" systems) could be considered for use in other ATM areas. It is recommended that the SESAR R&D plan includes specific items on UAS.

The major risks associated with IP3 are considered to be:

- Unsuccessful implementation of IP1 and IP2;
- Lack of convergence to ATM Target Concept, especially concerning:
  - o Unmanned Air Vehicle/Unmanned Aircraft System (UAV/UAS) operation with ATM;
  - o New methods for separation provision, particularly those which change the separation authority;
  - o Effective ground and airborne safety nets;
  - o Engagement of Social Partners.

6 Shaping the ATM Master Plan & Work Programme

The previous chapters have shown, starting from the OIs and per IP, what is required to implement the ATM Target Concept. This chapter provides "roadmap" views of the activities of the different enablers over the IP1/2/3 period. It hereby provides the link with the ATM Master Plan (D5) and associated Work Programme for 2008-2013 (D6) where further details will be presented. For more information see further the relevant sections in the chapters 3-5 or in the Task Deliverables.

The last section on research & development considerations is of a slightly different nature as it does not show a roadmap but addresses major orientations of the R&D part of the ATM Master Plan.
Recognising the need to address the deployment of each IP at a manageable level, a second level of granularity within the IP has been introduced focusing on Service Enhancement Transition Steps (SETS). In Annex III the link between Lines of Change and SETS is explained.

6.1 Architecture

This section describes the architecture roadmap which presents, in broad terms, the main functional steps and the main infrastructure enhancements for each stakeholders' systems in order to realise the ATM Target Concept. For systems to co-operate and share data in an effective way, **a common time reference mechanism** or process will have to be employed across the European ATM System. A more detailed description of the architecture roadmap can be found in Work Package 2.4.4 [Ref 17].

New Architecture model

While some of the early packages are based on existing systems evolution plans and thus relying on existing and fragmented system design, it is recognised that all packages to be delivered within IP2 and after, will rely on a new architecture development process relying on an Enterprise Architecture framework and taking a service oriented approach[20]. This means that all changes to be made to the ATM system will be the result of this new process where the architecture makes use of one shareable infrastructure for all SESAR Performance Partners and where all present and future applications make use of EATMS Service through published standard service interfaces. The roadmap shown in the next pages is the current estimate of how and where the services to be provided and the main technical evolutions are to be deployed according to current thinking.

En-Route & Approach - ATC

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 through SWIM, 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 rules, policies and services. Coflight and iTEC, currently being developed in Europe, are projects providing the first step towards a new generation of standardised component based systems. They will deliver flight information sharing and Air-Ground cooperation services. Initial SWIM services will be provided either directly from enhanced sub-systems or through an integration layer added to legacy sub-systems. This will be followed by a migration to systems based on standardised components and making use of the Common ATM Reference Model.

On a functional level, the eFDPs will provide support for improved conflict prediction, coordination and transfer, and the introduction of multi-sector planning and 2D precision clearances. Later, the En-Route and Approach ATC sub-systems will evolve to manage airspace users' trajectory requests and finally to manage all aspects of 4D trajectories. Support will also be provided to allow delegation of separation responsibilities from controllers to pilots, taking advantage of improved aircraft capabilities enabling self-separation and sequencing. This will be accompanied by updates to ground Safety Nets sub-systems to reduce false alerting and to provide focused alerting for mixed traffic operations.

AMAN will be initially improved to provide sequencing information into the local En-Route environment, later there will be more integration of DMAN and AMAN from adjacent airports and use of the aircraft's capability to handle Controlled Time of Overfly (CTO) on multiple waypoints.

Dynamic airspace management processes will provide support to local, sub-regional, and regional facilities, and will eventually support

20 - The follow-up of the D3 recommendation on the Enterprise Architecture and Service Oriented Approach has recently started; Initial conclusions are expected to be incorporated in D6 for further work during the post-definition phase.

the dynamic transfer of sectors between ACCs enabling management of local resources to reflect daily variations in traffic patterns.

Aerodrome ATC/Airport

In the Pre-SWIM phase (2008-2010), the existing Airport and Aerodrome ATC sub-systems (DMAN, SMAN and Runway usage management) providing the first generation of integrated airport operations controllers' tools are further developed to meet the Airport-CDM concept (through airport operations centres). Aerodrome ATC and Airport Demand and Capacity management sub-systems are introduced in support of strategic and pre-tactical airport operational planning.

A secure SWIM infrastructure, based on the development of a common ATM Information Reference Model, is expected to be available by 2013. A first set of services will be available around the same time and new services will be added, as needed, up to 2020. Coupled to the exchange of information via SWIM, the integration of local Aerodrome ATC sub-systems will provide major improvements to queue management. Further improvements will be derived from the introduction of a new Airport system, Environment Management, as well as from enhanced Turn-around management supporting the “En-Route to En-Route” concept and from enhanced runway management (separations based on dynamic wake-vortex information). In parallel, a new generation of TWR Controller Working Position will fully support the features brought up by the integration of these tools.

As a final step (2013-2015), enhancement of airport ground equipments will allow provision of advanced guidance service to aircraft and airport vehicles combined with routing, whilst in high density/complexity airport context, sequence management tools will be enhanced to cover the needs of multiple airports within the same TMA.

Airspace Users-AOC

AOC-ATM systems will implement changes either as “proprietary” or through a third party giving the service.

Priority will be given during the pre-SWIM phase on enhanced communication and information sharing with aerodromes and ATC actors using legacy bi-lateral communication means. This will be achieved through the implementation of the latest Airport-CDM plans. During this period a common flight plan format for OAT and General Air Traffic (GAT) flights coming with a need for improved flight planning will induce some adaptations in the military Wing Ops or other command and control centres.

Following this phase, SWIM will allow sharing of far more information, but will need modifications of the communications systems and new definitions of role and responsibility on the information CDM processes. SWIM will also support the UDPP process. In order to implement SWIM, adaptations to the common ATM information model will be made.

The new introduced concepts of NOP and Business Trajectories – coming with new required QoS - will call for improvements in the way the trajectory is computed and managed. Following the enhanced performance of aircraft, this could lead to a completely new generation of trajectory management systems (e.g. considering multiple CTOs, 3D precision trajectories in TMA, 4D-PTCs). This applies to AOC ATM civil 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.

Beyond these improvement steps, AOC-ATM trajectory management sub-systems will evolve to take into account dynamic routing and free route aspects.

Aircraft

The Communication aircraft architecture will be progressively integrated into the overall SWIM infrastructure by:

- The uplink of aeronautical data including meteorological data (D-OTIS, 2011);
- The uplink of ATC constraints/clearances/slight speed adjustment and the downlink of aircraft derived data/trajectory data (2013);
- The downlink of onboard meteorological data (2016);
- The downlink of the predicted trajectory in case of deviation and the reception of meteorological data provided by the ground system (2020).

The Navigation aircraft architecture will support new positioning, flight management and guidance system evolutions for enhanced altitude and time constraint management (2013), multiple time constraints and auto brake/taxi (2018), 3D-PTC & V-RNP (2020) and 4D-PTC and contract (2025).

The Surveillance aircraft architecture will move towards the necessary enhanced operations foreseen in the ATM Target Concept [Ref 2] with progressive evolution of the ADS-B transponder for ATSA (2009/10), ASAS Spacing (2011/13), ASAS Separation (2018); in addition new onboard equipment for wake vortex spacing (2020) and ASAS self separation (2025) will be introduced.

Network Information Management Systems (NIMS) & Advanced Airspace Management Systems (AAMS)

The actual CFMU-supported sub-systems will move to two regional closely-related systems (NIMS and AAMS) with the aim to support a more dynamic management of the network. The cornerstone of this change is the building and the continuous refining of the NOP along the planning layers.

On technical level, the first step is to adapt current strategic, pre-tactical and tactical systems around a set of logical data repositories (for demand, airspace and flight data) in order to provide actors with a single entry point (a NOP portal). Later on, the NOP portal will be complemented with a set of services provided in the framework of an API (Application Programming Interface) accessible in a transparent way for local/sub-regional applications through SWIM.

On functional level, and thanks to this new architecture, the NIMS and AAMS planning sub-systems will be closely cooperating around the NOP in planning the network resources usage for civil and military business needs. New CDM processes, involving airports and airspace users will improve capacity planning taking into account airline & airports schedule data. New tools and sub-system updates will permit to support free-routing and AFUA concepts (e.g. dynamic airspace allocation, dynamic sector shapes, variable airspace profile, etc.).

NIMS Demand & Capacity balancing sub-system will be updated to support the new role of arbitrator of the network management function in short-term planning and execution phases but it does not require any radical change compared to actual tactical CFMU system (ETFMS). The main functional change is to take into account airspace users priorities (expressed in the framework of a UDPP process for instance) when providing a DCB solution.

AIM

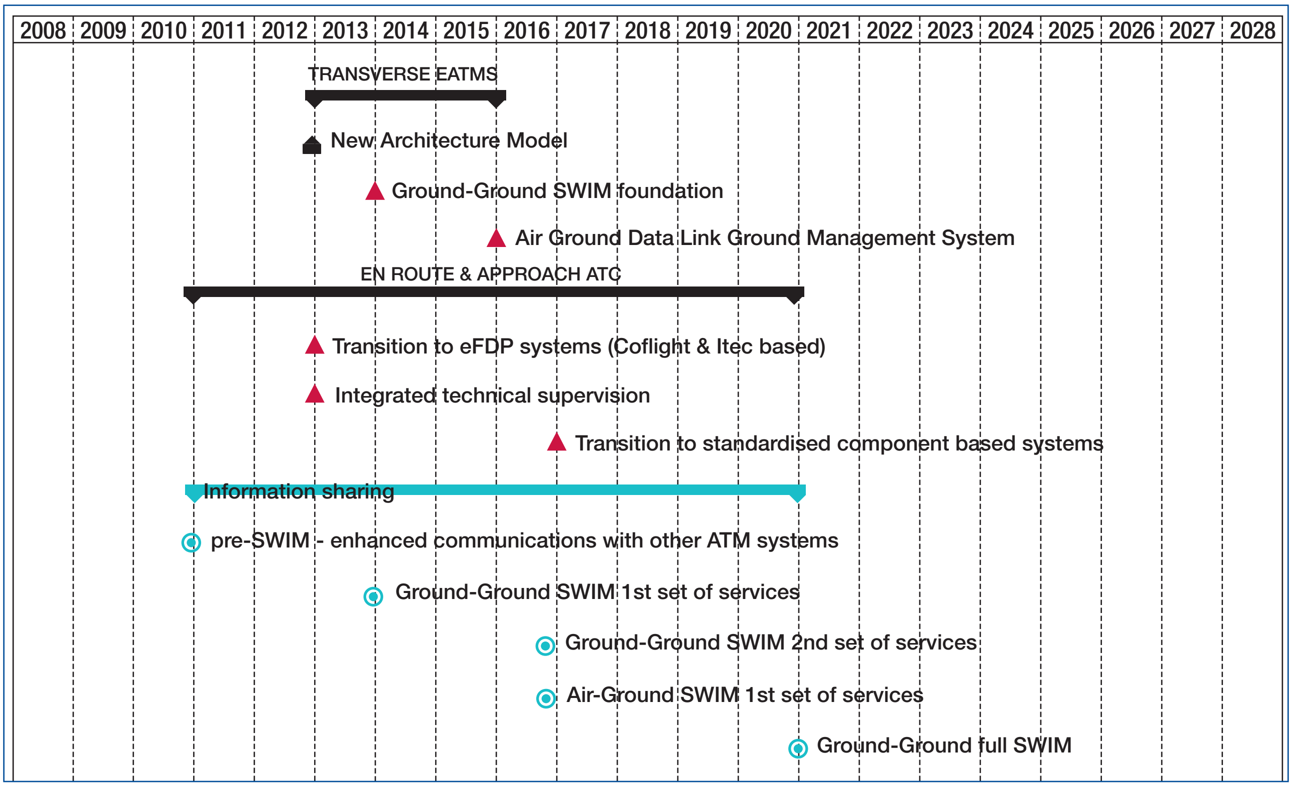
Aeronautical Information Services will evolve to Aeronautical Information Management where the traditional product centric provision of Aeronautical Information is replaced by a data centric and systems oriented solution (pre-SWIM) and then to Information Management corresponding to a full SWIM integration of AIM systems. The scope of Aeronautical Information will also be broadened to cover all ATM data (airport information, meteo data, obstacle and terrain data, environmental data, airspace data, and aircraft information).
For Airport Mapping, Terrain Information and Aircraft Information sub-systems new database systems are expected to be required.

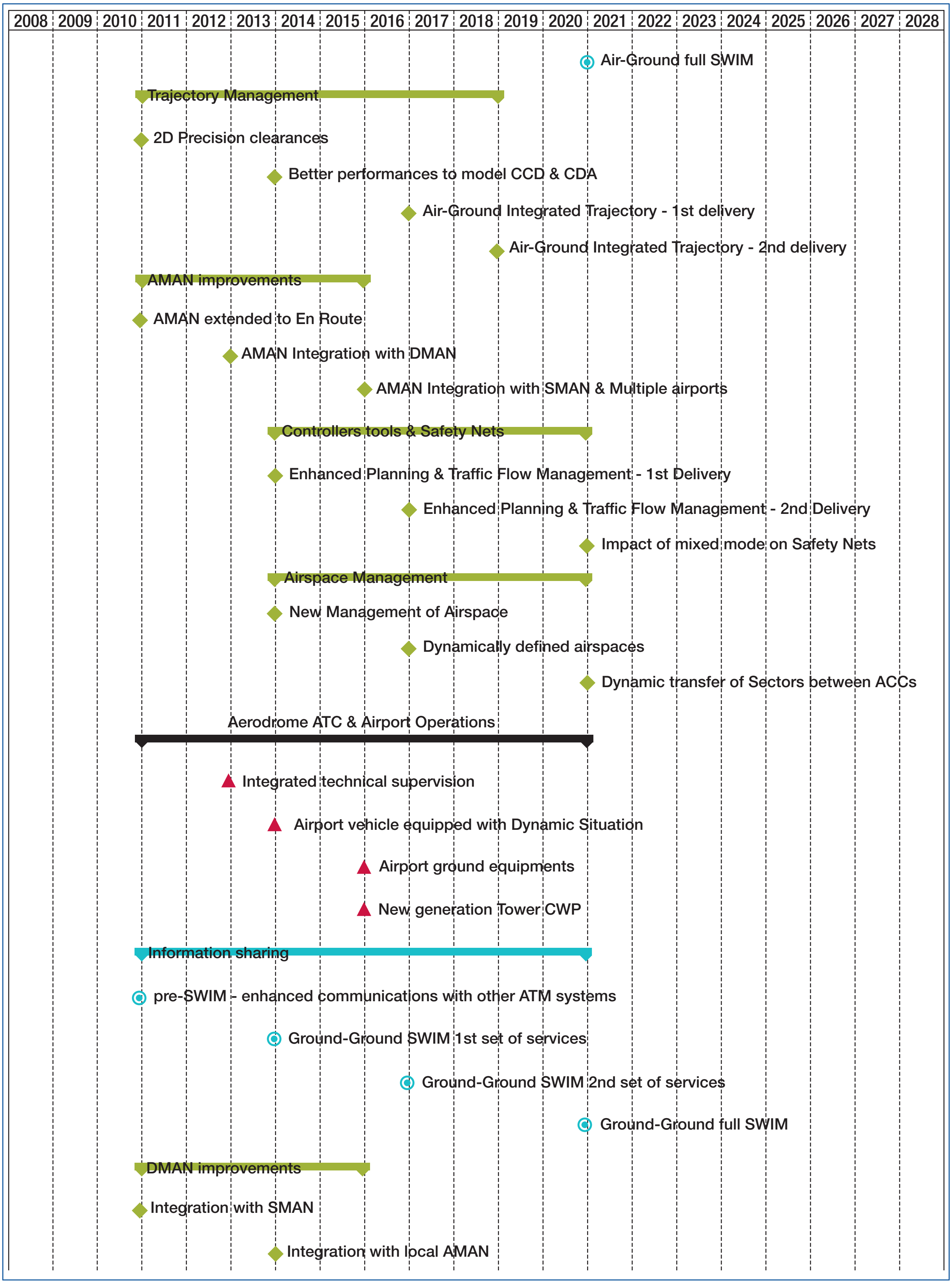
Air-Ground Data Link Ground Management System (AGDLGMS)

AGDLGMS is a new kind of system introduced either at sub-regional or regional level (i.e. one instance for the whole Europe or one per FAB) interfacing with the various mobile datalink networks, to provide efficient connectivity to aircraft. AGDLGMS will be implemented providing all the necessary Air-Ground core communication SWIM services and will be sharing all the common information thanks to its interface to the ground part of SWIM.

A first step (2016) will be achieved by allowing both Air and Ground systems to share all necessary AIS and flight information (including trajectory) they have to be aware of, also provision of Airborne weather information to the ground systems will be ensured through AGDLGMS. A second step (from 2020 onwards and based upon the latest available datalink technology) will provide further improvements such as the downlink of trajectory with TMR or broadcast of ground weather information (e.g. wind grids) to the airborne systems this time.
Figure 61 shows an integrated high level architecture roadmap, focusing on the main new element impacted.

Legend:
- ☗ Triangles are IOC dates for functional update;
- ▲ Diamonds are IOC dates for system changes.





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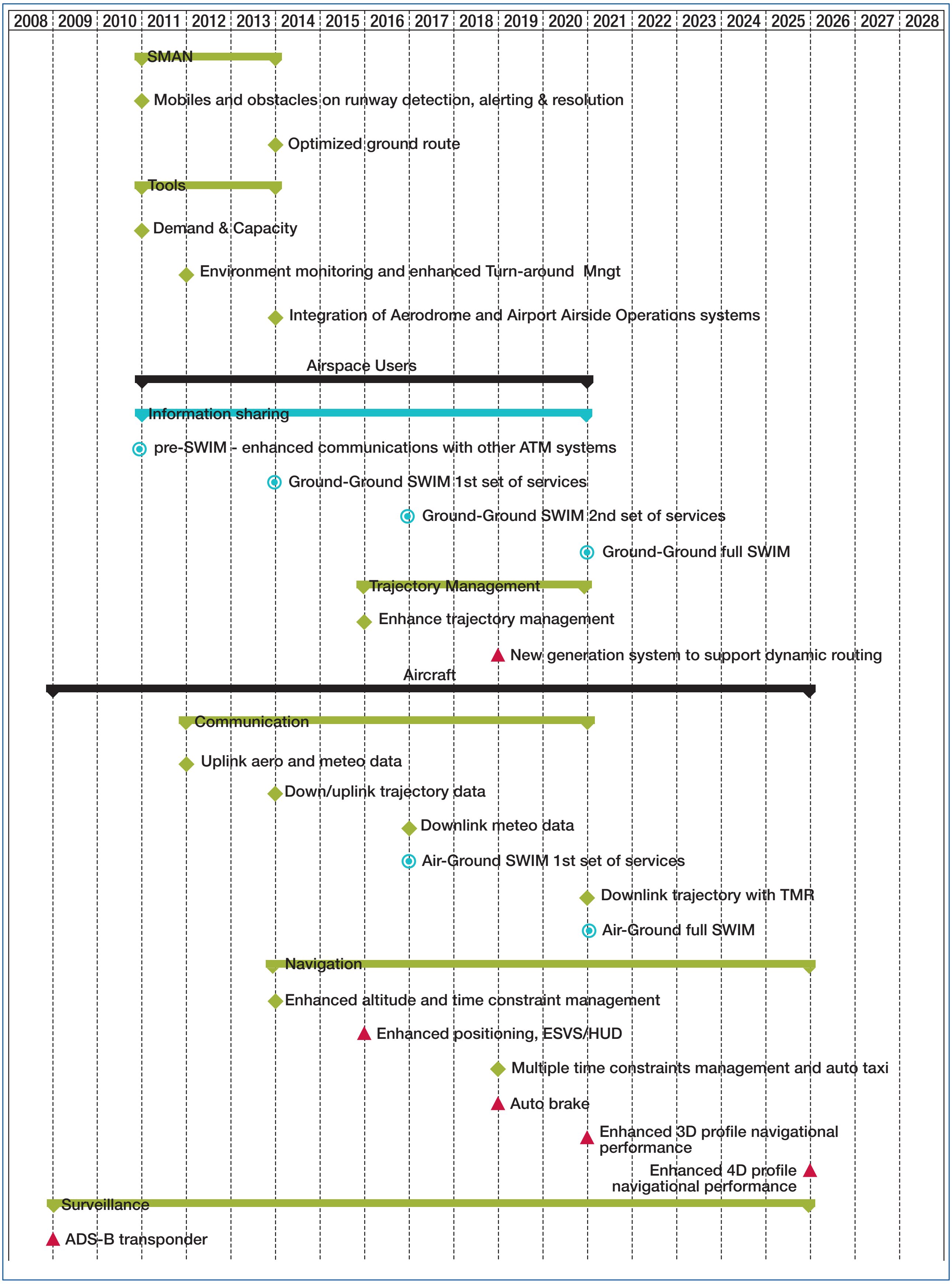
Air-Ground full SWIM
Trajectory Management
2D Precision clearances
Better performances to model CCD & CDA
Air-Ground Integrated Trajectory - 1st delivery
Air-Ground Integrated Trajectory - 2nd delivery
AMAN improvements
AMAN extended to En Route
AMAN Integration with DMAN
AMAN Integration with SMAN & Multiple airports
Controllers tools & Safety Nets
Enhanced Planning & Traffic Flow Management - 1st Delivery
Enhanced Planning & Traffic Flow Management - 2nd Delivery
Impact of mixed mode on Safety Nets
Airspace Management
New Management of Airspace
Dynamically defined airspaces
Dynamic transfer of Sectors between ACCs
Aerodrome ATC & Airport Operations
Integrated technical supervision
Airport vehicle equipped with Dynamic Situation
Airport ground equipments
New generation Tower CWP
Information sharing
pre-SWIM - enhanced communications with other ATM systems
Ground-Ground SWIM 1st set of services
Ground-Ground SWIM 2nd set of services
Ground-Ground full SWIM
DMAN improvements
Integration with SMAN
Integration with local AMAN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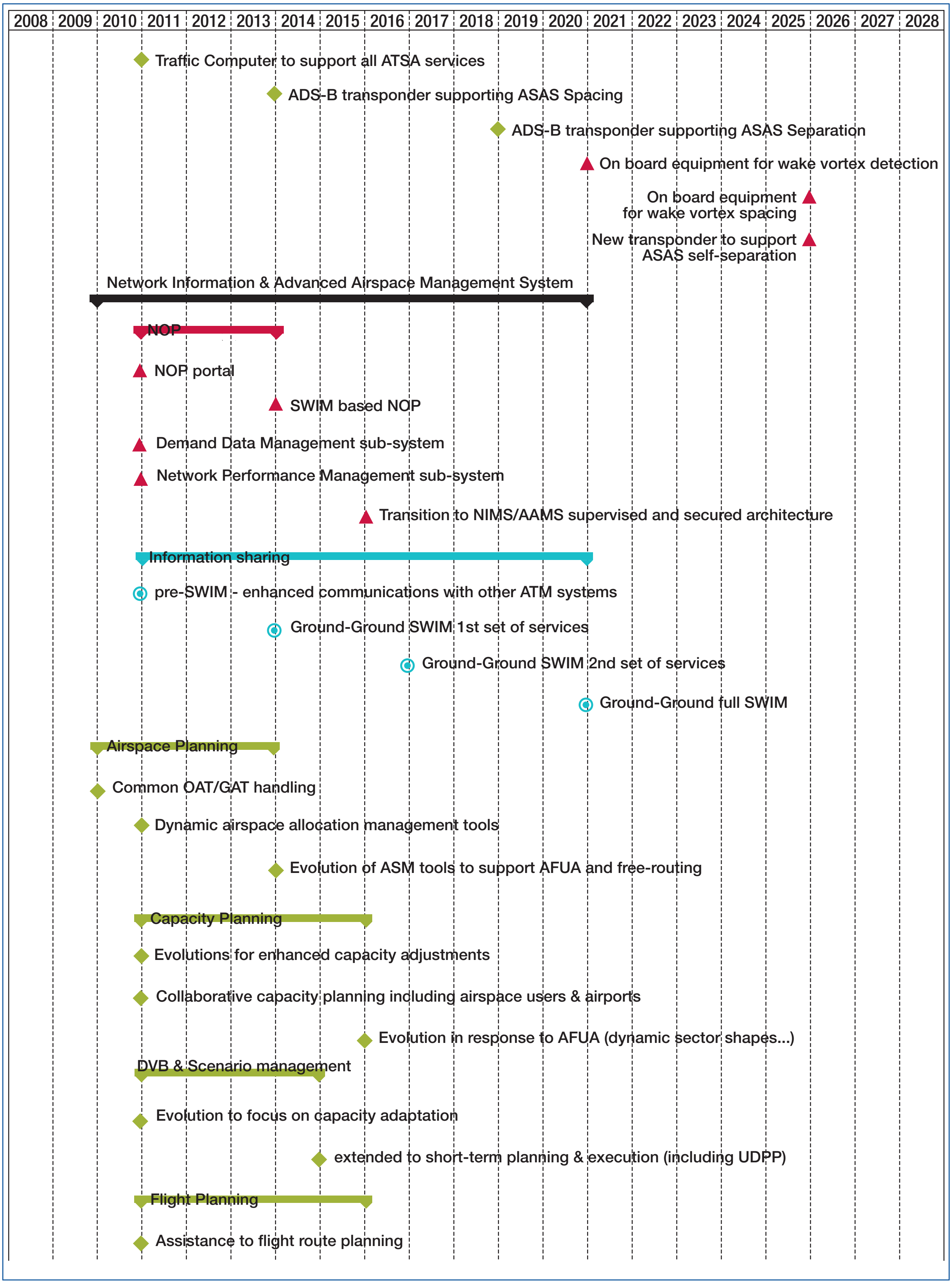
SMAN
Mobiles and obstacles on runway detection, alerting & resolution
Optimized ground route
Tools
Demand & Capacity
Environment monitoring and enhanced Turn-around Mngt
Integration of Aerodrome and Airport Airside Operations systems
Airspace Users
Information sharing
pre-SWIM - enhanced communications with other ATM systems
Ground-Ground SWIM 1st set of services
Ground-Ground SWIM 2nd set of services
Ground-Ground full SWIM
Trajectory Management
Enhance trajectory management
New generation system to support dynamic routing
Aircraft
Communication
Uplink aero and meteo data
Down/uplink trajectory data
Downlink meteo data
Air-Ground SWIM 1st set of services
Downlink trajectory with TMR
Air-Ground full SWIM
Navigation
Enhanced altitude and time constraint management
Enhanced positioning, ESVS/HUD
Multiple time constraints management and auto taxi
Auto brake
Enhanced 3D profile navigational performance
Enhanced 4D profile navigational performance
Surveillance
ADS-B transponder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Traffic Computer to support all ATSA services
ADS-B transponder supporting ASAS Spacing
ADS-B transponder supporting ASAS Separation
On board equipment for wake vortex detection
On board equipment for wake vortex spacing
New transponder to support ASAS self-separation
Network Information & Advanced Airspace Management System
NOP
NOP portal
SWIM based NOP
Demand Data Management sub-system
Network Performance Management sub-system
Transition to NIMS/AAMS supervised and secured architecture
Information sharing
pre-SWIM - enhanced communications with other ATM systems
Ground-Ground SWIM 1st set of services
Ground-Ground SWIM 2nd set of services
Ground-Ground full SWIM
Airspace Planning
Common OAT/GAT handling
Dynamic airspace allocation management tools
Evolution of ASM tools to support AFUA and free-routing
Capacity Planning
Evolutions for enhanced capacity adjustments
Collaborative capacity planning including airspace users & airports
Evolution in response to AFUA (dynamic sector shapes...)
DVB & Scenario management
Evolution to focus on capacity adaptation
extended to short-term planning & execution (including UDPP)
Flight Planning
Assistance to flight route planning

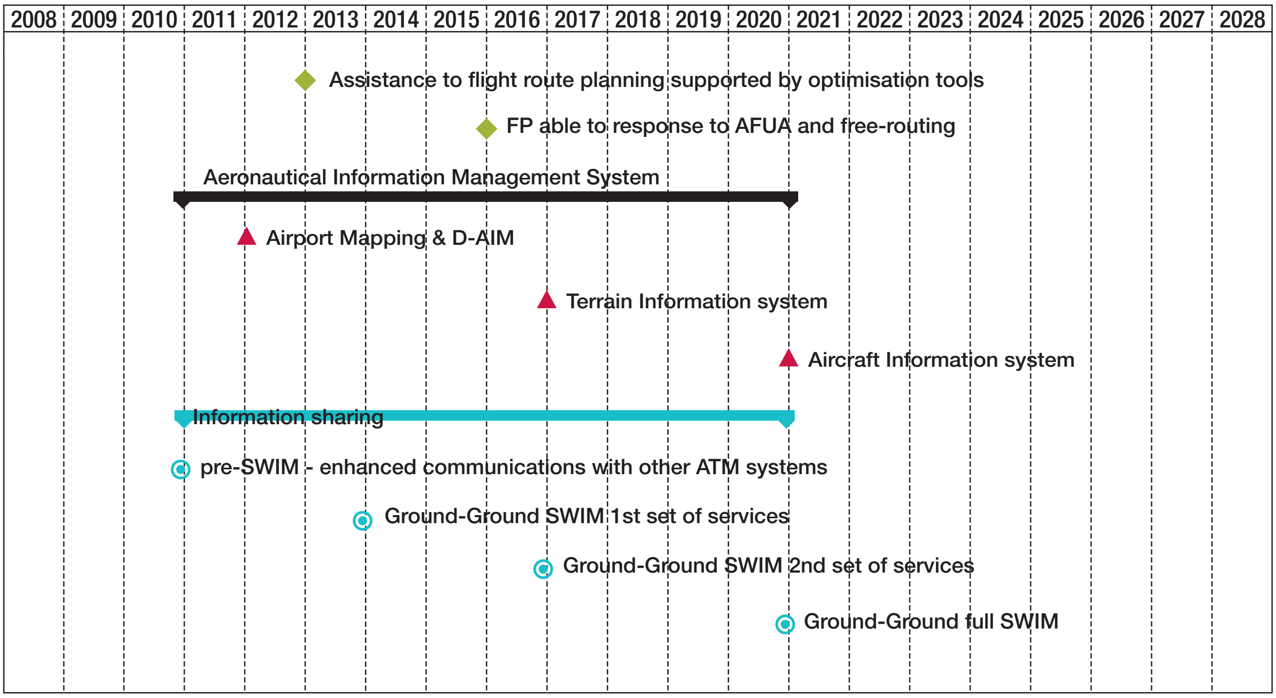


Figure 61: Architecture Roadmap

6.2 CNS Technology

This chapter describes the key elements of the CNS technology development and roadmap and starts to give outlines of the decommissioning and rationalisation scenarios which need to be further developed within the next SESAR phases.

It must be underlined that the proposed technology roadmap is the result of an expert judgment process which had to establish hypotheses for operational requirements of the ATM Target Concept. The selection process has identified new CNS technologies while making the best use of existing CNS technologies during the transition period. However, it has not been possible to push the analysis further in the context of the definition phase; in particular because the further selection of CNS technologies is highly dependent on the timely delivery of validated operational performance requirements. Nevertheless, the analysis has tried to establish the best possible link between the characteristics of CNS and the initial understanding of the future requirements. In doing so, R&D activities have been identified to validate this roadmap. It is recommended that they are started without delay as part of the SJU work programme.

This is particularly true for the new Air-Ground data-link and next generation data-link supporting ADS-B, and also for pending navigation issues.

Some enablers have been proposed due to their expected benefits in respect of cost-effectiveness and technical performance but they are not directly linked to Operational Improvement Step (OIs). For example in the surveillance domain: ADS-B can provide surveillance when radar is not available; improvements in PSR technology or alternative detection technology (e.g. Multi-Static Primary Surveillance Radar (PSR)) are needed to cope with newer composite aircraft and UAS. Digital technologies are in general used as cost effective replacements to analogue technology.
Another area requiring particular attention is radio spectrum since it is a finite resource for which there is an increasing demand from all sides of the community. Pressure is increasing on existing services to improve spectrum efficiency, while the cost for access to this radio spectrum is likely to increase. Therefore it is essential to:

- Maintain and where possible re-inforce the existing European function to coordinate and defend the European aviation interests in radio spectrum decision making forums, including coordination with other ICAO regions;
- Maintain a high integrity aviation Frequency Assignment database;
- Create a European function to monitor and audit European aviation frequency assignments usage;
- Investigate the impact on ATM spectrum of the need to provide safety-of-life assignments for control links between the remote pilot and the unmanned aircraft;
- Investigate more efficient spectrum technologies and interference mitigation techniques; and
- Consolidate the use of spectrum considering the potential decommissioning of former technologies.

6.2.1 Communication

To achieve the SWIM challenge and the underlying increased data exchange, the communications infrastructure needs to evolve. A common network transport protocol[21] will provide seamless communication between all actors, irrespective of the physical means of communication (radio, fixed wire, SATCOM, etc.), at the necessary QoS required.

Air/Ground Communication

The first phase improvement is the implementation of VDL mode 2/ATN already started with the Link 2000 + programme in Europe, for completion by 2015, and used for the first aircraft integration to SWIM.

To support the full SWIM integration, the final mobile data communication infrastructure will be a set of four components:

- New L band terrestrial data-link;
- Satellite data-link, to complement the terrestrial data-link and provide necessary performance[22];
- Airport data-link based upon wireless technology (IEEE 802.16e), to provide a high performance airport surface data link; and
- VDL2/ATN.

The research and development process for the final data communication infrastructure starting from the definition of the Quality of Service derived from the Operational requirements, up to the global standardisation and the full development can be very long if the current pace is maintained. To avoid hampering the deployment of the advanced SWIM services essential for the full implementation of the SESAR ATM Target Concept, R&D must be expedited with the objective of achieving initial operations by 2020 with full deployment by 2023/2025. The first step aiming to select the L band technology must be completed within two years. This R&D must better consider the needs of GA, than has previously been the case.

Prioritisation of datalink services (ATS and AOC)[23] supported by VDL2 needs to be agreed to ensure that essential services do not compete for datalink resources. In order to free VHF resources for datalink services, voice communication will be 8.33 kHz based which needs to be mandated for all airspace during IP1[24] and ACARS will start to be decommissioned. For the same reason, wireless airport data link (based on IEEE 802.16e) must be deployed during IP2. In the long term, voice could possibly move to digital, but further studies are needed to assess the performance benefits.

The military fleet will be progressively fitted with 8.33 kHz VHF radios[25]. The provision of UHF voice to accommodate non-compatible state aircraft must be sufficient to meet military GAT and OAT requirements but any withdrawal of Ultra High Frequency (UHF) services should only be made after appropriate consultation with military airspace users.

The progressive use of Satellite Communication (SATCOM) voice for routine communications in remote and oceanic areas could start at the earliest in 2010 and could be completed in 2020[26]. SATCOM voice will become the primary means.

Air-Air Communication

The full set of separation and self-separation applications necessary to reach the long-term SESAR performance goals require Air-Air point-to-point data communications. The new terrestrial datalink component (L-band technology) is the candidate to support them. However, today operational performance requirements for this datalink are not available, and thus, they need to be developed expeditiously if this enabler is to be deployed within the expected IP3 timeframe.

Ground/Ground Communication

To support the increasing data exchange needs, a pan-European IP-based network service is first put in place in IP1 to interconnect the existing ANSP ground data networks (Pan European Network Service (PENS) initiative) providing capacity and cost-efficiency. The Aeronautical Message Handling System (AMHS) for international interconnections, the Flight Message Transfer Protocol (FMTP) and possibly radar data exchange will gradually be deployed as "PENS" users.

Ground-Ground communication will evolve in a second step, to a seamless integrated European IP network that will support more applications. During IP2, all national ANSP network infrastructures will be fully integrated within the European IP network and managed seamlessly. All SWIM, data and voice services will be using the European IP network resulting in cost efficiencies.

VDL-4

All stakeholders have agreed to the datalink (VDL2) and ADS-B (1090 ES) roadmap for IP1 and IP2, and the evolution to new high performance L band solutions to support the operational needs foreseen in IP3. A minority[27] has proposed the addition of VDL4 technology to cover the IP1, IP2 period. The majority of stakeholders consider that there is no justification for VDL4 since it would be deployed for such a short period, it would add significant cost to all stakeholders, it brings no performance benefit compared to the technologies selected, it has a number of outstanding technical issues to resolve, and it would hinder the deployment of new VDL2 based ATS and AOC services by consuming additional VHF spectrum.

21 - E.g. ATN/OSI and IP are examples of network transport protocols.
22 - Non geostationary constellations might be considered depending on the related cost and whether polar coverage is required.
23 - Trajectory services are considered to have the highest priority.
24 - An extension of the existing mandate to flight level below FL195 is to be proposed by the end of IP1, but will need to consider all stakeholders in particular military and GA.
25 - Between 2007 and 2010 around 1,100 military transport type aircraft are planned to be retrofitted with 8.33 kHz radios. In addition retrofit of around 60% of the fighter aircraft and light state aircraft fleet is being considered.
26 - Non geostationary constellations might be considered depending on whether polar coverage is required.
27 - LFV and Austrocontrol : further explanation on LFV disagreement is presented in Annex VIII.

Those supporting VDL4 disagree with this expert judgement and consider that VDL4 is necessary to support IP2 applications. In addition they argue that VDL4 should be deployed in order to mitigate the risks associated with the deployment of the future IP3 L band technologies. However, the primary risk mitigation identified for the future L band datalinks is to expedite R&D and global standardisation activities, and hence the majority view is that effort and resources would be better spent in these areas, rather than on the deployment of VDL4 technology that would have such a limited lifetime.

6.2.2 Navigation

At the 2015 horizon, the availability of new GNSS constellations (Galileo, GPS L5) and the further development of augmentation means (ABAS, GBAS, SBAS) will improve the accuracy, availability and the integrity of the navigation signal thus allowing enhanced positioning services in all phases of flight, including airport surface. The improvement of navigation performance is the main pillar of the major OI steps (trajectory management, RNAV, CDA/CCD and Precision Trajectory Clearance) essential to deliver capacity and environmental benefits.

Progressive decommissioning of the conventional navaids (VHF Omni-directional Radio Range (VOR), Non Directional Beacon (NDB)) should be made possible with the availability of multiple GNSS constellations providing that the navigation in the considered airspaces relies only on RNAV capability. Decommissioning of En-Route and TMA terrestrial navaids could be completed in 2025, but this will require a significant rate of equipage of aviation users with dual constellation and possibly dual RNAV equipment to ensure the required performance. With consultation and appropriate planning with the civil and military airspace user communities, an early start of the gradual progressive removal of these terrestrial navigation aids should be possible, freeing up valuable spectrum that could be exploited for new aeronautical services. Tactical Navigation (TACAN) with its Distance Measuring Equipment (DME) is maintained for military use.

SBAS, as provided by European Global Navigation Overlay Service (EGNOS) in Europe, is an important enabler for many users, including rotorcraft, enabling precision approaches at airports and on helipad for those not equipped with equivalent alternative technologies. However, full GNSS type landing in the most demanding conditions (CAT2/3) can only be achieved though the use of GBAS type augmentation. With the right R&D impetus, initial GBAS (Cat 2/3) could be available within IP1 for some categories of operation. It would become universally available within IP2, through the exploitation of the new Galileo and GPS signals. The early implementation of GBAS is essential to bring a solution to the capacity shortfall in low-visibility conditions, resulting from ILS protection areas issues.

Besides the general replacement of ILS Cat 1 approaches by GNSS approaches, ILS Cat 1 capability has to be maintained in some locations until a military Joint Precision Approach and Landing Systems (JPALS) policy is defined.

Hence, dependent upon the evolution of GBAS Cat 2/3 developments, some Cat 2/3 ILS decommissioning could spread from 2018 onwards.

The use of ABAS including inertial systems mitigates the consequences of GNSS service loss. However, today it is neither technically nor operationally possible to state that GNSS will be the only means for positioning and it becomes necessary to assess the safety, security, operational and cost aspects linked to a redundant terrestrial positioning solution. It is thus recommended to urgently launch a study to assess the level of threat and perform a safety analysis encompassing the various phases of flights, the type of aircraft (commercial, business, general, etc.), the type of airports and operational scenarios to define the adequate terrestrial alternative (with its associated performances) to GNSS positioning source.

DME/DME and Inertial Reference System (IRS) where applicable[28] are proposed to provide an additional positioning means in case of GNSS outage, as a result of potential intentional or accidental jamming and/or solar storms. However, until availability of a full assessment of the performance capabilities of the future GNSS system, and the required performance of the future "backup" system, it is not possible today to indicate the required performance of these services.

Loran has been suggested by GA users but it has not been fully assessed yet.

Enhanced and synthetic vision systems will be progressively introduced to support poor visibility surface movement operations and improve landing minima.

When providing low visibility access, lighting is the most significant part of the Airport's infrastructure costs. Overall European and global coordination is required, together with increased research and development in the area of new Airport surface lighting using the advanced properties of LED technology, such as significantly reduced power consumption and dynamic colour change. Initial deployments could be foreseen within IP1, with support to more advanced SMGCS through IP2. For the longer timeframe, detection of the invisible light spectrum properties of LED (such as Infrared), with onboard sensors may provide additional navigation performance, but these need further research.

