SESAR JOINT UNDERTAKING

# European ATM **Master Plan**

Making Europe the most efficient and environmentally friendly sky to fly in the world

2024 EDITION

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# 1 Executive summary

Air traffic management (ATM) is a safety- and security-critical infrastructure for Europe, ensuring all types of **aircraft fly safely and as efficiently as possible**. Due to the cross-border nature of air transport and stringent safety and security requirements, ATM involves high levels of coordination, and interoperability among systems and stakeholders, including civil-military coordination.

**European ATM is at a crossroads**. The need for a fully scalable system that can adapt to fluctuating traffic demand, growing diversity of aircraft, and staff shortages, while addressing a rapidly evolving security landscape, is more pressing than ever. At the same time, ATM is impacted by and is impacting climate change, and is fully committed as part of the aviation industry to accelerate its transition to cleaner, more sustainable operations.

Balancing these complex demands while maintaining **Europe's competitive edge** in the global air transport system is a formidable challenge that no single ATM organisation or stakeholder can do alone. It requires a joined-up approach involving all stakeholders coming together to chart the way forward.

This is where the **European ATM Master Plan** comes in. It sets out the **vision and priorities** for the Digital European Sky, and for making Europe the most efficient and environmentally friendly sky to fly in the world by 2045.

A greater emphasis on digitalisation and the environment are the central focus of the plan, which outlines **five technological levers**, **a new service delivery model,** and **a supporting regulatory framework** as key enablers for accelerating this transformational change.

Commonly agreed by all European ATM stakeholders, the plan provides direction for investments and regulatory decision-making. It lays out **10 strategic deployment objectives** that need to be implemented by 2035. At the same time, the plan details **12 development priorities** needed to achieve the vision and to prepare for new challenges that are just over the horizon.

The **Single European Sky (SES)** initiative of the EU, including **SESAR (Single European Sky ATM Research)**, is a key driver of this transformation. SESAR defines, develops and deploys the innovative solutions that underpin the plan, in support of the goals of SES, as well as broader EU policies, such as the sustainable and smart mobility strategy[1]. This modernisation work is done in close coordination with the **European Union Aviation Safety Agency (EASA)** to ensure alignment between the Plan and the regulatory framework to accelerate deployment.

The transformation outlined in the plan holds **significant value for the European economy and society at large**. A more efficient and reliable air transport system will enhance connectivity, supporting economic growth and development across the continent. Improving the predictability of traffic and ensuring on-time arrivals and departures will help to significantly improve the overall passenger experience. It is estimated by 2050 that **every euro invested in deploying SESAR Solutions will result**

[1] European Commission, COM/2020/789, Sustainable and Smart Mobility Strategy – putting European transport on track for the future.

**in a return on investment for SESAR investors of at least EUR 17, increasing to EUR 53 taking into account the broader socio-economic benefits for Europe**.

In terms of sustainability, it is estimated that up to **400 million tonnes of CO2 could be saved by 2050**. This is equivalent to close to three years' worth of total CO2 emissions from aviation in Europe. Other environmental benefits of this transformation will include improved air quality, reduced noise pollution, and a more resilient and sustainable air transport system.

The European ATM Master Plan represents a **bold and ambitious vision for future air traffic management in Europe**. By addressing the challenges of **sustainability**, **scalability**, and **security**, and by placing a greater emphasis on **digitalisation** and **innovation**, we will create a system that meets the needs of our planet and our society, while achieving the highest safety levels. We will integrate aviation into the future multimodal transport system in Europe. The significant **economic and societal benefits** of this transformation make it imperative that **we act now**. With the commitment and collaboration of all stakeholders, we can achieve our goal of making Europe the most efficient and environmentally friendly sky to fly in the world and keeping Europe at the forefront of global air transport.



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## 2 Introduction

Air traffic management (ATM) is a safety- and security-critical infrastructure for Europe. It ensures that all types of aircraft fly safely and as efficiently as possible. ATM relies on a complex organisation of procedures and technologies. The cross-border nature of air transport and the need for safety and security mean that ATM requires a high level of coordination, harmonisation and interoperability between all stakeholders. This chapter provides context to the European ATM Master Plan, explaining the drivers behind this new edition, and how it is structured.

Air transport is in the spotlight because of environmental issues linked to the consumption of fossil fuels and the resulting emissions (CO2/non-CO2, local air quality, noise). On a global scale, aviation contributes approximately 2-3% of total anthropogenic CO2 emissions. However, as other industries transition to cleaner energy sources at a faster rate, the relative proportion of aviation emissions is anticipated to grow over the coming years. CO2 emissions for intra-European flights increased by nine million tonnes in 2023 (+12%) relative to 2022[2]. These emissions can be mitigated by ATM improvements. Indeed, the ATM-related benefit pool to tackle currently known CO2 inefficiencies is estimated at around 9.3%[3].

ATM itself is also impacted by climate change. Adverse weather caused by climate change is becoming a major cause of en-route capacity constraints in Europe, where the demand for mobility and air transport continues to grow. Commercial flights are expected to rise by 57% to approximately 16 million in 2050[4] even without considering the new forms of air mobility (e.g. innovative air mobility, higher airspace operations, etc). This underscores the sector's vitality, its crucial role in supporting economic and social activities across the continent, and the need for it to be able to adapt to minimise climate impacts.

From 2035 onwards, zero-emission aircraft (e.g. hydrogen and electric) will enter into service. However, compared to current aircraft, they are expected to carry fewer passengers, requiring more flights to move the same number of people. At the same time, the airspace will become more complex to manage with new types of air vehicles, such as drones, air taxis and high-altitude aircraft. This increasingly dense and complex mix of traffic will place extra pressure on ATM's capacity and its ability to provide the most environmentally efficient routes while maintaining safety as the paramount feature. At the same time, geopolitical crises, security threats, and natural events are all contributing to significant stress on air transport; today, the available airspace for civil aviation in Europe is reduced by around 20% due to the Russian war against Ukraine.