28 - Large aircrafts are fitted with high-performance IRS.

6.2.3 Surveillance

Surveillance is foreseen to remain a mix of SSR Mode S, Wide Area Multi-lateration (WAM) as independent surveillance, ADS-B Out for dependent surveillance and PSR (including MSPSR), the latter where required in addition for security reasons. Air Navigation Service providers will have a flexible choice of technologies depending on the respective operational requirements, geographic location and cost efficiency decisions.

A progressive introduction of newer types of non-cooperative surveillance technologies is expected to replace the older PSR technology if the expected performance and cost-effectiveness benefits are confirmed. Newer challenges of UASs, composite aircraft types and wind farms will also need to be accommodated by these newer technologies.

Most States are currently upgrading their Monopulse SSRs to SSR Mode S. Thus, they will not need to be replaced until about 2020. Already WAM systems are being implemented to provide SSR Mode S type coverage in locations where, for example, conventional SSR may be unsuitable. Gradually during the period ADS-B Out certified systems will start to become available and this will be the turning point for a change in direction for ground-based surveillance.

This change will be consolidated by a) an Implementing Rule requiring before 2015/2016 (to be confirmed when adopted) the mandatory carriage of a transponder suitable to support all forms of known ground based dependant surveillance[29], and b) by the fact that circa 2018 to 2025 a large number of service providers have conventional surveillance infrastructures that will be in need of replacement. Consequently this provides a major opportunity for service providers to rationalise their surveillance infrastructure by exploiting ADS-B and WAM as newer, potentially less expensive, forms of secondary surveillance.

Airborne surveillance to support ASAS applications through IP1 and IP2 is based on existing 1090 ES technology. It is foreseen that a new or a complementary ADS-B technology will be necessary to address the integrity, capacity and safety requirements of the advanced separation and self-separation applications which are necessary to achieve the long-term IP3 performance goals. Considering spectrum issues, it is proposed that such a system will operate in the L band, developed in close coordination with, and exploiting the new terrestrial point to point Air-Ground datalink technology. However, performance requirements in respect of advanced ASAS separation are urgently required in order to determine the evolution of the ADS-B datalinks. Assuming that requirements could be available towards the end of IP1, and it is deemed possible to meet the requirements using an existing technology, deployment could be foreseen within IP2. Should the requirement point to the development of new technical solution, a deployment would not be possible until several years later, within IP3. UAT is one candidate as the future ADS-B data link.

The introduction of technologies developed for military applications will improve performance in weather and wake vortex detection. Viable ground based wake vortex systems are expected to become available at the beginning of IP2. Cheaper forms of ground based weather radar will enable smaller airports to provide weather information. Airborne wake vortex detection is less mature than its ground based counterpart, but initial systems to support detection and provide cockpit advisories could be available within IP2.

Further, rationalisation of the surveillance infrastructure can be achieved by increasing the exchange of surveillance data across State borders using the already existing Surveillance Data Processing System (SDPS) technologies such as ATC Radar Tracker And Server (ARTAS) and associated interface standards (e.g. All purposed STructured EUROCONTROL suRveillance Information eXchange – ASTERIX), providing sufficient coverage is provided, decommissioning of redundant systems would be possible.

6.2.4 CNS Technology Roadmap

Figure 62 shows an integrated CNS technology roadmap. The CNS technology enablers are introduced in support of the main operational change that triggers their deployment and which is mentioned in the corresponding coloured bar.

29 - i.e. SSR, SSR Mode S, WAM, MLAT and ADS-B Out.

TIMELINE			2008 / 2009 / 2010 / 2011 / 2012
	Enablers	**Candidate Technologies**	**IP1**
COMMUNICATION			VDL2/ATN
	VDL2 future services	B-AMC, P34, AMACS	Future air/ground mobile
	New Air-Ground Datalink	SATCOM existing & new	New generation Air-ground
	Airport data link	802.16 aero	802.16aero
	Air-Ground Voice	VHF 8.33	above FL195
		SATCOM Voice	Recommended use of SATCOM voice
		Digital	
	Ground IP Network (voice + data)	a) PENS IP	PENS
		b) Ground IP	Ground IP
	Air to Air Datalink	B-AMC, P34, AMACS	Develop
NAVIGATION	GNSS services provision First need is the availability of 2 *constellations* *(GPS + Galileo OS)*	GPS L1 GPS L5 Galileo (OS, SoL…) Other core constellations Restricted signals mil use EGNOS, WAAS	SBAS(EGNOS) Galileo (OS) GPS L5
	GNSS receiver	dual constellation receivers	Dual
	ABAS	ABAS RAIM only	RAIM for new GNSS signals
		INS	INS based ABAS
		Low cost INS	
	GBAS	a) GBAS Cat 1	GBAS Cat1
		b) GBAS Cat 2-3	GBAS Cat 2/3 GPS L1 based
		c) GBAS Airport surface	GBAS Cat 2/3 Galileo
	Lighting		LED renew /replacement
SURVEILLANCE	ADS-B In/Out 1090 ES	Step 1: ADS-B 1090 Out	step 1
		Step 2: ADS-B 1090 In/Out	step 2 - ATSAW / ITP
		Step 3: ADS-B 1090 In/Out	
	Next generation ADS-B In/Out (if need is confirmed)	Technology choice dependent on detailed requirements	
	Independent Non-cooperative Surveillance	PSR	
		MSPSR next Generation	MSPSR
	Independent Cooperative Surveillance	SSR, WAM	
	Airport Surface Surveillance	SMR, Airport Multi Lat ADS-B Out	
	Ground Wake Vortex detection	Ground WV Detection	Ground Wake Vortext
	Ground weather radar		Next gen airport weather radar
	Airborne wake vortex detection	Wake vortex advisory	Wake Vortex Advisory
	Airborne weather radar		
	Low power GA SSR transponder	Low power SSR Transponder	LPST

legend

- start of R&D
- R&D activity
- Major event
- Rationalisation activity
- IOC
- deployment (IOC)

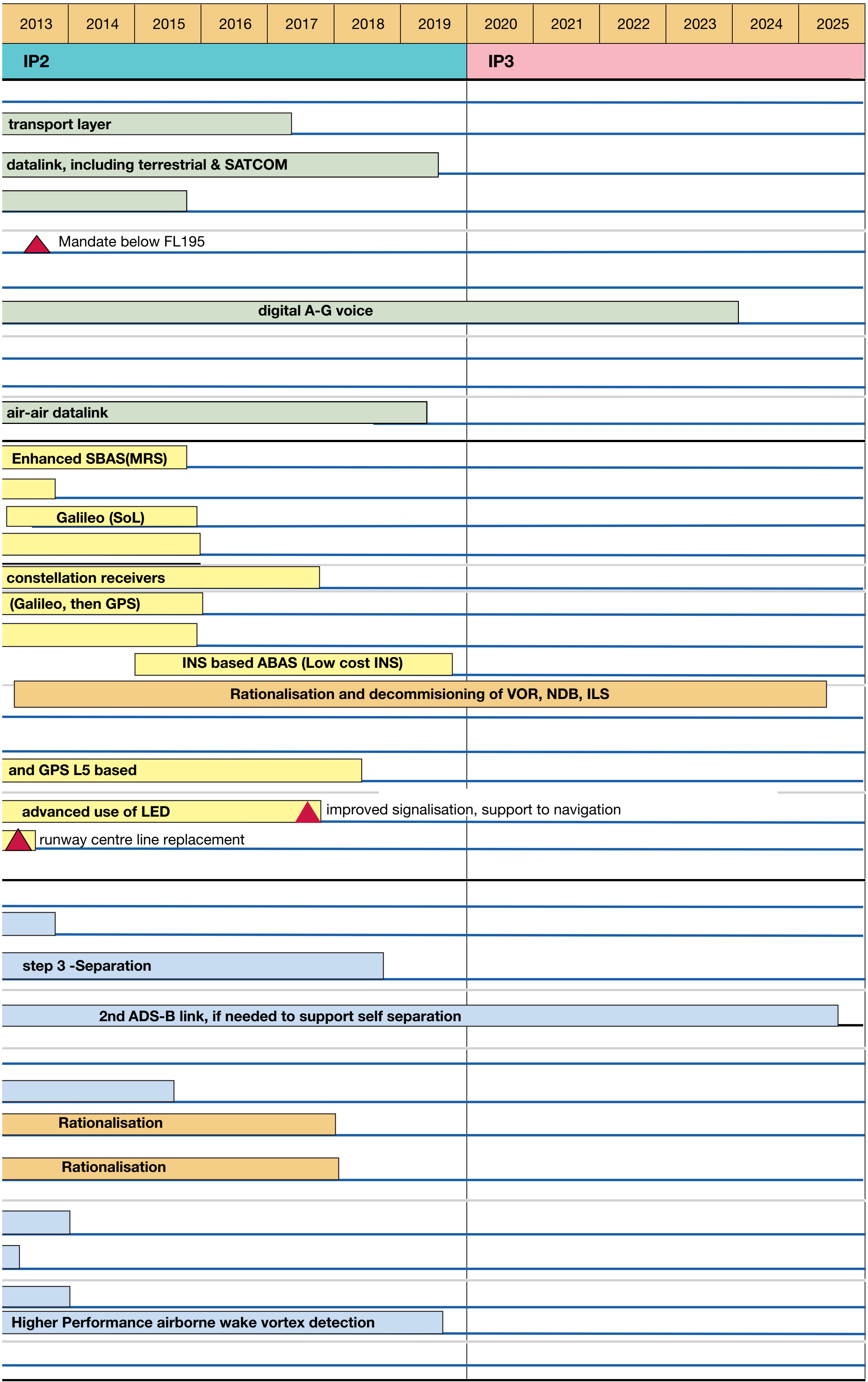


Figure 62 : CNS Technology Roadmap

6.3 Human Performance

The human performance roadmap shows the high-level steps that will enable the timely implementation of all SESAR operational improvements steps. It provides guidance for the inclusion of human performance activities in the SJU and in the development of the SESAR Master Plan (D5) and Work Programme (D6).

The Human Performance Steering function should ensure that Human Factors (HF), Recruitment, Training, Competence and Staffing (RTCS) and Change and Transition Management (CTM) factors are systematically addressed. This function will not address the existing European Social Dialogue processes. It is proposed that this function could support the following activities:

- Co-ordinate all human performance support during the SESAR development phase;
- Recommend human performance methods and techniques of sufficient quality;
- Review all human performance related work to ensure consistency of methods and content;
- Disseminate and exchange information with R&D providers, management at industry level, regulatory bodies and between other areas in SESAR (e.g. engineering);
- Stimulate timely implementation of required RTCS activities (e.g. adaptation of regulations and standards, timely training);
- Establish and review change and transition management factors, including participative processes and procedures.

The roadmap in Figure 63 shows the four high-level steps human performance institutional management, human factors implementation and R&D, recruitment/training/competence/staffing and social factors and change management.

6.3.1 Human Performance Institutional Management

- I-1: Implementation of Human Performance Steering Function (HPSF): to ensure that all human performance aspects are properly managed throughout the SESAR project a transversal co-ordination function, a so called Human Performance Steering Function (HPSF), will be set up;
- I-2: Agenda with R&D inputs to SJU, as well as action plans for regulatory and management activities, to document and disseminate Human Performance Management works;
- I-3: Human Performance Certification: to ensure that all human performance aspects will be addressed during certification processes for (integrated) airborne and ground systems.

6.3.2 Human Factors Implementation

- H-1: Human Factors Case: to timely and systematically identify, prioritise and manage human performance issues associated with each OI Step;
- H-2: Implement Best Practices: to stimulate widespread adoption of existing best practises;
- H-3: Development of a common toolbox of generic Human Performance methods and techniques, to make state-of-the-art, commonly adopted methods available to SESAR;
- H-4/5: Top-down analysis, to decide which ATM functions are best clustered together and assigned to human actors, automated systems or combinations of both;
- H-6: Research into how to optimise trade-off between advance planning and the need for tactical flexibility;
- H-7: Adoption of appropriate mechanisms for task and authority delegation.

6.3.3 Recruitment, Training, Competence and Staffing

Further R&D concerning the operational improvements will, through the HPSF, identify impacts on the training related Enabler areas:

- Competence requirements of operational staff affected;
- Regulations and standards;
- Verification of competence;
- Training;
- Recruitment and selection;
- Staffing;
- System design encompassing training feasibility (simulation infrastructure, coaching at live systems etc.).

The SESAR Human Performance agenda will be the link to trigger activities.

- T-1: Enhancement of a comparable competence baseline to enable implementation of harmonised systems and procedures in all areas of the ATM system (e.g. ATCOs, ATSEP);
- T-2 & T-3: Definition and adaptation of training and competence related standards and regulations;
- T-4: Identify RTCS in all SESAR R&D related to all OI Steps, e.g. examination of abilities and skills requirements for future tasks;
- T-5: Ensure collection and diffusion of recommendations, encompassing timelines for training planning and delivery, implementation of regulations, installation of simulation infrastructure, adaptation of selection profiles or recruitment strategies, manpower planning implications etc.

6.3.4 Social Factors and Change Management

- S-1: Establish a process for social factors and change management to assess and manage risks for all IPs;
- S-2: Ensure an interactive process between the SJU and the EU Sectoral Social Dialogue Committee for Civil Aviation, to allow the appropriate flow of information and relevant feed-back;
- S-3: Manage cultural & organisational diversity and enhance leadership competence, to address, manage and overcome the complex and wide variety of working practices, differences between ATM systems, infrastructures, organisational structures

their cultures as well as the implementation of changes in the frame of a proactive approach on a principle of partnership and participation;
- S-4: Manage future social challenges and enhance change processes by taking new ways of industrial relations and new contents for Social Partners into account.

impact on the time by which the legislative processes must be started or the time when implementation can be achieved.
In some cases European legislation may require amendments to existing national legislation to avoid creating discrepancies. In other cases amending national legislation is the optimal way to permit initial operation of new procedures. Note that in the case of IFR

Roadmap for Human Performance Management in the SESAR Development and Deployment Phases

	Year	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
code	Implementation Package			IP 1							IP 2						IP 3		
I	**Human Performance (HP) Institutional Management**																		
I-1	Implementation of Human Performance Steering Function	▲									tbd					tbd			
I-2	Issue and update (bi-yearly) Human Performance Agenda and activity plan	▲		▲		▲		▲		▲		▲		▲		▲		▲	
I-3	Human Performance certification of integrated air-ground systems								▲										
H	**Human Factors Implementation and R&D**																		
H-1	Carry out Human Factors Case for each OI-step	▲																	
H-2	Implement existing best Human Performance practices						▲												
H-3	Develop and update toolbox of Human Performance methods/techniques			▲		▲				▲				▲		▲			
H-4	Perform systematic top-down SESAR function analysis				▲														
H-5	Define new roles and responsibilities for future staff							▲											
H-6	Optimise trade-off between planning and flexibility				▲														
H-7	Define appropriate mechanisms for task delegation and authority sharing								▲										
T	**Recruitment, Training, Competence and Staffing (RCTS)**																		
T-1	Comparable competence baseline for European ATM operational staff						▲												
T-2	Adaptation of international/national/local RTCS standards, regulations, infrastructure (IP2)										▲								
T-3	Adaptation of international/national/local RTCS standards, regulations, infrastructure (IP3)															▲			
T-4	Ensure systematic examination of RTCS impacts in all SESAR R&D (IP2/3)						▲							▲					
T-5	Foster pro-active management of RTCS activities at industry level						▲							▲				▲	
S	**Social Factors and Change Management (SFCM)**																		
S-1	Assess & manage SFCM risks	▲			▲		▲		▲		▲		▲		▲		▲		▲
S-2	Manage interaction between SESAR JU and EU Sectoral Social Dialogue	▲			▲		▲				tbd						tbd		
S-3	Develop a strategy to manage cultural & organisational diversity - enhanced leadership							▲		▲		▲		▲		▲			▲
S-4	Manage future social challenges & enhanced change processes							▲						▲				▲	

Figure 63: Human Performance Roadmap

6.4 Legislation Aspects

Figure 64 shows the anticipated legislative activities (per IP) on a timeline throughout the SESAR implementation period in accordance with the implementation dates quoted for the OI Steps. The bars indicate anticipated elapsed time and are not a reflection of the amount of effort likely to be required in each case. In all cases of delay in technical, standardisation and ICAO development work, the legislative timeframe would need to be adapted with a corresponding impact on the relevant implementation dates.
Further, a three-year period has been assumed for the legislative development period, as this is a realistic minimum period to show on a relatively simplistic diagram. In some cases considerably longer than three years may be necessary. This will have a corresponding

Visual Contact Approaches the deadline to start legislative action to meet SESAR's target implementation dates has already passed which will likely hamper the implementation or require national actions.
EASA is proposing an amendment of the REGULATION (EC) No 1592/2002 of the EUROPEAN PARLIAMENT and of the COUNCIL of 15 July 2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency (the Basic Regulation), to extend its scope into the air traffic management and air navigation services (ATM/ANS). This new extension of competence of EASA could have significant impact on the future legislative aspects of SESAR.

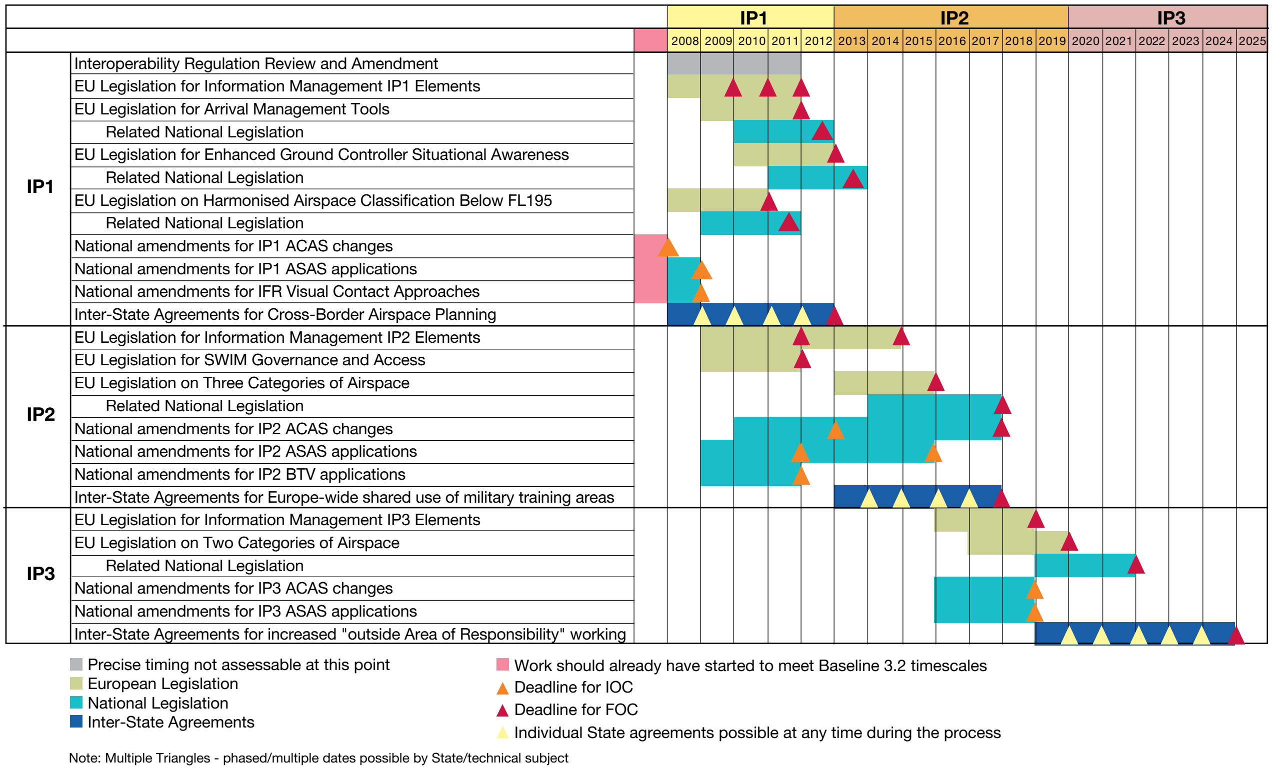


Figure 64: Legislation Roadmap

6.5 Safety

6.5.1 Safety Regulation

Figure 65 below provides a high-level overview on the expected steps for the 2008-2025 timeframe related to the establishment of the SESAR Safety Regulatory – Coordination Function (SSR-CF) and the establishment of its interfaces and processes as a preparation to its activities for IP1 to IP3. The safety regulatory impact is expected to increase from IP1 to IP3 given the content of the conceptual elements in the ATM Master Plan. IP1 activities are linked to the deployment of IP1 operational improvements. IP2 activities are linked to the developments done under the scope of the SJU with a possible overlap into IP3 developments. IP3 safety regulatory activities for the period 2016+ will depend on the allocation of the management of the ATM Master Plan in line with the processes described in the regulation on the establishment of the SJU.

The success of the SSR-CF is also linked to the scope and effectiveness of the safety management activities of the SJU.

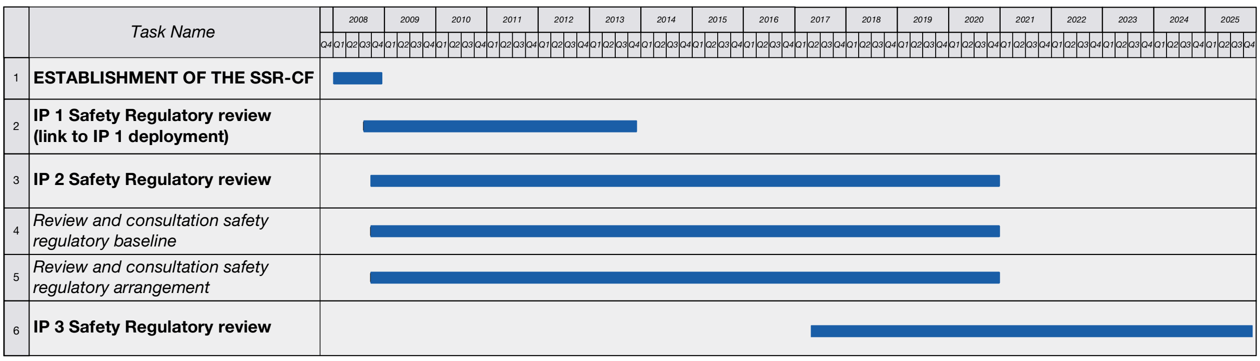


Figure 65: Safety Regulatory Roadmap

6.5.2 Safety Management

To face the future European Air Traffic Management (ATM) challenges with SESAR, significant changes to roles, responsibilities, equipment and procedures are planned. During these changes, it is imperative that safety is not compromised and is improved against a steady rise of traffic movements.

The SJU Safety Management System (SMS) should provide the framework for a systematic approach to safety management across the SJU but also paving the way for a SMS approach for development activities beyond the SJU existence.

Figure 66 provides a roadmap for SESAR SMS main and high level milestones throughout SESAR lifetime IP1 to IP3. The safety management approach will be further detailed in D6.

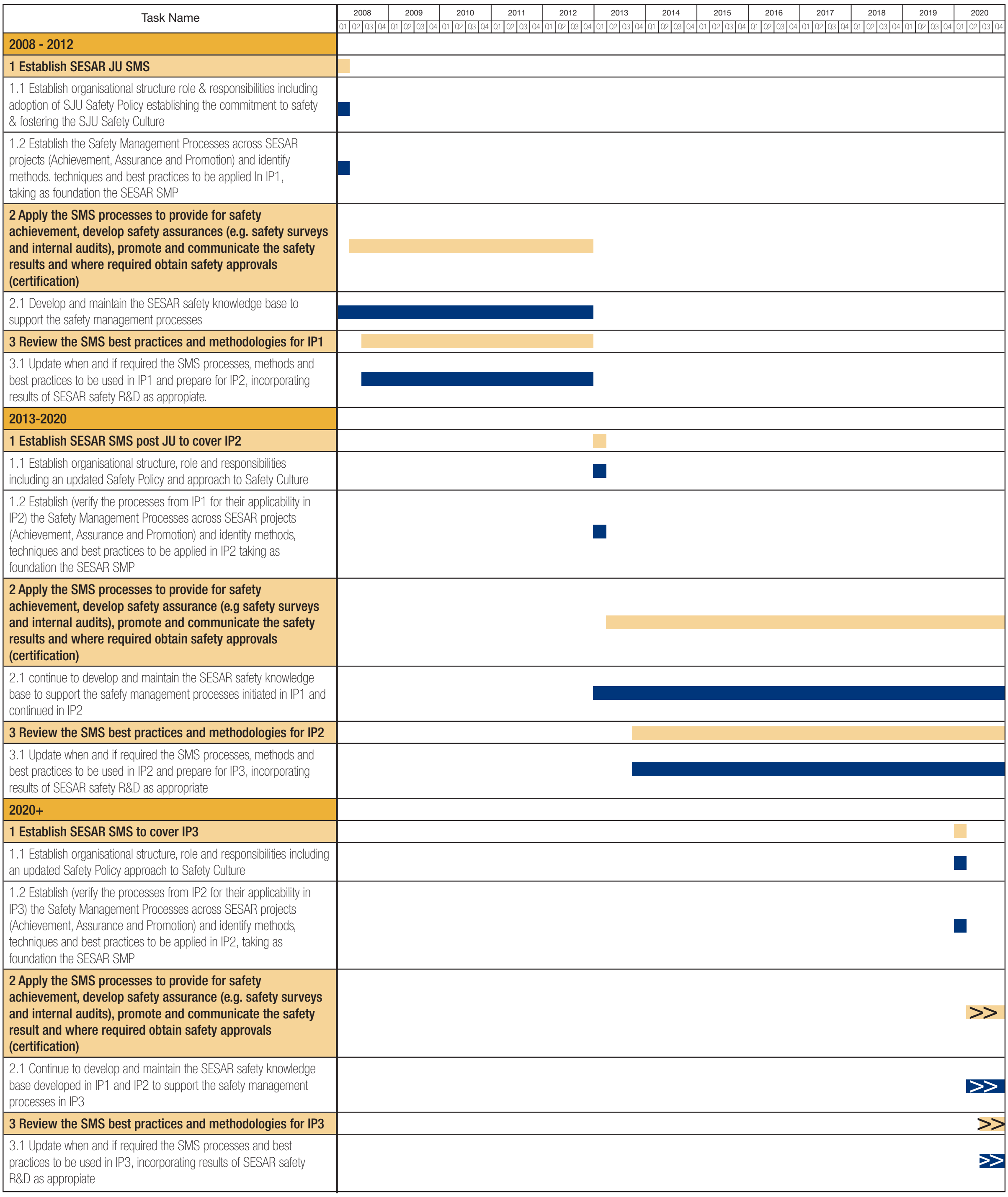


Figure 66: Safety Management Roadmap

6.6 Security

The Security Roadmap (which in some elements goes beyond what is strictly required for the implementation of the ATM Target Concept) is based on two main security improvements, which will be implemented during the SESAR Deployment sequence:

- Implementation of a Trusted Security Partnership Framework & Regulations (see chapter 3.2.2.2.3);
- Implementation of a Security Service in the ATM System.

One objective for the future ATM system in Europe is to establish a trusted security partnership among all stakeholders. The operational trend is to maximise the benefits of interdependence and integration and this requires that all the stakeholders become comfortable with this new environment.

A security service in the ATM System needs to be established to assure the self protection capability of the future ATM system against the evolving threat spectrum by implementing the security resilience life cycle.

To achieve this goal a number of security improvement steps are foreseen (supported by security enablers and security initiatives [Ref 6]) which are illustrated in the Figure below.

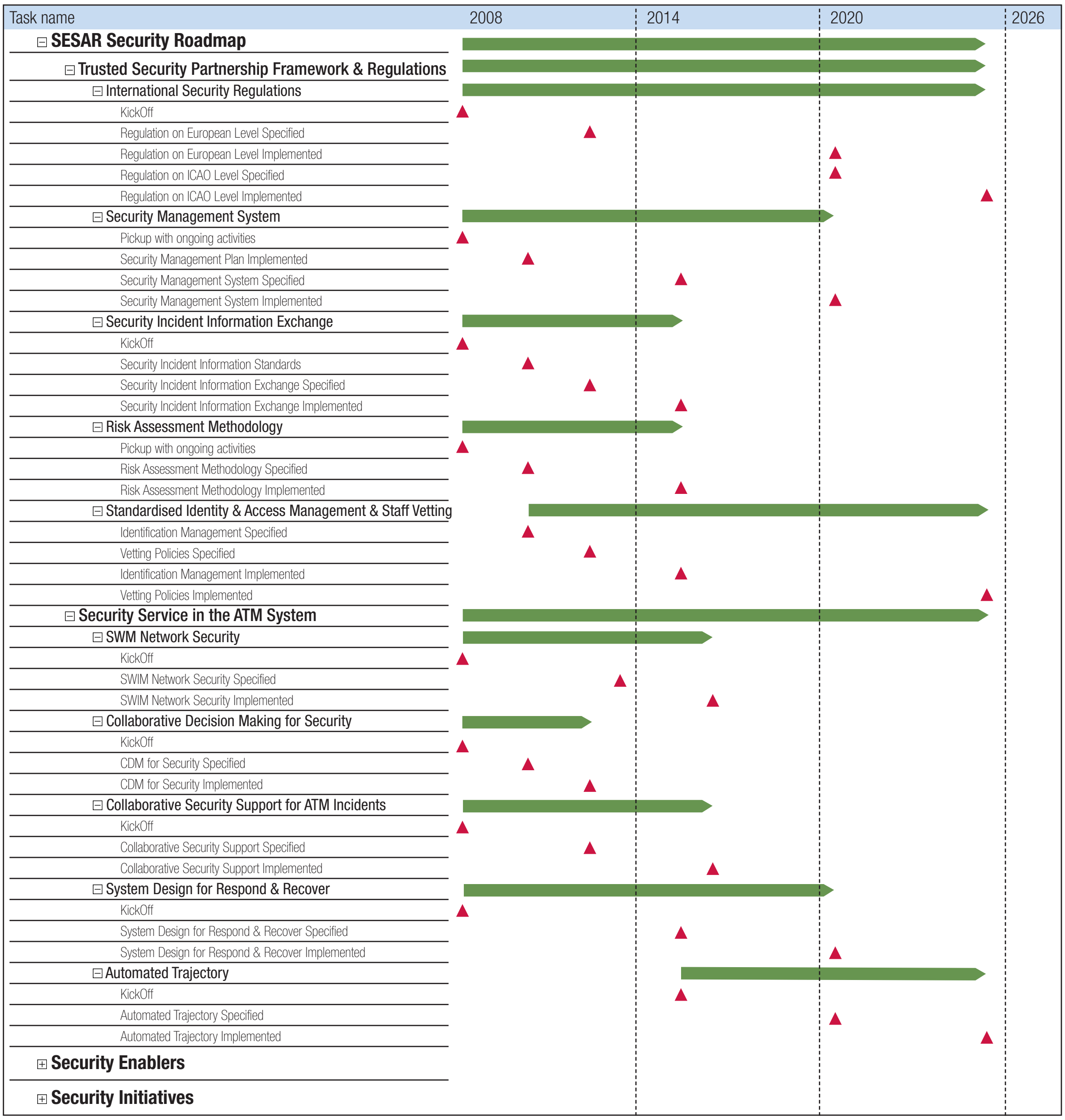


Figure 67: Security Roadmap of the Security Improvements and their Steps

6.7 Environment

The roadmap in Figure 68 presents the key aspects that will be required to develop sustainable environmental management within the time period of the ATM Target Concept implementation. The roadmap indicates key features that must be addressed in each of the respective IPs' steps. While this section is focused on managerial activities, it must be emphasized that concrete operational initiatives in benefit of environmental aspects, such as the Atlantic Interoperability Initiative to Reduce Emissions (AIRE), will be validated and implemented throughout the 3 IPs.

Performance Management

An effective system of ATM Performance Management is required, supported by the development of information systems, monitoring and reporting/feedback. A key milestone in this area will be the development of KPAs, KPIs and targets by 2009.

Assessment

A methodology will be required to ensure commonly recognised and endorsed assessment criteria are introduced. This methodology will include assessment models; trade-off tools and methods. A key milestone in this process will be the achievement of a common endorsement of the assessment framework by 2011.

Guidance (Multidimensional framework)

To provide ATM stakeholders with the necessary information, guidance, skills and competencies to deliver effective environmental management and performance, a framework of environmental guidance tools and support will be required. This will be a practical and continuously evolving resource and will include:

- The creation of a "Best Practice" database;
- The development of recommended environmental practices and procedures;
- The development of practical resource tools;
- The creation of a Central Environmental Guidance Web Portal.

The roadmap indicates that this guidance framework will be mainly completed within IP1 with key Milestones being the collection and collation of "best practices" by 2009 and common endorsement by stakeholders of the guidance framework by 2012.

Collaborative Environmental Management (CEM)

CEM is a keystone for future environmental management amongst and between ATM stakeholders to ensure common and consistent approach to environmental issues whilst at the same time taking local considerations (e.g. at and around airports) into consideration. A fundamental element of CEM will be the requirement for all SESAR ATM stakeholders to have adopted and implemented individual Environmental Management Systems (EMS).

Training

There is a need for greater environmental manpower resource throughout the ATM stakeholder community. If, as assumed, a significant environmental training and competence resource gap is identified it will be necessary to develop an approved training framework with universities and training institutes/providers.

Regulatory

At this stage in the SESAR Definition Phase, no specific regulatory proposals are submitted in this roadmap. It is envisaged that regulatory developments in respect of emissions trading (EU ETS introduced in 2011), Kyoto, air quality, noise and others will be ongoing throughout IP1, IP2 and IP3. As these regulatory elements are enacted, industry will require at least 12 months lead time to arrange implementation given that there will have been full engagement with industry in the development of the regulations.

Communications

Communication both internally (within the ATM community) and externally will be fundamental to the continued development of ATM and the wider aviation community. A key component of this element will be effective communication on environmental matters with society at large and, importantly, with communities living around airports.

Effective communications with local communities are fundamental in building trusted partnership between aviation and society and will be helpful in dispelling the myths that surround much of aviation's (including ATM's) activities.

It is foreseen that stakeholders (ANSPS, Airlines, Airports) will wish to share operational experience and learning. It is proposed that this framework is developed independently of regulatory oversight/control – on a "trusted partnership" basis between stakeholders, enabling benchmarking activities.

Governance

No specific institutional governance arrangements for Environment are proposed, however it is essential that environment is fully acknowledged and addressed within the governance framework that will be developed within the SESAR ATM Masterplan. It will be essential that ATM is open and transparent about its activities, impacts, and actions. A key component in this strategy will be the free access to results of research and the development of greater scientific certainty about aviation's overall environmental impact.
At the micro level, a good example of effective local governance arrangements is that of airports which develop Strategic Master Plans that are fully integrated with and supported by local land-use planning policy. In particular, these address environmental sustainability impacts, benefits and mitigation strategies within their scope.

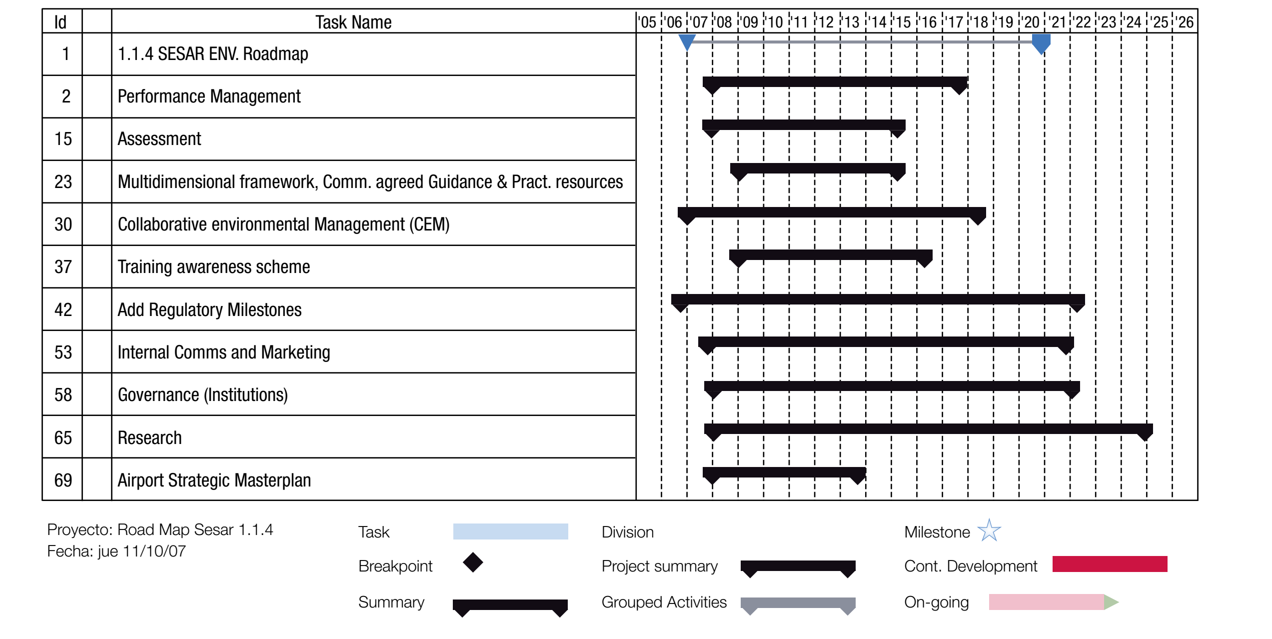


Figure 68: Environment Roadmap

6.8 Standardisation

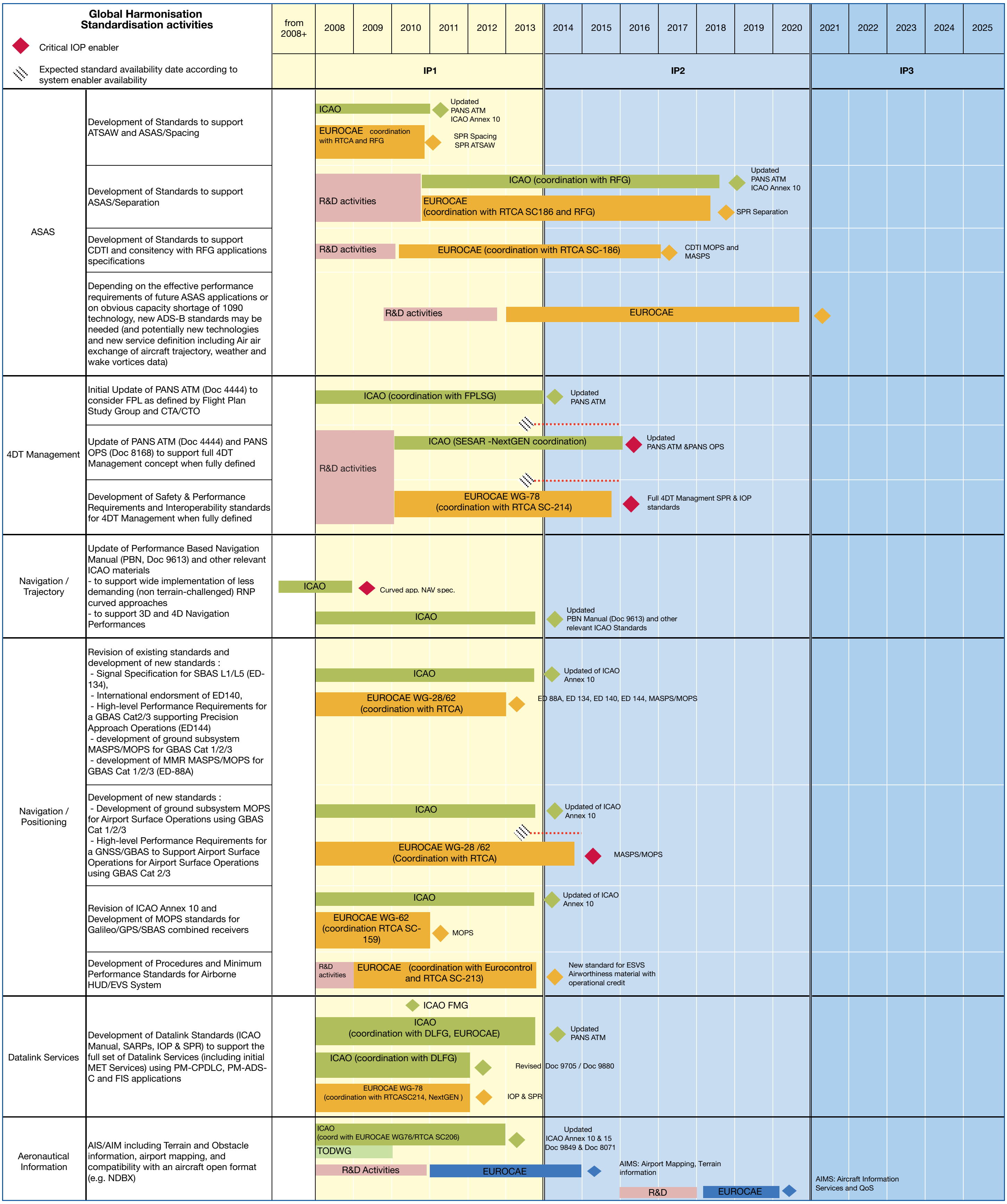
The Global and Regional Standardisation Roadmaps gives an overview of standardisation activities that have to be conducted to support the deployment of the SESAR implementation packages. This is built according to the available SESAR concept description and its supporting architecture & technology proposals.

The content of the standardisation roadmaps constitutes a first baseline of the Standardisation Plan that is one part of the SESAR Master Plan. New standardisation items will be added when the core elements of the ATM Target Concept will be further defined during the development phase.

Although they are not shown, regulatory activities have to be conducted in conjunction with the standardisation activities to provide the necessary regulatory tools (e.g. CSs & IRs) to timely support the implementation and associated demonstration of compliance for systems, materials and procedures.

The duration of the each standardisation activity have been estimated according to the experience of the SESAR Consortium members with the current standardisation process based on voluntary nature of stakeholders' participation that has the potential to cause delayed or sub-optimised standards development. Optimisation may be envisaged for strategic & relevant standardisation activities by a greater engagement of stakeholders and by setting an appropriate management & funding process to support those activities (including the necessary pre-requisite activities covering research and validation) and to meet sufficient levels of effectiveness.

The standard availability dates have been challenged with the IP sequence and its related system enablers. Most of the critical mapping cases between system enablers IOC dates and standard IOC dates are linked to IP2's system enablers.



Global Harmonisation Standardisation activities
Critical IOP enabler
Expected standard availability date according to system enabler availability
from 2008+
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
IP1
IP2
IP3
ASAS
Development of Standards to support ATSAW and ASAS/Spacing
ICAO
Updated PANS ATM ICAO Annex 10
EUROCAE coordination with RTCA and RFG
SPR Spacing SPR ATSAW
Development of Standards to support ASAS/Separation
R&D activities
ICAO (coordination with RFG)
Updated PANS ATM ICAO Annex 10
EUROCAE (coordination with RTCA SC186 and RFG)
SPR Separation
Development of Standards to support CDTI and consitency with RFG applications specifications
R&D activities
EUROCAE (coordination with RTCA SC-186)
CDTI MOPS and MASPS
Depending on the effective performance requirements of future ASAS applications or on obvious capacity shortage of 1090 technology, new ADS-B standards may be needed (and potentially new technologies and new service definition including Air air exchange of aircraft trajectory, weather and wake vortices data)
R&D activities
EUROCAE
4DT Management
Initial Update of PANS ATM (Doc 4444) to consider FPL as defined by Flight Plan Study Group and CTA/CTO
ICAO (coordination with FPLSG)
Updated PANS ATM
Update of PANS ATM (Doc 4444) and PANS OPS (Doc 8168) to support full 4DT Management concept when fully defined
R&D activities
ICAO (SESAR -NextGEN coordination)
Updated PANS ATM &PANS OPS
Development of Safety & Performance Requirements and Interoperability standards for 4DT Management when fully defined
EUROCAE WG-78 (coordination with RTCA SC-214)
Full 4DT Managment SPR & IOP standards
Navigation / Trajectory
Update of Performance Based Navigation Manual (PBN, Doc 9613) and other relevant ICAO materials
- to support wide implementation of less demanding (non terrain-challenged) RNP curved approaches
- to support 3D and 4D Navigation Performances
ICAO
Curved app. NAV spec.
ICAO
Updated PBN Manual (Doc 9613) and other relevant ICAO Standards
Navigation / Positioning
Revision of existing standards and development of new standards :
- Signal Specification for SBAS L1/L5 (ED-134),
- International endorsment of ED140,
- High-level Performance Requirements for a GBAS Cat2/3 supporting Precision Approach Operations (ED144)
- development of ground subsystem MASPS/MOPS for GBAS Cat 1/2/3
- development of MMR MASPS/MOPS for GBAS Cat 1/2/3 (ED-88A)
ICAO
Updated of ICAO Annex 10
EUROCAE WG-28/62 (coordination with RTCA)
ED 88A, ED 134, ED 140, ED 144, MASPS/MOPS
Development of new standards :
- Development of ground subsystem MOPS for Airport Surface Operations using GBAS Cat 1/2/3
- High-level Performance Requirements for a GNSS/GBAS to Support Airport Surface Operations for Airport Surface Operations using GBAS Cat 2/3
ICAO
Updated of ICAO Annex 10
EUROCAE WG-28 /62 (Coordination with RTCA)
MASPS/MOPS
Revision of ICAO Annex 10 and Development of MOPS standards for Galileo/GPS/SBAS combined receivers
ICAO
Updated of ICAO Annex 10
EUROCAE WG-62 (coordination RTCA SC-159)
MOPS
Development of Procedures and Minimum Performance Standards for Airborne HUD/EVS System
R&D activities
EUROCAE (coordination with Eurocontrol and RTCA SC-213)
New standard for ESVS Airworthiness material with operational credit
Datalink Services
Development of Datalink Standards (ICAO Manual, SARPs, IOP & SPR) to support the full set of Datalink Services (including initial MET Services) using PM-CPDLC, PM-ADS-C and FIS applications
ICAO FMG
ICAO (coordination with DLFG, EUROCAE)
Updated PANS ATM
ICAO (coordination with DLFG)
Revised Doc 9705 / Doc 9880
EUROCAE WG-78 (coordination with RTCASC214, NextGEN)
IOP & SPR
Aeronautical Information
AIS/AIM including Terrain and Obstacle information, airport mapping, and compatibility with an aircraft open format (e.g. NDBX)
ICAO (coord with EUROCAE WG76/RTCA SC206)
Updated ICAO Annex 10 & 15 Doc 9849 & Doc 8071
TODWG
R&D Activities
EUROCAE
AIMS: Airport Mapping, Terrain information
R&D
EUROCAE
AIMS: Aircraft Information Services and QoS

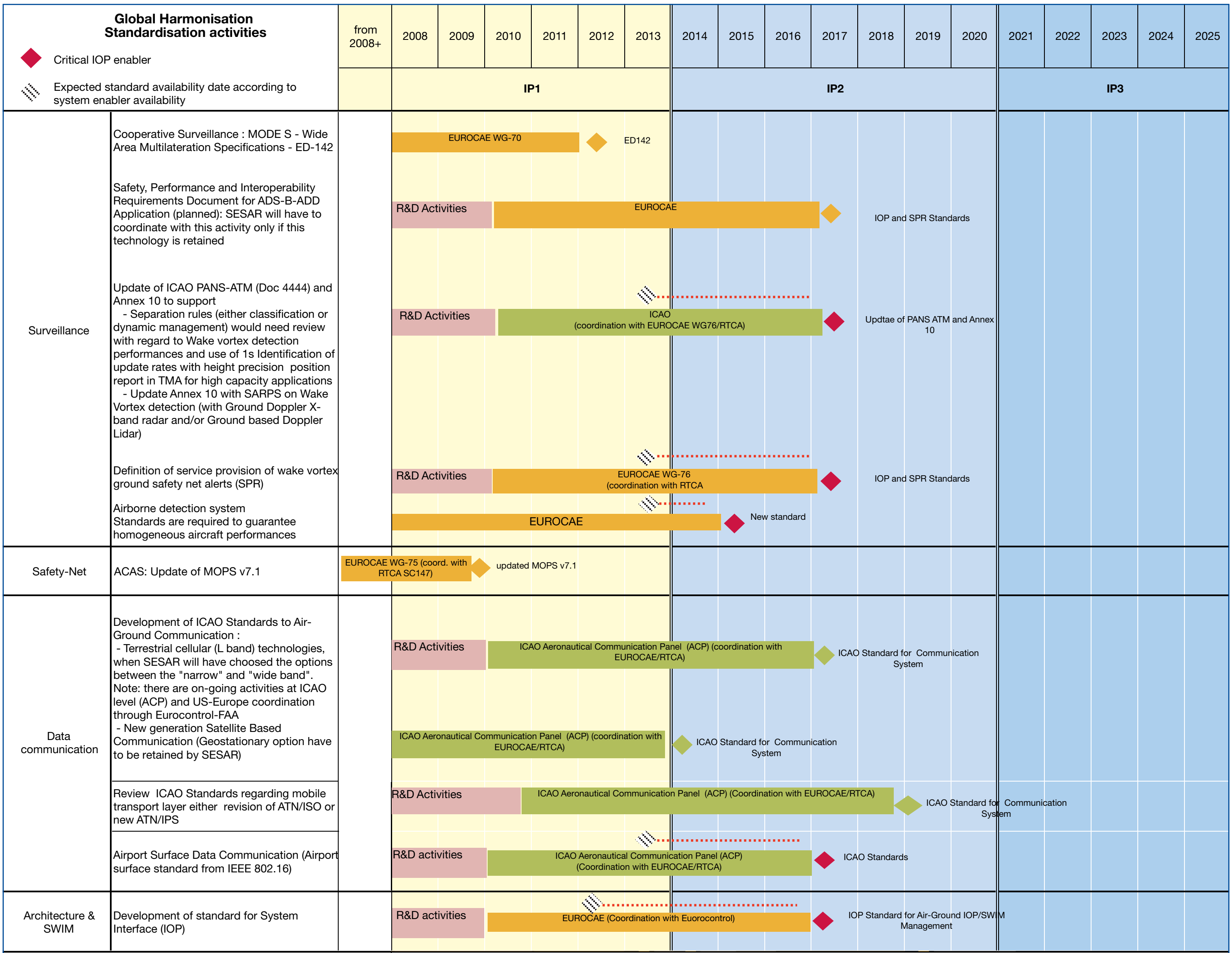


Figure 69: Global Harmonisation and Standardisation Activities

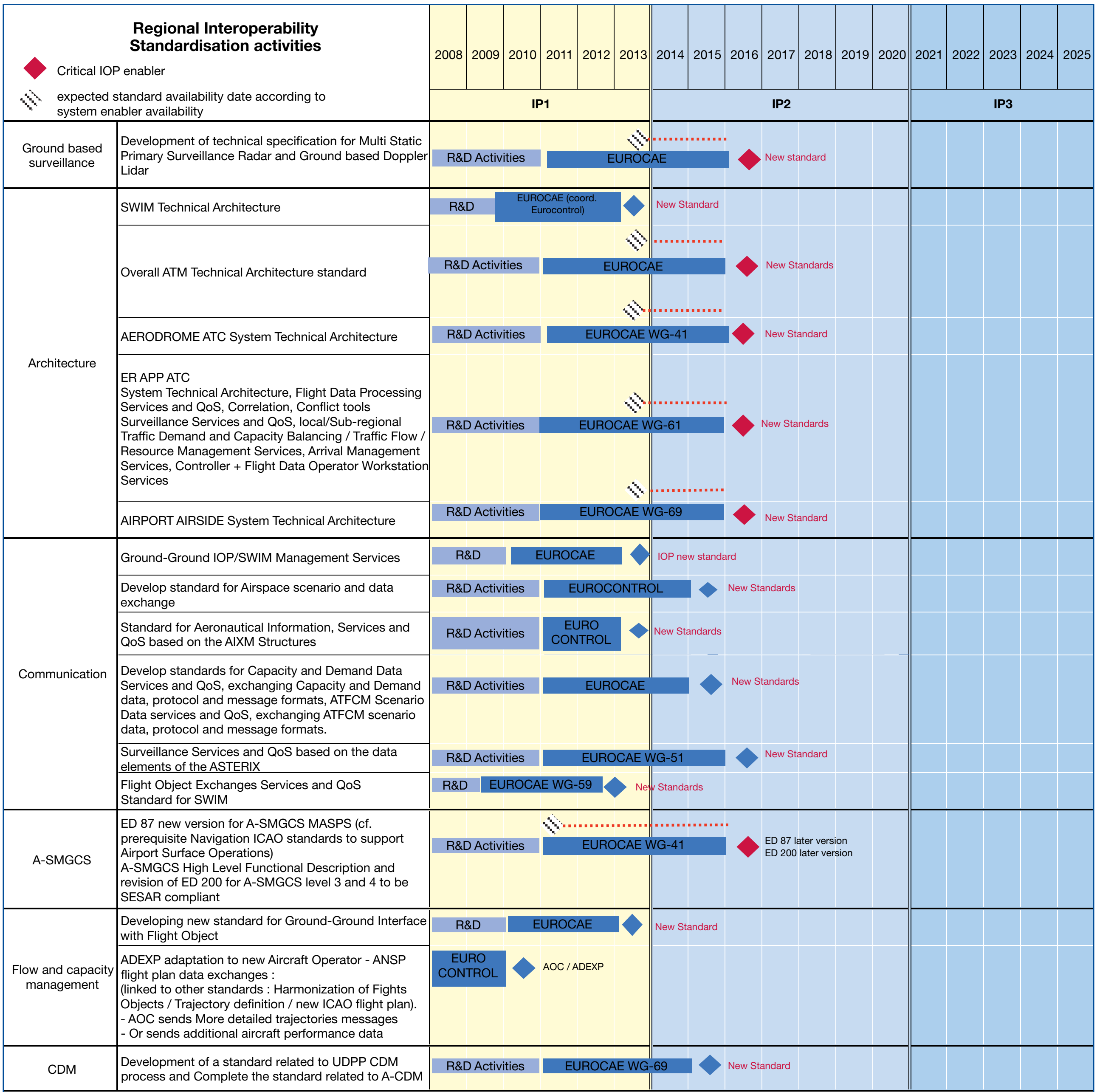


Figure 70: Regional Interoperability Standardisation activities

6.9 Research and Development Considerations

The following gives an overview of the conclusions and recommendations drawn from making a "snapshot assessment" of much of the current ATM research activities being performed in Europe and some of that being done in other parts of the World.

6.9.1 R&D Management Structure

European ATM research is at the leading edge in the world in many areas. However, analysis and assessment of the current European research landscape shows that it is:

- Complex;
- Addressing a very wide range of applications and technologies which:
  - Are progressing at different speeds;
  - Are targeting different levels of maturity;
  - Do not have clear deliverables.
- Not addressing and/or aimed at a common future target vision.

Areas of overlap have been identified, whilst significant gaps remain in the coverage of the needs and in the formal methods which are required to facilitate a rapid transfer of research successes into development and thence into deployment. Major divergences appear in the scale and magnitude of investment for elements addressing the same IPs.

Many R&D initiatives either concern local and/or regional aspects only, or address a "one size fits all" European perspective. Little evidence of systematic information sharing was discovered in the information collected, leading to a concern regarding the compatibility of the results which requires further analysis. Information with regard to investment is patchy.

The performance driven Future ATM System to be provided by the SESAR Deployment phase needs to consider the specific aspects of all European environments and users, whilst ensuring overall compatibility between these constituent parts. Commensurate with achieving this, the coordination and rationalisation of the research and development effort should be achieved through the SJU, so ensuring coherence throughout the development of systems. Thus, the SJU should co-ordinate the R&D effort required to implement the entire SESAR Target Concept, including any local adaptations required and aligned with the principle that "one size does not need to fit all".

In particular, decision-making mechanisms able to progress activities along validation and development phases need to be closely associated to the R&D work.

Whilst the actual work structure is yet to be defined, it is apparent that this must take into account the importance of integrating new technologies with operational processes and the results of research to provide the future European ATM System.

In addition to providing coherence, a single management process should take account of the need to avoid the "one size fits all" syndrome in R&D. The IP2&3 objectives will enable a top down, direct approach to validation of the mid-term concept and enabling technologies. Large scale validation projects would be supported by regional studies to take into account local constraints. Additional outstanding R&D issues could be identified as the validation activities progress.

For many of the elements of IP3, however, the knowledge base is less developed and therefore an activity portfolio, initially comprising small scale investigative studies, should be developed which will enable the community to refine a vision of future ATM System and establish the foundation required to progress to higher levels of maturity. However, these studies must fall within the SJU to ensure efficient use of investments and ensure coherent lifecycle development.

The SJU must also take into account the need for improved information exchange, dissemination and transparency within the R&D community to foster greater cooperation and coordination. Existing Thematic Network mechanisms provide a good basis to coordinate projects from the same area, or on key themes. Good examples are the ATM R&D Seminar organised by FAA/EUROCONTROL and the ASAS Thematic Network.

6.9.2 ATM R&D Repository

Budgets and results should be more freely available and assessment of projects should be encouraged to enable a full evaluation of progress in achieving expected performance requirements.

To this end, an improved Analysis of Research and Development in EUROCONTROL Programmes (ARDEP) "observatory" is necessary, supporting the SESAR community with the dynamics of progress through its continuous monitoring of the achievements and coverage of research and development. Its scope should also be widened to provide comprehensive information on national and/or regional and military activities, as well as to provide summary information of international developments. The data base needs to be kept up to date which means a faster and more continuous data collection process is required compared to the current ARDEP process. Thus, it is recommended that an R&D Observatory be developed to monitor and disseminate the on-going status of the budgets and results of the R&D being pursued.

6.9.3 R&D & E-OCVM

The European Commission and EUROCONTROL have made the recommendation to exploit the European Operational Concept Validation Methodology (E-OCVM) as a vehicle to assure consistent assessment of the operational concepts throughout their research

& development lifecycle and most importantly, to create the missing link between research and its application in operational use.

It is clear from the analysis and assessment made of the reported activities that systematic use of the methodology is not current practice today. This leads to the inability to evaluate current levels of maturity, assess and compile results from the research and the actual levels of performance that may be achieved at their conclusion. This also results in the inability to plan for, initiate and conduct the remaining work, and assess the investment required to achieve the implementation objectives. Thus, the use of E-OCVM should be adopted for all relevant projects.

A systematic application of the methodology alone is insufficient to support the development process. The methodology itself needs to be complemented by a management process which sanctions the formal transitions between each identified phase of the lifecycle. An existing example is the use of Technology Readiness Levels (TRL) with specific requirements which detail what must be achieved within each phase with a formal assessment of results before passing to the next phase.

It is suggested that similar mechanisms be developed to further complete the E-OCVM methodology, clearly identifying what must be provided and achieved in each phase. This should take into account the absolute necessity to assure the compatibility of E-OCVM with the TRLs exploited by certain manufacturers, and to ensure documented evidence of results in a structured and formalised manner, supporting both further investment decisions and standardisation/certification processes, e.g. EUROCAE ED78A [Ref 25], when applicable. Consequently, it is recommended that E-OCVM be extended to include lifecycle management, KPA assessment and HF assessment processes.

6.9.4 Innovative Research

The “snapshot assessment” has highlighted that there is low investment today for the longer term. When considering the very long lifecycles for the implementation of improvements within aeronautics it is very important that creativity and innovation are stimulated today in preparation for the future improvements and that appropriate levels of investment funds and resources are put in place to address these planning horizons, i.e. beyond the 2020 target.

Taking the example from the PHARE programme and other industrial sectors, between 5 to 10% of the overall investments in ATM R&D should be dedicated to innovation. The magnitude of the investments should be modulated to reflect increasing levels of maturity and progress.

As with other industrial sectors, ATM research should be promoted within academia, serving the dual purpose of stimulating creativity whilst preparing staff for tomorrow’s applications.

6.9.5 Synergies with Other Regions

The analysis of available data of international developments identified that there is a high degree of similarity with the evolution planned in the USA’s NextGen programme [Ref 29]. This programme is similar to SESAR in its objectives and there is a very high alignment between NextGen OI Steps and their time horizons with those of SESAR. It is very important that the two programmes progress at similar pace with maximum possible synergy to ensure a high degree of interoperability and achieve agreement of the content and availability of common global standards in a timely manner.

Many other regions/nations are also in the process of establishing major renovation programmes. This offers an opportunity to establish formal co-operation between Europe and the respective other regions. This would allow Europe to lead international harmonisation and consequently, provide European industry with a significant competitive advantage in the global market.

Working level arrangements exist between Europe, the USA and the Russian Federation. These have established dialogue and exchanges which, in many cases, have formed a foundation for international co-operative ventures in research, implementation and standardisation. However, initiatives were very much the consequence of a “bottom-up” identification process and the agreements are structured accordingly. It is, therefore, recommended that existing working level arrangements with the USA and the Russian Federation be developed and structured in accordance with SESAR developments. Furthermore, it is strongly recommended that similar arrangements be established with other regions/nations, in particular, Japan and China. Failure to ensure productive relations with these regions may lead to the development of technological innovations which are in opposition to the path adopted by SESAR.

It should be noted that no information upon developments in India has been obtained and that due to the nature of its economic and demographic development, further analysis is recommended.

6.9.6 European R&D Activities

EUROCONTROL is a major contributor to European R&D, with recognised competences and activities addressing all of the CNS/ATM domains. These are structured to match EATM and ATM2000+ needs which, at their inception, served as a reference to all and were approved by the States.

Like for all ATM stakeholders involved in R&D, the review of the EATM activities highlighted the further need to align them with the IPs and their time horizons, plus the performance objectives and operational requirements of SESAR. This adaptation, which is already underway, should occur in close coordination with stakeholders under suitable working arrangements.

The SJU should agree mechanisms to ensure alignment of ATM

R&D activities with all of its Members and other sponsors of ATM R&D, the contents of the ATM Master Plan (SESAR Deliverable D5) being the sole reference of the activities to be pursued.

6.9.7 Validation Infrastructure

Current validation infrastructure is based upon a set of disparate tools that cover a wide variety of study topics and system-wide validation scenarios and which have been developed over the last decades in a much dispersed manner. For the most part, they address specific problems, geographic areas and/or operational domains which are targeted at today's ATM environment. ARDEP has identified that upwards of €20M is spent annually for their continued maintenance and development.

A detailed analysis of existing validation tools and platforms show that current System-wide models cover a wide variety of study topics and validation scenarios. However, future System-wide concept aspects (e.g. CDM and future DCB practices) and other such elements (e.g. environmental and weather impacts) still require further developmental activities in order to address known needs and requirements. The SESAR Target Concept is a System-wide concept which encompasses processes and solutions interacting on that basis and will require System-wide validation.

The validation of operational concept elements driven by SESAR may require the use of high fidelity models reproducing the whole of the ECAC area (i.e. all ECAC airspace and airports to be modelled in full detail). Technically this is possible since such modelling capabilities exist, but such a large scale model is limited by current computing capabilities, the resources and time needed to build such a model, and the lack of information from many stakeholders concerning their assets to allow for undertaking high fidelity modelling.

It is important to note that even though many of the necessary capabilities to realistically model operational processes and the corresponding impacts are already developed, they do not exist within a single tool. This drives current development needs toward the use of simulation platforms which allow for the integration of various tools in order to run a complete analysis to validate whether the key performance targets are met. Also, component- or agent-based software architectures applied to future tools is a promising way to provide integrated capabilities whilst at the same time enabling flexibility to pursue different objectives via System-wide modelling.

In conclusion, it is recommended that the ATM Master Plan (D5) should incorporate the requirement to rationalise existing validation infrastructure and to develop new validation infrastructure required to validate the SESAR ConOps.

7 List of References

1 Milestone Objective Plan D4: ATM Deployment Sequence – MGT-0506-004-03-00

2 Milestone Deliverable D3: ATM Target Concept - DLM-0612-001-02-00

3 Milestone Deliverable D2: Air Transport Framework – The Performance Target - DLM-0607-001-02-00

4 Milestone Deliverable D1: Air Transport Framework – The Current Situation - DLM-0602-001-03-00

5 ICAO Global Air Traffic Management Operational Concept – Doc 9854

6 Task Deliverable: 1.1.3/D4 - Security

7 Task Deliverable: 1.1.4/D4 – Environment

8 Task Deliverable: 1.2.2/D4 – Definition of new mechanisms for timely and harmonised decision making

9 Task Deliverable: 1.3.2/D4 – Prepare a proposal for the financial and investment plan

10 Task Deliverable: 1.4.2/D4 – Consolidate and update the CBA model with data supporting the trade-offs and Financial Pans

11 Task Deliverable: 1.5.2/D4 – Identification of potential modifications to existing legislation and regulation

12 Task Deliverable: 1.6.2/D4 – Study of impact of new concepts and procedure on safety regulations, including compliance and synchronisation with ICAO safety standards

13 Work Package Deliverable: WP1.7/D4 – Human factors impacts; Recruitment, training and licensing; Social factors & Change Management

14 Task Deliverable: 2.2.4/D4 – Resulting set of recommendations for operational concepts trade-off analysis

15 Task Deliverable: 2.3.1/D4 – Compute and map operational concepts & airspace KPIs based on identified available tools and methodologies

16 Task Deliverable: 2.3.2/D4 – Investigate needs for new appropriate modelling and validation tools and methodologies

17 Task Deliverable: 2.4.4/D4 – Consolidation of mid- and long-term architecture

18 Task Deliverable: 2.5/D4 – Technology Assessment

19 Task Deliverable: 2.6.2/D4 – Active contribution to ongoing standardisation

20 Task Deliverable: 3.1.1/3.1.2/3.1.3/D4 – Integration of ATM European Initiatives & Programmes

21 Task Deliverables 3.2.3/3.2.4/3.2.6/3.2.7/D4 - Short-term Improvements and Deployment Plan
Task Deliverable 3.2.5/D4 - Standardisation Activity for Short-Term Implementation

22 Task Deliverable: 3.3.2/D4 – Establishment of deployment costs

23 Task Deliverable: 3.3.3/D4 – Trade-off scenario and selection of transition scenarios

24 SESAR Performance Objectives and Targets

25 EUROCAE ED78A

26 Performance Review Report 2006

27 EUROCONTROL STATFOR Long Term Forecast 2004
http://www.eurocontrol.int/statfor/public/subsite_homepage/homepage.html

28 EUROCONTROL "Challenges To Growth" Study Report 2004
http://www.eurocontrol.int/eatm/gallery/content/public/library/CTG04_report.pdf

29 http://www.faa.gov/about/office_org/headquarters_offices/ato/publications/oep/nextgenvision/
http://www.jpdo.gov/

30 Milestone Objective Plan D5: ATM Master Plan – MGT-0506-005-03-00

31 Milestone Objective Plan D6: Work Programme for 2008-2013 – MGT-0506-006-03-00

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

33 EUROCONTROL E-OCVM (European Operational Concept Validation Methodology)
http://www.eurocontrol.int/eec/piblic/standard_page/validation_ocvm.html

8 List of Abbreviations and Terminology

Abbreviations

Abbreviation	Explanation
2D, 3D, 4D	2 Dimensional, 3 Dimensional, 4 Dimensional
AAMS	Advanced Airspace Management System
AAS	Airborne Approach Spacing
ABAS	Aircraft Based Augmentation System
ACARE	Advisory Council for Aeronautics Research in Europe
ACARS	Aircraft Communications Addressing and Reporting System
ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
ACDA	Advanced Continuous Descent Approach
ACCD	Advanced Continuous Climb Departure
ADD	Airborne Derived Data
ADS-B/-C	Automatic Dependent Surveillance – Broadcast/-Contract
AFUA	Advanced Flexible Use of Airspace concepts
AGDL	Air-Ground Data Link
AGDLGMS	Air-Ground Data Link Ground Management System
AI/AIM/AIMS/AIS	Aeronautical Information/Management/Management System/Publication/Service
AMAN	Arrival Management/Arrival Manager
AMHS	Aeronautical Message Handling System
ANS/-P	Air Navigation Service/-Provider
AO	Aerodrome/Airport Operations
AOC	Airline Operational Control
AOM	Airspace Organisation and Management
APOC	Airport Operations Centre
APM	Approach Path Monitor
APP	Approach
APW	Approach Proximity Warning
ARDEP	Analysis of Research and Development in EUROCONTROL Programmes
ARN	Air Traffic Service Route Network
ASAS	Airborne Separation Assistance System
ASAS-SSEP	ASAS Self Separation
ASM	Airspace Management
ASPA	Airborne SPAcing
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATCC	Air Traffic Control Center
ATCO	Air Traffic Control Officer
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATMPP	ATM Performance Partnership

Abbreviation	Explanation
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Service
ATSA – AIRB/ITP/SURF/VSA	Airborne Traffic Separation Assurance – AIRB – Airborne/ITP – In Trail Procedure in Oceanic airspace/SURF – Enhanced traffic situational awareness on airport surface/VSA – Enhanced visual separation on approach
ATSAW	Airborne Traffic Situational Awareness
ATSEP	Air Traffic Safety Electronics Personnel
AUO	Airspace User Operations
BA	Business Aviation
B/C	Benefit to Cost ratio
Bn	Billion
BS	Benefit Start
BTV	Brake To Vacate
CASA	Computer Assisted Slot Allocation
C&P	Crossing & Passing
CAT	Category
CBA	Cost Benefit Analysis
CCD	Continuous Climb Departure
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CEM	Collaborative Environment Management
CM	Conflict Management
CNS/ATM	Communication Navigation Surveillance/Air Traffic Management
ConOps	SESAR Concept of Operations
CPDLC	Controller Pilot Data Link Communication
CTA	Controlled Time of Arrival
CTM	Change and Transition Management
CTO	Controlled Time of Over– fly
DCB	Demand and Capacity Balancing
DLM	Milestone Deliverable
DLT	Task Deliverable
DLW	Work Package Deliverable
DMAN	Departure Manager
DME	Distance Measuring Equipment
DMEAN	Dynamic Management of the European ATM Network
EATM/EATMS	European Air Traffic Management/System
EC	European Commission
ECAC	European Civil Aviation Conference
ECIP	European Convergence and Implementation Plan
EDGE	Enhanced Data rates for Gsm Evolution
EGNOS	European Global Navigation Overlay Service
EHS	Enhanced Surveillance (Secondary Surveillance Mode–S Radar)
ELS	Elementary Surveillance (Secondary Surveillance Mode–S Radar)
EU	European Union
EVS	Enhanced Visual System
ES	Extended Squitter
ETA	Estimated Time of Arrival
HF	Human Factors/High Frequency
FAA	Federal Aviation Administration (USA)
FAB	Functional Airspace Blocks
FASTI	First ATC Support Tools Implementation

Abbreviation	Explanation
FDP/S	Flight Data Processing/System
FMS	Flight Management System
FOC	Full Operating Capability
FPL	Flight Plan
FUA	Flexible Use of Airspace
G2G	Gate to Gate
GA	General Aviation
GAT	General Air Traffic
GBAS	Ground Based Augmentation System
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
HUD	Head Up Display
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFR	Instrumental Flight Rules
INS	Inertial Navigation System
IOC	Initial Operating Capability
IOP	Interoperability
IP	Implementation Package, Internet Protocol
IR	Implementing Rule (SES instrument)
IRS	Inertial Reference System
JPALS	Joint Precision Approach and Landing Systems
KPA	Key Performance Area
KPI	Key Performance Indicator
ILS	Instrument Landing System
ITP	In Trail Procedure
LCIP	Local Convergence and Implementation Plan
LED	Light Emitting Diode
LINK 2000+	EUROCONTROL LINK 2000+ Programme
LoC	Line of Change
LVO	Low Visibility Operations
M	Million
MET	Meteorological information Service
MIL	Military
MLAT	Multi-lateration
MOP	Milestone Objective Plan
MSAW	Minimum Safe Altitude Warning
MSPSR	Multi-Static Primary Surveillance Radar
NDB	Non Directional Beacon
NEASCOG	NATO/EUROCONTROL ATM Security Coordinating Group
NIMS	Network Information Management System
NOP	Network Operation Plan
NPV	Net Present Value
OAT	Operational Air Traffic
OI/OIS	Operational Improvement/Operational Improvement Step
OSI	Open Systems Interconnection
PENS	Pan-European Network Services
PRC	Performance Review Commission
PRNAV	Precision Area Navigation

Abbreviation	Explanation
PRU	Performance Review Unit
PSR	Primary Surveillance Radar
PT	Predicted Trajectory
PTC	Precision Trajectory Clearances
QoS	Quality of Service
R&D	Research and Development
RA	Resolution Advisory
RAIM	Receiver Autonomous Integrity Monitoring
RBT	Reference Business/Mission Trajectory
RNAV	Area Navigation
RNDSG	(EUROCONTROL) Route Network Development Sub-Group
RNP	Required Navigation Performance
ROT	Runway Occupancy Time
RTA	Required Time of Arrival
RTCS	Recruitment, Training, Competence and Staffing
RVSM	Reduced Vertical Separation Minima
S&M	Sequencing & Merging
SATCOM	Satellite Communications
SBAS	Space/Satellite Based Augmentation System
SBT	Shared Business/Mission Trajectory
SENSE	EUROCONTROL HF Domain Work Programme
SES	Single European Sky
SESAR	Single European Sky ATM Research
SETS	Service Enhancement Transition Steps
SJU	SESAR Join Undertaking
SMAN	Surface Manager
SMR	Surface Movement Radar
SOA	Service Oriented Approach
SSR	Secondary Surveillance Radar
STATFOR	EUROCONTROL Air Traffic Statistics and Forecast Service
STCA	Short Term Conflict Alert
SVS	Synthetic Vision System
SWIM	System Wide Information Management
TACAN	Tactical Navigation
TMA	Terminal Manoeuvre Area
TMR	Trajectory Management Requirements
TRA	Temporary Restricted Area
TS	Traffic Synchronisation
TSA	Temporary Segregated Area
TTA	Target Time of Arrival
TWR	Aerodrome Control Tower
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UDPP	User Driven Prioritisation Process
UHF	Ultra High Frequency
VDL	VHF Digital link
VHF	Very High Frequency
VoIP	Voice over IP
VOR	Very High Frequency Omni directional Radio Range
WAM	Wide Area Multi-lateration
WV	Wake Vortex

9 List of Figures and Tables

Annexes

10.1 ANNEX I - Solution Risks

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

Risk & Assessment	Impact	Probability	Ongoing Mitigation Actions
D1/R1 - Lack of a solution to break the capacity barrier	H	L	• Considered to have been addressed by the definition ATM Deployment Sequence.
D1/R2 - Not possible to address the fragmentation issue with respect to the cost effectiveness objectives	H	M	• ATM Master Plan will integrate D4 and ongoing Cost Assessment Group work into the Benefits Plan taking into account requirements such as cost-effectiveness and fragmentation.
D1/R3 - Lack of an assessment of the scope and content of the ATM Master Plan due to business planning and CBA modelling limitations	M	H	• ATM Master Plan will integrate D4 and ongoing Cost Assessment Group work into the Benefits Plan taking into account requirements such as cost-effectiveness and fragmentation; • D5 Task 3.4.4 will identify its' results and recommendations including those related to Master Plan contents that could not be fully assessed.
D1/R4 - Failure to address the enforcement of a common regulatory framework	H	L	• Considered to have been addressed by the decision to recommend adoption of High Level Group report. • Establishment of regulatory interface body
D1/R5 - Lack of a clear governance structure (including leadership, political and decision making arrangements)	H	M	• Institutional Enablers have been identified during D4 and will form the basis for integration of appropriate actions in the ATM Master Plan and further consolidated in WP4.1/D6. • While the governance structure has been clarified for the SJU it still has to be defined for the post JU phase.
D1/R6 - Lack of credible ATM performance assessment and monitoring – to support the performance-based approach	M	L	• The ATM Master Plan will identify appropriate tools and management processes to ensure the performance based approach. • European Regulation to support and enforce deployment of the performance-based approach.
D1/R7 - Lack of interoperability in a global context.	M	L	• Considered to have been addressed by the D4 Standardisation Roadmap.
D1/R8 - Lack of acceptance of the ATM Master Plan by all actors	H	M	• Continued proactively management of the buy-in of the ATM Master Plan by all Stakeholders (at all levels) at each milestone; • Additional actions coordinated with all stakeholders via the SESAR Communications Group.
D1/R9 - Lack of standardised and modular systems to facilitate the transition	M	L	• Integrate D4 Architecture and Technology enablers into ATM Master Plan; • Continue work on Service Oriented Architecture approach for definition of SESAR JU WBS.
D3/R1 - The detailed definition of the ATM Target Concept may induce technically infeasible requirements.	M	M	• Consolidation of captured R&D assessment into the in ATM Master Plan.

Risk & Assessment	Impact	Probability	Ongoing Mitigation Actions
D3/R2 - Implementation schedule to implement the 2020 ATM Target Concept is unachievable.	H	M	• Approval and acceptance of ATM Deployment Sequence by all Stakeholders • Acceptance by Stakeholders of ATM Master Plan will be commitment to achieve schedule; • ATM Master Plan – Risk Management Plan will capture schedule risks and mitigation actions.
D3/R3 - Unachievable performance objectives – identified during future performance assessment.	M	M	• Episode 3 to perform early detailed validation; • SESAR Joint Undertaking validation activities; • Performance Partnership to then perform gap analysis and decide upon corrective actions; • D4 consolidated approach and methodology and areas for further work to be integrated in the ATM Master Plan. • D3 Performance Booklet forms an agreed baseline for future work.
D3/R4 - The lack of ATM business framework (ATMPP) may endanger the development of the ATM Target Concept.	M	H	• WP4.1/D6 will address issues of Management Structure. Including consideration of the further development of the Performance Partnership, ensuring full participation of all stakeholders (in particular the Airspace Users) in the Development phase.
D3/R5 - Unavailable spectrum capacity/capability	M	M	• Continued participation in relevant international bodies; • Integration of the Technology Roadmap into ATM Master Plan and appropriate risk management.
D3/R6 – Unavailability of a fair commercial and institutional framework to operate and provide Navigation and Communication satellite services	M	M	• Continued participation in relevant international bodies; • Integration of the Legal and Technology Roadmap Milestones into ATM Master Plan.
D3/R7 - The potential failure to demonstrate the safety of the SESAR Target Concept and also achievement of the goal of a 10x increase in safety performance.	H	M	• WP1.6 continues to provide a safety related advisory service to D5 and D6. • Integration of Safety Management System principles and Safety Roadmap in the ATM Master Plan.
D3/R8 - Cost effectiveness target will not be met by SESAR and other ATM initiatives.	H	H	• Considered to have been addressed by the evolution and understanding of the cost assessment model and identification that the political targets can be achieved by contributions from SESAR and other ATM initiatives.
D4/R1 – Lack of convergence to ATM Target Concept by R&D initiatives	M	M	• Work Package 3.4/D5 Risk Management Plan • R&D Management Plan and Risk Management Plan to consider and propose actions to address the stakeholders minority position captured during the D1 to D4 activities.
D4/R2 – UAV/UAS are not accommodated by the ATM Target Concept due to lack of R&D	M	M	• Include specific items on UAS in the SESAR R&D plan.
D4/R3 – Lack of appropriate feedback loop from the Cost and Benefit Analysis to the deployment sequence definition in order to optimize it; Validation of some key inputs used for performance and cost assessment; and an agreed and stable technology platform endorsed by all stakeholders	H	H	• The concrete implementation of the D4 outcome is at risk unless the necessary investments are made and the associated return of investments across the implementation packages is obtained. These improvements should ensure that the D4 results better approximate the original performance targets (D2).
D4/R4 – Lack of Buy-in in the investment	H	H	• Further work to be identified in the Master Plan (D5)

10.2 ANNEX II - Specific Process Assessment

10.2.1 Introduction

This chapter summarises how safety and environment have been considered in the Milestone 4 of SESAR. It also performs a sustainability impact assessment of the Milestone 4 of SESAR.

10.2.2 Consideration of Safety Management in D4

This chapter tracks how the safety has been considered in the Milestone 4.
During D4, the safety screening of the OI steps has been conducted, as a refinement of the concept screening made in D3.
The impact of the SESAR IP deployment sequence on safety management and regulatory aspects has been investigated and has been included in the Safety roadmap in chapter 6 of the present document.

10.2.3 Consideration of Environment Management in D4

This chapter tracks how Environmental Management has been conducted during Milestone 4.

During D4, the screening of the OI steps from the environmental sustainability viewpoint has been conducted, as a refinement of the concept screening made in D3.
The impact of the SESAR IP deployment sequence on environment management and regulatory aspects has been investigated and has been included in the Environment roadmap in chapter 6 of the present document.

10.2.4 Sustainability Impact Assessment

This chapter conforms to PART I/section A of the Initial Impact Assessment Screening. It is an augmented version of Annex II of D3, enriched with the last part of the assessment of the SESAR Solution, as produced during M4.

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

Problem analysis: What are the main problems identified?

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

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

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

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

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

Policy options: What are the main policy options?

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

- The "do-nothing" option consists in having the ATM network expand its activities with the current environmental management approach (including the overall evolution of environmental regulation) and none of the SESAR concept elements that provide further environmental improvement;
- The "institutional improvement" option, based on seeking an harmonised management of environmental considerations across the ATM network by promoting Collaborative Environment Management Systems at different levels in the ATM network;
- The "SESAR option", which combines operational improvements based on the new ATM ConOps and the related technology uplift with the institutional improvements.

Impacts: Positive and negatives?