All these factors call for a more scalable, resilient, and efficient ATM system, leveraging digitalisation and automation to allow aircraft to fly optimal flight trajectories anywhere and anytime in the network. This system cannot be delivered by any single stakeholder or Member State alone since, by its very essence, aviation is international and requires common and coordinated action. It requires greater

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[2] EUROCONTROL, European aviation overview 2023
[3] EUROCONTROL, Performance review report 2023 - an assessment of air traffic management in Europe
[4] EUROCONTROL, Aviation outlook 2050: air traffic forecast shows aviation pathway to net zero CO2 emissions

interoperability, enhanced collaboration and synergies between all civil and military actors, as well as boosting cooperation and investment on breakthrough innovations.

## 2.1 EU policy framework supporting the modernisation of ATM

The EU has established the Single European Sky (SES)[5] framework aimed at harmonising and improving the performance of ATM through five pillars: economic regulation, airspace organisation/network management, technological innovation, safety, and the human dimension. These pillars are interrelated and interdependent. The technological pillar is the Single European Sky ATM Research (SESAR) project, an essential enabler for all other components of the SES.

The SES and SESAR are, in turn, key enablers for the EU sustainable and smart mobility strategy[6], which fosters the green and digital transition of the transport sector. The objective of this twin transition is to reduce emissions and facilitate connectivity in a seamless and resilient multimodal transport network. This is crucial for reaching climate neutrality by 2050 and a reduction of greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Recent measures include RefuelEU [7], which sets the framework for the introduction of sustainable aviation fuels (SAF), and an ambitious update of the EU emissions trading system (ETS) to complement the International Civil Aviation Organization (ICAO) carbon offsetting and reduction scheme for international aviation (CORSIA)[8].

SESAR aims to modernise ATM by developing and deploying technological and operational innovations in support of SES and EU policies. The SESAR project comprises three interrelated collaborative phases that **define**, **develop** and **deploy** innovative technological systems and operational procedures. Together, these phases constitute the ATM innovation cycle (see Figure 1) and align with the Digital European Sky defined by the European ATM Master Plan covering the full geographical scope of the ECAC area[9]. This ATM innovation cycle is designed to be flexible and adaptable to emerging operational needs and the latest scientific developments.

The EU supports innovation in aviation via its research programme Horizon Europe[10], establishing the Clean Aviation Joint Undertaking[11] to pave the way for the zero-emission aircraft of the future, and the SESAR Joint Undertaking[12] to develop and deliver the Digital European Sky. The EU is also supporting the deployment of SESAR in the form of Digital Sky Demonstrators and Common Projects[13] via its

[5] European Commission, Single European Sky
[6] European Commission, COM/2020/789, Sustainable and Smart Mobility Strategy – putting European transport on track for the future.
[7] Regulation (EU) 2023/2405 of the European Parliament and of the Council of 18 October 2023 on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation)
[8] ICAO, Carbon offsetting and reduction scheme for international aviation.
[9] European Civil Aviation Conference, ECAC brings together the widest grouping of Member States of any European organisation dealing with civil aviation, and is currently composed of 44 Member States
[10] Horizon Europe is the EU's key funding programme for research and innovation
[11] Clean Aviation Joint Undertaking
[12] SESAR JU website
[13] Commission Implementing Regulation (EU) 2021/116


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infrastructure programme Connecting Europe Facility[14]. To coordinate the Common Projects, the EU has appointed a SESAR Deployment Manager[15].