- In the "do-nothing" option, current efforts made to establish environmental best practices allow voluntary ATM actors (Airspace users, Airports and ANSP) to improve their performance on a case-by-case basis. However, owing to the reinforcement of European regulations on environment, this means that the pressure to reduce the environmental impact of aviation is translated into weakly coordinated local approaches that in most cases lead to conservative operational restrictions on air transport operations, especially at busy airports. The consequence of this approach is the inability to accommodate the air transport demand and a negative impact on the economic development. The order of magnitude of the effect of this option is indicated by the long-term forecast study from EUROCONTROL, comparing scenarios with and without stringent Environmental restrictions: this might amount to 30% of un-accommodated demand;

- In the "institutional improvement" option, the harmonised management of environmental considerations across the ATM network is obtained by promoting Collaborative Management Systems at different levels in the ATM network. This would relieve to some extent the impact of local operational restrictions by offering benchmarking capabilities to actors across the network support for identifying and disseminating best practices and coordinate environmental policies so as to avoid network inefficiencies. However, the ConOps and associated technology currently in place limits the benefit of harmonisation. The lack of capacity at busy airports or in busy airspace volumes leads to flight inefficiencies that have negative environmental impact, and as a consequence may lead to operational restrictions when traffic demand increases;
- In the "SESAR option", in addition to the institutional improvements, ATM operations and system are improved, which leads to capacity increase giving simultaneously more throughput and a better flight-by-flight efficiency. The combination of both effects leads to decouple the economic progress from the environmental impact. In addition, local environmental rule-making, especially in terms of airport operation restrictions, which could lead to network inefficiencies and offset a part of the capacity increase, is prevented by the collaborative environmental management approach;

10.3 ANNEX III : Building and Constructing the IP

This annex further describes the steps followed to build the ATM Transition Information Model (covering LoC, IP, OI Step and enablers).

Lines of Change

The Lines of Change (LoCs) are identifiable and well defined operational areas of the ATM environment, including all its aspects (procedures, practices, processes, systems, institutions, etc.), that will need to undergo change in order to meet declared performance objectives and arrive at the SESAR ConOps end-state.

The LoCs align closely with the leading characteristics of the ConOps but go into finer detail. Their high-level descriptions are presented in Table 7.

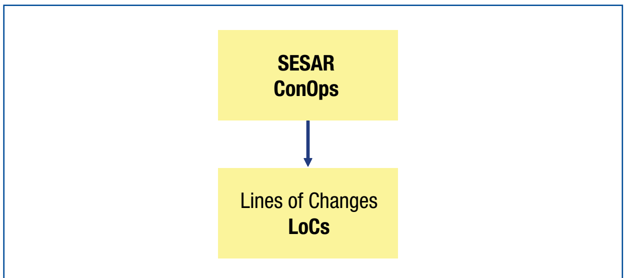


Figure 71: Lines of Change

Operational Improvements Steps

An Operational Improvement (OI) Step implies an enhancement in performance. By assigning individual OI Steps to the LoC they support, the relevance of the OI Steps to the main evolutionary directions of the ConOps. Consequently, potentially missing OI Steps can be identified, or may turn out to be superfluous. OI Steps are therefore related with the performance needs to be attained. They contribute individually to the performance targets for the time frame that they

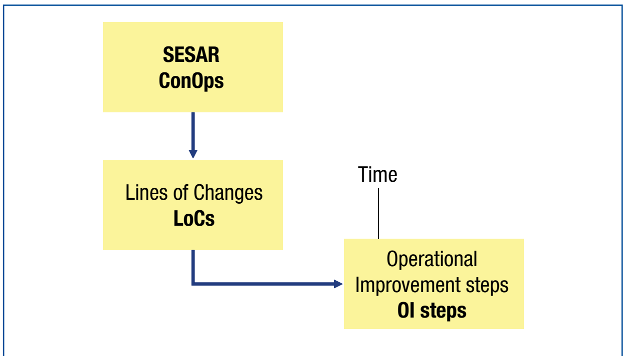


Figure 72: Operational Improvement Steps

are aimed at. This contribution is evaluated through simulations and expert judgments (before implementation) and through feedback from the objective direct performance measurement after implementation.

The Enablers

Enablers are - in terms of systems, procedures, institutional and human aspects - needed in order to facilitate the desired OI Step, i.e. their implementation and deployment. They are not necessarily specific to a given OI Step, i.e. they may "enable" a range of OI Steps.

The enablers have been characterised from four different perspectives:

- Procedural: Procedures to be defined for supporting new operations and airspace management;
- Human: Actions required to ensure conformity with human factors requirements including the need for recruitment, training and the management of change;

Name	Description	Main ConOps Aspects covered
Information Management	All aspects of creating, sharing, obtaining, providing, protecting and using information.	Basic and essential support for all aspects of the ConOps. Support to CDM
Moving from airspace to trajectory based operations	All aspects related to trajectory based operations including the steps required to move from the airspace based to the trajectory-based concept. Includes all aspects related to operations that continue to be airspace based (e.g. military).	Airspace categories. Trajectory based operations. User preferred routing environment. Enhanced integration of diverse airspace use. Access and equity. Minimising segregation.
Collaborative planning using the Network Operations Planner	All aspects related to the initiation, development, refinement, sharing and updating of the Business/Mission Trajectories and all aspects related to the development and use of the NOPLA. Also includes all aspects related to the creation of the NOP using NOPLA. Includes also longer term resource planning. Includes all aspects related to the sharing of flight data, processing of incoming and generation of outgoing ICAO E-FPL. Includes user preferred routing.	Collaborative planning. Trajectory based operations. Network Operations Plan and related applications. Trajectory sharing. Flight data input. All planning horizons. Airport planning
Managing the Network	All aspects related to the development and management of the ATM network, including the provision of the necessary resources to cater for demand Includes all aspects related to automated configuration tools. Includes free route operations (network aspects).	Regional and Sub-regional network management. Demand and capacity balancing
Managing Business Trajectories (Military Mission Trajectories) in real time.	All aspects related to the execution of user or ATM originated changes to the trajectory actually being flown (for conflict management, implementing queue management constraints, avoiding weather or restricted areas, etc.).	Managing/implementing constraints. Trajectory management requirements. ATC coordination using shared trajectories. Complexity management
Cooperative ground and airborne decision making tools.	All aspects related to decision-making automation (e.g. ground based conflict detection and resolution, what-if, ASAS conflict probe, etc.)	Controller and pilot automation tools
Queue management tools	All aspects related to tools used to set up and manage queues (except for implementing the results, see 5 above). Includes UDPP.	Arrival and departure management. UDPP.
New separation modes	All aspects related to realising the various ANSP and airborne separation modes.	ANSP modes. Airborne modes. Mixed mode operations.
Improved cooperative ground and airborne safety nets.	All aspects related to advanced STCA and ACAS. Includes the management of variable separation minima.	Collision avoidance.
Airport throughput, Safety and Environment	All aspects related to airport throughput from terminal operations through final, ground movement and turn round as well as departure until established on departure route. Also includes all aspects related to airside safety.	Spacing on final. Runway operations. Taxi guidance and operations. Runway safety.

Table 7: LoC to ConOps Traceability

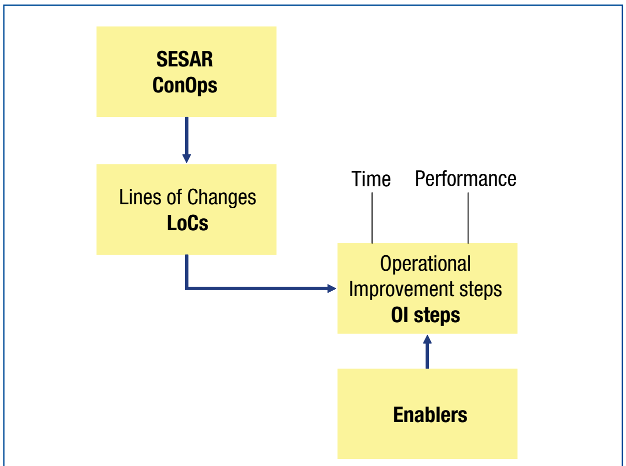


Figure 73: Introduction of the Enablers

- System: Evolution of the system architecture (changes in functionality or infrastructure) and technology to be developed and deployed;
- Institutional, including: regulation to be put in place, e.g. Interoperability, Implementing Rules, Incentive mechanisms or Safety regulation and standards to be developed, and adopted, either at regional or global level.

The timely introduction of the enablers is essential to obtain the needed performance from an implementation package to meet the required performance targets over time.

The Overall Process

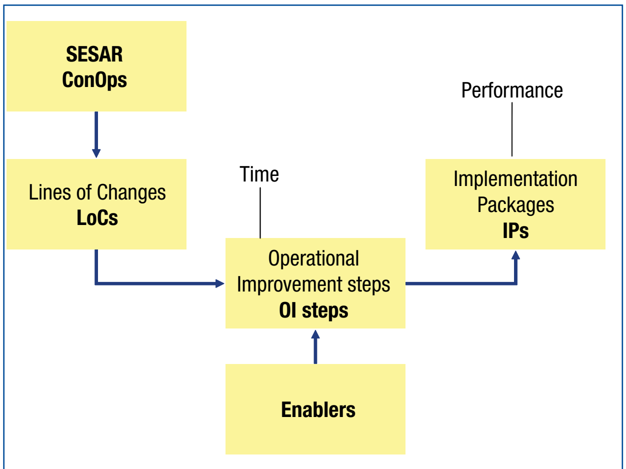


Figure 74: Information Model

The information model is the synthesis of the overall process for the applied methodology (see example of application in Annex VI).

The Financial Affordability

To demonstrate that the selected Implementation Packages were affordable for the stakeholders iterative CBA were performed all along the IP sequence design.

The D4 CBA has focused on the support to the decision making by the civil Airspace Users, identified in D1 as the weakest link of the value chain, being the major interface with the public demand for air transport[30].

To assess the financial affordability the process as shown in Figure 75 was applied. It was run for IP1 and then IP2 and compared to the "baseline scenario of business as usual" without the SESAR OI Steps based on the most dominant quantifiable parameters[31]:

- Capacity: the effect on capacity was established through a set of Influence Diagrams translating the OI Steps in increased fuel efficiency and reduction of un-accommodated demand and delays. The effect on predictability, combined with the "throughput under low visibility" was translated in cancelled flights. Using the FAP model these performance improvement were quantified in a usable format for the CBA;
- Cost effectiveness: The cost effectiveness expressed in ANSP costs per flight was derived from the ATCO productivity (in direct relation with capacity) and ANSP SESAR investment cost to be incurred for pre-implementation (R&D, prototypes, validation) of the enablers supporting the OI Steps and for their deployment over the full ECAC;
- Airline costs: The airborne investments for Airlines have been assessed from the definition of the equipage needed for the OI Steps. Different avionics packages and different level of equipage of the fleet have been considered for the various Airlines (Major, Low Fare, Regional…). They include retrofit costs as well as forward fit costs when the avionics packages is not yet considered as part of the standard equipage by the aircraft manufacturers. Airborne investments are composed mainly of implementation costs, the associated pre-implementation costs (R&D) being recovered mainly in the recurrent prices of the avionics units.

10.3.1 Main Operational Changes per Line of Change

The following list shows the full set of OI steps included in the SESAR database. OI steps in the database are characterised by a number of attributes like e.g. code, title, description, rationale, IOC date, FOC date, associated Implementation Package, associated LoC, operating context, etc. Please refer to the task 2.2.4/D4 deliverable for further details on the OI steps and the database.
In the present annex, OI steps are listed per Implementation Package and per Line Of Change (LoC), with their Code, Title and IOC date. The list also clarifies the link between the main operational changes

30 - Since most of two other major stakeholders, ANSPs and Airports are presently operating, by and large, on a full cost recovery principle, their own CBA (often negative) is less important than the contribution of their investments to the capability to manage the traffic growth while improving their cost effectiveness, resulting in lower unit costs to the airspace users per flight.

31 - Uncertainties in the baseline performances scenarios are as much important as uncertainties in the IP performances assessment since the benefits are quantified on the basis of the differences between these two performances developments.

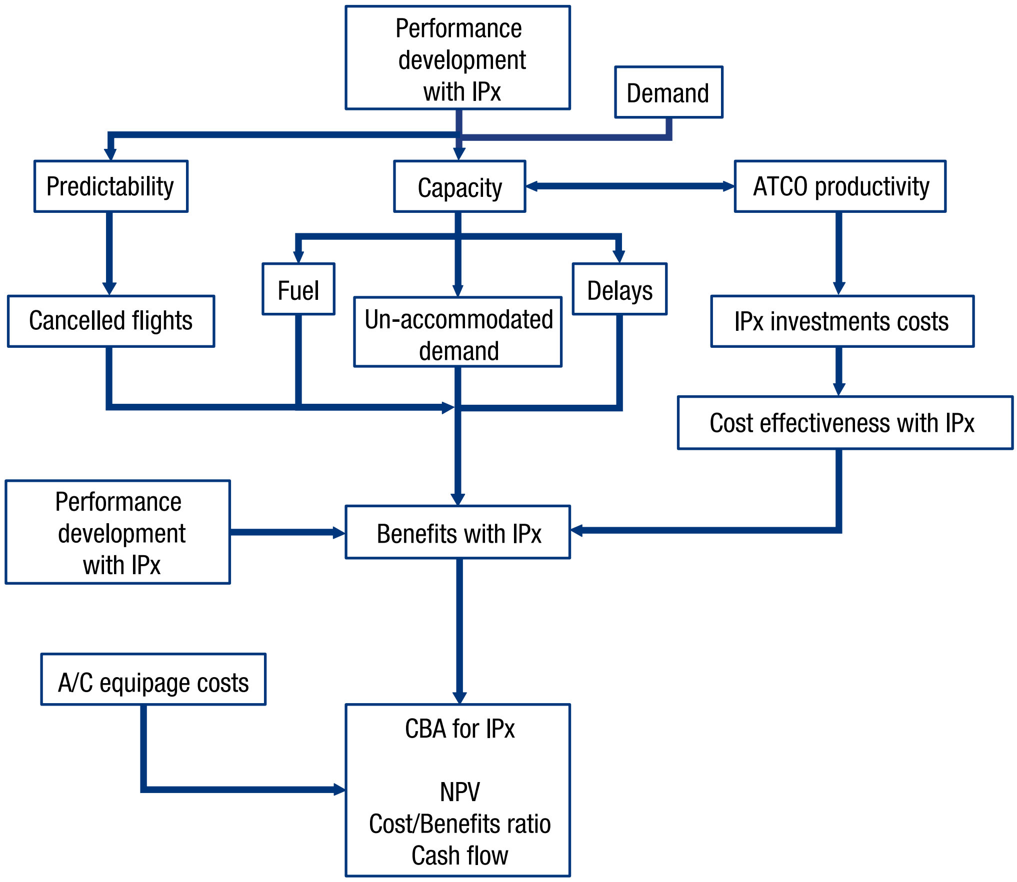


Figure 75: Iterative CBA Process

displayed in the Implementation Package diagrams of Chapter 3, 4 and 5, and the OI steps included in the database. Each of the main operational changes (i.e. "diamonds" shown in the chapter's 3, 4 and 5 figures) is included in the following list (in blue). All the OI steps grouped in each of these main operational changes are then listed by their code, title and IOC date.

IP1 LOC L01: Information Management

- **Improved consistency between airport/ATFCM slots**
  DCB-0301: Improved Consistency between Airport Slots, Flight Plans and ATFM Slots [2012]
- **Improved flight plan management**
  DCB-0302: Collaborative Management of Flight Updates [2007]
  IS-0101: Improved Flight Plan Consistency Pre-Departure [2007]
  IS-0102: Improved Management of Flight Plan After Departure [2009]
  IS-0201: Integrated Pre-Flight Briefing [2007]
  AUO-0201: Enhanced Flight Plan Filing Facilitation [2008]
- **ATIS via datalink**
  IS-0401: Automatic Terminal Information Service Provision through Use of Datalink [2007]
- **Common quality measures for Aeronautical information**
  IS-0202: Improved Supply Chain for Aeronautical Data through Common Quality Measures [2009]
- **Common data model for aeronautical information**
  IS-0203: Harmonised Aeronautical Information through Common Data Model [2007]
- **Digitalised Aeronautical Information**
  IS-0204: Facilitated Aeronautical Data Exchanges through Digitalised Information [2011]
- **Baseline common information model**
  IS-0701: SWIM - baseline an initial common information model based on existing and consistent standards [2011]
- **Interoperability between AOC and ATM systems**
  IS-0301: Interoperability between AOC and ATM Systems (FDPS) [2010]
- **Interoperability between AOC and Weather Information Systems**
  IS-0407: Interoperability between AOC and Weather Information Systems [2007]
- **Miscellaneous OI steps**
  IS-0402: Extended Operational Terminal Information Service Provision Using Datalink [2011]

IP1 LOC L02: Moving from Airspace to Trajectory based Operations

- **Harmonised, enhanced and coordinated use of civil/military airspace**
  AOM-0101: Harmonised ICAO Airspace Classification at FL195 and below [2008]
  AOM-0201: Moving Airspace Management Into Day of Operation [2008]
  AOM-0202: Enhanced Real-time Civil-Military Coordination of Airspace Utilisation [2009]
  AOM-0203: Cross-Border Operations Facilitated through Collaborative Airspace Planning with Neighbours [2007]
  AOM-0205: Modular Temporary Airspace Structures and Reserved Areas [2008]
- **Enhanced ASM/ATFCM Coordination process**
  DCB-0203: Enhanced ASM/ATFCM Coordinated Process [2009]
- **OAT Flight planning and transit system**
  AOM-0302: Harmonised OAT Flight Planning [2010]
  AOM-0303: Pan-European OAT Transit System [2010]
- **Improvements to Route Network/multiple route options**
  AOM-0401: Multiple Route Options & Airspace Organisation Scenarios [2007]
  AOM-0402: Further Improvements to Route Network [2007]
- **Terminal Airspace organisation adapted through best practice/P-RNAV/FUA**
  AOM-0601: Terminal Airspace Organisation Adapted through Use of Best Practice, PRNAV and FUA Where Suitable [2007]
- **Enhanced Terminal design using P-RNAV**
  AOM-0602: Enhanced Terminal Route Design using P-RNAV Capability [2010]
- **CDA/CCD**
  AOM-0701: Continuous Descent Approach (CDA) [2007]
  AOM-0703: Continuous Climb Departure [2007]
- **Flexible/modular Sectorisation**
  AOM-0801: Flexible Sectorisation Management [2007]
  AOM-0802: Modular Sectorisation Adapted to Variations in Traffic Flows [2007]
- **Automated support for dynamic Sectorisation**
  CM-0102: Automated Support for Dynamic Sectorisation and Dynamic Constraint Management [2012]
- **Miscellaneous OI steps**
  AOM-0301: Harmonised EUROCONTROL ECAC Area Rules for OAT-IFR and GAT Interface [2008]

IP1 LOC L03: Collaborative Planning using the Network Operations Planner

- **Interactive capacity planning, NOP**
  DCB-0101: Enhanced Seasonal NOP Elaboration [2007]
  DCB-0201: Interactive Network Capacity Planning [2007]
- **Interactive Rolling NOP**
  DCB-0102: Interactive Rolling NOP [2008]
- **Network management with ATFCM techniques**
  AUO-0101: ATFM Slot Swapping [2007]
  DCB-0204: ATFCM Scenarios [2007]
  DCB-0206: Coordinated Network Management Operations Extended Within Day of Operation [2007]
  DCB-0303: Improved Operations at Airport in Adverse Conditions Using ATFCM Techniques [2008]

IP1 LOC L04: Managing the Network

- **Short-term ATFCM measures**
  DCB-0205: Short Term ATFCM Measures [2010]
- **Network performance assessment**
  SDM-0101: Network Performance Assessment [2007]
- **Civil-Military Cooperation Assessment**
  SDM-0102: Civil-Military Cooperation Performance Assessment [2009]
- **Sustainability performance assessment**
  SDM-0103: Sustainability Performance Management of the ATM Network [2010]
- **Miscellaneous OI steps**
  DCB-0207: Management of Critical Events [2007]

IP1 LOC L05: Managing Business Trajectories in real Time

- **Initial datalink application**
  AUO-0301: Voice Controller-Pilot Communications (En Route) Complemented by Data Link [2007]
- **Cruise-climb techniques**
  AUO-0304: Initiating Optimal Trajectories through Cruise-Climb Techniques [2010]
- **Automated support to traffic load, coordination and transfer**
  CM-0101: Automated Support for Traffic Load (Density) Management [2007]
  CM-0201: Automated Assistance to Controller for Seamless Coordination, Transfer and Dialogue [2008]
- **Sector team/new roles**
  CM-0301: Sector Team Operations Adapted to New Roles for Tactical and Planning Controllers [2008]

IP1 LOC L06: Cooperative Ground and Airborne Decision making Tools

- **Automated assistance to controller for conflict prevention and flight conformance monitoring**
  CM-0202: Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace [2007]
  CM-0203: Automated Flight Conformance Monitoring [2007]

IP1 LOC L07: Queue Management Tools

- **AMAN**
  TS-0102: Arrival Management Supporting TMA Improvements (incl. CDA, P-RNAV) [2007]
- **AMAN extended in En-route**
  TS-0305: Arrival Management Extended to En Route Airspace [2010]
- **DMAN**
  TS-0201: Basic Departure Management (DMAN) [2007]
- **DMAN and pre-departure**
  TS-0202: Departure Management Synchronised with Pre-departure Sequencing [2010]
- **AMAN/DMAN integration**
  TS-0301: Integrated Arrival Departure Management for full traffic optimisation, including within the TMA airspace [2012]

IP1 LOC L08: New Separation Modes

- **ATSAW in flight and on surface**
  AUO-0401: Air Traffic Situational Awareness (ATSAW) on the Airport Surface [2010]
  AUO-0402: Air Traffic Situational Awareness (ATSAW) during Flight Operations [2010]
- **ATSA-ITP (oceanic)**
  AUO-0503: In-trail Procedure in Oceanic Airspace (ATSA-ITP) [2009]
- **Manual ASAS Sequencing & Merging**
  TS-0107: ASAS Manually Controlled Sequencing and Merging [2009]

IP1 LOC L09: Effective Ground and Airborne Safety Nets

- **Ground safety nets**
  CM-0801: Ground Based Safety Nets (TMA, En Route) [2007]
- **ACAS linked with Auto-pilot/FD display**
  CM-0803: Enhanced ACAS through Use of Autopilot or Flight Director [2008]

IP1 LOC L10: Airport throughput, Safety and Environment

- **Improved Runway Incursion prevention processes**
  AO-0101: Reduced Risk of Runway Incursions through Improved Procedures and Best Practices on the Ground [2007]
  AO-0102: Automated Alerting of Controller in Case of Runway Incursion or Intrusion into Restricted Areas [2008]
  AO-0103: Improved Runway-Taxiway Lay-out, Signage and Markings to Prevent Runway Incursions [2009]
- **Controller increased situational awareness in LVPs**
  AO-0201: Enhanced Ground Controller Situational Awareness in all Weather Conditions [2007]
- **Foreign Object Debris detection on airport surface**
  AO-0202: Detection of FOD (Foreign Object Debris) on the Airport Surface [2010]
- **Moving map for Vehicle drivers and aircraft**
  AO-0203: Guidance Assistance to Airport Vehicle Driver [2009]
  AUO-0602: Guidance Assistance to Aircraft on the Airport Surface [2008]
- **Dynamic surface navigation information for aircraft (traffic context)**
  AUO-0603: Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing [2010]
- **CDM processes**
  AO-0501: Improved Operations in Adverse Conditions through Airport Collaborative Decision Making [2007]
  AO-0601: Improved Turn-Around Process through Collaborative Decision Making [2007]
  AO-0602: Collaborative Pre-departure Sequencing [2007]
  AO-0603: Improved De-icing Operation through Collaborative Decision Making [2007]
  DCB-0304: Airport CDM extended to Regional Airports [2008]
- **Interlaced Take-Off and Landing**
  AO-0402: Interlaced Take-Off and Landing [2007]
- **Improved aircraft separations and parallel runway operations**
  AO-0403: Optimised Dependent Parallel Operations [2012]
  AO-0303: Fixed Reduced Separations based on Wake Vortex Prediction [2012]
- **Use of Runway Occupancy Time Reduction Techniques**
  AUO-0701: Use of Runway Occupancy Time (ROT) Reduction Techniques [2007]
- **Brake to vacate procedure**
  AUO-0702: Brake to Vacate (BTV) Procedure [2008]
- **Crosswind Reduced Separations for Departures and Arrivals**
  AO-0301: Crosswind Reduced Separations for Departures and Arrivals [2009]
- **Time based separation for arrivals**
  AO-0302: Time Based Separation for Arrivals [2012]
- **Improved LVPs procedures**
  AO-0502: Improved Operations in Low Visibility Conditions through Enhanced ATC Procedures [2009]
- **Visual Contact Approaches**
  AUO-0501: Visual Contact Approaches When Appropriate Visual Conditions Prevail [2009]
- **ATSA-VSA**
  AUO-0502: Enhanced Visual Separation on Approach (ATSA-VSA) [2010]
- **Sustainable operations at airport**
  AO-0701: Effective Collaboration between ATM Stakeholders Supported by Environmental Management Systems [2007]
  AO-0702: Improved Relations to Neighbours [2007]
  AO-0703: Noise Management to Limit Exposure to Noise on the Ground [2007]
  AO-0704: Optimised Design and Procedures for Airport manoeuvring Areas to Reduce Gaseous Emissions and Noise Disturbance [2007]

AO-0705: Reduced Water Pollution [2007]
AO-0706: (Local) Monitoring of Environmental Performance [2007]
AUO-0802: Ground Movement Techniques to Reduce Gaseous Emissions and Noise Disturbance [2007]
AUO-0803: Reduced Noise Footprint on Departure [2007]

- **Miscellaneous OI steps**
  AO-0305: Additional Rapid Exit Taxiways (RET) and Entries [2006]
  AUO-0801: Environmental Restrictions Accommodated in the Earliest Phase of Flight Planning [2009]
  AO-0504: Improved Low Visibility Runway Operations Using MLS [2010]
  AO-0503: Reduced ILS Sensitive and Critical Areas [2008]

IP2 LOC L01: Information Management

- **SWIM - Ground-Ground limited services**
  IS-0702: SWIM - European Ground Communication Infrastructure [2013]
  IS-0703: SWIM - governance & supervision [2013]
  IS-0704: SWIM - Ground-Ground limited services [2013]
- **SWIM - Ground-Ground extended services**
  IS-0705: SWIM - Ground-Ground extended services [2016]
- **SWIM - Air-Ground limited services**
  IS-0706: SWIM - European Air-Ground Communication Infrastructure [2016]
  IS-0707: SWIM - Air-Ground limited services [2016]
- **Use of ADD to Enhance ATM Ground System**
  IS-0302: Use of Aircraft Derived Data (ADD) to Enhance ATM Ground System Performance [2013]
- **Use of PT to Enhance ATM Ground System**
  IS-0303: Use of Predicted Trajectory (PT) to Enhance ATM Ground System Performance [2016]
- **Use of Airborne Weather Data by Meteorological Service to Enhance Weather Forecast**
  IS-0501: Use of Airborne Weather Data by Meteorological Service to Enhance Weather Forecast [2016]

IP2 LOC L02: Moving from Airspace to Trajectory based Operations

- **3 categories of airspace**
  AOM-0102: Three Categories of Airspace [2015]
- **Flexible military structures**
  AOM-0206: Flexible Military Airspace Structures [2016]
- **OAT Trajectories**
  AOM-0304: OAT Trajectories [2015]
- **Free routing from ToC to ToD**
  AOM-0403: Pre-defined ATS Routes Only When and Where Required [2018]
  AOM-0502: Use of Free Routing from ToC to ToD [2018]
- **Free routing in cruise above a certain level**
  AOM-0501: Use of Free Routing for Flight in Cruise Inside FAB Above Level XXX [2015]
- **ACDA/ACCD**
  AOM-0702: Advanced Continuous Descent Approach (ACDA) [2013]
  AOM-0705: Advanced Continuous Climb Departure [2013]
- **Tailored arrival**
  AOM-0704: Tailored Arrival [2015]
- **Miscellaneous OI steps**
  AOM-0204: Europe-wide Shared Use of Military Training Areas [2013]
  SDM-0203: Generic (non-geographical) controller validations [2015]

IP2 LOC L03: Collaborative Planning using the Network Operations Planner

- **SWIM enabled NOP planning using SBT/RBT + dynamic ATFCM**
  DCB-0103: SWIM enabled NOP [2016]
  AUO-0203: Shared Business/Mission Trajectory (SBT) [2016]
  AUO-0204: Agreed Reference Business/Mission Trajectory (RBT) through Collaborative Flight Planning [2016]
  DCB-0208: Dynamic ATFCM [2016]
  CM-0402: Coordination-free Transfer of Control through use of Shared Trajectory [2016]
- **UDPP and Network management**
  AUO-0102: User Driven Prioritisation Process (UDPP) [2015]
  DCB-0305: Network Management Function In Support of UDPP [2015]

IP2 LOC L05: Managing Business Trajectories in real Time

- **Management/revision of RBT using datalink**
  AUO-0302: Successive Authorisation of Reference Business/-Mission Trajectory (RBT) Segments using Datalink [2016]
  AUO-0303: Revision of Reference Business/Mission Trajectory (RBT) using Datalink [2016]
- **Automated support for complexity assessment**
  CM-0103: Automated Support for Traffic Complexity Assessment [2013]
- **Full set of complexity management tools**
  CM-0104: Automated Controller Support for Trajectory Management [2016]
  CM-0302: Ground based Automated Support for Managing Traffic Complexity Across Several Sectors [2016]

IP2 LOC L06: Cooperative Ground and Airborne Decision making Tools

- **Full set of advanced tools (conflict resolution advisories, etc.) using RBT/SBT**
  CM-0204: Automated Support for Near Term Conflict Detection & Resolution and Trajectory Conformance Monitoring [2016]
  CM-0401: Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number [2016]

CM-0404: Enhanced Tactical Conflict Detection/Resolution and Conformance & Intent Monitoring [2016]
CM-0405: Automated Assistance to ATC Planning for Preventing Conflicts in Terminal Area Operations [2015]
CM-0406: Automated Assistance to ATC for Detecting Conflicts in Terminal Areas Operations [2015]

- **Dilution of conflicts by speed adjustments**
  CM-0403: Conflict Dilution by Upstream Action on Speed [2016]

IP2 LOC L07: Queue Management Tools

- **CTA through use of datalink**
  TS-0103: Controlled Time of Arrival (CTA) through use of datalink [2016]
- **Integrated queue management - step 1**
  TS-0104: Integration of Surface Management Constraint into Arrival Management [2014]
  TS-0203: Integration of Surface Management Constraint into Departure Management [2014]
  TS-0302: Departure Management from Multiple Airports [2013]
  AO-0207: Surface Management Integrated With Departure and Arrival Management [2013]
- **Multiple CTOs**
  TS-0106: Multiple Controlled times of Over-fly (CTOs) through use of data link [2018]
- **Integrated queue management - step 2**
  TS-0303: Arrival Management into Multiple Airports [2015]
  TS-0306: Optimised Departure Management in the Queue Management Process [2015]
  TS-0304: Integrated Arrival/Departure Management in the Context of Airports with Interferences (other local/regional operations) [2015]

IP2 LOC L08: New Separation Modes

- **2D-PTC on pre-defined routes**
  CM-0601: Precision Trajectory Clearances (PTC)-2D Based On Pre-defined 2D Routes [2013]
- **3DPTC on pre-defined routes**
  CM-0602: Precision Trajectory Clearances (PTC)-3D Based On Pre-defined 3D Routes [2016]
- **2DPTC on User preferred trajectories**
  CM-0603: Precision Trajectory Clearances (PTC)-2D On User Preferred Trajectories [2016]
- **ASEP-ITP implemented**
  CM-0701: Ad Hoc Delegation of Separation to Flight Deck - In Trail Procedure (ASEP-ITP) [2018]
- **ASPA-S&M implemented**
  TS-0105: ASAS Sequencing and Merging as Contribution to Traffic Synchronization in TMA (ASPA-S&M) [2013]

IP2 LOC L09: Effective Ground and Airborne Safety Nets

- **STCA using enriched surveillance information**
  CM-0802: ACAS Resolution Advisory Downlink [2016]
  CM-0807: Enhanced Ground-based Safety Nets Using Wide Information Sharing [2017]

IP2 LOC L10: Airport throughput, Safety and Environment

- **Airport safety nets for pilot and controller**
  AO-0104: Airport Safety Nets including Taxiway and Apron [2013]
  AUO-0605: Automated Alerting of Runway Incursion to Pilots (and Controller) [2013]
- **Enhanced navigation for airport vehicles**
  AO-0204: Airport Vehicle Driver's Traffic Situational Awareness [2013]
  AO-0206: Enhanced Guidance Assistance to Airport Vehicle Driver Combined with Routing [2013]
- **Automated surface movement planning and routing**
  AO-0205: Automated Assistance to Controller for Surface Movement Planning and Routing [2013]
- **Improved surface navigation**
  AUO-0604: Enhanced Trajectory Management through Flight Deck Automation Systems [2018]
- **BTV via datalink**
  AUO-0703: Automated Brake to Vacate (BTV) using Datalink [2013]
- **Adjustment of separation based on WV detection**
  AO-0304: Dynamic Adjustment of Separations based on Real-Time Detection of Wake Vortex [2015]
- **Improved Visibility operations (GBAS, EVS)**
  AO-0505: Improved Low Visibility Runway Operations Using GNSS/GBAS [2013]
  AUO-0403: Enhanced Vision for the Pilot in Low Visibility Conditions [2013]

IP3 LOC L01: Information Management

- **SWIM - full services**
  IS-0708: SWIM - Ground-Ground full services [2020]
  IS-0709: SWIM - Air-Ground extended services [2020]
- **A/A services including weather hazards**
  IS-0710: Air-Air Exchange services [2025]
  IS-0406: Aircraft Dissemination of Information on Weather Hazards to Other Aircraft [2025]
- **Advanced trajectory management (TMR)**
  IS-0305: Automatic RBT Update through TMR [2020]

IP3 LOC L02: Moving from Airspace to Trajectory based Operations

- **Two Categories of Airspace**
  AOM-0103: Two Categories of Airspace [2020]
- **Dynamic Mobile Areas (DMA)**
  AOM-0208: Dynamic Mobile Areas (DMA) [2020]
- **Free routing outside TMA**
  AOM-0503: Use of Free Routing from Terminal Area Operations-

exit to Terminal Area Operations-entry [2020]

- **Dynamically shaped airspace network configuration and terminal areas**
  AOM-0803: Dynamically Shaped Sectors Unconstrained By Predetermined Boundaries [2025]
  AOM-0804: Dynamic Management of Terminal Airspace [2025]
- **Miscellaneous OI steps**
  SDM-0202: Transfer of area of responsibility for trajectory management [2020]

IP3 LOC L08: New Separation Modes

- **4D PTC**
  CM-0501: 4D Contract for Equipped Aircraft with Extended Clearance PTC-4D [2025]
- **3DPTC on user preferred trajectories**
  CM-0604: Precision Trajectory Clearances (PTC)-3D On User Preferred Trajectories (Dynamically applied 3D routes/profiles) [2020]
- **ASEP Crossing and Passing applications**
  CM-0702: Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P) [2020]
- **Self-Adjustment of Spacing based on airborne WV detection**
  AUO-0504: Self-Adjustment of Spacing Depending on Wake Vortices [2025]
- **ASAS-SSEP mixed mode**
  CM-0704: Self Separation in Mixed Mode [2025]

IP3 LOC L09: Effective Ground and Airborne Safety Nets

- **Improved compatible ground and airborne safety nets**
  CM-0804: ACAS Adapted to New Separation Modes [2020]
  CM-0805: Short Term Conflict Alert Adapted to New Separation Modes [2020]
  CM-0806: Improved Compatibility between Ground and Airborne Safety Nets [2020]

IP3 LOC L10: Airport throughput, Safety and Environment

- **SVS in low visibility condition**
  AUO-0404: Synthetic Vision for the Pilot in Low Visibility Conditions [2020]
- **Remotely Controlled Aerodrome**
  SDM-0201: Remotely Provided Aerodrome Control Service [2020]

10.3.2 Service Enhancement Transition Steps And Operational Contexts

The realisation of the SESAR ConOps will evolve through a transition path from the current ATM situation to the ATM Target Concept. As mentioned before the Lines of Change are directly derived from the SESAR ConOps and represent the main identifiable and well-defined operational areas of the ATM environment, that will need to undergo changes/series of changes in order to meet declared performance objectives and arrive at the desired end-state described in the SESAR ConOps. This approach will permit, during all stages of SESAR evolution, to have a global operational view of the evolution of the main changes, in particular each Line of Change, required to realise the SESAR ConOps.

The realisation of the Lines of Change will be organised through time periods by "Implementation Packages" as OI steps and enablers containers. However, this level of granularity, even considered as satisfactory to trigger initial benefits assessment, is not considered sufficient to progress the work in a programmed way. It was therefore considered that further refinement should follow two main compatible axes which will lead to an orientation of the "Implementation Packages" to a service enhancement perspective, organised within specific operational contexts, representing effectively where will occur the realisation and deployment. This leads to the notion of Service Enhancement Transition Steps (SETS). Planned for use in D5 and/or D6, the SETS will give a service perspective of the deployment (together with the enablers). Performance targets (in D2) have been specified at operational context level. Since the SETS group the OI steps according to operational context, the SETS are also the means to establish and maintain the link between operational changes, performance benefits and performance targets.

Five SETS have been defined:

- **SETS a - Facilitating Trajectory Management through Information Management**
  These SETS address the evolution of information service in support of trajectory management. The cornerstone of this evolution is the implementation of SWIM.
- **SETS b - Facilitating Trajectory Management through Network Management**
  These SETS address the evolution of services taking place in the business development and planning phases to prepare and support trajectory-based operations (incl. airspace management, collaborative flight planning, Network Operations Plan). They include also the services (incl. in the execution phase) to facilitate trajectory-based operations in case of capacity issues (UDPP, Network function).
- **SETS c - Trajectory Management in En-Route airspace**
  These SETS address the evolution of services delivered to airspace users in support of trajectory-based operations in En-Route.
- **SETS d - Trajectory Management in Terminal Area**
  These SETS address the evolution of services delivered to airspace users in support of trajectory-based terminal area.
- **SETS e - Trajectory Management at Airports**
  These SETS address the evolution of services delivered to airspace users in support of trajectory-based operations at airport (incl. aerodrome service and airport airside).

Allocation of OI Steps to SETS is presented in the following tables for each Lines of Change.

LoC 01 – Information Management

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L01	DCB-0301	Improved Consistency between Airport Slots, Flight Plans and ATFM Slots	Information Management	IP1	SETS1-a
L01	DCB-0302	Collaborative Management of Flight Updates	Information Management	IP1	SETS1-a
L01	IS-0101	Improved Flight Plan Consistency Pre-Departure	Information Management	IP1	SETS1-a
L01	IS-0102	Improved Management of Flight Plan After Departure	Information Management	IP1	SETS1-a
L01	IS-0201	Integrated Pre-Flight Briefing	Information Management	IP1	SETS1-a
L01	IS-0401	Automatic Terminal Information Service Provision through Use of Datalink	Information Management	IP1	SETS1-a
L01	IS-0402	Extended Operational Terminal Information Service Provision Using Datalink	Information Management	IP1	SETS1-a
L01	IS-0202	Improved Supply Chain for Aeronautical Data through Common Quality Measures	Information Management	IP1	SETS1-a
L01	IS-0203	Harmonised Aeronautical Information through Common Data Model	Information Management	IP1	SETS1-a
L01	IS-0204	Facilitated Aeronautical Data Exchanges through Digitalised Information	Information Management	IP1	SETS1-a
L01	IS-0701	SWIM - baseline an initial common information model based on existing and consistent standards	Information Management	IP1	SETS1-a
L01	IS-0702	SWIM - European Ground Communication Infrastructure	Information Management	IP2	SETS2-a
L01	IS-0703	SWIM - governance & supervision	Information Management	IP2	SETS2-a
L01	IS-0704	SWIM - Ground-Ground limited services	Information Management	IP2	SETS2-a
L01	IS-0705	SWIM - Ground-Ground extended services	Information Management	IP2	SETS2-a
L01	IS-0706	SWIM - European Air-Ground Communication Infrastructure	Information Management	IP2	SETS2-a
L01	IS-0707	SWIM - Air-Ground limited services	Information Management	IP2	SETS2-a
L01	IS-0708	SWIM - Ground-Ground full services	Information Management	IP3	SETS3-a
L01	IS-0709	SWIM - Air-Ground extended services	Information Management	IP3	SETS3-a
L01	IS-0710	Air-Air Exchange services	Information Management	IP3	SETS3-a
L01	IS-0301	Interoperability between AOC and ATM Systems (FDPS)	TMA, En-Route	IP1	SETS1-c SETS1-d
L01	IS-0302	Use of Aircraft Derived Data (ADD) to Enhance ATM Ground System Performance	TMA, En-Route	IP2	SETS2-c SETS2-d
L01	IS-0303	Use of Predicted Trajectory (PT) to Enhance ATM Ground System Performance	TMA, En-Route	IP2	SETS2-c SETS2-d
L01	IS-0305	Automatic RBT Update through TMR	TMA, En-Route	IP3	SETS3-c SETS3-d

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L01	IS-0406	Aircraft Dissemination of Information on Weather Hazards to Other Aircraft	Information Management	IP3	SETS3-a
L01	IS-0407	Interoperability between AOC and Weather Information Systems	Information Management	IP1	SETS1-a
L01	IS-0501	Use of Airborne Weather Data by Meteorological Service to Enhance Weather Forecast	Information Management	IP2	SETS2-a

Table 8: OI Steps per SETS in "LoC 01 – Information Management"

LoC 02 – Moving from airspace to trajectory based operations

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L02	AOM-0101	Harmonised ICAO Airspace Classification at FL195 and below	Network	IP1	SETS1-b
L02	AOM-0102	Three Categories of Airspace	Network	IP2	SETS2-b
L02	AOM-0103	Two Categories of Airspace	Network	IP3	SETS3-b
L02	AOM-0201	Moving Airspace Management Into Day of Operation	Network	IP1	SETS1-b
L02	DCB-0203	Enhanced ASM/ATFCM Coordinated Process	Network	IP1	SETS1-b
L02	AOM-0202	Enhanced Real-time Civil-Military Coordination of Airspace utilisation	Network	IP1	SETS1-b
L02	AOM-0203	Cross-Border Operations Facilitated through Collaborative Airspace Planning with Neighbours	Network	IP1	SETS1-b
L02	AOM-0204	Europe-wide Shared Use of Military Training Areas	Network	IP2	SETS2-b
L02	AOM-0205	Modular Temporary Airspace Structures and Reserved Areas	Network	IP1	SETS1-b
L02	AOM-0206	Flexible Military Airspace Structures	Network	IP2	SETS2-b
L02	AOM-0208	Dynamic Mobile Areas (DMA)	Network	IP3	SETS3-b
L02	AOM-0301	Harmonised EUROCONTROL ECAC Area Rules for OAT-IFR and GAT Interface	Network	IP1	SETS1-b
L02	AOM-0302	Harmonised OAT Flight Planning	Network	IP1	SETS1-b
L02	AOM-0303	Pan-European OAT Transit System	Network	IP1	SETS1-b
L02	AOM-0304	OAT Trajectories	Network	IP2	SETS2-b
L02	AOM-0401	Multiple Route Options & Airspace Organisation Scenarios	Network	IP1	SETS1-b
L02	AOM-0402	Further Improvements to Route Network	Network	IP1	SETS1-b
L02	AOM-0403	Pre-defined ATS Routes Only When and Where Required	Network	IP2	SETS2-b
L02	AOM-0501	Use of Free Routing for Flight in Cruise Inside FAB Above Level XXX	Network	IP2	SETS2-b
L02	AOM-0502	Use of Free Routing from ToC to ToD	Network	IP2	SETS2-b
L02	AOM-0503	Use of Free Routing from Terminal Area Operations-exit to Terminal Area Operations-entry	Network	IP3	SETS3-b

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L02	AOM-0601	Terminal Airspace Organisation Adapted through Use of Best Practice, PRNAV and FUA Where Suitable	TMA	IP1	SETS1-d
L02	AOM-0602	Enhanced Terminal Route Design using P-RNAV Capability	TMA	IP1	SETS1-d
L02	AOM-0701	Continuous Descent Approach (CDA)	APT, TMA	IP1	SETS1-d SETS1-e
L02	AOM-0702	Advanced Continuous Descent Approach (ACDA)	APT, TMA	IP2	SETS2-d SETS2-e
L02	AOM-0703	Continuous Climb Departure	APT, TMA	IP1	SETS1-d SETS1-e
L02	AOM-0704	Tailored Arrival	APT, TMA	IP2	SETS2-d SETS2-e
L02	AOM-0705	Advanced Continuous Climb Departure	APT, TMA	IP2	SETS2-d SETS2-e
L02	AOM-0801	Flexible Sectorisation Management	En-Route	IP1	SETS1-c
L02	AOM-0802	Modular Sectorisation Adapted to Variations in Traffic Flows	En-Route	IP1	SETS1-c
L02	AOM-0803	Dynamically Shaped Sectors Unconstrained By Predetermined Boundaries	En-Route	IP3	SETS3-c
L02	AOM-0804	Dynamic Management of Terminal Airspace	TMA	IP3	SETS3-d
L02	CM-0102	Automated Support for Dynamic Sectorisation and Dynamic Constraint Management	En-Route	IP1	SETS1-c
L02	SDM-0201	Remotely Provided Aerodrome Control Service	APT	IP3	SETS3-e
L02	SDM-0202	Transfer of area of responsibility for trajectory management	En-Route	IP3	SETS3-c
L02	SDM-0203	Generic (non-geographical) controller validations	TMA, En-Route	IP2	SETS2-c SETS2-d

Table 9: OI Steps per SETS in “LoC 02 – Moving from Airspace to Trajectory based Operations”

LoC 03 – Collaborative Planning using the Network Operations Planner

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L03	DCB-0101	Enhanced Seasonal NOP Elaboration	Network	IP1	SETS1-b
L03	DCB-0102	Interactive Rolling NOP	Network	IP1	SETS1-b
L03	DCB-0103	SWIM enabled NOP	Network	IP2	SETS2-b
L03	DCB-0201	Interactive Network Capacity Planning	Network	IP1	SETS1-b
L03	AUO-0101	ATFM Slot Swapping	Network	IP1	SETS1-b
L03	AUO-0102	User Driven Prioritisation Process (UDPP)	Network	IP2	SETS2-b
L03	AUO-0201	Enhanced Flight Plan Filing Facilitation	Network	IP1	SETS1-b
L03	AUO-0203	Shared Business/Mission Trajectory (SBT)	Network	IP2	SETS2-b
L03	AUO-0204	Agreed Reference Business/Mission Trajectory (RBT) through Collaborative Flight Planning	Network	IP2	SETS2-b

Table 10: OI Steps per SETS in “LoC 03 – Collaborative Planning using the Network Operations Planner”

LoC 04 – Managing the Network

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L04	DCB-0204	ATFCM Scenarios	Network	IP1	SETS1-b
L04	DCB-0205	Short Term ATFCM Measures	Network	IP1	SETS1-b
L04	DCB-0206	Coordinated Network Management Operations Extended Within Day of Operation	Network	IP1	SETS1-b
L04	DCB-0207	Management of Critical Events	Network	IP1	SETS1-b
L04	DCB-0208	Dynamic ATFCM	Network	IP2	SETS2-b
L04	DCB-0303	Improved Operations at Airport in Adverse Conditions Using ATFCM Techniques	Network	IP1	SETS1-b
L04	DCB-0305	Network Management Function In Support of UDPP	Network	IP2	SETS2-b
L04	SDM-0101	Network Performance Assessment	Network	IP1	SETS1-b
L04	SDM-0102	Civil-Military Cooperation Performance Assessment	Network	IP1	SETS1-b
L04	SDM-0103	Sustainability Performance Management of the ATM Network	Network	IP1	SETS1-b

Table 11: OI Steps per SETS in "LoC 04 – Managing the Network"

LoC 05 – Managing Business Trajectories in real Time

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L05	AUO-0301	Voice Controller-Pilot Communications (En-Route) Complemented by Data Link	En-Route	IP1	SETS1-c
L05	AUO-0302	Successive Authorisation of Reference Business/Mission Trajectory (RBT) Segments using Datalink	APT, TMA, En-Route	IP2	SETS2-c SETS2-d SETS2-e
L05	AUO-0303	Revision of Reference Business/Mission Trajectory (RBT) using Datalink	APT, TMA, En-Route	IP2	SETS2-c SETS2-d SETS2-e
L05	AUO-0304	Initiating Optimal Trajectories through Cruise-Climb Techniques	En-Route	IP1	SETS1-c
L05	CM-0101	Automated Support for Traffic Load (Density) Management	TMA, En-Route	IP1	SETS1-c SETS1-d
L05	CM-0103	Automated Support for Traffic Complexity Assessment	TMA, En-Route	IP2	SETS2-c SETS2-d
L05	CM-0104	Automated Controller Support for Trajectory Management	TMA, En-Route	IP2	SETS2-c SETS2-d
L05	CM-0301	Sector Team Operations Adapted to New Roles for Tactical and Planning Controllers	En-Route	IP1	SETS1-c
L05	CM-0302	Ground based Automated Support for Managing Traffic Complexity Across Several Sectors	En-Route	IP2	SETS2-c
L05	CM-0201	Automated Assistance to Controller for Seamless Coordination, Transfer and Dialogue	TMA, En-Route	IP1	SETS1-c SETS1-d
L05	CM-0402	Coordination-free Transfer of Control through use of Shared Trajectory	TMA, En-Route	IP2	SETS2-c SETS2-d

Table 12: OI Steps per SETS in "LoC 05 - Managing Business Trajectories in real Time"

LoC 06 – Cooperative Ground and Airborne Decision making Tools

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L06	CM-0202	Automated Assistance to ATC Planning for Preventing Conflicts in En-Route Airspace	En-Route	IP1	SETS1-c
L06	CM-0203	Automated Flight Conformance Monitoring	En-Route	IP1	SETS1-c
L06	CM-0204	Automated Support for Near Term Conflict Detection & Resolution and Trajectory Conformance Monitoring	En-Route	IP2	SETS2-c
L06	CM-0401	Use of Shared 4D Trajectory as a Mean to Detect and Reduce Potential Conflicts Number	En-Route	IP2	SETS2-c
L06	CM-0403	Conflict Dilution by Upstream Action on Speed	En-Route	IP2	SETS2-c
L06	CM-0404	Enhanced Tactical Conflict Detection/Resolution and Conformance & Intent Monitoring	En-Route	IP2	SETS2-c
L06	CM-0405	Automated Assistance to ATC Planning for Preventing Conflicts in Terminal Area Operations	TMA	IP2	SETS2-d
L06	CM-0406	Automated Assistance to ATC for Detecting Conflicts in Terminal Areas Operations	TMA	IP2	SETS2-d

Table 13: OI Steps per SETS in "LoC 06 – Cooperative Ground and Airborne Decision making Tools"

LoC 07 – Queue Management Tools

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L07	TS-0102	Arrival Management Supporting TMA Improvements (incl. CDA, P-RNAV)	TMA	IP1	SETS1-d
L07	TS-0103	Controlled Time of Arrival (CTA) through use of datalink	TMA	IP2	SETS2-d
L07	TS-0104	Integration of Surface Management Constraint into Arrival Management	TMA	IP2	SETS2-d
L07	TS-0106	Multiple Controlled times of Over-fly (CTOs) through use of data link	TMA, En-Route	IP2	SETS2-c SETS2-d
L07	TS-0303	Arrival Management into Multiple Airports	TMA	IP2	SETS2-d
L07	TS-0305	Arrival Management Extended to En-Route Airspace	TMA, En-Route	IP1	SETS1-c SETS1-d
L07	TS-0201	Basic Departure Management (DMAN)	APT	IP1	SETS1-e
L07	TS-0202	Departure Management Synchronised with Pre-departure Sequencing	APT	IP1	SETS1-e
L07	TS-0203	Integration of Surface Management Constraint into Departure Management	APT	IP2	SETS2-e
L07	TS-0302	Departure Management from Multiple Airports	APT	IP2	SETS2-e
L07	TS-0306	Optimised Departure Management in the Queue Management Process	APT	IP2	SETS2-e
L07	TS-0301	Integrated Arrival Departure Management for full traffic optimisation, including within the TMA airspace	APT, TMA	IP1	SETS1-d SETS1-e
L07	TS-0304	Integrated Arrival/Departure Management in the Context of Airports with Interferences (other local/regional operations)	APT, TMA	IP2	SETS2-d SETS2-e

Table 14: OI Steps per SETS in "LoC 07 – Queue Management Tools"

LoC 08 – New Separation Modes

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L08	CM-0501	4D-PTC for Equipped Aircraft with Extended Clearance 4D-PTC	En-Route	IP3	SETS3-c
L08	CM-0601	Precision Trajectory Clearances (PTC)-2D Based On Pre-defined 2D Routes	TMA, En-Route	IP2	SETS2-c SETS2-d
L08	CM-0602	Precision Trajectory Clearances (PTC)-3D Based On Pre-defined 3D Routes	TMA, En-Route	IP2	SETS2-c SETS2-d
L08	CM-0603	Precision Trajectory Clearances (PTC)-2D On User Preferred Trajectories	TMA, En-Route	IP2	SETS2-c SETS2-d
L08	CM-0604	Precision Trajectory Clearances (PTC)-3D On User Preferred Trajectories (Dynamically applied 3D routes/profiles)	TMA, En-Route	IP3	SETS3-c SETS3-d
L08	AUO-0401	Air Traffic Situational Awareness (ATSAW) on the Airport Surface	APT	IP1	SETS1-e
L08	AUO-0402	Air Traffic Situational Awareness (ATSAW) during Flight Operations	TMA, En-Route	IP1	SETS1-c SETS1-d
L08	AUO-0503	In-trail Procedure in Oceanic Airspace (ATSA-ITP)	En-Route	IP1	SETS1-c
L08	CM-0701	Ad Hoc Delegation of Separation to Flight Deck - In Trail Procedure (ASEP-ITP)	En-Route	IP2	SETS2-c
L08	CM-0702	Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P)	En-Route	IP3	SETS3-c
L08	TS-0105	ASAS Sequencing and Merging as Contribution to Traffic Synchronisation in TMA (ASPA-S&M)	TMA	IP2	SETS2-d
L08	TS-0107	ASAS Manually Controlled Sequencing and Merging	TMA	IP1	SETS1-d
L08	AUO-0504	Self-Adjustment of Spacing Depending on Wake Vortices	APT, TMA	IP3	SETS3-d SETS3-e
L08	CM-0704	Self Separation in Mixed Mode	En-Route	IP3	SETS3-c

Table 15: OI Steps per SETS in "LoC 08 – New Separation Modes"

LoC 09 – Effective Ground and Airborne Safety Nets

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L09	CM-0801	Ground Based Safety Nets (TMA, En-Route)	TMA, En-Route	IP1	SETS1-c SETS1-d
L09	CM-0802	ACAS Resolution Advisory Downlink	TMA, En-Route	IP2	SETS2-c SETS2-d
L09	CM-0803	Enhanced ACAS through Use of Autopilot or Flight Director	TMA, En-Route	IP1	SETS1-c SETS1-d
L09	CM-0804	ACAS Adapted to New Separation Modes	TMA, En-Route	IP3	SETS3-c SETS3-d
L09	CM-0805	Short Term Conflict Alert Adapted to New Separation Modes	TMA, En-Route	IP3	SETS3-c SETS3-d
L09	CM-0806	Improved Compatibility between Ground and Airborne Safety Nets	TMA, En-Route	IP3	SETS3-c SETS3-d
L09	CM-0807	Enhanced Ground-based Safety Nets Using Wide Information Sharing	TMA, En-Route	IP2	SETS2-c SETS2-d

Table 16: OI Steps per SETS in "LoC 09 – Effective Ground and Airborne Safety Nets"

LoC 10 – Airport throughput, Safety and Environment

Line of Change Code	OI step Code	OI Step Title	Operating Context	IP	Service Enhancement Transition Steps
L10	AO-0101	Reduced Risk of Runway Incursions through Improved Procedures and Best Practices on the Ground	APT	IP1	SETS1-e
L10	AO-0102	Automated Alerting of Controller in Case of Runway Incursion or Intrusion into Restricted Areas	APT	IP1	SETS1-e
L10	AO-0103	Improved Runway-Taxiway Lay-out, Signage and Markings to Prevent Runway Incursions	APT	IP1	SETS1-e
L10	AO-0104	Airport Safety Nets including Taxiway and Apron	APT	IP2	SETS2-e
L10	AO-0201	Enhanced Ground Controller Situational Awareness in all Weather Conditions	APT	IP1	SETS1-e
L10	AO-0202	Detection of FOD (Foreign Object Debris) on the Airport Surface	APT	IP1	SETS1-e
L10	AUO-0605	Automated Alerting of Runway Incursion to Pilots (and Controller)	APT	IP2	SETS2-e
L10	AO-0203	Guidance Assistance to Airport Vehicle Driver	APT	IP1	SETS1-e
L10	AO-0204	Airport Vehicle Driver's Traffic Situational Awareness	APT	IP2	SETS2-e
L10	AO-0205	Automated Assistance to Controller for Surface Movement Planning and Routing	APT	IP2	SETS2-e
L10	AO-0206	Enhanced Guidance Assistance to Airport Vehicle Driver Combined with Routing	APT	IP2	SETS2-e
L10	AO-0207	Surface Management Integrated With Departure and Arrival Management	APT	IP2	SETS2-e
L10	AUO-0602	Guidance Assistance to Aircraft on the Airport Surface	APT	IP1	SETS1-e
L10	AUO-0603	Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing	APT	IP1	SETS1-e
L10	AUO-0604	Enhanced Trajectory Management through Flight Deck Automation Systems	APT	IP2	SETS2-e
L10	AO-0501	Improved Operations in Adverse Conditions through Airport Collaborative Decision Making	APT	IP1	SETS1-e
L10	AO-0601	Improved Turn-Around Process through Collaborative Decision Making	APT	IP1	SETS1-e
L10	AO-0602	Collaborative Pre-departure Sequencing	APT	IP1	SETS1-e
L10	AO-0603	Improved De-icing Operation through Collaborative Decision Making	APT	IP1	SETS1-e
L10	DCB-0304	Airport CDM extended to Regional Airports	APT	IP1	SETS1-e
L10	AO-0402	Interlaced Take-Off and Landing	APT	IP1	SETS1-e
L10	AO-0403	Optimised Dependent Parallel Operations	APT	IP1	SETS1-e
L10	AUO-0701	Use of Runway Occupancy Time (ROT) Reduction Techniques	APT	IP1	SETS1-e
L10	AUO-0702	Brake to Vacate (BTV) Procedure	APT	IP1	SETS1-e

L10	AUO-0703	Automated Brake to Vacate (BTV) using Datalink	APT	IP2	SETS2-e
L10	AO-0301	Crosswind Reduced Separations for Departures and Arrivals	APT	IP1	SETS1-e
L10	AO-0302	Time Based Separation for Arrivals	APT	IP1	SETS1-e
L10	AO-0303	Fixed Reduced Separations based on Wake Vortex Prediction	APT	IP1	SETS1-e
L10	AO-0304	Dynamic Adjustment of Separations based on Real-Time Detection of Wake Vortex	APT	IP2	SETS2-e
L10	AO-0305	Additional Rapid Exit Taxiways (RET) and Entries	APT	IP1	SETS1-e
L10	AO-0502	Improved Operations in Low Visibility Conditions through Enhanced ATC Procedures	APT	IP1	SETS1-e
L10	AO-0503	Reduced ILS Sensitive and Critical Areas	APT	IP1	SETS1-e
L10	AO-0504	Improved Low Visibility Runway Operations Using MLS	APT	IP1	SETS1-e
L10	AO-0505	Improved Low Visibility Runway Operations Using GNSS/GBAS	APT	IP2	SETS2-e
L10	AUO-0403	Enhanced Vision for the Pilot in Low Visibility Conditions	APT	IP2	SETS2-e
L10	AUO-0404	Synthetic Vision for the Pilot in Low Visibility Conditions	APT	IP3	SETS3-e
L10	AUO-0501	Visual Contact Approaches When Appropriate Visual Conditions Prevail	APT, TMA	IP1	SETS1-d SETS1-e
L10	AUO-0502	Enhanced Visual Separation on Approach (ATSA-VSA)	APT, TMA	IP1	SETS1-d SETS1-e
L10	AO-0701	Effective Collaboration between ATM Stakeholders Supported by Environmental Management Systems	APT	IP1	SETS1-e
L10	AO-0702	Improved Relations to Neighbours	APT	IP1	SETS1-e
L10	AO-0703	Noise Management to Limit Exposure to Noise on the Ground	APT	IP1	SETS1-e
L10	AO-0704	Optimised Design and Procedures for Airport manoeuvring Areas to Reduce Gaseous Emissions and Noise Disturbance	APT	IP1	SETS1-e
L10	AO-0705	Reduced Water Pollution	APT	IP1	SETS1-e
L10	AO-0706	(Local) Monitoring of Environmental Performance	APT	IP1	SETS1-e
L10	AUO-0801	Environmental Restrictions Accommodated in the Earliest Phase of Flight Planning	APT	IP1	SETS1-e
L10	AUO-0802	Ground Movement Techniques to Reduce Gaseous Emissions and Noise Disturbance	APT	IP1	SETS1-e
L10	AUO-0803	Reduced Noise Footprint on Departure	APT	IP1	SETS1-e

Table 17: OI Steps per SETS in “LoC 10 – Airport throughput, Safety and Environment”

10.4 ANNEX IV : Performance Assessment Method and Assumptions

Performance assessment has been conducted with different approaches depending on the KPA:

- For Capacity and QoS (Efficiency, predictability and flexibility), a KPA breakdown structure has been built to identify the elementary performance factors influencing the KPA, and then the OI steps have been connected to the performance factors. This has led to a set of influence diagrams supporting the assessment. For a subset of indicators, a judgmental quantitative assessment has been conducted;
- For other KPA, a screening approach has been adopted. The screening process consists in a systematic review of the OI steps for identifying potential issues, gap and blocking points.

10.4.1 Performance Baseline

Each IP has been individually assessed on its contribution towards the evolution of the ATM Target Concept and its ability to meet the performance targets over time. To prevent double counting, a baseline is defined from which the attribution of the individual IP to the performance is measured. This baseline is established through an extrapolation of the present practice, the so-called "business as usual" or "do nothing scenario".

their IOC in the IP time period. For the purpose of D4 CBA computation, the time lag after the start of the IP slot was set in function of the IP definition.

10.4.2 Traffic Forecast Data

For consistency reasons, the traffic forecast used for performance assessment is the long term forecast published in 2004 (LTF2004)[Ref 27]. This is due to the fact that airport capacity assessment uses data from the EUROCONTROL Challenges-to-Growth study (CTG04) that are based on 2004 forecast [Ref 28]. More precisely, the capacity of the runway systems of the top 100 airports in IFR yearly movements is used to assess the capacity increase provided by IP1 and IP2 and check if the 2020 target is met. In addition, the airport capacity constraint introduced in LTF2004 is relaxed since the estimates of airport capacity increase made by CTG04 is to be revised in SESAR. Therefore, the "**unconstrained** A scenario" of LTF2004 is considered for estimating the potential capacity gap from airports despite IP1 and IP2 deployment. According to this scenario, the traffic demand amounts to 18 million IFR flights in 2020. The capacity gap due to airports is estimated to be about 1 million flights.

For airspace capacity, there is no need for traffic data, since the

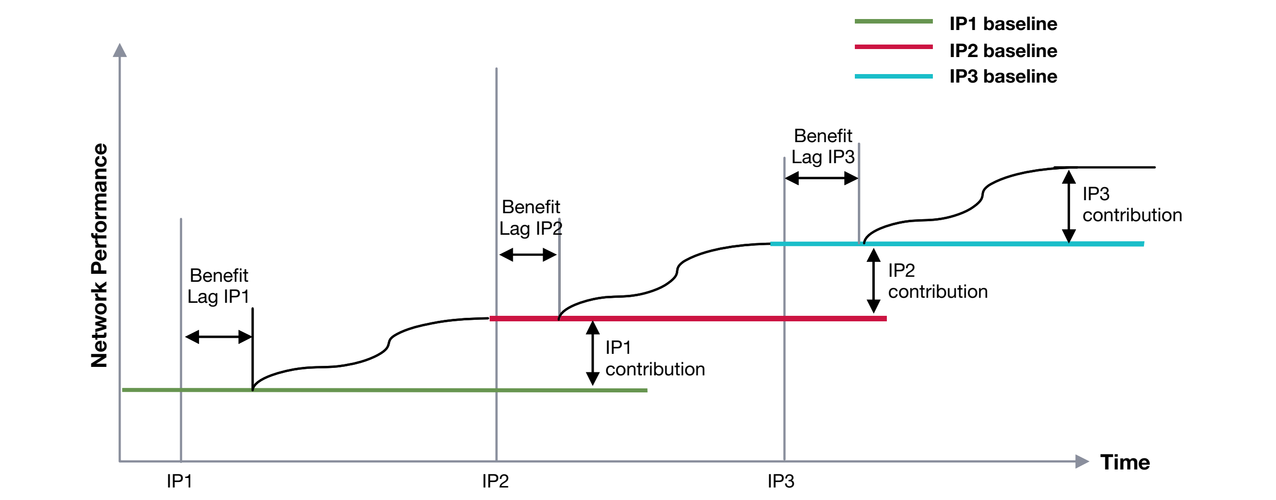


Figure 76: Benefit over Time

Figure 76 provides an overview of how the baseline for each IP is determined taking account of the time lag between the introduction of an IP and when the related performance improvement starts to accrue. At this level of abstraction, individual OI steps are not visible; However, the "S" curve for an IP contribution is actually the cumulated curve of all individual "S" curves for OI steps. Each OI step curve has an IOC time where it starts, a BS time where is starts to contribute to the IP benefit and a FOC time where the full benefit is delivered. The IP curve cumulates the curves of OI steps that have

assessment in the present study is made for a typical sector or group of sectors or a typical TMA in high-density airspace. The results obtained for capacity increases are then consolidated using the FAP tool as described in section below.

For fuel efficiency, there is no need for traffic data. Fuel efficiency is based on the analysis of one typical flight, decomposed in flight phases. Consolidation at the network level is performed directly according to the accommodated traffic.

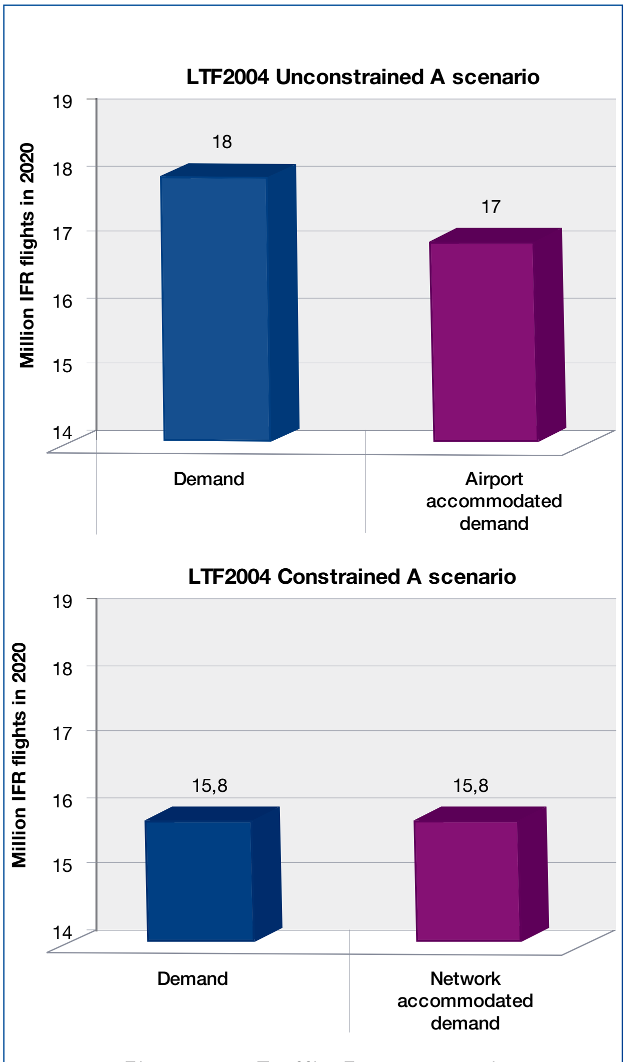


Figure 77: Traffic Forecast and Accommodated Traffic

For low visibility capacity, the approach is based on a yearly cancellation number provided by one airspace user. This number is scaled up to represent the total number at the European level.

At the network level, the traffic forecast scenario is not the LTF2004 **unconstrained** A scenario, but the constrained one. This is due to the fact that the unconstrained scenario A generates unrealistically high delay at the network level when applied to the FAP tool. Such delays would not materialise since flights would no longer be economical. Based on computed delay, the decision has been taken to use the LTF2004 **constrained** A scenario as a reference for cost estimates, cost efficiency estimates and CBA, with a traffic demand of 15.8 million flights in 2020.

To sum up, the traffic forecast used are depicted by Figure 77 below, together with the corresponding results.

10.4.3 Quantitative Assessment Methodology

The assessments were performed as follows:

- KPA breakdown structure definition. In order to describe the effect of the known IP2 Operational steps on those performance areas, it was necessary to propose a description of the elementary performance factors influencing the KPA and of the relationship between these factors. These descriptions are called Influence Diagrams (ID). The notations are given in Task 2.3.1 [Ref 15];
- Mapping of Operational Improvement Steps to performance factors. For each performance category, each Operational Improvement (OI) step was tentatively assigned to an performance factor. All the OI steps related to a given performance factor determine an OI step cluster;
- Qualitative assessments. For each OI step cluster, a qualitative assessment was made as to the magnitude of its potential positive effect (Low, Medium, High) or its potential negative effect. The results of this qualitative assessment are presented in Task 2.3.1 DLT [Ref 15];
- Quantitative assessments. For Capacity, Fuel Efficiency and Low visibility capacity degradation, quantitative assessments were then made.

In this section, we only describe the method and assumptions used for the quantitative assessment.
Figure 78 below introduces the notation for influence diagrams used during D4.

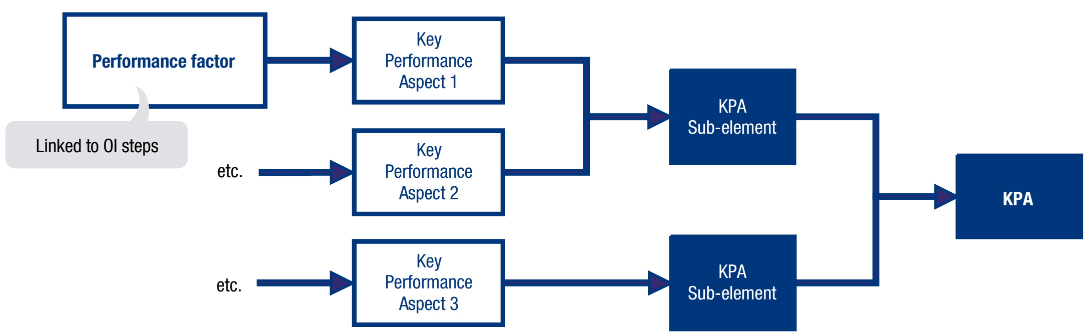


Figure 78: Influence Diagrams Notation

Capacity

Network capacity is decomposed into Airspace and Airport capacity.
The associated diagrams are given by Figure 79 and Figure 80.

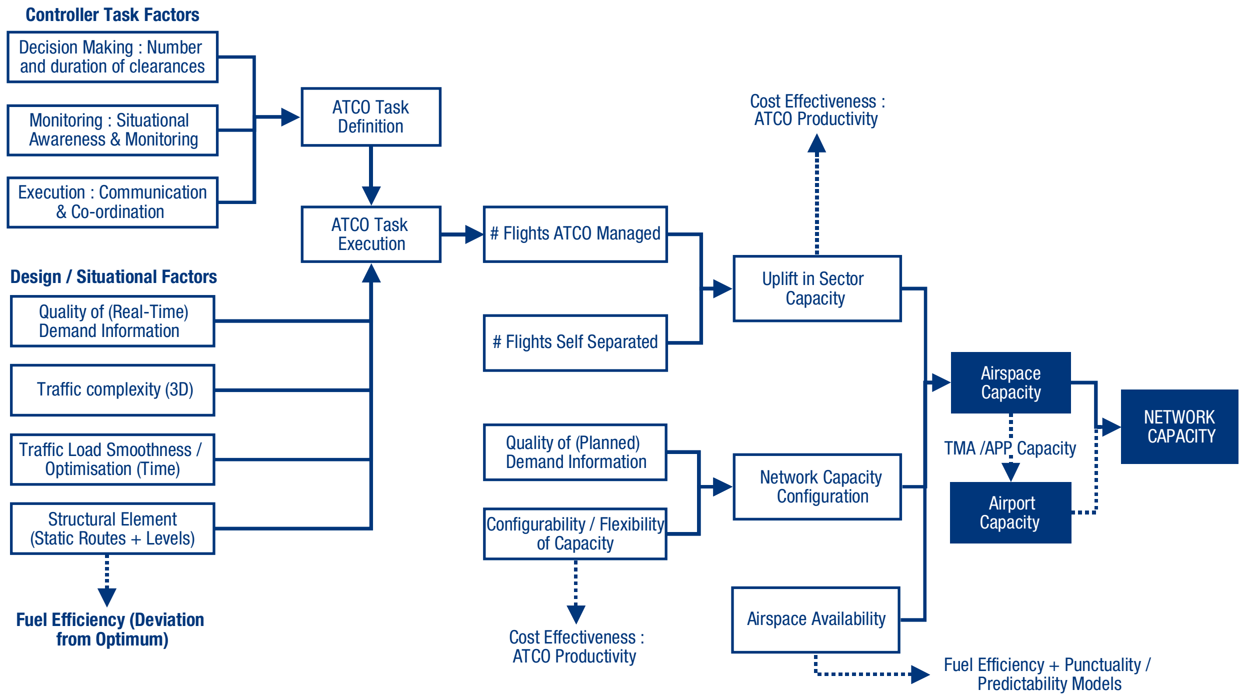


Figure 79: Airspace Capacity Influence Diagram

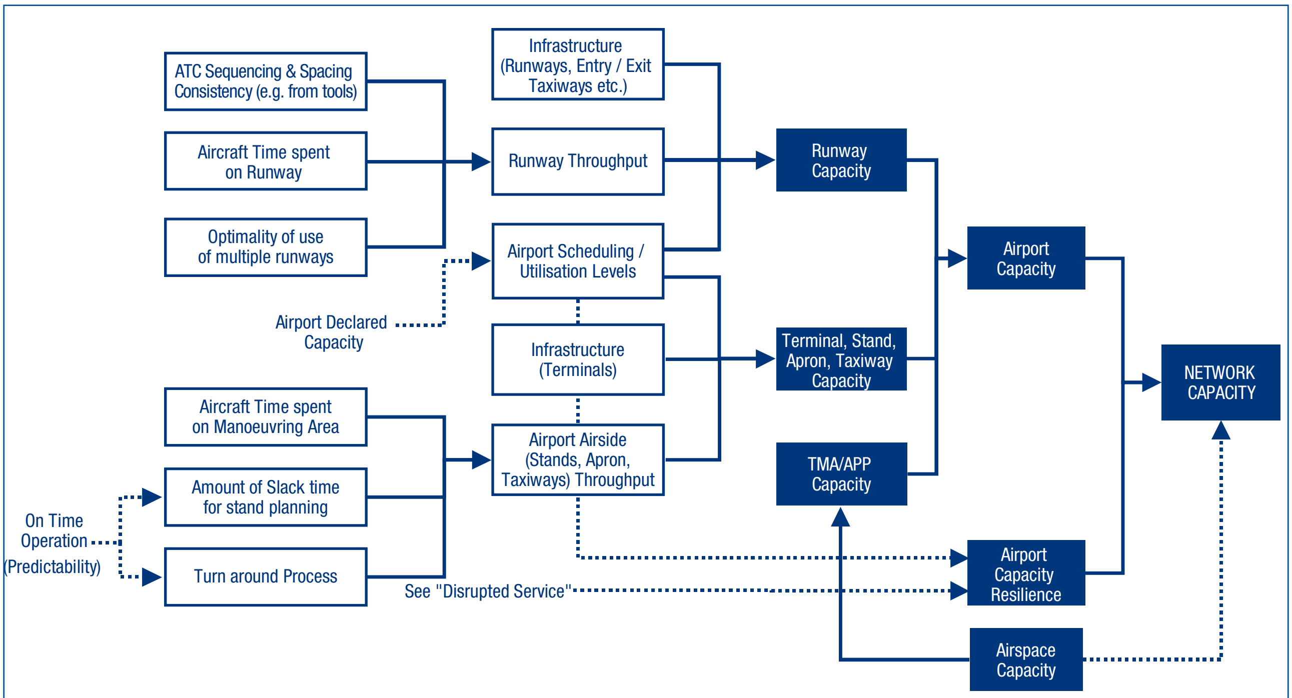


Figure 80: Airport Capacity Influcence Diagram

The assessment of airspace capacity has assigned a value to each of the left hand side performance factors. The consolidation from left to right adds the capacity contributions of each branch. It is worth noting that ATCO workload reduction is transformed in capacity increase through a square-root law to represent the fact that tactical activities are mostly driven by the number of pairs of aircraft in a control sector. This assumption is deemed conservative. The detailed assessment is described in Task 2.3.1 DLT [Ref 15].

Another important aspect is that assessment is made for high density airspace and is presented as the potential increase of capacity. This means that at the network level, each airspace volume has to be assessed in terms of density and the throughput demand for this airspace compared to the potential provided by SESAR. In some airspace volumes (ACC, TMA), this potential may be insufficient for accommodating the demand. This consolidation at the network level is performed using the FAP tool (see below).

The assessment of airport capacity has been restricted to the runway capacity branch of the influence diagram. It is based on consolidated busy-hour capacity of the top 100 airports in terms of IFR movements and reuses the Challenges-to-Growth data [Ref 28].

Concentrating on runway systems throughput makes the assumption that airports manage to locate their bottleneck on the runway system. This reflects what happens for the most congested airports in Europe today, but is an optimistic assumption, since many airports are constrained by the surrounding TMA capacity and/or the Airport infrastructure capacity and cannot benefit from their full runway system capacity. This assumption might become less optimistic if the average utilisation of airports increases. Another source of uncertainty is the level of operational restrictions due to environmental considerations that degrade the potential daily throughput of airports, even if the busy hour throughput is close to the Best-in-Class.

Fuel Efficiency

The fuel efficiency diagram has been constructed by estimating the inefficiencies introduced by ATM restrictions. The values have been expressed first in terms of deviation percentages compared to the fuel optimal route or profile. Each deviation has been then weighted with the relative fuel flow and the time spent in the corresponding phase of the flight, leading to the individual values of the inefficiency percentage.

The total value of 12% for 2006 results from this assessment. It differs from the 9% estimate indicated in D3 [Ref 2]. This results from different values for fuel consumptions percentage per phase of flight and different inefficiency assessment. The main difference is in the TMA assessment where D3 has estimated a weighted 1% inefficiency whereas the D4 assessment estimates is 4.3%. The assessment team judgment is that 1% is underestimated. However, the sensitivity of this value to the sample of airports considered is very high, owing to the fact that inefficiencies are related to the SID/STAR structure and the potential queuing for arrival.

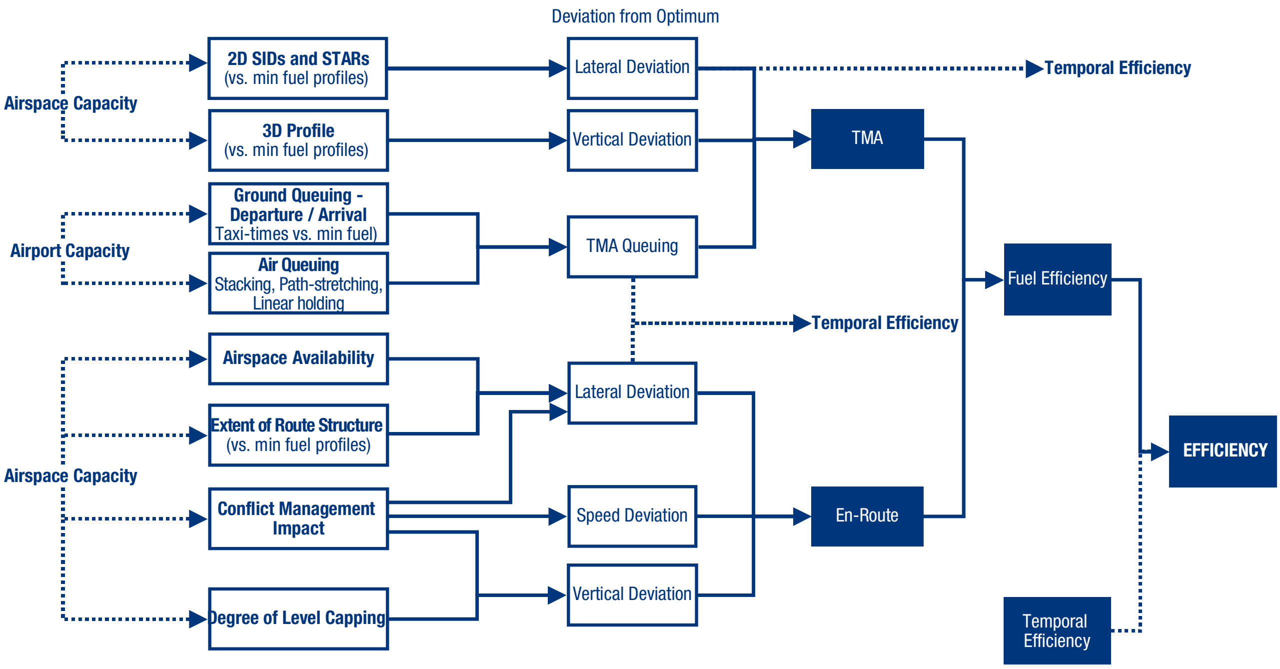


Figure 81: Fuel Efficiency Influence Diagram

Low Visibility Capacity

A disrupted service influence diagram has been produced, because two KPAs are related to the effect of disruption: capacity and predictability. The resulting influence diagram is shown below.