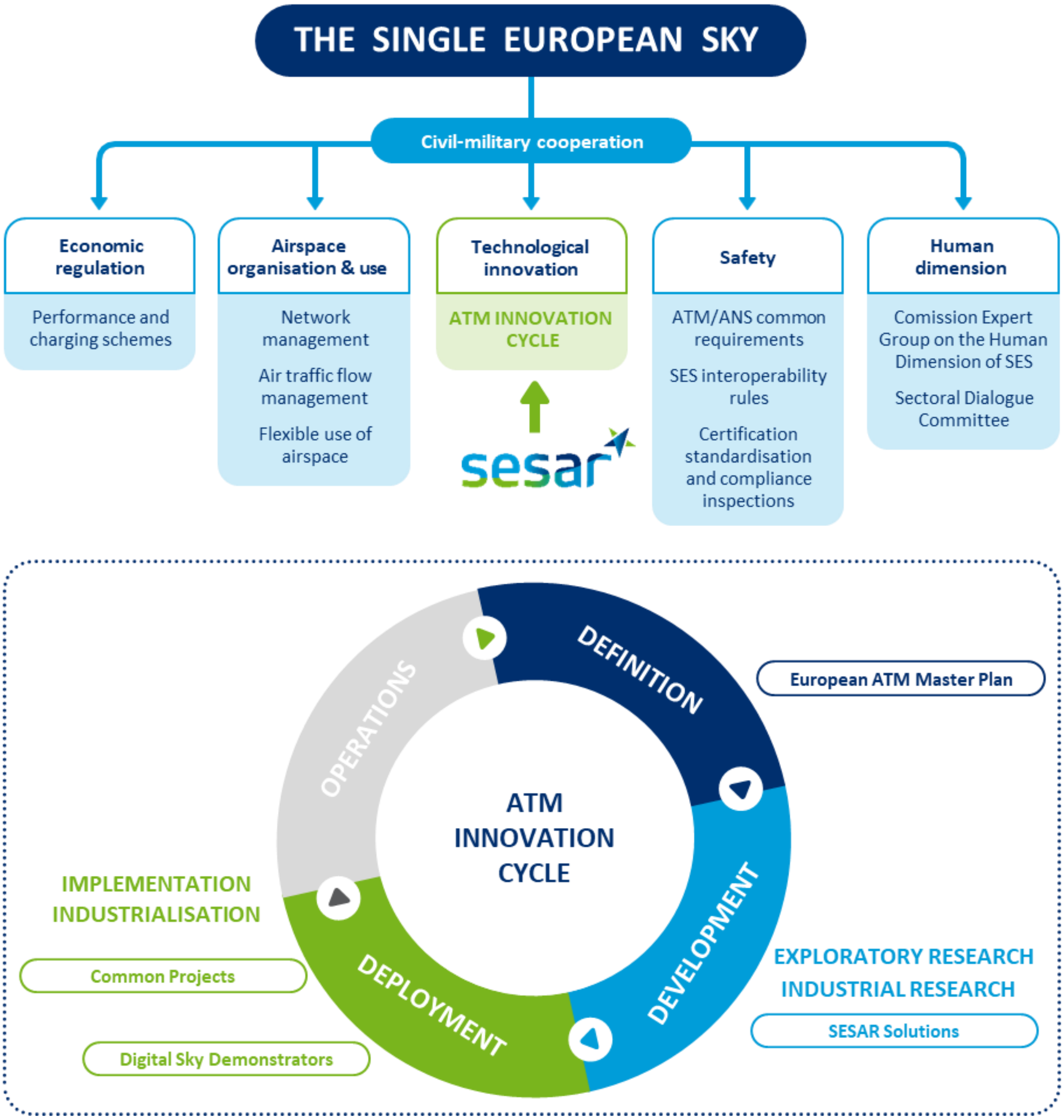


**Figure 1: ATM innovation cycle**

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14 Connecting Europe Facility is a key EU funding instrument to promote growth, jobs and competitiveness through infrastructure investment at European level.

15 SESAR Deployment Manager

ATM modernisation and close civil-military collaboration are also vital to the EU's future security and defence strategy in the air domain, ensuring the protection and effective use of the airspace[16].

The EU sees ATM modernisation as a global effort. Through cooperation with ICAO and partners in other world regions, Europe aims to maintain its leadership in aviation by shaping global standards, ensuring global interoperability and harmonisation, and asserting its technological and industrial leadership. These efforts are vital prerequisites for safe, secure, efficient, and sustainable global ATM.

## 2.2 Why is the European ATM Master Plan important?

The Master Plan sets out the vision for the Digital European Sky by 2045, the strategic deployment objectives to be implemented by 2035, and the development priorities for the coming years. It therefore plays an important role in directing investments towards innovation priorities and planning for regulatory decision-making on ATM modernisation[17]. Commonly agreed by all European ATM stakeholders, the Master Plan is the roadmap to make Europe the most efficient and environmentally friendly sky to fly in the world. It is the key driver for the entire ATM innovation cycle in Europe and an important input to other strategic European documents, such as the European Plan for Aviation Safety (EPAS) and the Network Strategy Plan (NSP) that will take due account of the Master Plan as foreseen by the EU regulatory framework.

## 2.3 Why this update and what are the key changes?

The Master Plan requires regular updates to reflect evolving needs or new constraints, in particular:

- making Europe the most efficient and environmentally friendly sky to fly in the world;
- integration of innovative air mobility (IAM[18]);
- integration of the next generation aircraft for zero/low emissions aviation by 2035;
- the new security and defence context in Europe;
- the need for the Master Plan to support wider and faster deployment to help drive future investments and the evolution of the supporting regulatory framework;
- stronger connection with the other pillars of the SES.

Representatives from air navigation service providers (ANSPs), airspace users, airports, ground and airborne manufacturing industries, research organisations, professional staff organisations and institutional partners collaborated intensively to develop the present edition.

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[16] See Council Conclusions on EU Security and Defence adopted on 27 May 2024

[17] Indeed, the Master Plan is also the main reference document for ATM modernisation efforts in a number of regulations (such as EASA, Network Functions, Common Projects, the Performance and Charging regulation)

[18] Commission Implementing Regulation (EU) 2024/1111 of 10 April 2024, "innovative air mobility (IAM) operations" refers to any operation with vertical take-off and landing (VTOL)-capable aircraft in congested and non-congested areas.

## 2.4 What's in the Master Plan

**The vision**: describes where we want to be as a sector by 2045, our performance ambition, and the levers that will bring about the transformation.

**Roll-out:** provides the current state of play in terms of development and deployment, and the timeline for the full roll-out of the vision in four phases (A-D).

**Deployment priorities:** details the new strategic deployment objectives (SDOs) to ensure the relevant SESAR Solutions are deployed, including a new service delivery model.

**Development priorities:** describes the industrial and exploratory research activities required for delivering solutions in line with the vision and performance ambition.

**Benefits, investment needs and risks:** outlines the expected benefits, (capacity, fuel, CO2, punctuality, cost-efficiency), the investment needs and associated risks and mitigations across the ECAC area, as well as what that means for Europe's economy and citizens.

**Roadmaps**: provide timelines for the development and deployment activities that have been prioritised for key areas (e.g. trajectory-based operations (TBO), communication, navigation and surveillance (CNS), civil-military, etc.). These can be found in the appendices.

# 3 The vision

This chapter sets out the vision for 2045: to make Europe the most efficient and environmentally friendly sky to fly in the world, describing what this might look like in section 3.1. Sections 3.2 to 3.6 detail the performance ambitions that drive this vision and show how an even stronger emphasis on digitalisation is the only way to achieve it.