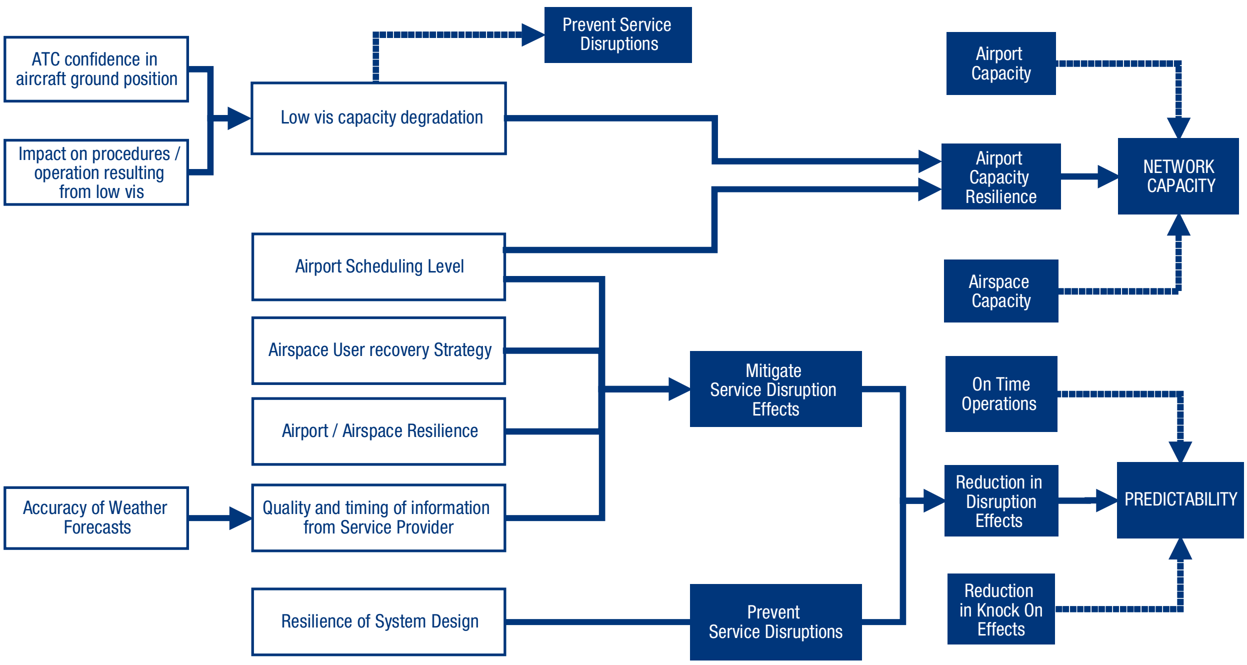


Figure 82: Disrupted Service Influence Diagram

It was not possible to build a bottom up estimate of the effect of combined OI steps on the airport capacity or the predictability. Both models and baseline data are missing. The approach has been based on a macroscopic assessment of the effect of meeting the targets set for airport declared capacity in low visibility conditions. The yearly number of cancelled flights due to low visibility conditions has been estimated for 2006, 2013 and 2020 assuming that the number of cancelled flights is smaller than the capacity degradation (airspace users accept a temporary slight QoS degradation in these conditions).

CBA Performance Input Generation using FAP

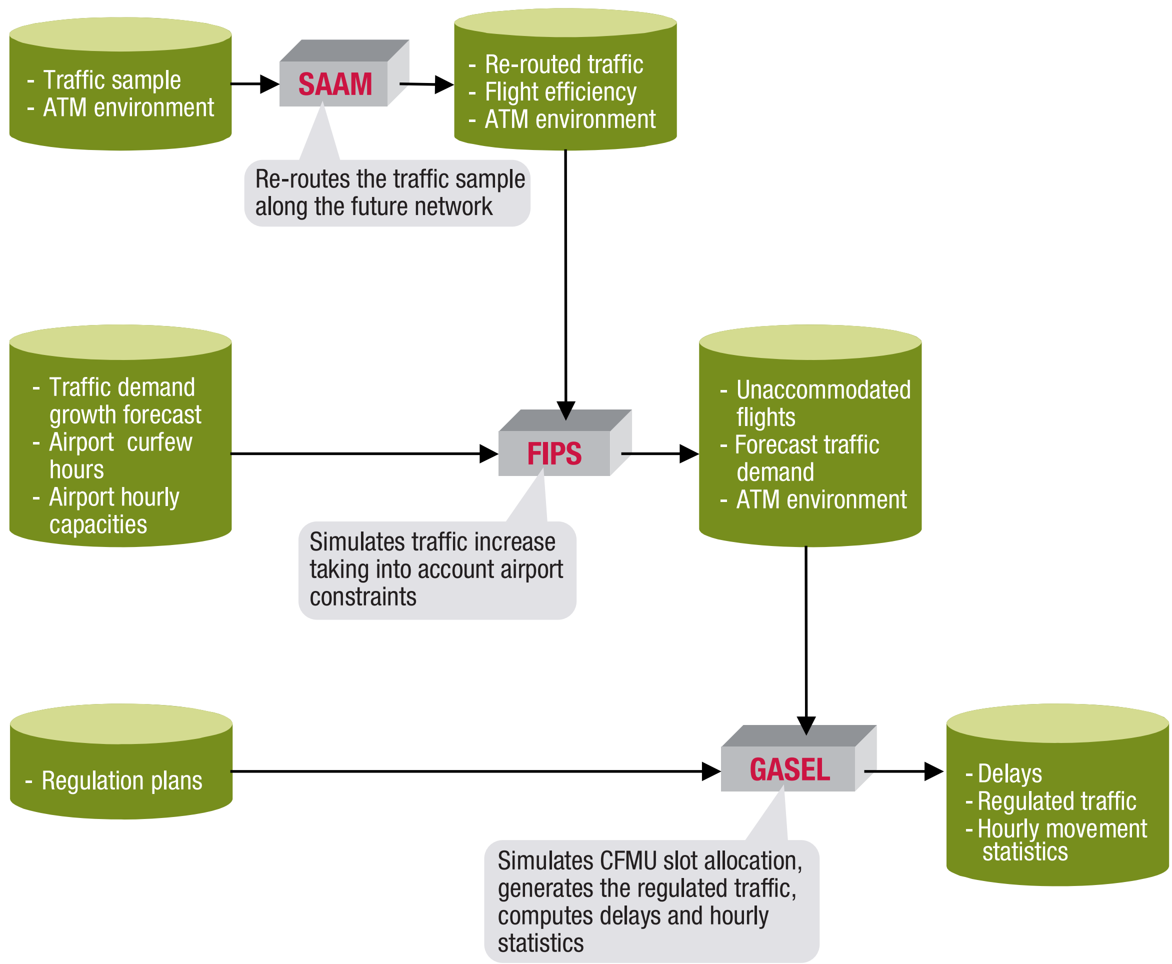


Figure 83: Overview of the Future ATM Profile (FAP) Tool

The CBA process cannot take directly the capacity assessment results as input. The Future ATM Profile (FAP) tool from EUROCONTROL is used to apply potential capacity increase provided by the assessment activities to a network model submitted to a daily traffic sample of the year under study.

The FAP tool is routinely used by EUROCONTROL for performance planning activities.

FAP is in fact a set of three software tools (Figure 83).
The FAP model implements the ARNV5 network model based on the current or planned airspace structure: typically, sectorisation and ACCs are the current ones, but capacity of airspace volumes can increase to represent new capacity deployment (resulting for instance from productivity improvements). FAP is composed of:

- The SAAM tool determining the routing followed by the flights, according to the city-pairs flows and the route network;
- The FIPS tool generating traffic increase by cloning flight plans and distributing them in time for each city pair flows, taking airports capacity into account. This determines unaccommodated flights due to airport capacity limits;
- The Generic ATM Simulator Engine and Library (GASEL) tool simulating the execution of slot allocation and providing the delay figures according to airspace volume capacities (control sector, ACCs) aid airport capacities. The capacities of the airspace volume are derived in different ways:
  - o For the “business a usual” scenario (i.e. without IP1, nor IP2), LCIP/ECIP capacity increase objectives are extrapolated up to 2013, then a macroscopic model of capacity increase is applied to derive the capacity profile over the 2013-2020 period, taking

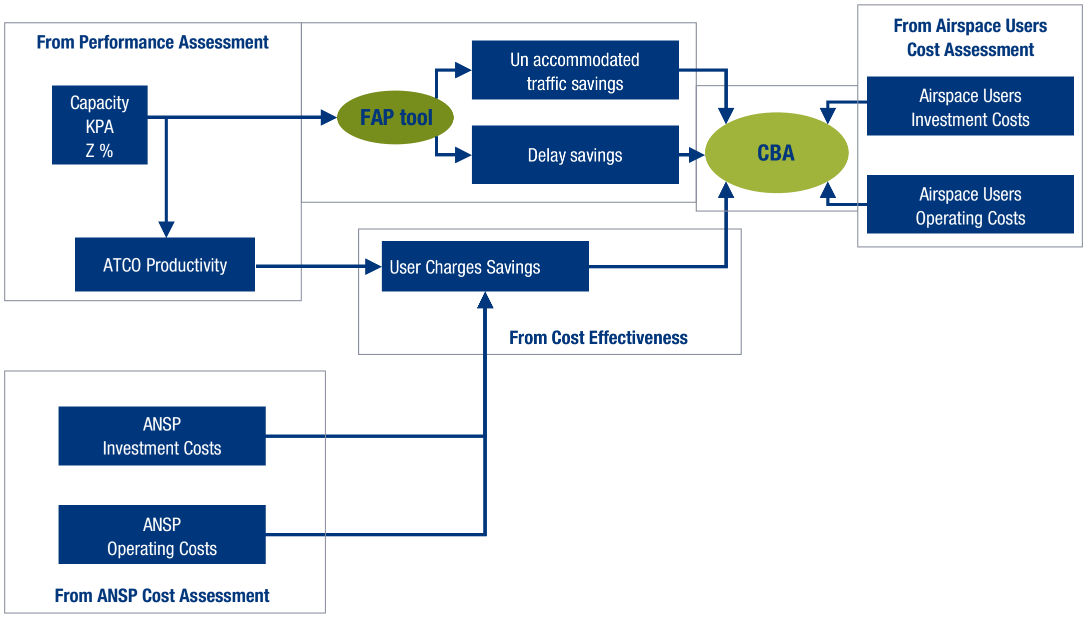


Figure 84: The CBA Performance Input Building Process

into account the category of airspace volumes (high/medium/low complexity) and their possible evolution throughout the period;

- For the IP1 scenario, expected capacity increase are applied according to initiative contributions;
- For the IP2 scenario, further capacity increase is applied according to IP2 assessment. In the ECAC ATM network, airspace volumes with high density traffic in 2020 have their capacity increased by the corresponding IP2 contribution (43% in En-route airspace, 24% in TMA) on top of IP1 contribution. Other airspace volumes have their capacity increased according to the macroscopic model, starting from IP1 contribution but without IP2 contribution. This is based on the assumption that almost all delay is generated in high complexity airspace. This does not preclude that some IP2 OI steps are deployed in low/medium density airspace, but the effect on the average delay will be negligible.

As it is, FAP does not implement the elements of the SESAR concept that are not present in the current mode of operation. In addition, using ATFM delay as indicator of QoS is not in line with the SESAR D2 KPIs for QoS.

Consequently FAP is used as a simplified network model where flows are constrained by the capacity of the traversed airspace volume, with adaptation of the flow to the capacity expressed in the form of unaccommodated flights in the Flight Increase ProcesS (FIPS) module and in the form of departure slot allocation in the GASEL module.

However, there is no other tool available for aggregating local capacity figures and city-pairs flows at the level of the European ATM network to produce the European-wide indicators values set as targets for SESAR. Despite the approximations made by using FAP, it is assumed that the estimate of the gap in overall throughput (unaccommodated flights) is correctly estimated. There is more uncertainty around the actual meaning of the estimated delay, owing to the fact that the ATFM delay indicator will be superseded by D2 indicators before 2020 and the current TACTical module of CFMU (TACT)/Computer Assisted Slot Allocation (CASA) slot allocation process will no longer exist as today. Nevertheless, as a conservative approach, it can be used to determine the cost of delay in the CBA.

10.5 Annex V: Cost Assessment Method and Assumptions

10.5.1 Airspace Users Costs Assessment

In order to support Implementation Package cost benefit analysis and financial affordability analysis the investment costs for airspace users have been analysed. The airborne investment costs have been assessed for both IP1 and IP2, however those relative to IP3 have not been addressed yet. The D3 ground investment costs have been used as an input (without change) for the D4 assessment. They are marginal compared to airborne investment costs and have been taken into account as operating costs. The assumptions used for D4 are similar to those used for D3 and the main ones are repeated here.

10.5.1.1 Scheduled Airlines and Business Aviation Airborne Investment Costs

The airborne investment costs have been elaborated from the definition of the equipage needed for the OI Steps and identified in the Systems Enablers with the following assumptions:

- Only costs for new ATM functions or required performance improvements identified in the System Enablers of IP1 and IP2 have been considered;
- Commonality with NextGen systems has been assumed to compute equipage unit costs;
- Retrofit costs are included as well as forward fit costs when the avionics packages is not yet considered as part of the standard equipage by aircraft manufacturers at the IOC date. Forward fit costs are only included to IOC plus 7 years, then are assumed to be zero (i.e. has become "basic");
- Retrofit installation cycles are fully synchronised with maintenance schedules - No related aircraft down time costs;
- Airborne investments are composed mainly of implementation costs, the associated pre-implementation costs (R&D) being recovered mainly in the recurrent prices of the avionics units;
- Includes all avionic packages both "structural" required equipment (retrofit and forward fit needed) and "incidental" equipment to meet specific local operational conditions or specific airspace users operational requirements;
- Airborne investment costs represent 100% of the ATM avionics costs foreseen until 2020;
- Includes all scheduled airlines (Legacy, Low Fares, Regional and Charter airlines) as well as on-demand aircraft operators (Business Aviation) – registered in Europe (8000 in 2008, 9500 in 2013, and 12500 in 2020);
- High participation - 100% of aircraft are fully equipped for the structural packages;
- The cost estimates are based on the averages but are highly sensitive to:
  - o The variation of installation costs for individual aircraft (e.g. type, age configuration, etc.);
  - o The effect on the individual business case from a potential slippage of the deployment of an IP step required to improve the overall network;
  - o The hidden costs appearing with further refinement of the operational definition and system functions;
  - o The possible need of required modification to existing functions.

The following sections provide an overview for IP1, IP2 of:

- The avionics packages and assumptions for the percentage of the fleet to be equipped.
  Note that these fleet equipage assumptions have been used for this cost assessment and for the subsequent cost benefit analysis;
- The resulting investment costs when applied to the forecast registrations for base, low and high scenarios for structural and incidental avionics packages for scheduled airlines and business aviation;
- A total approximate airborne investment.

Implementation Package #1 (IP1)

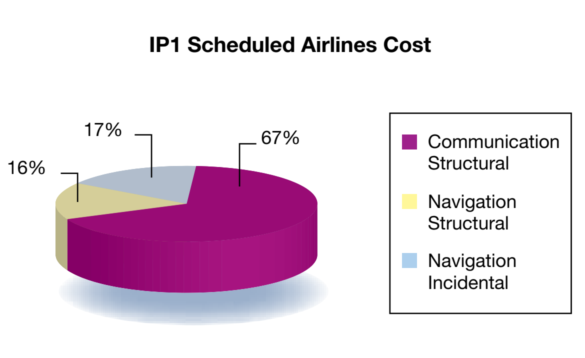


Figure 85: IP1 Scheduled Airlines Cost

System Airspace User Type	Scheduled Airlines		Business Aviation	
	Structural	Incidental	Structural	Incidental
Investment per a/c				
Retrofit per a/c				
Base	k€ 312	k€ 70	k€ 260	k€ 70
Low	k€ 206	k€ 18	k€ 150	k€ 30
High	k€ 456	k€ 158	k€ 410	k€ 150
Forward Fit per a/c				
Base	k€ 165	k€ 30	k€ 220	k€ 60
Low	k€ 120	k€ 10	k€ 120	k€ 30
High	k€ 250	k€ 50	k€ 350	k€ 80

"***Structural***" **avionics packages**
- Navigation (runway incursion): 100% of a/c;
- Communication (ADS-B in/out, CPDLC): 100% of a/c (with 25% a/c equipped with CPDLC in 2013).

"***Incidental***" **avionics packages**
- Navigation (SBAS, GBAS Cat1) – % of a/c to be equipped (Retrofit/Forward fit):
- SBAS: Major (10%/30%), Regional/Lowfares (50%), Business (60%/100%);
- GBAS Cat 1: Major (10%/20%), Region/Lowfares (20%), Business (0%/20%).

Total airborne investment costs for IP1:
- Scheduled Airlines: around €2.0 Bn;
- Business Aviation: around €0.6 Bn.

Figure 85 shows, for scheduled airlines only, the avionics package investment costs as a percentage of the total airborne investment costs for IP1.

Implementation Package #2 (IP2)

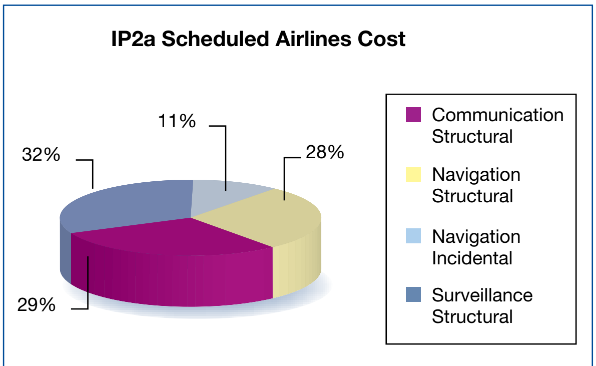


Figure 86: IP2a Scheduled Airlines Cost

System Airspace User Type	Scheduled Airlines		Business Aviation	
	Structural	Incidental	Structural	Incidental
Investment per a/c				
Retrofit per a/c				
Base	k€ 792	k€ 62	k€ 450	k€ 140
Low	k€ 407	k€ 27	k€ 300	k€ 30
High	k€ 1 343	k€ 183	k€ 690	k€ 240
Forward Fit per a/c				
Base	k€ 364	k€ 90	k€ 370	k€ 280
Low	k€ 215	k€ 50	k€ 240	k€ 70
High	k€ 569	k€ 246	k€ 640	k€ 400

The implementation of IP2 System Enablers has been divided into 2 steps – IP2a and IP2b according to the following criteria:
- IP2a: avionics items whose IOC date ≥2011 and IOC date < 2015;
- IP2b: avionics items whose IOC date ≥ 2015 and IOC date < 2020.

IP2a

"***Structural***" **avionic packages**
- Navigation (3D Vert., Airport Moving Map, GBAS Cat 2/3) – 100% of a/c;
- Communications (access to SWIM, New 802.16, ADS-B in) – 100% of a/c;
- Surveillance (Air Traffic Situation. Awareness, ASAS Spacing (ASPA), Runway incursion) – 100% of a/c.

"***Incidental***" **avionic packages**
- Navigation capabilities (HUD/EVS, Brake to Vacate);
- % of a/c to be equipped (Retrofit/Forward fit):
  - HUD/EVS: Major (0%/10%), Regional/Low fares (20%/50%), Business (20%/50%);
  - BTV: Major (50%/60%), Regional/Low fares (50%/60%), Business (20%).

Total airborne investment costs for IP2a:
- Scheduled Airlines: around €5.5 Bn;
- Business Aviation: around €1.8 Bn.

Figure 86 shows, for scheduled airlines only, the avionics package investment costs as a percentage of the total airborne investment costs for IP2a.

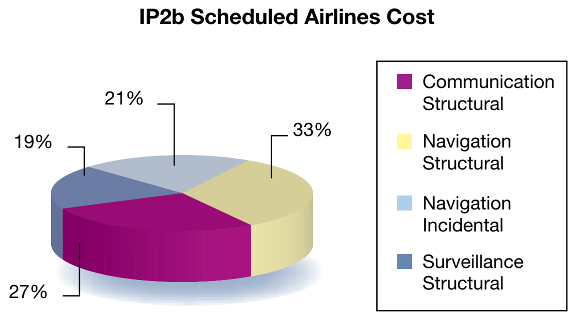


Figure 87: IP2b Scheduled Airlines Cost

System Airspace User Type		Scheduled Airlines		Business Aviation	
		Structural	Incidental	Structural	Incidental
Investment per a/c	Retrofit per a/c				
	Base	k€ 465	k€ 155	k€ 230	k€ 80
	Low	k€ 254	k€ 48	k€ 140	k€ 30
	High	k€ 744	k€ 256	k€ 350	k€ 120
	Forward Fit per a/c				
	Base	k€ 254	k€ 30	k€ 190	k€ 20
	Low	k€ 134	k€ 10	k€ 110	k€ 10
	High	k€ 399	k€ 50	k€ 320	k€ 40

IP2b
"***Structural***" **avionic packages**
- Navigation (4D Trajectory) – 100% of a/c
- Communications (New A/G data-links) – 100% of a/c;
- Surveillance (ASAS separation(ASEP)) – 100% of a/c.

"***Incidental***" **avionic packages**
- Navigation capabilities (Galileo/GPS L5) – % of a/c to be equipped (Retrofit/Forward fit):
- Galileo/GPS L5: Major (100%), Regional/Low fares (100%), Business (100%) **Assuming the constellation is not funded by the Airspace Users.**

Total airborne investment costs for IP2b:
- Scheduled Airlines: around €4.0 Bn;
- Business Aviation: around €1.0 Bn.

Figure 87 shows, for scheduled airlines only, the avionics package investment costs as a percentage of the total airborne investment costs for IP2b.

10.5.1.2 General Aviation Airborne Investment Costs

The General Aviation airborne investment costs are relative to IP2b only. For the purposes of the cost assessment the following sub-categories have been defined by the GA community:
1. GA aircraft to be equipped to operate IFR (17100 in 2020, 13%);
2. All other GA aircraft to be equipped to operate VFR (114900 in 2020, 87%).

For subcategory (1) the "structural" avionic package includes aircraft communications capabilities (ADS-B In/Out, access to SWIM). It also includes an "incidental" package containing SBAS based navigation.

Figure 88 shows, for General Aviation only, the avionics package investment costs as a percentage of the total airborne investment costs for IP2b for General Aviation.
For subcategory (2) includes a "structural" package consisting of communication capabilities, GNSS based navigation capabilities and a "squitter".

Total airborne investment costs for IP2b:
- General Aviation: around €0.95 Bn.

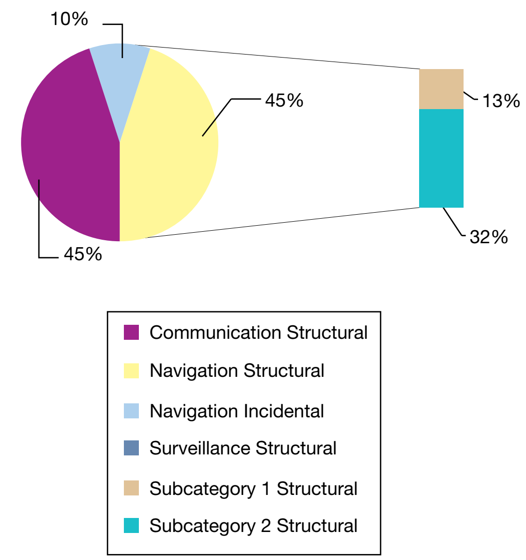


Figure 88: General Aviation Costs

10.5.1.3 Military Airborne Investment Costs

Military airborne investment costs have been calculated using as a basis the estimates of civil airspace users and applying very conservative multiplication factors to the unit cost of the avionic packages depending on the type of aircraft (transport, fighters, light aircraft, helicopters – not including UAS) with the following assumptions:

- Forward fit costs for all new aircraft procurement and retrofit costs for all older aircraft due to the long military aircraft life cycle;
- The percentage of the fleet required to fly as GAT – 100% for transport aircraft, and 60% for others aircraft types.

Military airborne investment costs are considered to be significant and the military cost benefit analysis is likely to be negative due to the difficulty to quantify military specific benefits.

Implementation Package 1

"***Structural***" avionics packages
- Navigation (2D RNP & cruising cruise) - transport a/c only;
- Communication
- VHF 8.33 kHz – all of GAT as per assumption 2 above;
- ADS-B in/out, CPDLC – transport a/c only;
- Surveillance (Mode S ELS/EHS) – all of GAT as per assumption 2 above.

"***Incidental***" avionics packages
- Navigation (SBAS, GBAS cat1, ACAS RA auto-guidance)
- SBAS: (10% of transport a/c and fighter, 100% light a/c);
- GBAS cat1 (100% of all);
- ACAS RA auto-guidance - 15% of transport a/c only.

Total airborne investment costs for IP1:
- Military: €3.4 Bn.

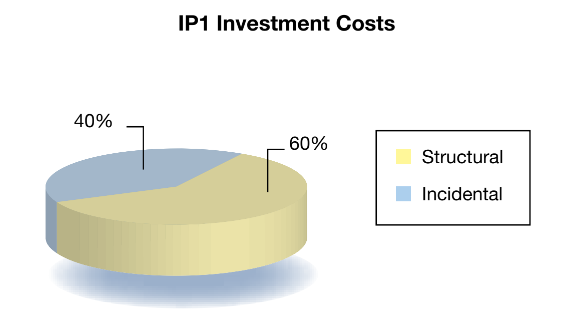


Figure 89: IP1 Military Cost

Implementation Package 2

"***Structural***" avionics packages
- Navigation (4D trajectory) – transport a/c only
- Communications (New A/G data-links, ADS-B in).
  - New A/G data-links, ADS-B in+ – 100% transport a/c, 20% fighters.
- Surveillance (Air Traf. Situation. Awareness (ASPA/ASEP) – transport a/c only.

"***Incidental***" avionics packages
- Navigation capabilities (Galileo/GPS L5) – all.

Total airborne investment costs for IP2:
- Military: €3.0Bn

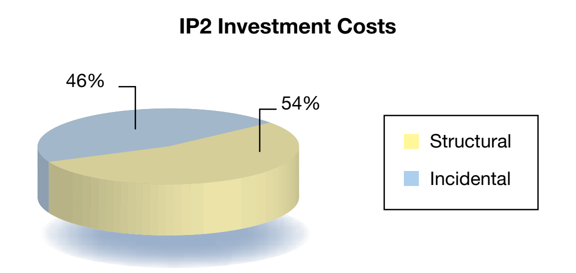


Figure 90: IP2 Military Cost

10.5.2 ANSP Cost Assessment

ANSP costs have been assessed, not only for IP1 and IP2 as needed for the CBA, but also for IP3 since all the SESAR costs (investment and operations) impact the Cost Effectiveness KPI assessment over the considered period (2008 to 2020).

The cost of the investments to improve the technical systems has been assessed on the basis of the Architecture elements impacted by the "system enablers" supporting the different OI steps of the Implementation Packages (applying same approach as the D3 one).

In addition to D3 practice, the costs of the CNS investments have been assessed in more detail, per IP and per domain (communication, navigation and surveillance) with a dual objective: to add precision to the SESAR related implementation costs and to gather more knowledge on the breakdown of the overall investment costs. The investments for some critical "Human Factors" integration activities and their management needed for Social Factors and Change Management issues has been added to these investments costs. The additional (around 20%) ANSP staff training costs have been identified as extra yearly operating costs.

The ANSP costs assessment is based on the following main assumptions:

- Pre-implementation costs (R&D and non recurrent activities covering the E-OCVM phases from V0 to V4 included) are based on the assumption that there will be one or two (maximum) different developments (coordinated procurement as reflected by the current flight data processing development industry "grouping");
- In the absence of better inputs, pre-implementation duration of enablers was defined as 1, 2 or 3 years depending on the assessment of the level of impact on the system/subsystem. Start date of R&D was calculated accordingly with reference to the IOC date;
- Systems improvements (incl. CNS) are deployed throughout ECAC. Implementation capital costs have been calculated considering the number of units (ACC, sectors, tower, approach) as known in 2005;
- Decommissioning of CNS investments and potential related savings were not assessed due to the consideration that they remain marginal until 2020.

The following Figures give an overview of the overall cost per IP (excluding CNS), and of the breakdown of these costs over the main ATM systems identified in the Architecture.

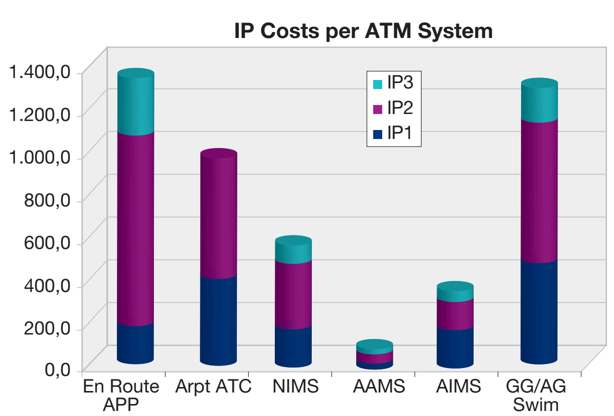


Figure 91: Implementation Packages Investment Costs per ATM Systems

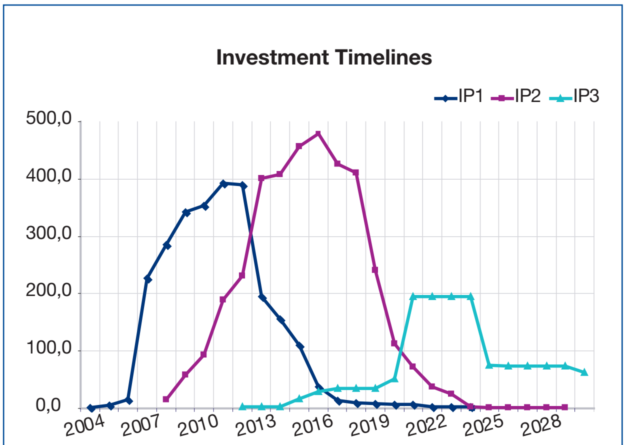


Figure 92: Total Investment Costs Timeline

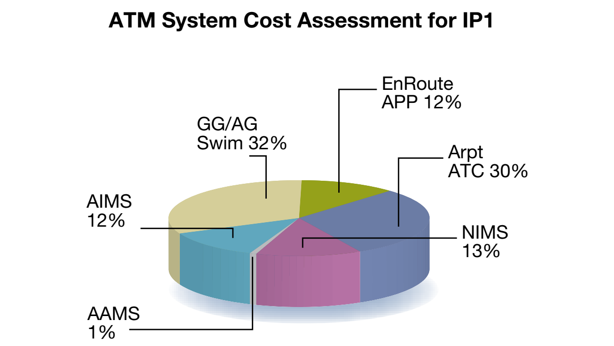


Figure 93: IP1 Investment Costs per System

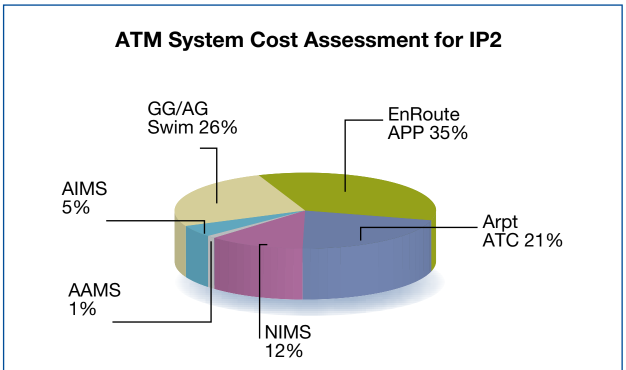


Figure 94: IP2 Investment Costs per System

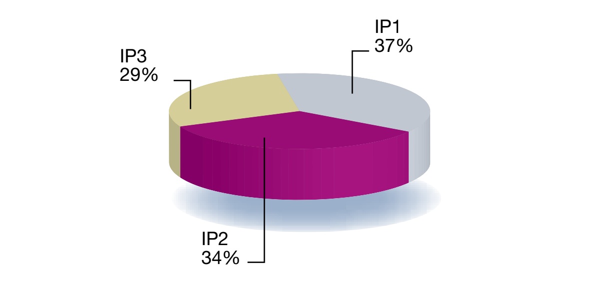


Figure 95: CNS Investment Costs per IP

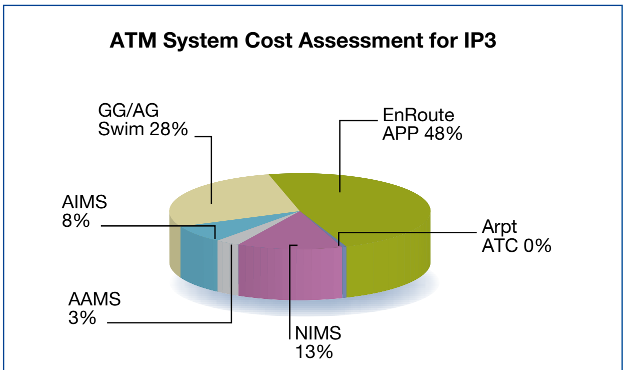


Figure 96: IP3 Investment Costs per System

Cost Evolution from D3 to D4

The overall result of the cost assessment is shown in Figure 97. The changes for the investment in the Architecture systems result from the better definition of the technical enablers and the increase of the number of implemented units for some subsystems.

The estimated CNS investment have been assessed and remain at approximately 40% (when CNS related Land & Building costs are included) of the overall budget with €3,08Bn directly associated to SESAR, plus €1,94Bn not affected by SESAR.

The remaining investments expenditures refer to non CNS Land and Building, approximately 30% (€5,13Bn) of the overall investments and to unrecoverable VAT (considered at a 10% average rate – €1,56Bn) which was not considered in the price used for investment appraisal.

Other investments not yet detailed have been assessed at approximately €1,29Bn.

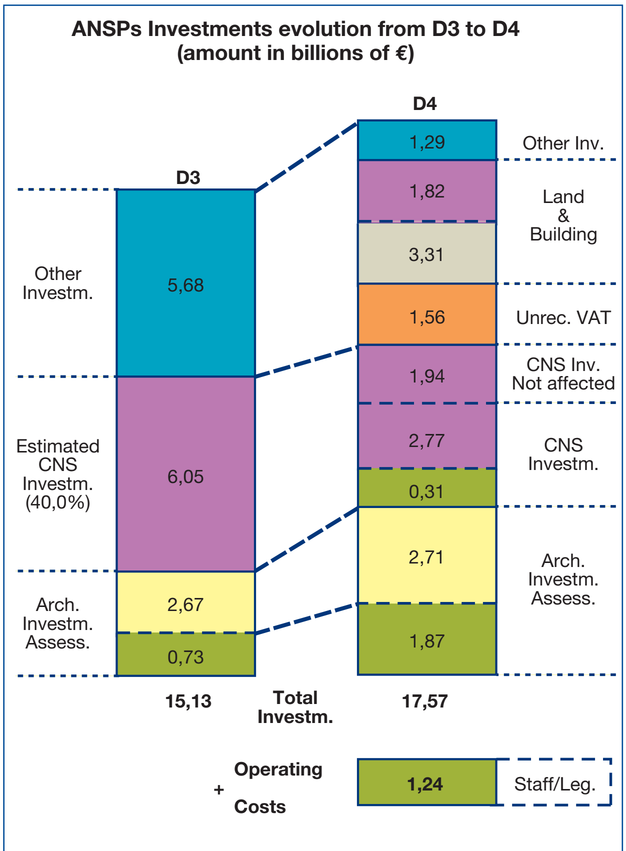


Figure 97: ANSP Investment Expenditures Evolution from D3[32] to D4

10.5.3 Airport Cost Assessment

Airport costs have been assessed using the same methodology as the one used for ANSP costs.

In addition to the D3 assessment, the CNS costs and the Airport Operations Centre (APOC) costs (key infrastructure to manage and coordinate airport operations and act as connecting node to network) have been assessed.

The same assumptions considered in D3 generally apply, including the number of the applicable airports (called "SESAR Airports") which has been taken as 150. Airport infrastructure costs such as runways, terminals, etc. have been considered out of the SESAR scope and were therefore (as it was for D3) not assessed.

The Airport Airside Operation System (AAOS) forms essentially the airport architectural systems. The subsystems making up the AAOS are: Stand & Gate Management system; Turn-around Management system; Stand Turn-around Management system; De-icing Management system; Demand & Capacity Management system; Performance Management system; Environment Management system; Airport Mapping system; Technical Supervision and Ground/Ground SWIM.

For IP1 airports will mainly have to implement (or improve) connection infrastructure to the ATM network. It is not foreseen to develop/install much technology during IP 1 period.

For IP2, airports investments will be almost only CNS technologies expenditures: WiMAx (802.16 aero) plus Airfield Ground Lighting (AGL) new technology systems. No investments will be made for Airport Operations Centre (APOC) system infrastructure.

The costs are expected to be higher during IP1 than for IP2. No costs have been identified by airports for IP3 OIs. It is expected that for some OI investments at airports that IP1 and IP2 costs will arise throughout the life of the SESAR ATM implementation programme.

32 - Reminder: during D3, the total investment (15.13 Bn€) was assessed from the addition of an investment of 14.4 Bn€ as planned by ANSP without SESAR (1.2 Bn€ p.a. over 12 years) plus an additional 0.73 Bn€ due to SESAR impact on these planned investments.

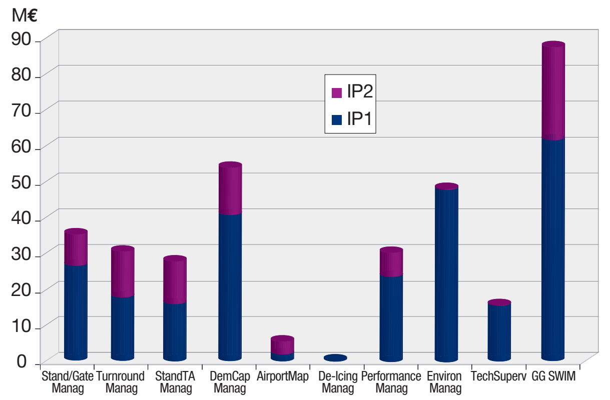


Figure 98: Implementation Packages Investment Costs per AAOS Systems

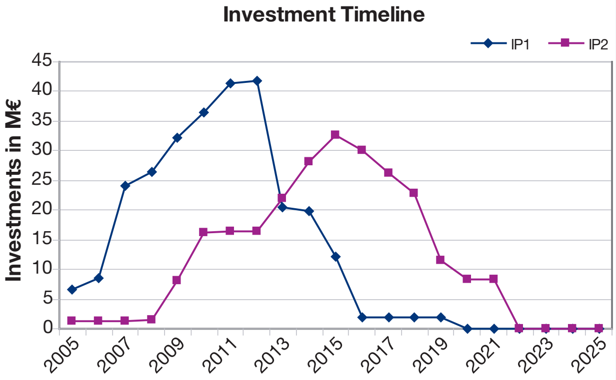


Figure 99: Total Investment Cost Timeline

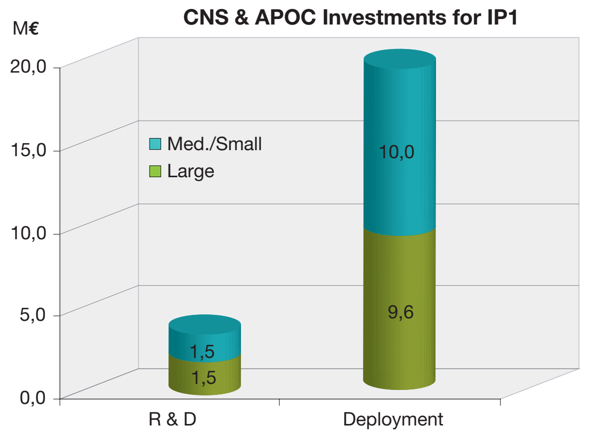


Figure 100: IP1 Investments for APOC (incl. CNS)

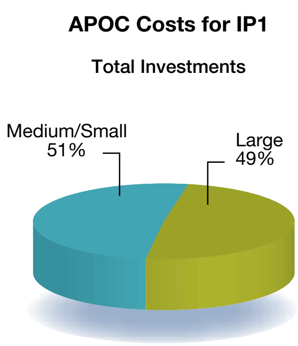


Figure 101: IP1 APOC Investments Repartition

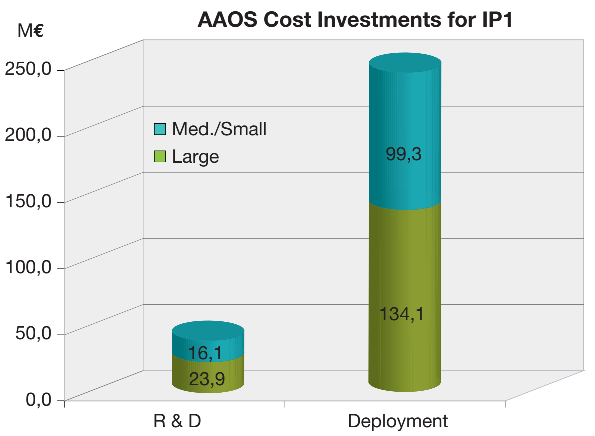


Figure 102: IP1 Investments for AAOS

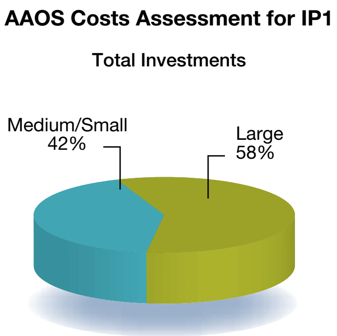


Figure 103: IP1 AAOS Investments Repartition

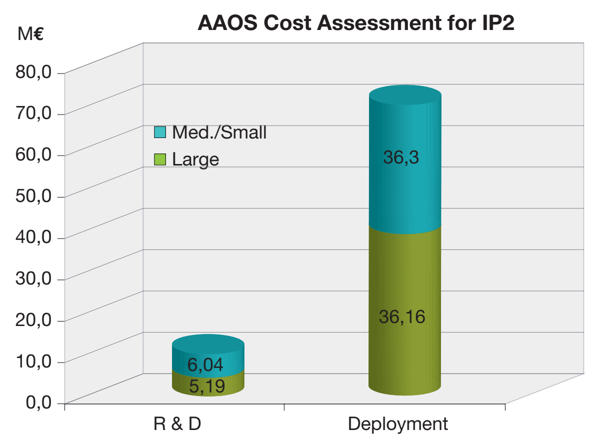


Figure 104: IP2 Investment for AAOS

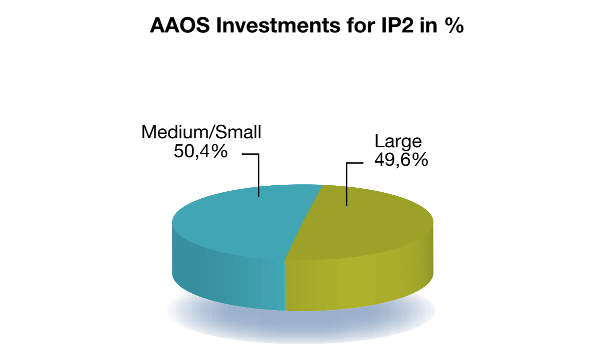


Figure 105: IP2 AAOS Investment Repartition

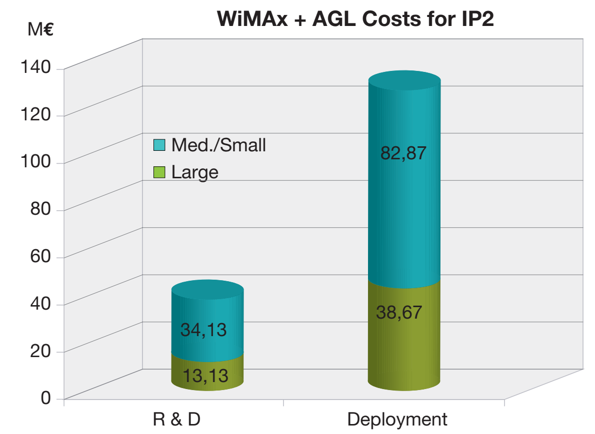


Figure 106: IP2 CNS Investment

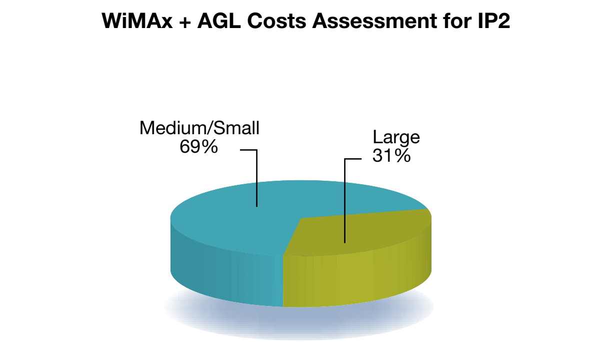


Figure 107: IP2 CNS Investment Repartition

Cost Evolution from D3 to D4

The main airport investment cost estimate differences between D3 and D4 (from €0,36M to €0,60M for all cost categories) arise from the introduction of the APOC & Airport CNS investment costs in D4. It should be noted that ATC Aerodrome systems costs have been assessed by ANSPs and consequently the needed investment is included in the ANSP cost assessment.

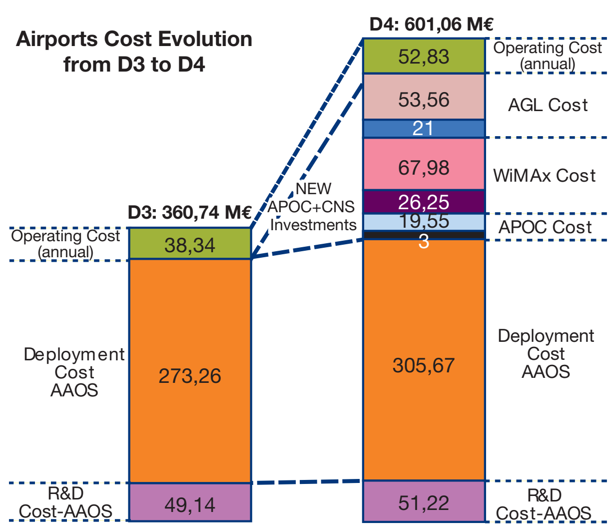


Figure 108: Airports Investment Expenditure Evolution from D3 to D4

10.5.4 Cost Effectiveness

In order to support the assessment of the airspace users unit costs development (Cost Effectiveness KPI CEF-1 – see D2) a financial model has been developed.

To calculate the different cost elements of the gate-to-gate ATM cost base[33], the model uses mainly the historical dependencies identified between:

- The "ATCO on duty" costs and the "investment costs";
- The other side the other cost categories (other staff costs, operating costs, depreciation, etc.).

These dependencies were established by experts on the basis of the EUROCONTROL ACE 2005 Report (June 2007) and of other data provided by EUROCONTROL, including the Central Route Charges Office (CRCO).

The assessment of the unit costs development, over the period [2005 - 2025], was done in three incremental steps corresponding to the different SESAR implementation scenarios:

- The business as usual scenario – i.e. the scenario in which from the 2007 baseline, the ATM system would continue to develop according to the historical way of doing business. This is with reference to this business as usual scenario that the cost and benefits impacts of the other scenarios are assessed;
- The IP1 scenario – assessing the situation not only until 2013, but also how it would develop further in absence of other improvements in the concept of operation;
- The IP2 scenario.

Assessment of IP1 took into account the impacts on the business as usual scenario of the costs of IP1 (R&D, validation, training, operations…) and of associated IP1 benefits, mainly "ATCO productivity" developments for ACC and APP/TWR. Then, assessment of IP2 did the same but applying the impacts on the IP1 scenario results.

Main Assumptions and Dependencies

- The traffic forecast used for all the scenario are the SESAR D2 traffic forecasts (STATFOR scenario A - constrained demand);
- All the cost figures included are either actual value or are in 2005 cost basis ignoring inflation;
- Technical Support staff changes in line with SESAR and non-SESAR investments. Additional staff costs due to SESAR are those identified in the SESAR cost assessment;
- Administrative and other staff remains a stable percentage of the total staff costs;
- Salary cost for staff increases by slightly over 1% over inflation from 2010;
- The "direct operating non-staff costs" until 2013 are shared in 67% for the non-SESAR part of the assets and 33% for the assets related to SESAR. This percentage decreases over time from 2013 and is fully replaced by SESAR operations costs by 2020. Additional training costs from SESAR cost assessment have been added in this cost element;

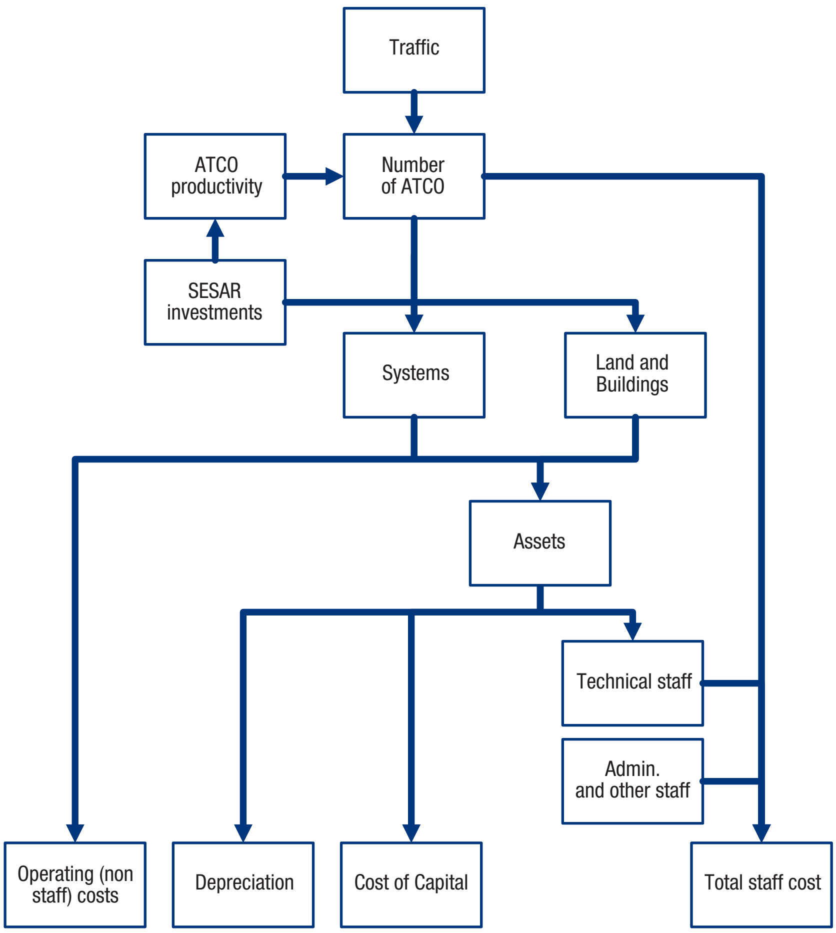


Figure 109: Simplified Dependencies Diagram in ANS Costs Structure

33 - Staff cost, operating non staff cost, depreciation costs, cost of capital, MET cots, Eurocontrol costs, Government costs.

- Depreciation costs for non-SESAR portion remain proportional to the non-SESAR investments. For SESAR investments, additional calculations have been provided and added;
- Cost of capital reflects the amount of capital invested;
- Institutional (EUROCONTROL and Government) and Meteorology costs increase marginally over inflation. Additional legislation and regulatory costs from SESAR costs assessment have been added in this cost element.

Business as Usual Scenario (from 2005 baseline)

The business as usual scenario figures include current and planned investments and current cost assumptions for staff and operations prepared by expert judgment of various sources such as the ACE reports.

The investments grow rapidly from 2010 onwards to overcome flight capacity and flight accommodation problems by sectorisation of air traffic control.

ATCO productivity increases by 1%+ per year over the initial period. However, this productivity increase is going to disappear from 2012 and due to inefficiencies is expected to then start to decrease due to increased complexity in (inter) sectors management.

The business as usual scenario shows a unit cost downward trend until 2010 as a result of the increase in traffic (PRU forecast). After 2010, ignoring the barrier that the current ATM system could meet for sustaining the capacity increase, the base case projects a steady increase to €855/flight by 2020 as the ATCO workforce increases and related staff costs, direct operating costs and investment costs follow suit.

SESAR IP1 and IP2 Scenarios

Both IP1 and IP2 programmes introduce investments that generate operational productivities (replacing traditional investment in new sectors and additional manpower).

Investments are expected to start in 2008 for IP1 and grow up to 2020 with the inclusion of IP2 and IP3. The portion of the total ANSP investment for SESAR investments amounts to approximately €7.7 to €8.0 Bn (2008 to 2025).

With the deployment of SESAR, ATCO productivity gains of up to 4% per annum are assessed for the period 2013 to 2025. Therefore, variations in ATCO numbers reflect both traffic and productivity developments[34].

Figure 110 gives the relative evolution of the ANS cost structure elements.

The following figures display the timeline of the SESAR improvements leading to a unit cost of around €630/flight in 2020.

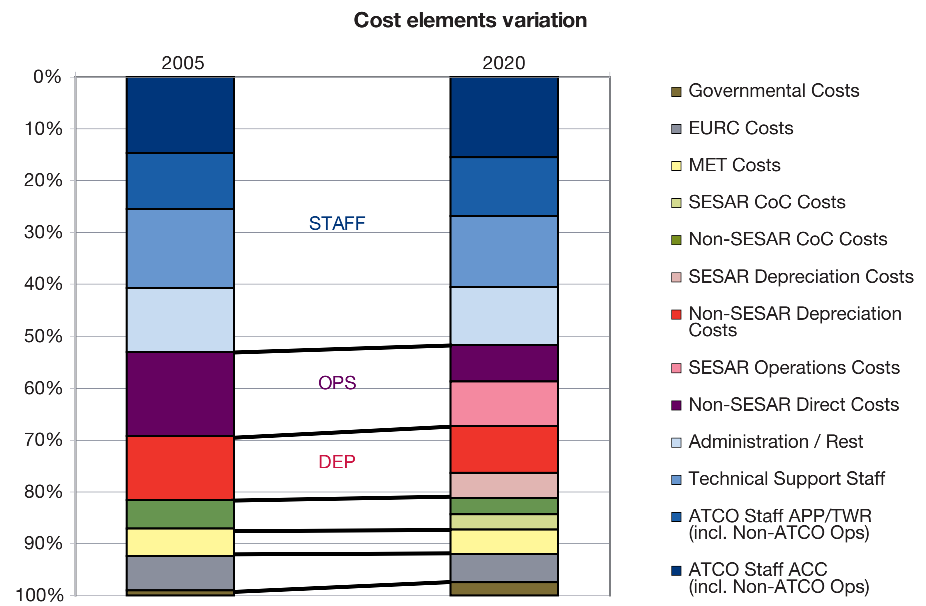


Figure 110: Costs Structure Evolution

34 - D3 assertion that the ATM Target Concept could allow to manage the 2020 without significant increase in the average number and total costs of the ATCO in operation was refined by D4 detailed assessment of the ATCO productivity. Current results show that 2020 ATCO number will be similar to 2011 ATCO number and around 19400.

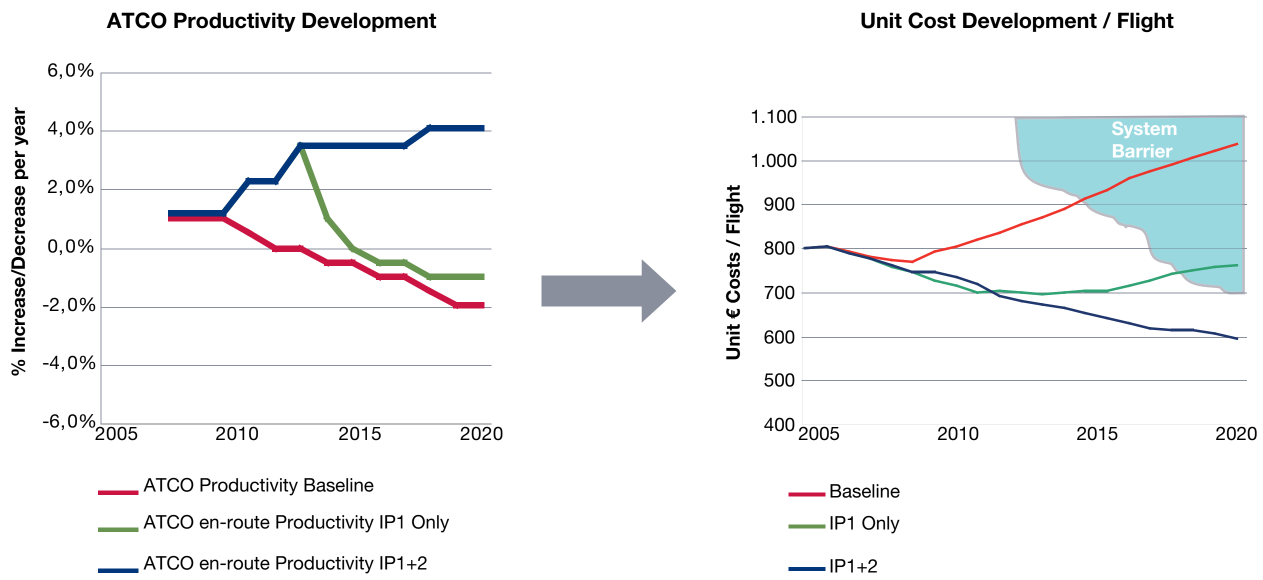


Figure 111: Development of Unit cost/flight

10.5.5 Cost Benefit Analysis Inputs

Cost Benefit Analysis (CBA) were performed using "EUROCONTROL Standard Inputs for CBA" or specific inputs defined by the SESAR Work Package 1.4 – CBA during D1 to D4. The following are a number of key inputs:

- Cost per minute for delays – €34/minute for delays larger than 15 minutes with decreasing costs for delays under 15 minutes;
- Value of an additional accommodated flight – €700/additional accommodated flight;
- Cost of a flight cancellation – €30,000/cancelled flight;
- Value of 1% fuel efficiency – has been computed using the following standard inputs: fuel price: US$0.54/kg; average flight duration: 1.65h; average consumption: 2,400 kg/h; CO_2 emission per kg of fuel: 3,149 CO2 kg; CO_2 tax: €15/Tonne; US$/€ exchange rate: 0.77;
- Delay between IP start date and first benefit year – 1 year for IP1, 2 years for IP2a and 2 years for IP2b;
- Discount rate: 8%.

10.6 Annex VI: Enablers

This section presents the system, CNS technology and human enablers identified with the OI Steps, according to the Information Model methodology (as presented in Annex III).
The methodology which has been applied to identify the link between the OI Step and the enablers is illustrated through an example.

10.6.1 Example Illustrating the Information Model to Derive Enablers from OI Steps:

The implementation of the Airport aspects of the ATM Target Concept (identified under the **Line of Change 10**: Airport throughput, Safety and Environment) will be achieved through the full implementation of 8 different Operational Improvements (OI):

- Improving Safety of Operations on the Airport Surface;
- Improving Traffic Management on the Airport Surface;
- Improving Airport Collaboration in the Pre-Departure Phase;
- Using Runways Configuration to Full Potential;
- Maximising Runway Throughput;
- Improving Operations under Adverse Conditions incl. Low Visibility;
- Visual Conducted Approaches; and
- Implementing Sustainable Operations at Airport).

To achieve the implementation of the first OI, several OI steps have been identified, one of them being the implementation of **Airport Safety nets including Taxiway and Apron** (*OI Step AO-0104*).

State before change: Automated alerting system is limited to the runway and is based upon a set of rules that assist controllers in detecting the most serious conflicts; this system has no knowledge of aircraft intent and in some cases the time window to determine and communicate a solution may be very limited.

Operational evolution (state after change):

- The system detects potential conflicts/incursions involving mobiles (and stationary traffic) on runways, taxiways and in the apron/stand/gate area based on Surveillance data and generates alarms and resolution advisories (depending on the complexity of resolution possibilities);
- The alarms and resolution advisories are provided to controllers, pilots, and vehicle drivers;
- The systems also alert the controller in case of unauthorized/-unidentified traffic.

A set of analyses have been performed on this OI Step by experts in the following areas:

- **System and Information needs:** Experts have analysed the impact of this OI step on the European Air Traffic Management System (EATMS) architecture and have identified the need for evolution of only the **AERODROME-ATC ATM system** compared to the previous change steps; this evolution has been captured in a set of evolutions synthesised in **system enablers** [Ref 17], as follow:
  - o A data link service to uplink alarms regarding detected conflicts concerning mobiles on the movement area to aircraft and vehicles (for use with A-SMGCS supporting advanced level functions; most likely A-SMGCS commonly identified as "Level-3"). This has been captured under the system enabler *Air-ground data link communications service for surface movement conflict alarms. Availability:* 2005;
  - o Automated assistance to controllers in resolving detected conflicts concerning mobiles on the movement area, derived from more precise surveillance data (for use with A-SMGCS supporting advanced level functions; most likely A-SMGCS commonly identified as "Level-4"). This has been captured under the system enabler *Surface movement control work-station equipped with tools for resolution of surface conflicts. Estimated availability:* 2008.

- **Procedure**: To support this EATMS architecture evolution, Experts have captured the need for the following procedural enablers definition [Ref 14]:
  - o Cockpit procedure to automatically exchange alerts between airborne and ground systems through data link (Automatic exchange of alerts via data link);
  - o ATC Procedures (Airport) for systematic, standard responses to safety net alerts.

- **CNS Technology:** To support the system and information needs, experts identified the need for the following new **CNS Technology enablers** [Ref 18]:
  - o Higher performance airport surveillance. This has been captured under the system enabler *Airport Surface Surveillance (SMR, MLAT, ADS-B).* Availability: 2007;
  - o Higher performance primary radar. This has been captured under the system enabler Independant Non Co-operative Surveillance. Availability: 2007;
  - o Wireless communications infrastructure in protected band to handle the data traffic between mobile and fixed elements of Aircraft Operators, Airport Operators, ATC and other services (e.g. ground handling, meteorology, fire and rescue). This has been captured under the system enabler *New Airport Datalinks* Estimated availability: 2015.
  - o In complement, the availability of Low Power Transponder allowing General Aviation aircraft to be electronically visible in airports has been considered as an enabler. This has been captured under the system enabler *Low Power Transponder (LPST). Estimated availability: 2011.*

- **Human:** To support the operational evolution, experts identified the following new **human enablers** [Ref 13] specific to this OI Step:
  - o New standards/regulations for apron controllers required (must be started 4 years in advance) *(Regulations and standards)*;
  - o Apron controllers verification of competence (additionally to TWR controllers) as this would affect the separation procedures *(Verification of competence)*;
  - o Training for all staff mentioned in OI Step (pilots, ATCOs, apron control, vehicle drivers on apron) *(Training)*;
  - o ATSEP training required as part of interdisciplinary training;
  - o Integrate the systems in training simulators *(System design and Training)*.

- **Institutional:** To support the OI Step implementation, experts have identified the following new **institutional enablers** [Ref 11 & 19]:
  - o National Legislation - to permit/require carriage/use of new/changed technologies;
  - o Develop a standard for A-SMGCS level 3 and 4 *(ASMGCS-0201 New EUROCAE Standard for A-SMGCS (Level 3&4) including SMAN)*.

The consolidation of the analysis of this OI Step concluded that the Initial Operational Capability date for this OI Step is 2015, considering that strong and timely standardisation and institutional frameworks are introduced to support the OI Step implementation.

10.6.2 System Enablers

This section presents an overview of the content of the SESAR database with regards to the Architecture System Enablers. The methodology followed by WP 2.4 to produce the list of architecture system enablers was the following:

- The list of OI steps was analysed, in order to determine which system and sub-system (as defined in D3) was impacted by each OI step;
- Then the nature of the impact on the system/sub-system was described;
- The list of all the impacts was rationalized, grouping them according to the nature of the change, the functional scope and the time horizon at which the change was estimated to be technically feasible;

- This resulted into a list of architecture system enablers, each one being characterised with a code, title, description, feasibility date, code of the OI steps it supports , etc. The full list of architecture system enablers is described in the Task 2.4.4 DLT [Ref 17] and included in the SESAR database.

In the Implementation Packages chapters (3, 4 and 5) of the present document, only a synthesis of the main architecture system enablers associated to some major OI steps are included. The following tables present the complete set of architecture system enablers, as well as the supported OI steps.

AOC - ATM

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AOC-ATM-01	Data model to allow transfer of CTA inside AOC-ATM system without SWIM	TS-0103
AOC-ATM-02	Data model to allow transfer of update trajectory from ATC world to AOC-ATM system without SWIM	AUO-0302 ; AUO-0303 ; DCB-0208
AOC-ATM-03	Data model to allow transfer of trajectory from AOC-ATM system into ATC world without SWIM	AUO-0204
AOC-ATM-04	Data model to allow transfer of trajectory from AOC-ATM system into ATC world with SWIM	AUO-0203 ; AUO-0204 ; DCB-0103
AOC-ATM-05	Data model to allow transfer of update trajectory from ATC world to AOC-ATM system with SWIM	no direct link to any OI Step
AOC-ATM-07	Modification of AOC-ATM trajectory management system to allow quality of service requested by NOP for pre-flight trajectory (or new systems)	DCB-0103
AOC-ATM-09	Modification of AOC-ATM trajectory management system to allow integration of information outside trajectory	DCB-0103
AOC-ATM-10	Modification of AOC-ATM trajectory management system to allow quality of service requested by NOP for pre-flight trajectory (or new systems) free flight and dynamic routing	AOM-0501 ; AOM-0502 ; AOM-0503 ; AOM-0403
AOC-ATM-11	Modification of AOC-ATM trajectory management system to allow quality of service requested by NOP for pre-flight trajectory (or new systems) automatic integration of new constraints for SBT negotiation	AUO-0203 ; AUO-0204 ; DCB-0103
AOC-ATM-12	Modification of AOC-ATM system to allow answer to CDM processes with airports	no direct link to any OI Step
AOC-ATM-13	Modification of AOC-ATM system to allow answer to CDM processes with ATM world	AUO-0102 ; DCB-0305
AOC-ATM-14	Modification of military flight planning system to allow flight plan for OAT flights	AOM-0302 ; AOM-0303 ; AOM-0304

AIRCRAFT

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AIRCRAFT-01	Enhanced positioning on the airport and in flight (SBAS).	AUO-0602
AIRCRAFT-02	Enhanced positioning on the airport and in flight (Galileo, GPS L5).	AUO-0604
AIRCRAFT-03	Determination of a preferred trajectory avoiding an area not existing in onboard data base.	AOM-0206 ; AOM-0304
AIRCRAFT-04	Flight management and guidance to improve lateral navigation (2D RNP).	AOM-0602 ; AOM-0501 ; AOM-0502 ; AOM-0702 ; AOM-0704
AIRCRAFT-05	Flight management to improve vertical navigation (barometric VNAV).	AOM-0702 ; AOM-0704
AIRCRAFT-06	Flight management and guidance to perform Localizer Precision with Vertical guidance (LPV) approach (e.g. SBAS)	AOM-0602
AIRCRAFT-07	Flight management and guidance to perform steep and curved approach (e.g. SBAS)	AOM-0602
AIRCRAFT-08	Flight management and guidance to perform wake vortex free approach.	AUO-0504
AIRCRAFT-09	Flight management and guidance to perform climbing cruise.	AUO-0304
AIRCRAFT-10	Flight management and guidance to improve vertical navigation (VRNP).	CM-0604
AIRCRAFT-11	Flight management and guidance to improve time constraints management (CTA).	AOM-0704 ; TS-0103
AIRCRAFT-12	Flight management and guidance to perform multiple time constraints management (CTOs).	TS-0106
AIRCRAFT-13	Flight management and guidance to improve longitudinal navigation (4D contract).	CM-0501
AIRCRAFT-14	Monitoring of the conformance of the current PT versus RBT according to thresholds.	IS-0305
AIRCRAFT-15	Flight management and guidance to support ASAS spacing (ASPA).	AUO-0504 ; TS-0105
AIRCRAFT-16	Flight management and guidance to support ASAS separation (ASEP).	CM-0701 ; CM-0702
AIRCRAFT-17	Flight management and guidance to support ASAS self separation (SSEP).	CM-0704
AIRCRAFT-18	Flight management and guidance to support automatic braking according to a pre-defined runway exit.	AUO-0702
AIRCRAFT-19	Flight management and guidance to support automatic taxi.	AUO-0604 ; AUO-0802
AIRCRAFT-20	Automatic prevention of runway incursion (e.g. stop bar).	AUO-0604 ; AUO-0605
AIRCRAFT-21	Automatic guidance according to Resolution Advisory from ACAS.	CM-0803
AIRCRAFT-22	Enhanced vision of terrain on head up display in low visibility conditions.	AUO-0403
AIRCRAFT-23	Synthetic vision on head up display in low visibility conditions.	AUO-0404
AIRCRAFT-24	Airport moving map and own aircraft position display in cockpit.	AUO-0602
AIRCRAFT-25	Airborne Traffic Situational Awareness to support surface operations (ATSA-SURF).	AUO-0401 ; AUO-0603
AIRCRAFT-26	Airborne traffic situational awareness to support in flight operations.	AUO-0402 ; AUO-0504 ; TS-0105

AIRCRAFT (cont'd)

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AIRCRAFT-27	Airborne Traffic Situational Awareness to support enhanced Visual Separation on Approach (ATSA-VSA).	AUO-0502
AIRCRAFT-28	Airborne Traffic Situational Awareness to support In-Trail Procedure (ATSA-ITP).	AUO-0503
AIRCRAFT-29	Onboard conflict detection and resolution to support ASAS self separation.	CM-0704
AIRCRAFT-30	Onboard detection of wake vortices for use as safety net.	AUO-0504
AIRCRAFT-31	Automatic loading in onboard navigation system of up linked route, altitude and time constraints.	CM-0601 ; CM-0602 ; AUO-0303 ; TS-0103 ; AOM-0206 ; CM-0603 ; CM-0604; AOM-0804
AIRCRAFT-33	Automatic loading in onboard navigation system of up linked clearances.	AUO-0302 ; AUO-0504 ; CM-0701 ; CM-0702 ; TS-0105 ; AUO-0703 ; CM-0601 ; CM-0603
AIRCRAFT-34	Automatic loading in onboard navigation system of up linked 3D/4D Precision Trajectory Clearances.	CM-0501 ; CM-0604
AIRCRAFT-35	Automatic loading in onboard navigation system of minor speed adjustment uplinked by ground system.	AOM-0304 ; CM-0403
AIRCRAFT-36	Downlink of aircraft derived data (e.g. ETA, weight, speed, wind).	AOM-0704 ; IS-0302
AIRCRAFT-37	Downlink of predicted trajectory in case of activation onboard of agreed or revise trajectory or in case proposal of onboard preferred trajectory avoiding an up linked area	IS-0303 ; AOM-0304 ; AOM-0501 ; AOM-0502 ; AOM-0702 ; CM-0401 ; AOM-0206 ; CM-0603
AIRCRAFT-38	Automatic downlink of predicted trajectory on request or in case of delta versus Reference Business Trajectory more than thresholds.	IS-0305 ; AOM-0503 ; CM-0501 ; CM-0604
AIRCRAFT-40	Uplink of an area dynamically activated and not existing in onboard data base.	AOM-0206
AIRCRAFT-43	Automatic uplink of the prevention to avoid runway incursion (stop bar).	AUO-0604
AIRCRAFT-44	Automatic downlink of alerts generated by airborne system.	CM-0802
AIRCRAFT-45	Uplink of aeronautical or MET data for use by relevant onboard system of service (D-OTIS).	IS-0402
AIRCRAFT-46	Uplink/broadcast of aeronautical or MET data for use by relevant onboard system or service.	IS-0406
AIRCRAFT-47	Downlink of meteo data from onboard sensor.	IS-0501
AIRCRAFT-48	Air air exchange of aircraft position/vector (ADS-B OUT).	AUO-0401 ; AUO-0402 ; AUO-0502 ; AUO-0503 ; AUO-0504 ; CM-0701 ; CM-0702 ; TS-0105
AIRCRAFT-49	Air air exchange of aircraft position/vector (ADS-B IN).	AUO-0401 ; AUO-0402 ; AUO-0502 ; AUO-0503 ; AUO-0504 ; CM-0701 ; CM-0702 ; TS-0105
AIRCRAFT-50	Air air exchange of aircraft trajectory, weather and wake vortices data (ADS-B IN/OUT).	CM-0704 ; AUO-0504 ; IS-0406
AIRCRAFT-52	Automatic uplink of alerts generated by ground system.	CM-0806
AIRCRAFT-53	Adjustment of auto throttle to support Noise Abatement Departure Procedure (NADP).	AUO-0803
AIRCRAFT-54	ACAS adaptation to new separation modes	CM-0804

ENROUTE APPROACH ATC

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
ER APP ATC 14	Enhance Controller tools to use Aircraft derived 4D trajectory data.	IS-0302
ER APP ATC 15	Enhance FDP to Support for Dynamic Sectorisation and Dynamic Constraint Management.	CM-0102
ER APP ATC 17	Enhance Traffic and Flow Management sub-systems to support dynamic flow management in co-ordination with local, regional, and European levels.	CM-0302 ; DCB-0208
ER APP ATC 51	Enhance AMAN to collaborate with the local SMAN and DMAN.	TS-0301 ; AO-0207 ; TS-0104 ; AO-0403
ER APP ATC 61	Adapt Controller and Local and Sub-regional Demand & Capacity balancing tools to manage delegation of separation responsibilities to aircraft.	CM-0701 ; CM-0702 ; TS-0105
ER APP ATC 67	Evaluate the impact on FDP systems and Control Tools for provision of Self-separation in mixed mode of operations	CM-0704 ; AOM-0303 ; AOM-0304
ER APP ATC 68	Enable Controller workstation to indicate when aircraft systems indicates an RA occurrence.	CM-0802
ER APP ATC 69	Enhance STCA to use different separations for different types of aircraft/operations.	CM-0805
ER APP ATC 70	Manage ADD received from aircraft for FDP and Tool use.	IS-0302
ER APP ATC 74	Enhance AMAN to provide time-based separation.	AO-0302 ; AO-0303 ; AO-0304
ER APP ATC 76	Enable systems to differentiate between different traffic type airspaces.	AOM-0102 ; AOM-0103 ; AOM-0501
ER APP ATC 77	Enable systems to use dynamically defined airspaces.	AOM-0206 ; AOM-0208 ; AOM-0803 ; AOM-0804
ER APP ATC 78	Enhance FDP sub-system to use 3D trajectories.	AOM-0502 ; AOM-0503
ER APP ATC 79	Enhance FDP sub-system to allow continuous descend from defined (approach) fixes.	AOM-0702 ; AOM-0704
ER APP ATC 82	Enhance Local/Sub regional Traffic and Capacity sub-systems to use SBT and RBT.	AUO-0203 ; AUO-0204 ; AUO-0303
ER APP ATC 86	Enhance FDP sub-system to use available 4D trajectories	CM-0402
ER APP ATC 90	Enable En-Route and Approach ATC sub-systems to manage 4D contract .	CM-0501
ER APP ATC 91	Enable En-Route and Approach ATC sub-system to manage 3D Precision trajectory clearances.	CM-0602 ; CM-0604
ER APP ATC 92	Enhance controller planning tools.	CM-0104 ; CM-0405
ER APP ATC 93	Enhance Resource Management and Planning Tools to use Traffic Complexity Assessment.	CM-0103
ER APP ATC 99	Use Meteorological systems provided enhanced local real-time information.	IS-0703 ; IS-0707 ; IS-0708
ER APP ATC 100	Enhance En-route ATC sub-systems to use RBT and PT provided from aircraft systems and provide constraints and clearances to aircraft systems.	AUO-0302 ; AUO-0303 ; CM-0603 ; CM-0604 ; CM-0403 ; CM-0404 ; IS-0303 ; IS-0305
ER APP ATC 109	Enhance AMAN to serve multiple airports.	TS-0303
ER APP ATC 110	Enhance AMAN to collaborate with non-local SMAN and DMAN.	TS-0304
ER APP ATC 111	Enhance AMAN to provide arrival sequence time information into En Route decision making.	TS-0305

ENROUTE APPROACH ATC (cont'd)

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
ER APP ATC 118	Enhance AMAN to reduced distance separation in specific conditions.	AO-0301 ; AO-0303
ER APP ATC 119	Enhance En-route ATC sub-systems (mainly communication and Controller workstation) to enable CPDLC dialog with pilot.	AUO-0301
ER APP ATC 120	Enhance MTCD to use 4D trajectory, clearances, and requests.	CM-0204 ; CM-0401 ; CM-0404
ER APP ATC 121	Enable En-Route and Approach ATC sub-system to manage 2D Precision trajectory clearances.	CM-0603
ER APP ATC 122	Enhance FDP sub-system to allow continuous climb departures to defined end points.	
ER APP ATC 123	Enhance FDP and Traffic and Capacity Tools to Support use of Modular Sectorisations for Variations in Traffic Flows.	SDM-0202
ER APP ATC 124	Basic Resource Management and Planning Tools.	CM-0101
ER APP ATC 127	Enhanced Traffic Management Tools to support use of SWIM based NOP.	DCB-0103
ER APP ATC 128	Introduce Basic AMAN	TS-0102
ER APP ATC 129	Upgrade FDP and provide Controller Tools to provide assistance to ATC Planning for Preventing Conflicts in En Route Airspace	CM-0202
ER APP ATC 130	Upgrade FDP and provide Controller Tools to provide controller with warnings if aircraft deviate from a clearance or plan	CM-0203
ER APP ATC 131	Provide Demand & Capacity balancing tools into sub-regional ACCs	
ER APP ATC 132	Transition ER and APP ATC systems from use of direct ADGL connection and to use of European gateway.	
ER APP ATC 133	Upgrade Ground Safety Nets to provide Area Penetration Warning (APW), Minimum Safe Altitude Warning (MSAW) and Approach Path Monitoring to Controller Workstations.	CM-0801
ER APP ATC 134	Upgrade FDP and Surveillance (Workstation presentations) to reflect system impacts of a major change of Transition Altitude.	no direct link to any OI Step
ER APP ATC 136	Enhance STCA for TMA specific operations.	CM-0406
ER APP ATC 137	Upgrade Ground Safety Nets to use SWIM available additional information	CM-0807
ER APP ATC 138	Implement Integration layer to support information sharing through SWIM.	IS-0703 ; IS-0707 ; IS-0708
ER APP ATC 139	Update FDP and Tools to enable CTOs for sequencing at other intermediate merging points and not only on arrival (CTA).	TS-0106

AERODROME ATC

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AERODROME-ATC-01	Surface movement control workstation equipped with tools for controller-pilot dialogue using datalink	AUO-0301
AERODROME-ATC-02	Surface movement management tools updated for enhanced conflict detection and alert	AUO-0605
AERODROME-ATC-03	Surface movement control workstation equipped with tools for runway incursion detection and alerting	AO-0202
AERODROME-ATC-04	Surface movement control workstation enhanced to use and display aircraft-derived information	AO-0201
AERODROME-ATC-05	Surface movement data processing system enhanced with processing for collaborative gate and stand management	AO-0207
AERODROME-ATC-08	Independent management of the departure and arrival sequence at the aerodrome	TS-0102
AERODROME-ATC-09	Integration of Arrival/Departure sequence management with surface management	AO-0207 ; TS-0104
AERODROME-ATC-10	Enhanced arrival/departure sequence with external aerodrome and CDM taking into account the user TTA	TS-0304 ; TS-0306
AERODROME-ATC-11	Surface movement data processing system enhanced to integrate aircraft-derived information	AO-0201
AERODROME-ATC-12	Provision of the optimised ground route	AO-0205 ; AUO-0302
AERODROME-ATC-13	Surface movement data processing system enhanced with storage and dissemination of surface routes	AO-0205
AERODROME-ATC-16	Runway usage management system enhanced for processing dynamic wake-vortex information	AO-0304
AERODROME-ATC-21	Air-ground datalink communications service for surface movement conflict alarms	AUO-0301 ; AUO-0605 ; AO-0104
AERODROME-ATC-22	Surface movement control workstation equipped with tools for resolution of surface conflicts	TS-0301 ; AUO-0605 ; AO-0104
AERODROME-ATC-28	Surface movement control workstation equipped with initial tools for Aerodrome Control Service	AO-0201
AERODROME-ATC-30	Surface movement control workstation equipped with a wind shear monitoring tool	AO-0301
AERODROME-ATC-33	Airport Demand and Capacity system enhanced to better handle arrival and departure	DCB-0201 ; TS-0301 ; AO-0402
AERODROME-ATC-35	Surface movement management tools enhanced to process the Runway Exit proposal to be uplinked to the aircraft.	AUO-0703
AERODROME-ATC-36	Airport surveillance data processing and distribution upgraded to store and forward additional ADD	AO-0201
AERODROME-ATC-37	Airport technical supervision enhanced to monitor new Ground-Ground data communications services	no direct link to any OI Step
AERODROME-ATC-38	Airport recording system enhanced to store Surface Movement data	no direct link to any OI Step
AERODROME-ATC-39	Digital ATIS (D-ATIS) provision to the aircraft	IS-0402
AERODROME-ATC-40	Digital OTIS (D-OTIS) provision to the aircraft	IS-0402
AERODROME-ATC-41	DMAN enhanced to handle departure from multiple airports,	TS-0302
AERODROME-ATC-42	Runway usage management system enhanced for processing static wake-vortex information	AO-0303

AIRPORT

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AIRPORT-28	Airport vehicles equipped with static airport map display	AO-0203
AIRPORT-29	Airport vehicles equipped with two-way mobile communications	AO-0203
AIRPORT-30	Airport wireless communications infrastructure for mobile data	AO-0203
AIRPORT-31	Airport CDM (levels 1 & 2)	DCB-0304 ; AUO-0101 ; AO-0601 ; AO-0603
AIRPORT-33	Provision by the Airport Demand & Capacity of the relevant information to the Aerodrome ATC	TS-0203 ; TS-0104
AIRPORT-34	Airport equipped with (real time) environmental monitoring systems	AO-0701 ; AO-0705 ; AO-0706
AIRPORT-35	Airport CDM (levels 3 & 4)	no direct link to any OI Step