## 3.1 Digital European Sky: making Europe the most efficient and environmentally friendly sky to fly in the world

It's 2045 and European air traffic management is fully integrated into a multimodal transport system including innovative air mobility solutions (e.g. air taxis), enabling passengers to move seamlessly door to door, safely reaching their destination on time and with the lowest environmental footprint possible. All flights/missions (crewed or uncrewed) operate in a way that maximises, to the fullest extent, aircraft capabilities to reduce the overall climate impact of aviation (CO2 and non-CO2). Air traffic management processes and services optimise each flight trajectory considering the individual performance characteristics of each aircraft, user preferences, real-time traffic, local circumstances and meteorological conditions throughout the network. Trajectory optimisation is systematic, continuous and extremely precise. Potential conflicts between trajectories or traffic bottlenecks are resolved much earlier than in the past, bringing safety benefits. Passengers know that when they take a flight their environmental footprint will be as low as it can be, and that there will be no time wasted in the air or on the ground during the journey.

This transformation is possible thanks to the implementation of a new service delivery model (service-oriented and cloud-based) in which service providers can dynamically and collaboratively scale capacity up or down in line with demand by all airspace users. These capacity adjustments are implemented in real time and ensure optimal and efficient dual (both civil and military) use of resources at any moment across the network (airspace, data, infrastructure and human-machine teaming). The continuous optimisation of every flight/mission from gate to gate is systematically guaranteed thanks to high connectivity between air-ground and ground-ground components. Each aircraft[19] is continuously connected and sharing its trajectory with a highly automated traffic management system (one single trajectory reference is agreed and shared across all involved actors on the ground and in the air). For certain phases of flight, the system is fully automated and able to handle both nominal and non-nominal situations.

In this new environment, the role of the human has significantly evolved, performing only the tasks that are too complex for automation to handle, teaming up with automation to address increasing traffic complexity. Voice communication is no longer the primary way of communicating as most routine tasks are managed through machine-to-machine applications. Large volumes of data flow securely and effectively across trusted users, enhancing the ability not only to optimise but also to

[19] Refers to civilian and State aircraft when interoperable, considering that the military operations aim first to fulfil their mission while ensuring civil aviation safety and considering environmental impact.


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detect, mitigate, and respond to new threats. In doing so, ATM always remains resilient and adaptable to evolving security dynamics.

The design and ability of the European air traffic management system to harness the full potential of digital technologies - enhancing safety, security and sustainability - has become so evident that, globally, all stakeholders decide to adopt this model.

## 3.2 Performance ambition

The vision is driven by the need to improve air traffic management in key performance areas (see Figure 2) in line with the SES performance framework[20]covering safety, environment, capacity, and cost-efficiency. These are complemented by additional performance areas described hereafter. While these performance areas are complementary and interdependent it is widely acknowledged that to achieve much higher levels of environmental performance, the ATM system must be designed to handle significantly more capacity than today.

Accordingly, the future ATM system should be designed to:

- Avoid any negative climate impact due to ATM on the ground and in the air (**sustainability**). As the challenge to achieve climate neutrality goes beyond CO2, the future design of the system should be able to adapt to minimise the total climate impact of aviation, while addressing noise and local air quality.
- Help transform the way **capacity** is delivered enabling service providers to dynamically and collaboratively scale capacity up or down (**scalability**) in line with all demand (both civil and military, crewed and uncrewed). These capacity adjustments should be implementable within minutes and ensure an optimal and cost-effective use of resources at any moment (airspace, data, infrastructure, and human-machine teaming).
- Further increase **safety** levels as traffic becomes more complex to manage.
- Ensure that data flows effectively and securely across trusted users (**security**).
- Address evolving security and defence needs, providing flexibility within a civil-military ATM environment (**security defence**)[21].
- Improve the overall **passenger experience**.

To achieve optimal performance, improvements should also be made in the following areas:

- **predictability:** ensures that flights follow expected patterns and schedules;

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[20] Commission Implementing Regulation (EU) No 409/2013
[21] See Civil-Military roadmap in appendix A5

- **punctuality:** relates to on-time departures and arrivals;
- **cost-efficiency:** refers to optimum resource allocation, productivity, and effective use of technologies and rationalisation (e.g. infrastructure).

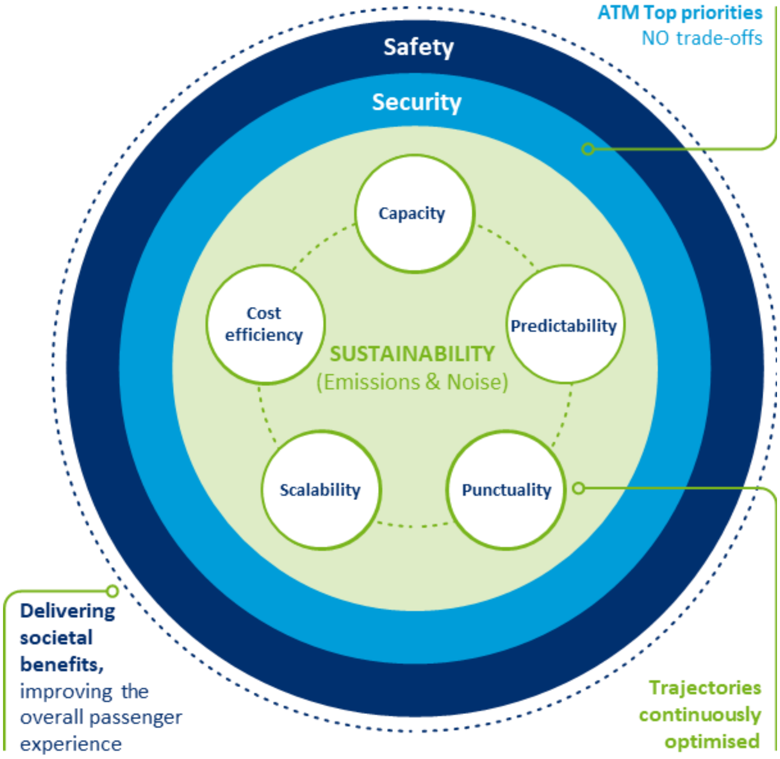


**Figure 2: Performance areas in support of overall passenger experience**

*See Chapter 7 for details of the expected performance benefits.*

## 3.3 Key transformation levers

Delivering the vision requires a strong focus on five key transformation levers (see Figure 3), as well as various tools, policy measures and the full collaboration of involved aviation stakeholders.

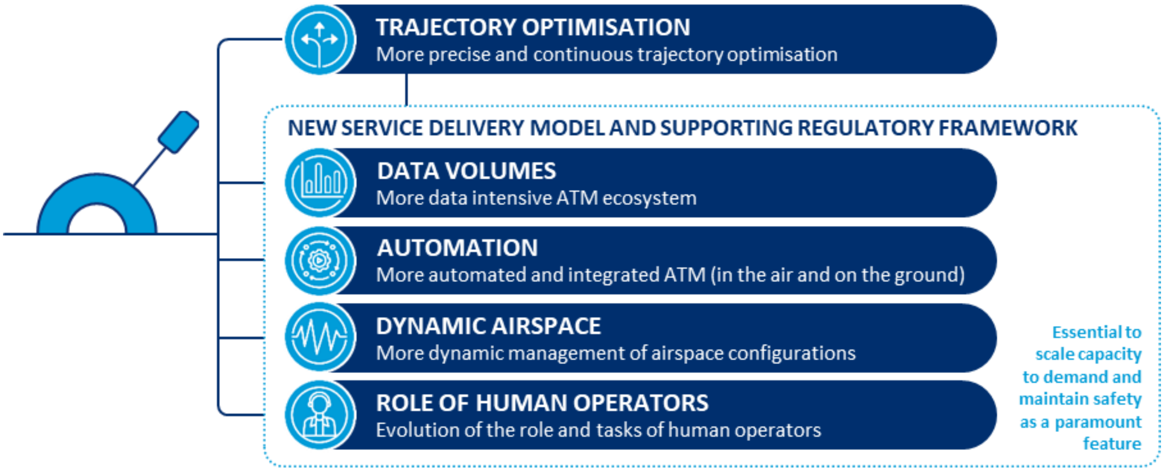


**Figure 3: Transformation levers**

### 3.3.1 Trajectory optimisation

The skies of tomorrow will be more diverse. Electric and hydrogen aircraft, large remotely piloted uncrewed and autonomous aircraft and high-altitude vehicles will enter the mix of operations, and the needs of the military will evolve. Guaranteeing systematic, continuous and precise optimisation of all aircraft trajectories throughout their life cycle, from planning to execution, from gate to gate, and within congested airspace is only possible with trajectory-based operations (TBO).

*See Appendix 1 for the TBO roadmap.*

### 3.3.2 Data volumes

Trajectory optimisation will require the collection and processing of large volumes of data, including individual aircraft performance characteristics, user preferences, real-time traffic information and meteorological conditions throughout the network. Increased real-time sharing of secure and trusted data will enable airborne and ground systems and actors to stay interconnected and share the same situational awareness.

### 3.3.3 Automation

Higher levels of automation will be introduced in the air and on the ground in the form of advanced digital tools (in some cases using artificial intelligence) to deal safely with complex decision-making while increasing capacity and environmental performance. This increased automation will require the teaming up of human operators and systems (i.e. human-machine teaming) to make best use of the large volumes of data to optimise trajectories.

*See Appendix A.3 which defines the automation roadmap, including a framework for categorisation of the levels of automation, ensuring alignment with the Artificial Intelligence (AI) Roadmap 2.0 from the European Union Aviation Safety Agency (EASA)[22].*

### 3.3.4 Dynamic airspace

Dynamic airspace enables a near real-time configuration of the airspace with human operators and systems teaming up to meet the needs of all airspace users (civil and military) and to manage capacity more efficiently.

For certain phases of flight, the system will be fully automated and able to handle both nominal and non-nominal situations. Airspace configuration, which today is designed to minimise complexity for human operators, will become more dynamic in near real-time.

### 3.3.5 Role and function of human operators

The teaming up of human operators and systems (i.e. human-machine teaming) will result in a gradual evolution of the role and skills of the human operator (e.g. air traffic controllers, air traffic safety electronic personnel, flight crew and operators, etc.), as well as the emergence of new roles.

*See Appendix A.3 for details of the automation roadmap and human-machine teaming.*

## 3.4 New service delivery model and supporting regulatory framework

Up until now, the ATM service delivery model has typically evolved every 10 to 20 years through major upgrades to the core ATM system. To facilitate deeper and faster changes across the five transformation levers, the model will be replaced by a data-driven, and cloud-based service-oriented architecture (SOA) for all operational environments.

The new service delivery model will enhance flexibility, scalability, resilience and innovation through a service-oriented design with open and standardised interfaces based on application programming interface technologies (API). This architecture will enable faster innovation, a higher degree of automation, and seamless integration of new services, through:

> The new service delivery model has already gained the support of ANSPs and manufacturers, as illustrated by the signing of a joint statement of commitment in June 2024.
>
> Read the statement

- open ATM patterns enabling the integration of components provided by various system providers to facilitate multi-vendor solutions using open platforms and interfaces;

[22] EASA Artificial Intelligence Roadmap 2.0, Human-centric approach to AI in aviation

- decoupling of service and infrastructure layers through cloud computing (including the various system components);
- a 'cloud-native architecture' of components with standardised and open interfaces that can be deployed on commodity cloud technologies.

The approach will also unlock data and enable quicker deployment of new features, advancing human-machine interactions, while ensuring interoperability in operations, airspace and technology across multiple service providers.

Furthermore, the transition to SOA will facilitate the development of a future-proof EASA regulatory framework for air traffic management in Europe. Rather than overhauling and certifying an entire system, this framework will enable the development or update of specific services to meet new standards. In doing so, it will be better aligned with best practices applied in other safety- and security-critical sectors.