NETWORK INFORMATION MANAGEMENT SERVICE

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
NIMS-02	Ground-ground data communications services for flight plan filing and exchange (e.g. AMHS)	AOM-0202 ; AOM-0302 ; IS-0102 ; AUO-0102 ; DCB-0305 ; AUO-0203 ; AUO-0204 ; TS-0306
NIMS-04	ATFCM capacity planning sub-system enhanced to take into account dynamic sector shapes	AOM-0803 ; AOM-0804
NIMS-05	Flight Planning management sub-system equipped with route finding and optimisation tools	AUO-0102 ; DCB-0305 ; AOM-0304
NIMS-06	Network information management system equipped with post-analysis tools for airport traffic	
NIMS-07	Capacity planning tools for ATCCs	
NIMS-08	Strategic and pre-tactical demand-capacity balancing evaluation, simulation and display tools	DCB-0205 ; DCB-0204 ; DCB-0206
NIMS-09	Capacity planning and scenario management equipped with tool to assess the impact of requested flight level changes	CM-0302
NIMS-10	Capacity planning and scenario management equipped with sector management tool to assist ATCCs in defining sector configurations	AOM-0801
NIMS-11	Capacity planning and scenario management equipped with tool to assist ATCCs in reducing controller workload	
NIMS-12	Capacity planning and scenario management equipped with tool to identify imbalance between arrivals and departures	DCB-0205 ; TS-0301
NIMS-13	Capacity planning and scenario management equipped with tools to identify the possible re-routed flights/flows providing the best benefits	DCB-0205
NIMS-14	Demand Data Repository	AOM-0206 ; AOM-0208
NIMS-16	Adaptation of all NIMS sub-systems to the common ATM information model	IS-0703
NIMS-17	Enhanced assistance to flight planning	AUO-0102 ; DCB-0305 ; AOM-0304

NETWORK INFORMATION MANAGEMENT SERVICE (cont'd)

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
NIMS-18	Flight Planning management sub-system enhanced to use the latest airspace information	AUO-0201 ; IS-0101 ; IS-0102 ; AOM-0206 ; AUO-0201
NIMS-19	Flight Planning management sub-system enhanced for AFUA	AOM-0208 ; AOM-0803 ; AOM-0804
NIMS-20	Enhanced responsiveness of Flight Planning management sub-system	AUO-0201 ; DCB-0102 ; AUO-0203 ; IS-0102
NIMS-21	Flight Planning management sub-system enhanced to support 4D and to comply with standards	AUO-0102 ; DCB-0208 ; DCB-0305 ; AUO-0203 ; AUO-0204 ; AOM-0403 ; AOM-0501 ; AOM-0502 ; AOM-0503 ; IS-0709 ; AOM-0304
NIMS-22	Enhanced performance management sub-system	SDM-0103
NIMS-23	Capacity planning and scenario management equipped with tools integrating airport/airline schedule data, to assist ATCCs in optimising the use of airport holding patterns, to identify other usable capacity	DCB-0205 ; DCB-0301
NIMS-24	Flight planning sub-system enhanced by acquiring information on real-time events	AOM-0202 ; AOM-0204 ; DCB-0102 ; AUO-0102 ; DCB-0305 ; IS-0102 ; TS-0306
NIMS-25	Enhanced interaction of Network DCB sub-system	AUO-0102 ; DCB-0305 ; TS-0306 ; DCB-0205 ; TS-0306 ; TS-0304 ; TS-0301
NIMS-26	Enhanced responsiveness of Network DCB sub-system	DCB-0208 ; DCB-0305 ; TS-0306 ; TS-0304
NIMS-27	Network DCB sub-system enhanced with improved accuracy of processing real-time data	CM-0102 ; DCB-0205 ; AUO-0102 ; DCB-0305 ; SDM-0103 ; DCB-0208 ; TS-0306 ; CM-0302 ; TS-0306 ; TS-0304 ; TS-0301
NIMS-28	Network DCB sub-system equipped with an improved short term traffic prediction tool, with tools for optimising re-routing	DCB-0208 ; TS-0306 ; DCB-0205 ; DCB-0206 ; TS-0306 ; TS-0304 ; TS-0301
NIMS-29	Network DCB sub-system enhanced for Network Operations Plan (NOP) preparation and dissemination	AOM-0206 ; DCB-0103
NIMS-30	ATFCM scenario management sub-system equipped with tools for assessing the impact of airspace changes on capacity	AOM-0704 ; AOM-0803 ; AOM-0804

ADVANCED AIRSPACE MANAGEMENT SYSTEM

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AAMS-03	Airspace Data Repository	AOM-0206
AAMS-04	Airspace management system enhanced for external user access to the airspace data repository	AOM-0202 ; AOM-0203 ; AOM-0204 ; DCB-0102 ; DCB-0203
AAMS-05	Airspace management system enhanced to exchange information with the Network Operations Plan	no direct link to any OI Step
AAMS-06	Airspace management system enhanced to generate and distribute planned airspace usage information	DCB-0102 ; DCB-0203 ; AOM-0202 ; AOM-0403 ; AOM-0501 ; AOM-0502 ; AOM-0503
AAMS-07	Airspace management system enhanced to provide real time airspace status information	DCB-0203 ; AOM-0202 ; AOM-0203 ; AOM-0204 ; AOM-0206 ; AOM-0403 ; AOM-0501 ; AOM-0502 ; AOM-0503 ; AOM-0704 ; AOM-0803 ; AOM-0804

ADVANCED AIRSPACE MANAGEMENT SYSTEM (cont'd)

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AAMS-08	Airspace management system enhanced to support improved collaborative airspace planning	AOM-0202 ; AOM-0205 ; DCB-0203
AAMS-09	Airspace management system enhanced to support the integrated European airspace planning process	AOM-0202
AAMS-10	Airspace management system enhanced with commonly applied GAT/OAT handling	AOM-0202 ; AOM-0204 ; AOM-0303
AAMS-11	Airspace management system enhanced with real-time functions and dialogues for dynamic airspace allocation	AOM-0201 ; AOM-0205 ; AOM-0704 ; AOM-0803 ; AOM-0804 ; DCB-0203
AAMS-12	Airspace management system equipped with a pan-European airspace coordination tool	AOM-0204
AAMS-13	ASM scenario management sub-system equipped with tools for assessing the impact of airspace changes on capacity	AOM-0704 ; AOM-0803 ; AOM-0804
AAMS-14	Airspace management system equipped with tools for collection of real-time airspace data	AOM-0202 ; DCB-0102 ; DCB-0203
AAMS-15	Scenario management sub-system equipped with tools to support pre-tactical CDM	AOM-0202
AAMS-16	Airspace management system equipped with tools able to deal with flexible use of airspace and free-routing	AOM-0102 ; AOM-0103 ; AOM-0304 ; AOM-0803 ; AOM-0804 ; AOM-0206 ; AOM-0208 ; AOM-0501 ; AOM-0502 ; AOM-0503 ; AOM-0702 ; AOM-0704
AAMS-17	Adaptation of all AAMS sub-systems to the common ATM information model	no direct link to any OI Step
AAMS-18	Airspace management system enhanced to support the European-wide use of Military Training Area as part of the integrated European airspace planning process	AOM-0204

AERONAUTICAL INFORMATION MANAGEMENT SERVICE

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AIMS-06	Aeronautical Information system providing airspace information static and dynamic	no direct link to any OI Step
AIMS-07	Generation of pre-flight briefing information	IS-0201
AIMS-13	Controlled & Harmonised Aeronautical Information Network Activity (CHAIN)	IS-0202
AIMS-14	Aeronautical Information system adapted to provide aeronautical information to users through services (D-AIM)	no direct link to any OI Step
AIMS-15	Aeronautical Information data repository enhanced to be able to handle Dynamic Mobile Areas.	AOM-0208
AIMS-16	Electronic Terrain and Obstacle Data (TOD)	no direct link to any OI Step
AIMS-17	Aeronautical Information enhanced with digital NOTAMs	IS-0204 ; IS-0703
AIMS-18	Aircraft Information system	no direct link to any OI Step
AIMS-19	Aeronautical Information system is interfaced to receive and distribute aeronautical information electronically to military systems.	IS-0204
AIMS-20	Airspace Data Repository	AOM-0206

AERONAUTICAL INFORMATION MANAGEMENT SERVICE (cont'd)

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AIMS-21	Airspace management system enhanced for external user access to the airspace data repository	AOM-0202; AOM-0204; DCB-0102; DCB-0203
AIMS-22	Airspace management system enhanced to provide real time airspace status information	DCB-0203; AOM-0202; AOM-0203; AOM-0204; AOM-0206; AOM-0403; AOM-0501; AOM-0502; AOM-0503; AOM-0704; AOM-0803; AOM-0804
AIMS-23	Airspace Management system equipped with tools for collection of real time airspace data	AOM-0202; DCB-0102; DCB-0103

AIR GROUND SWIM

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
AGSWIM-34	New System AGDLGMS	IS-0501 ; TS-0103 ; DCB-0103 ; IS-0305; TS-0106
AGSWIM-35	Flight Data updates transmitted by AGDLGMS to the Aircraft	IS-0305
AGSWIM-36	Flight Data dialogues supported by AGDLGMS	IS-0305 ; TS-0106
AGSWIM-37	Flight Data updates made by the aircraft leading to ground shared flight data updates	IS-0305
AGSWIM-38	SWIM services delivery to AGDLGMS	IS-0305 ; TS-0106
AGSWIM-39	Transmission of the air derived data to the FDP of the responsible ATSU	IS-0302 ; CM-0807
AGSWIM-41	AGDLGMS in support to provide extended OTIS to the aircraft	no direct link to any OI Step
AGSWIM-42	Transmission of NOTAMs to the aircraft through AGDLGMS	AOM-0206
AGSWIM-43	AGDLGMS in support to provide weather information to the aircraft	no direct link to any OI Step
AGSWIM-44	Transmission by AGDLGMS of the airborne Weather Data to the meteo system for weather model improvement	IS-0501
AGSWIM-45	Transmission of CTA (initial and potential updates) to the aircraft through datalink	TS-0103
AGSWIM-46	Datalink supporting dialogues and exchanges for ASAS S&M	TS-0105
AGSWIM-47	Air-ground data communications service for surface information and guidance (D-SIG)	AUO-0401
AGSWIM-49	Air-ground datalink communications service for Aircraft derived data (ADS B ADD)	IS-0302 ; CM-0807
AGSWIM-51	Air-ground datalink communications service for arrival manager information delivery	TS-0103
AGSWIM-54	High integrity air-ground datalink communications service supporting different kind of applications	AUO-0302 ; AUO-0303 ; CM-0401 ; AOM-0206 ; IS-0303
AGSWIM-56	Basic air-ground datalink communications service supporting different kind of applications	AUO-0301 ; IS-0401
AGSWIM-57	Enhanced air-ground datalink communications service supporting different kind of applications	CM-0802 ; CM-0403 ; AUO-0703 ; AOM-0208 ; AOM-0303 ; AOM-0304

METEO

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
METEO-01	Integrates Weather information owned by ATM ground systems	no direct link to any OI Step
METEO-02	Integrates Weather information owned by aircraft	IS-0501
METEO-03	Provision of accurate weather information	no direct link to any OI Step

GROUND GROUND SWIM

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
GGSWIM-05	Definition of a new flight plan format to capture GAT, OAT/GAT and pure OAT flights.	AOM-0303 ; IS-0701 ; IS-0702 ; IS-0704
GGSWIM-06	ATM Information extended with the Common Flight Object	AUO-0302 ; AUO-0303 ; CM-0401 ; CM-0402 ; CM-0403 ; DCB-0103 ; CM-0405 ; IS-0305 ; IS-0703 ; IS-0707 ; IS-0708 ; SDM-0202
GGSWIM-07	Ground-ground data communications services for flight data	AUO-0302 ; AUO-0303 ; CM-0401 ; CM-0402 ; CM-0403 ; DCB-0103 ; IS-0305 ; IS-0703 ; IS-0707 ; IS-0708
GGSWIM-10	SWIM Supervision infrastructure.	IS-0705
GGSWIM-11	ATM Information based on a common Aeronautical Information Exchange Model (AIXM)	IS-0204 ; IS-0701 ; IS-0702 ; IS-0704
GGSWIM-12	ATM Information based on a common data exchange model for Airport Mapping (AMXM)	IS-0701 ; IS-0702 ; IS-0704
GGSWIM-13	ATM information based on a common data exchange model for MET (WXXM)	IS-0701 ; IS-0702 ; IS-0704
GGSWIM-14	ATM information based on a common data exchange model for Airport Network Information (ANXM)	IS-0701 ; IS-0702 ; IS-0704
GGSWIM-15	ATM information based on a common data exchange model for Environmental Information (ENXM)	IS-0701 ; IS-0702 ; IS-0704
GGSWIM-21	Common ATM Information Model Integrating all Data Sharing Domains	IS-0701 ; IS-0702 ; IS-0704 ; SDM-0202
GGSWIM-26	Ground-ground data communications services for demand & capacity information	AOM-0801 ; CM-0102 ; CM-0103 ; CM-0104 ; CM-0302 ; DCB-0201 ; DCB-0203 ; DCB-0206 ; DCB-0208 ; IS-0204
GGSWIM-29	Ground-ground data communications services for dissemination of meteo information	CM-0302 ; IS-0703 ; IS-0707 ; IS-0708
GGSWIM-35	Ground-ground data communications services for ATFCM	DCB-0102 ; DCB-0205 ; DCB-0208 ; DCB-0303 ; DCB-0304 ; DCB-0305 ; AOM-0304
GGSWIM-47	ATM Information based on a common data exchange model for Capacity and Demand data.	IS-0702
GGSWIM-48	ATM Information based on a common data exchange model for ATFCM Scenario data	CM-0405 ; IS-0702 ; SDM-0202
GGSWIM-49	Ground-ground data communications services for airspace reservation/availability	AOM-0202
GGSWIM-50	Ground-ground data communications services for flight plan filing and exchange (e.g. AMHS)	IS-0102
GGSWIM-51	Ground-ground multiservice data communications	AOM-0206 ; CM-0201 ; DCB-0102 ; DCB-0103 ; AOM-0303

GROUND GROUND SWIM (cont'd)

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
GGSWIM-52	Ground-ground data communications services for aeronautical information	IS-0204 ; CM-0405 ; SDM-0202
GGSWIM-53	A common Aeronautical Information Conceptual Model (AICM).	IS-0203 ; CM-0405 ; IS-0702
GGSWIM-54	Definition of interface between AOC and AFTCM/ATC for provision of additional flight data	IS-0301
GGSWIM-55	Ground SWIM network	IS-0706 ; SDM-0201 ; SDM-0202
GGSWIM-56	Common exchange model for flight information	IS-0702 ; IS-0704
GGSWIM-57	Ground-ground data communications services for ATFCM using SWIM network	DCB-0103 ; DCB-0208

ALL

Architecture System Enabler Code	Architecture System Enabler Title	Supported Operational Improvement Step Codes
ALL-1	Technical Supervision	no direct link to any OI Step
ALL-2	Secure ATMS System infrastructure	no direct link to any OI Step

10.6.3 CNS Technology Enablers

Table 18 below captures the CNS Technology enablers per IP, the OI Steps from which they are derived, and their link with the LoC; more detailed information is provided in Task 2.5 DLT [Ref 18] where all CNS technology enablers are systematically presented in the form of:

- description;
- link with OI steps (providing justification for the concept);
- status/maturity;
- outline roadmap;
- risks/constraints.

IP1 COMMUNICATION ENABLERS					
Enablers	**Technology**	**IOC**	**Link to concept**	**LoC**	**Comment**
CTE-C2a	A-G existing VDL2 datalink	2007	AOM-0208; AOM-0702; AOM-0704; AUO-0301; AUO-0302; AUO-0303; AUO-0603; AUO-0703; CM-0401; CM-0402; CM-0601; CM-0602; CM-0603; CM-0702; DCB-0304; IS-0302; IS-0303; IS-0305; TS-0103; TS-0105; TS-0301; TS-0302; IS-0706	1, 5, 8, 10	
CTE-C3	Military datalink accommodation	2012	IS-0706; IS-0709; AOM-0304	1, 2	
CTE-C4a	Airport Datalinks (WIFI, EDGE, GPRS, ...)	2007	IS-0101; IS-0201	1	802.11 or 802.16 for AOC useage
CTE-C5	8.33 kHz Voice communications Air-Ground	2007	Needed for all voice coms to avoid saturation. AUO-0301	5	Mature technology.
CTE-C6	SATCOM Voice for ATC	2011	improve performance of voice service	5	Mature technology enabler, but standardisation required
CTE-C8	VoIP for ground telephony	2010	improve performance and cost-effectiveness of voice service	5	Mature technology
CTE-C10	AMHS	2007	IS-0101; IS-0102; IS-0201; IS-0202; IS-0204; IS-0301; IS-0702; DCB-0201; DCB-0203; DCB-0302	1, 2, 3, 4, 5	mature technology, ICAO standard, enablers civil/mil coordination
CTE-C11a	PENS	2010	DCB-0301; IS-0204; IS-0301; IS-0702	1, 3, 4, 5, 6, 7	PENS, European Backbone
IP1 NAVIGATION ENABLERS					
Enabler	**Technology**	**IOC**	**Link to concept**	**LoC**	Comment
CTE-N2	SBAS	2008	AUO-0602; AUO-0603; AO-0203; AOM-0602	10, 2	required by BA and GA for airport access
CTE-N3a	ABAS	2007	AOM-0601; AOM-0602; AOM-0702; AOM-0703; AOM-0704	2	
CTE-N4a	GBAS Cat 1	2009	AUO-0603	10	using L1 only, supports inital CAT2/3 ops in some environments, using CAT1 ground
CTE-N4b	GBAS Cat 2-3 initial, GPS L1 based	2011	AO-0206; AO-0505; AUO-0404	9	
CTE-N5a	DME / DME	2010	AOM-0602	10	update of DME inertial
CTE-N6	ILS	2007	AO-0503	10	
CTE-N7	MLS	2007	AO-0504	10	mature technology, option for airports/users. Provides higher capacity than ILS - available before GBAS
CTE-N9a	HUD / EVS	2011	AUO-0403	10	
CTE-N10	Moving Map for airport surface navigation	2007	AUO-0602	10	
CTE-N11	New lighting technology	2012	improved environmental and cost-effectiveness performance	10	
IP1 SURVEILLANCE ENABLERS					
Enabler	**Technology**	**IOC**	**Link to concept**	**LoC**	**Comment**
CTE-S1	ADS-B Out 1090 Step1	2008	AO-0102; AUO-0402; AUO-0502; AUO-0603; AUO-0605; CM-0203	8, 9, 10	ADS-B Out 1090 to support NRA, RAD trials. (DO-260)
CTE-S2a	ADS-B In/Out 1090 (260) to support ATSAW, ITP (Step 2)	2010	AO-0403; AUO-0401; AUO-0402; AUO-0502;AUO-0603; AUO-0605	8, 10	ADS-B In/Out supports ATSAW and spacing ("DO-260A+"). Some initial "UPS" type ops could be available before, if neccessary
CTE-S4a	Independent Non-cooperative Surveillance (PSR)	2007	AO-0102; AO-0201; AO-0202; AO-0402; AUO-0605; CM-0203; CM-0801; AO-0104	6, 9, 10	Mature technology
CTE-S5	Independent Cooperative Surveillance sensors (SSR, WAM)	2007	AO-0102; AO-0201; AO-0402; AUO-0605; CM-0203; CM-0801	6, 8, 10	SSR Mode S or WAM. ANSP choice. No impact on users (fitted with Mode S or ADS-B Out)
CTE-S7a	Ground weather radar (existing technology)	2007	AO-0304	10	
CTE-S9	Airport Surface Surveillance (SMR, MLAT or ADS-B)	2007	AO-0102; AO-0201; AO-0402; AUO-0603; AUO-0605; CM-0203; CM-0801; A0-0205; AUO-0602; AO-0104	6, 9,10	ASD-B (small airports). MLAT large airports
CTE-S10	Low Power SSR Transponder (LPST).	2011	AO-0104; AO-0204; AO-0205; AO-0206; CM-0406; CM-0601	6,10	For GA. If requirements early enough
CTE-S11a	Upgrades to TCAS, TAWS etc	2008	CM-0802; CM-0803	9	

Table 18 : Technology Enablers

Enabler	Technology	IOC	Rationale (supported OI step)	LoC	Comment
IP2 COMMUNICATION ENABLERS					
CTE-C2b	Enhanced VDL2 AG datalink (Common network protocol ATN+ or IP+ based)	2018	IS-0709; IS-0710	1	
CTE-C4b	New Airport Datalink	2015	AUO-0302; AUO-0303; AO-0104	5, 7, 10	new 802.16 aeronautical standard
CTE-C9	VoIP for ground segment of airground voice	2013	improve performance and cost-effectiveness of voice service	5	For Ground segment of A-G datalink
CTE-C11b	Ground IP Network	2013	DCB-0203; AUO-0203; DCB-0103; CM-0401; CM-0402; TS-0302; TS-0304; TS-0306; AOM-0208	1, 3, 4, 5, 6, 7	National subnetworks
IP2 NAVIGATION ENABLERS					
Enabler	**Technology**	**IOC**	**Link to concept**	**LoC**	**Comment**
CTE-N1a	Multi constellation GNSS	2015	AUO-0604	10	
CTE-N1b	Multi constellation GNSS (Safety of Life)	2017	AUO-0604	10	If necessary, update to include SoL services.
CTE-N3c	ABAS / RAIM	2015	AOM-0704	2	update to include dual constellations
CTE-N3b	ABAS / INS	2015	AOM-0206; AOM-0704	2	
CTE-N4c	GBAS Cat 2-3 universal, Galileo and GPS L5 based	2018	AUO-0404	10	
CTE-N4d	GBAS airport surface	2018	AUO-0604	10	
CTE-N5b	DME / DME inertial	2013	improved performances	2, 10	update of DME inertial
IP2 SURVEILLANCE ENABLERS					
Enabler	**Technology**	**IOC**	**Link to concept**	**LoC**	**Comment**
CTE-S2b	ADS-B 1090 in/out (260A) to support full spacing e.g S&M (step3)	2013	CM-0701; TS-0105	8, 9	ADS-B Out 1090 to support initial spacing ("DO-260")
CTE-S2c	ADS-B 1090 in/out (260A+) to support initial separation (step 4)	2018	CM-0701	8, 9	ADS-B Out 1090 to support separation ("DO-260A++")
CTE-S4b	Independent Non-cooperative Surveillance (MSPSR)	2015	CM-0406	5, 6, 7	
CTE-S6	Ground Wake vortex radar	2013	AO-0304	10	cheaper form of weather radar for smaller airports
CTE-S7b	Ground weather radar (next generation)	2013	improve performances and cost-effectiveness of the PSR surveillance	10	cheaper form of weather radar for smaller airports
CTE-S8a	Airborne wake vortex detection	2013	AO-0304	10	
IP3 COMMUNICATION ENABLERS					
Enabler	**Technology**	**IOC**	**Link to concept**	**LoC**	**Comment**
CTE-C1	High performance Air-Ground Datalink.	2020	AOM-0208; CM-0501; CM-0704	8	terrestrial & SAT component
CTE-C12	Air to Air Datalink	2020	CM-0704; IS-0710; IS-0406	8	
CTE-C7	Digital Air-Ground voice	2025	improve performance and cost-effectiveness of voice service	5	studies into voice saturation needed to determin if needed.
IP3 NAVIGATION ENABLERS					
Enabler	**Technology**	**IOC**	**Link to concept**	**LoC**	**Comment**
CTE-N9b	HUD / SVS	2020	AUO-0404	10	higher performance than EVS
IP3 SURVEILLANCE ENABLERS					
Enabler	**Technology**	**IOC**	**Link to concept**	**LoC**	**Comment**
CTE-S3	New ADS-B link	2025	AUO-0504; CM-0702; CM-0704	8	If new technology needed. Developed in conjunction with CTE-C1/C12
CTE-S8b	Airborne wake vortex detection (Higher performance)	2020	AUO-0504; IS-0406	8	higher performance for spacing
CTE-S11b	New Collision Avoidance Systems	2013	CM-0804; CM-0806	9	requirements unknown

Table 18 : Technology Enablers (cont'd)

10.6.4 Human Factors Enablers

This Annex includes the families of Human Factors enablers that need to be considered for all OI Steps and from which enablers specific to each OI Step can be identified

Human Factors Enabler	Description
Ergonomic adaptations of working environment	This covers the ergonomics of the physical environment (e.g. cockpit, control tower) in which the human operator works.
Adaptation of procedures (nominal and non-nominal situations)	System changes (e.g. increased automation) will necessarily require adaptation of procedures, both for the nominal situation, and especially also for the non-nominal situations.
Acceptable task demand and complexity	The task demand and task complexity should stay within acceptable limits (not too high and not too low).
Manage changes in team interaction	This covers changes in for example leadership and team dynamics, cultural differences and interpersonal conflicts.
Manage human performance consequences of changes in communication.	SWIM and CDM processes will lead to the exchange of new kinds of information between actors. New actors will be involved in this process (e.g. ATSEPS). Human performance issues with the introduction of digital data-link need solving.
Usable and acceptable Human Machine Interaction	Displays, input devices, output devices and alerts are to be designed according to human factors principles and thus meet usability and acceptability requirements of the human operators.
Optimised automation support (nominal and non-nominal situations)	Educated decision on which ATM functions should be clustered together and can best be assigned to human actors, automation or combinations of both (based on automation strategy). Roles and responsibilities are to be clearly assigned to the human and the system and the manner in which they are expected to collaborate is to be made clear, both in nominal situations and in non-nominal situations (e.g. during automation degradation).

10.7 Annex VII: IP1 Supporting Initiatives

The following tables describe the allocation of the ongoing European initiatives to the OI Steps.

OI Step Id	LoC	OI Step Title	DMEAN	Air Traffic Flow and Capacity Management	EUROCONTROL AIM Activities	EUROCONTROL CHAIN Programme	Airport CDM (A-CDM)	EUROCONTROL LINK 2000+ Programme	SLOT Management/Alignment	ACE	EUROCONTROL ANT and ANT Sub-Groups	Functional Airspace Blocks	Eurocontrol 8.33 Programme	NEASCOG	Cost-Effectiveness Planning Programme	EATM Human Resources Programme	EU Social dialogue	Advanced Flight Data Processing System	Eurocontrol FASTI Programme	EUROCONTROL TMA2010+ Initiatives	EUROCONTROL MODE S / ACAS	CDA/A-CDA/Green Approach/	EAPPLB	OPTIMAL	EUROCONTROL CASCADE Programme	AMAN/DMAN/Spacing Tools	RNAV Implementation in TMA
IS-0201	L1	Integrated Pre-Flight Briefing	☑	☑	☑	☑																					
IS-0203	L1	Harmonised Aeronautical Information through Common Data Model		☑	☑	☑																					
DCB-0302	L1	Collaborative Management of Flight Updates	☑	☑			☑																				
IS-0101	L1	Improved Flight Plan Consistency Pre-Departure	☑	☑																							
IS-0204	L1	Facilitated Aeronautical Data Exchanges through Digitalised Information	☑		☑	☑																					
IS-0102	L1	Improved Management of Flight Plan After Departure	☑	☑																							
IS-0701	L1	SWIM - baseline an initial common information model based on existing and consistent standards		☑	☑		☑																				
IS-0401	L1	Automatic Terminal Information Service Provision through Use of Datalink						☑																			
IS-0402	L1	Extended Operational Terminal Information Service Provision Using Datalink						☑																			
IS-0407	L1	Interoperability between AOC and Weather Information Systems					☑																				
IS-0202	L1	Improved Supply Chain for Aeronautical Data through Common Quality Measures		☑	☑	☑																					
DCB-0301	L1	Improved Consistency between Airport Slots, Flight Plans and ATFM Slots	☑	☑			☑		☑	☑																	
AOM-0101	L2	Harmonised ICAO Airspace Classification at FL195 and below									☑																
DCB-0203	L2	Enhanced ASM/ATFCM Coordinated Process	☑	☑																							
AOM-0201	L2	Moving Airspace Management Into Day of Operation	☑																								
AOM-0203	L2	Cross-Border Operations Facilitated through Collaborative Airspace Planning with Neighbours	☑									☑															
AOM-0205	L2	Modular Temporary Airspace Structures and Reserved Areas	☑									☑															
AOM-0202	L2	Enhanced Real-time Civil-Military Coordination of Airspace Utilisation	☑									☑															

AOM-0301	L2	Harmonised EUROCONTROL ECAC Area Rules for OAT-IFR and GAT Interface	☑																								
AOM-0303	L2	Pan-European OAT Transit System	☑																								
AOM-0302	L2	Harmonised OAT Flight Planning	☑																								
AOM-0401	L2	Multiple Route Options & Airspace Organisation Scenarios	☑	☑								☑	☑														
AOM-0402	L2	Further Optimisation of Route Network	☑									☑	☑														
DCB-0201	L3	Interactive Network Capacity Planning	☑	☑						☑																	
DCB-0101	L3	Enhanced Seasonal NOP Elaboration	☑	☑						☑																	
DCB-0102	L3	Interactive Rolling NOP based on ATFCM Network Information Management System	☑	☑						☑																	
AUO-0101	L3	Slot Swapping	☑	☑																							
AUO-0201	L3	Enhanced Flight Plan Filing Facilitation	☑	☑																							
DCB-0205	L4	Short Term ATFCM Measures	☑	☑																							
DCB-0206	L4	Coordinated Network Management Operations Extended Within Day of Operation	☑	☑																							
DCB-0207	L4	Management of Critical Events	☑	☑										☑													
DCB-0204	L4	ATFCM Scenarios	☑	☑																							
DCB-0303	L4	Improved Operations at Airport in Adverse Conditions Using ATFCM Techniques	☑	☑			☑			☑																	
SDM-0103	L4	Sustainability Performance Management of the ATM Network	☑	☑																							
SDM-0101	L4	Network Performance Assessment	☑	☑											☑												
SDM-0102	L4	Civil-Military Cooperation Performance Assessment	☑																								
IS-0301	L1	Interoperability between AOC and ATM Systems (FDPS)	☑																								
AOM-0801	L2	Flexible Sectorisation Management	☑	☑								☑				☑	☑										
AOM-0802	L2	Modular Sectorisation Adapted to Variations in Traffic Flows	☑									☑	☑			☑	☑										
CM-0102	L2	Automated Support for Dynamic Sectorisation and Dynamic Constraint Management																☑	☑								
AUO-0301	L5	Voice Controller-Pilot Communications (En Route) Complemented by Data Link						☑										☑	☑								
AUO-0304	L5	Initiating Optimal Trajectories through Cruise-Climb Techniques																									
CM-0301	L5	Sector Team Operations Adapted to New Roles for Tactical and Planning Controllers										☑				☑	☑	☑	☑								
CM-0202	L6	Automated Assistance to ATC Planning for Preventing Conflicts in En Route Airspace																	☑	☑	☑						
CM-0203	L6	Automated Flight Conformance Monitoring																☑	☑				☑				

OI Step Id	LoC	OI Step Title	DMEAN	Air Traffic Flow and Capacity Management	EUROCONTROL AIM Activities	EUROCONTROL CHAIN Programme	Airport CDM (A-CDM)	EUROCONTROL LINK 2000+ Programme	SLOT Management/Alignment	ACE	EUROCONTROL ANT and ANT Sub-Groups	Functional Airspace Blocks	Eurocontrol 8.33 Programme	NEASCOG	Cost-Effectiveness Planning Programme	EATM Human Resources Programme	EU Social dialogue	Advanced Flight Data Processing System	Eurocontrol FASTI Programme	EUROCONTROL TMA2010+ Initiatives	EUROCONTROL MODE S / ACAS	CDA/A-CDA/Green Approach/	EAPPLB	OPTIMAL	EUROCONTROL CASCADE Programme	AMAN/DMAN/Spacing Tools	RNAV Implementation in TMA
AUO-0503	L8	In-trail Procedure in Oceanic Airspace (ATSA-ITP)																							☑		
CM-0101	L5	Automated Support for Traffic Load (Density) Management		☑														☑	☑								
CM-0201	L5	Automated Assistance to Controller for Seamless Coordination, Transfer and Dialogue																☑	☑								
TS-0305	L7	Arrival Management Extended to En Route Airspace																		☑						☑	
AUO-0402	L8	Air Traffic Situational Awareness (ATSAW) during Flight Operations																							☑		
CM-0801	L9	Ground Based Safety Nets (TMA, En Route)																☑	☑	☑							
CM-0803	L9	Enhanced ACAS through Use of Autopilot or Flight Director																			☑						
IS-0301	L1	Interoperability between AOC and ATM Systems (FDPS)	☑																								
AOM-0701	L2	Continuous Descent Approach (CDA)																		☑		☑		☑			☑
AOM-0601	L2	Terminal Airspace Organisation Adapted through Use of Best Practice, PRNAV and FUA Where Suitable	☑																	☑							☑
AOM-0703	L2	Continuous Climb Departure																									
AOM-0602	L2	Enhanced Terminal Route Design using P-RNAV Capability																		☑							☑
CM-0101	L5	Automated Support for Traffic Load (Density) Management		☑														☑	☑								
CM-0201	L5	Automated Assistance to Controller for Seamless Coordination, Transfer and Dialogue																☑	☑								
TS-0102	L7	Arrival Management Supporting TMA Improvements (incl. CDA, P-RNAV)																		☑						☑	
TS-0101	L7	Basic Arrival Management (AMAN)																		☑						☑	
TS-0301	L7	Integrated Arrival Departure Management for full traffic optimisation, including within the TMA airspace																		☑						☑	
TS-0305	L7	Arrival Management Extended to En Route Airspace																		☑						☑	

TS-0107	L8	ASAS Manually Controlled Sequencing and Merging																			☑					
AUO-0402	L8	Air Traffic Situational Awareness (ATSAW) during Flight Operations																						☑		
CM-0801	L9	Ground Based Safety Nets (TMA, En Route)															☑	☑	☑							
CM-0803	L9	Enhanced ACAS through Use of Autopilot or Flight Director																		☑						
AOM-0701	L2	Continuous Descent Approach (CDA)																	☑		☑		☑			☑
AOM-0703	L2	Continuous Climb Departure																								
TS-0101	L7	Basic Arrival Management (AMAN)																	☑						☑	
TS-0201	L7	Basic Departure Management (DMAN)																	☑						☑	
TS-0202	L7	Departure Management Synchronised with Pre-departure Sequencing																	☑						☑	
TS-0301	L7	Integrated Arrival Departure Management for full traffic optimisation, including within the TMA airspace																	☑						☑	
AUO-0401	L8	Air Traffic Situational Awareness (ATSAW) on the Airport Surface																		☑				☑		

OI Step Id	LoC	OI Step Title	DMEAN	Air Traffic Flow ans Capacity Management	Airport CDM (A-CDM)	EUROCONTROL LINK 2000+ Programme	SLOT Management / Alignment	ACE	Eurocontrol FASTI Programme	EUROCONTROL ANT and ANT Sub-Grouns	EUROCONTROL TMA2010+ Initiatives	EUROCONTROL MODE S / ACAS	CDA/A-CDA/Green Approach/Tailored Arrivals	European Action Plan for the Prevention of B	OPTIMAL	MAN/DMAN/Spacing Tools	RNAV Implementation in TMA	Visual contact approaches	EAPPRI	A-SMGCS – Levels I and II	PRM – Precision Radar Monitoring	SMAN – Surface Management Tool	European Safety Programme	Additional RETs/Entries and improved RWY crossings	AACG Recommendations for handling NLAs	Perimeter Taxiways	Brake to Vacate procedure and avionics	Effective Collaboration between operational stakeholders	Dependent and independent Parallel Instrument Arrivals	Enhanced Separation Techniques	CAPMAN – RWY Capacity Management Tool	Tailored Arrivals	IMAGINE	Noise Monitoring System and Flight Tracking	Introduce an "Air Quality Monitoring System"	Optimised fuel consumption and emissions in the ground segment	Better relations to neighbours
AUO-0502	L10	Enhanced Visual Separation on Approach (ATSA-VSA)											☑																								
AUO-0501	L10	Visual Contact Approaches When Appropriate Visual Conditions Prevail																☑																				
AUO-0502	L10	Enhanced Visual Separation on Approach (ATSA-VSA)											☑																								
AUO-0501	L10	Visual Contact Approaches When Appropriate Visual Conditions Prevail																☑																				
AO-0201	L10	Enhanced Ground Controller Situational Awareness in all Weather Conditions			☑														☑	☑	☑	☑															
AO-0102	L10	Automated Alerting of Controller in Case of Runway Incursion or Intrusion into Restricted Areas																	☑	☑		☑	☑														
AO-0101	L10	Reduced Risk of Runway Incursions through Improved Procedures and Best Practices on the Ground																	☑	☑		☑	☑	☑	☑												
AO-0103	L10	Improved Runway-Taxiway Lay-out, Signage and Markings to Prevent Runway Incursions																	☑				☑	☑	☑	☑	☑										
AO-0202	L10	Detection of FOD (Foreign Object Debris) on the Airport Surface																	☑	☑	☑	☑			☑												
AO-0203	L10	Guidance Assistance to Airport Vehicle Driver																		☑		☑															
AUO-0603	L10	Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing																	☑	☑		☑															
AUO-0602	L10	Guidance Assistance to Aircraft on the Airport Surface																	☑	☑		☑															
AO-0601	L10	Improved Turn-Around Process through Collaborative Decision Making				☑																															
AO-0602	L10	Collaborative Pre-departure Sequencing				☑										☑						☑						☑									

AO-0501	L10	Improved Operations in Adverse Conditions through Airport Collaborative Decision Making			☑																																
DCB-0304	L10	Airport CDM extended to Regional Airports	☑	☑	☑																																
AO-0603	L10	Improved De-icing Operation through Collaborative Decision Making			☑																																
AO-0403	L10	Optimised Dependent Parallel Operations						☑								☑					☑								☑								
AO-0402	L10	Interlaced Take-Off and Landing						☑								☑														☑	☑						
AUO-0701	L10	Use of Runway Occupancy Time (ROT) Reduction Techniques						☑								☑											☑				☑						
AUO-0702	L10	Brake to Vacate (BTV) Procedure																									☑										
AO-0302	L10	Time Based Separation for Arrivals								☑						☑														☑	☑	☑					
AO-0301	L10	Crosswind Reduced Separations for Departures and Arrivals						☑		☑																											
AO-0305	L10	Additional Rapid Exit Taxiways (RET) and Entries																						☑													
AO-0303	L10	Fixed Reduced Separations based on Wake Vortex Prediction								☑						☑														☑	☑						
AO-0504	L10	Improved Low Visibility Runway Operations Using MLS								☑																											
AO-0502	L10	Improved Operations in Low Visibility Conditions through Enhanced ATC Procedures								☑											☑																
AO-0503	L10	Reduced ILS Sensitive and Critical Areas								☑																											
AO-0701	L10	Effective Collaboration between ATM Stakeholders Supported by Environmental Management Systems			☑																							☑					☑	☑	☑		
AUO-0801	L10	Environmental Restrictions Accommodated in the Earliest Phase of Flight Planning											☑															☑									
AO-0702	L10	Improved Relations to Neighbours																															☑	☑	☑	☑	☑
AO-0703	L10	Noise Management to Limit Exposure to Noise on the Ground											☑		☑													☑					☑	☑		☑	☑
AO-0704	L10	Optimised Design and Procedures for Airport manoeuvring Areas to Reduce Gaseous Emissions and Noise Disturbance											☑		☑													☑						☑	☑	☑	☑
AO-0705	L10	Reduced Water Pollution																										☑									☑
AO-0706	L10	(Local) Monitoring of Environmental Performance																										☑						☑	☑		☑
AUO-0802	L10	Ground Movement Techniques to Reduce Gaseous Emissions and Noise Disturbance											☑															☑						☑	☑	☑	☑
AUO-0803	L10	Reduced Noise Footprint on Departure								☑			☑				☑											☑						☑			☑

10.8 Annex VIII – LFV Disagreement on Section 6.2

It is with disappointment that we can conclude that the issue of trying to solve the statement of disagreement regarding CNS technology enablers from D3 in WP 2.5 has failed.

Within SESAR it is important that technology selection is driven by genuine operational needs rather than by selecting technologies first, letting them dictate the availability of services.

Clear evidence on how the selected technology enablers described in D4 will deliver the agreed performance imposed by the operational concept with 4D trajectories and a net centric SWIM based ATM is still missing. D4 includes discrepancies between expected service deployment and availability of supporting CNS technologies. The potential of some available multimode solutions are ignored while the expectation on future unknown solutions is high introducing unacceptable levels of risks in SESAR.

As in D3 this has created a serious disagreement between us as partners in the Consortium. To give a few examples of the above are the lack of explanation of how existing and unknown technical enablers will deliver the envisaged net centric ATM architecture. The question on how security requirements will be met using existing and unknown technical enablers in the net centric ATM environment is disregarded or deferred. A clear view on how to mitigate the large operational gap of IP1 and IP2 between services foreseen and technology performance to support in the roadmap is missing. The "expert judgement" on VDLM4 still contains fundamental errors where facts have repeatedly been disregarded, claiming that available and existing technology without any evidence will prior to 2020 be sufficient to support cost efficient time critical applications including the use of 4DTrajectories. The ignored issue of regional variations of needs in Europe and differences between airspace users will cause an unacceptable distribution of costs amongst stakeholders.

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