### 3.4.1 Transition to the new service delivery model

The implementation of this new service delivery model represents a significant evolution for a typical area control centre (ACC), which today relies primarily on on-site infrastructure, consisting of servers with dedicated hardware and on-premises software deployments. The infrastructure of tomorrow's ACC will be far more versatile, incorporating both on-premises components and leveraging various cloud types (i.e. private, public, and hybrid). This new architecture will support multiple deployment models, including infrastructure as a service (IaaS), platform as a service (PaaS), software as a service (SaaS), and cloud-based business services (BaaS). This evolution will enable ACCs to scale their service delivery more efficiently, integrate new technologies seamlessly, and benefit from faster innovation. It will also increase resilience as it will enable the operation of services from different locations, and dynamically switch locations in case of local system disruptions, as illustrated in Figure 4:

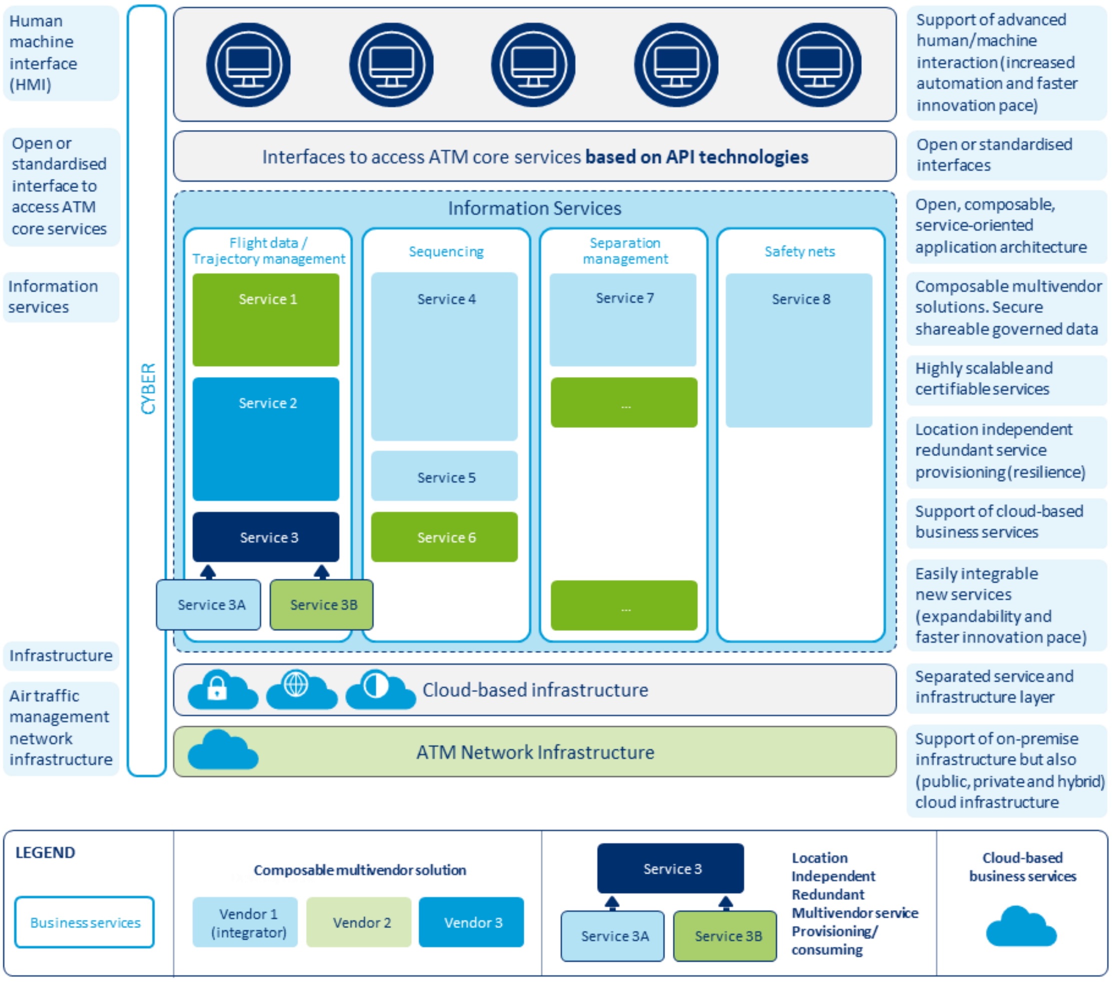


**Figure 4: Visualisation of the new service delivery model for a typical ACC**

*A breakdown of the different business services enabled by the new service delivery model for a typical ACC is available in Appendix 7.*

### 3.4.2 A layered approach for service delivery

The transition affects not just individual ACCs but the entire ATM system, focusing on three main service delivery layers: business, services, and infrastructure, as illustrated in Figure 5.

- The **business** layer captures business goals, processes, functions, and organisational arrangements of all concerned stakeholders including new entrants (i.e. airspace users, air traffic service providers, Network Manager, local airspace management and air traffic flow and capacity management cells, airport operators, uncrewed aircraft systems (UAS), innovative air mobility operators, vertiport operators and the related U-space service providers delivering drone/UAS traffic management). This layer also describes an open-market ecosystem for service delivery and the specific roles, responsibilities, and capabilities of each of these stakeholders.
- The **services** layer outlines the future service landscape in a data-driven architecture. This layer is organised along four service domains.





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- **End user** services cover air transport services for passengers and cargo, as well as interfaces with other modes of transport within an innovative multimodal mobility framework. These services aim to deliver a high-quality passenger experience.
- **Core services** refer to ATM and U-space air traffic management services and functionalities in a highly inclusive and dynamic airspace. These services are critical for improving safety, capacity, operational efficiency, and sustainability against a backdrop of traffic growth and increasing traffic complexity and diversity.
- **Information management** services provide accredited, quality-assured, and timely information exchange between all stakeholders to support the aforementioned core services on flight and flow, airspace, weather (MET) and environmental information. These services are essential to enabling scalable and flexible ATM and U-space service provision.
- **Support and utility** services provide access to communication, navigation and surveillance (CNS) services, system-wide information management (SWIM) infrastructure, and information technology (IT) services (including cloud-based services). These services contribute to secure, resilient, and cost-efficient operations. *See Appendix A.2 for the CNS Roadmap*.

- The **infrastructure** layer refers to technology and infrastructure systems, such as ground and airborne systems, MET sensors, CNS, SWIM, IT (including cloud) infrastructure, as well as ATM network infrastructure (such as pan-European network service (PENS) or more broadly speaking the network infrastructure provided by the designated Network Manager). This layer is closely interconnected with other layers in the architecture ensuring alignment between technology and business goals and providing the necessary resources. This layer contributes to reducing climate impact through virtualisation (e.g. virtual centres, remote towers), rationalisation, cloud-computing, and adoption of new power supply technologies. Within this layer, civil-military dual-use technologies, in particular in the domain of CNS, will enable greater interoperability, optimise the use of radio spectrum, and increase economic and environmental sustainability performance. *See Appendix A.2 for the CNS Roadmap.*

*Development and deployment activities have been carried out on the service delivery model. See Chapter 4, section 4.2 for the current state of play.*

*The architecture is part of priority setting for future development and deployment. More details are provided in Chapters 5 and 6, alongside roadmaps in the appendices.*

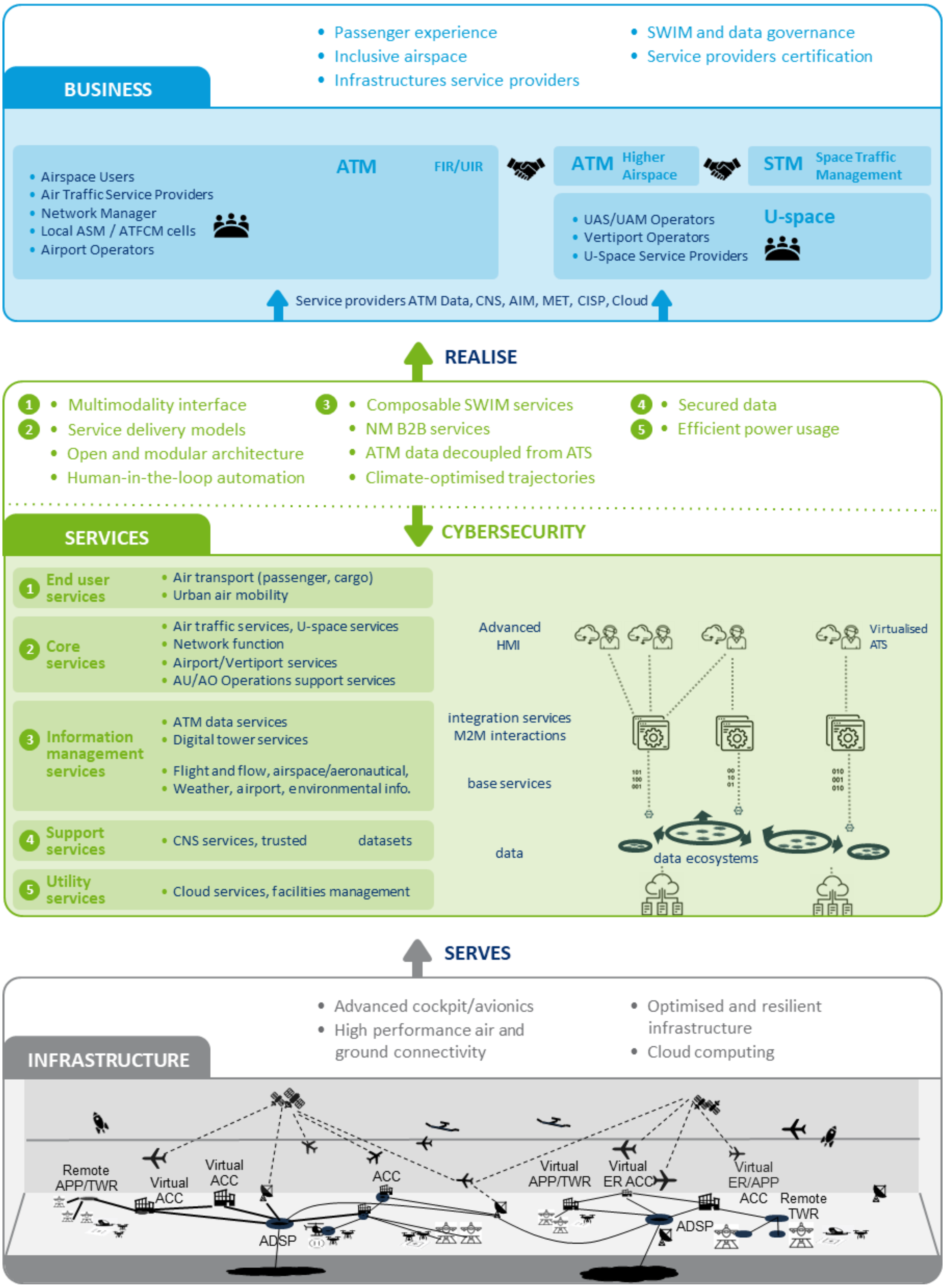


**Figure 5: Target enterprise architecture**





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## 3.5 Enabling new forms of mobility and use of the sky

As described in Section 3.1, the aim is to enable the market uptake of innovative air mobility (IAM[23]) solutions covering new forms of air mobility, initially through crewed vertical take-off and landing (VTOL) capable aircraft (VCA) operations.

Aligned with the European Commission's Drone Strategy 2.0[24], U-space 2.0 (see Figure 6) is the next evolution of U-space to fully integrate drone and ATM operations to support scaling up of innovative air mobility and services. U-space 2.0 enables increased uncrewed aircraft traffic and is a move towards the integration of crewed and uncrewed aircraft into the same airspace. Other airspace users such as general aviation (GA) and rotorcraft will obtain operational and safety benefits thanks to interoperability and seamless information sharing between all airspace users.

U-space foundation services (U1) and initial services (U2) are already being rolled out. Meanwhile, advanced services (U3) and full services (U4) require further development activities.

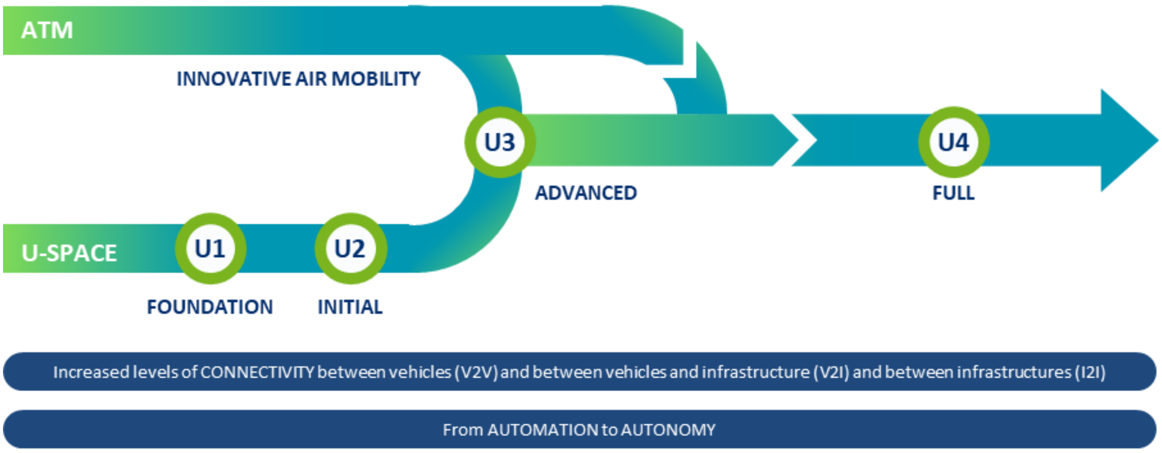


**Figure 6: U-space 2.0 in the context of the overall ATM evolution**

*See Appendix A.4 for the U-space 2.0 roadmap.*

[23] According to the European Drone Strategy 2.0, the concept of innovative air mobility ('IAM') is to accommodate operations with novel aircraft designs (that do not automatically fall under one of the known categories, but which have vertical take-off and landing (VTOL) capabilities for take-off and landing, specific (distributed) propulsion features, can be operated in uncrewed configuration, etc.), that are conceived to offer a new air mobility of people and cargo, in particular in congested (urban) areas, based on integrated air and ground-based infrastructure.

[24] COM (2022) 652, A Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Ecosystem in Europe

## 3.6 Collective action on security aspects enabling dual use of technologies

New threats demand greater resilience and an increased security posture in ATM. Recent geopolitical unrest, for example, has created a multifaceted crisis for European ATM, combining operational, economic, and logistical challenges that will continue to shape the landscape of European aviation for years to come. As a result, military airspace requirements are growing, as is the need for dual-use technologies that serve both civil and military applications, and that optimise the utilisation of the airspace for all. The vision therefore includes elements such as advanced flexible use of airspace and the integration of remotely piloted aircraft systems (RPAS), but also leverages dual-use technologies such as AI and advanced CNS systems to enhance both civil and military air traffic operations.

Airspace configuration and management will be fully dynamic to deliver the right capacity at the right time, supported by dynamic civil-military collaborative decision-making (CDM), irrespective of air traffic controllers' physical locations. RPAS will fly safely in all classes of airspace, sharing it with crewed aviation and other airspace users, and will be integrated into airport operations. Civil and military stakeholders will share plans, decisions, and updates via a SWIM technology solution.

*See Appendix A.5 for the civil-military roadmap.*

Cyber-attacks are growing in frequency and sophistication, calling for ongoing vigilance and further enhanced technologies to protect the future ATM system, which will be more data-driven, open to trusted users, connected and interdependent. In this respect, this ATM Master Plan will be key to feed into upcoming defence-related EU activities such as the EU airspace strategy for security and defence.

*See Appendix A.6 for the cybersecurity capabilities roadmap.*

# 4 Roll-out

This chapter describes the critical path and the high-level timeline for ensuring a smooth transition from today's ATM system to tomorrow's Digital European Sky. It also provides an update on the status of development and deployment activities and establishes the conditions that will determine a successful roll-out of the vision by 2045.

## 4.1 Roll-out in four phases

The roll-out is divided into four overlapping phases.

**Phase A**: addresses known critical network performance deficiencies by enhancing collaboration between stakeholders, including across state borders and with aircraft, implementing initial system-wide information management (SWIM), and introducing initial network capacity and demand balancing measures. Deployment is to be completed by 2025.

**Phase B**: delivers efficient services and infrastructure through the launch of first ATM data services, the introduction of cross-border free-route operations, and the integration of advanced airport performance management into the network. Deployment is underway and will be completed by 2030.

**Phase C**: defragments European skies through virtualisation and dynamic airspace configuration, supported by the gradual introduction of higher levels of automation support, the full integration of airports into ATM at network level, and the management of routine drone operations. Development for this phase is near completion and deployment is underway, with completion expected by 2035.

**Phase D**: the Digital European Sky, makes Europe the most efficient and environmentally friendly sky to fly in the world by delivering a fully scalable system for crewed and uncrewed aviation, supported by a digital ecosystem, full air-ground system integration, distributed data services, and high levels of automation and connectivity. Development for this phase has started and deployment should be completed by 2045.

Figure 7 illustrates the deployment across the four phases in line with the ambition to complete the deployment by 2045.

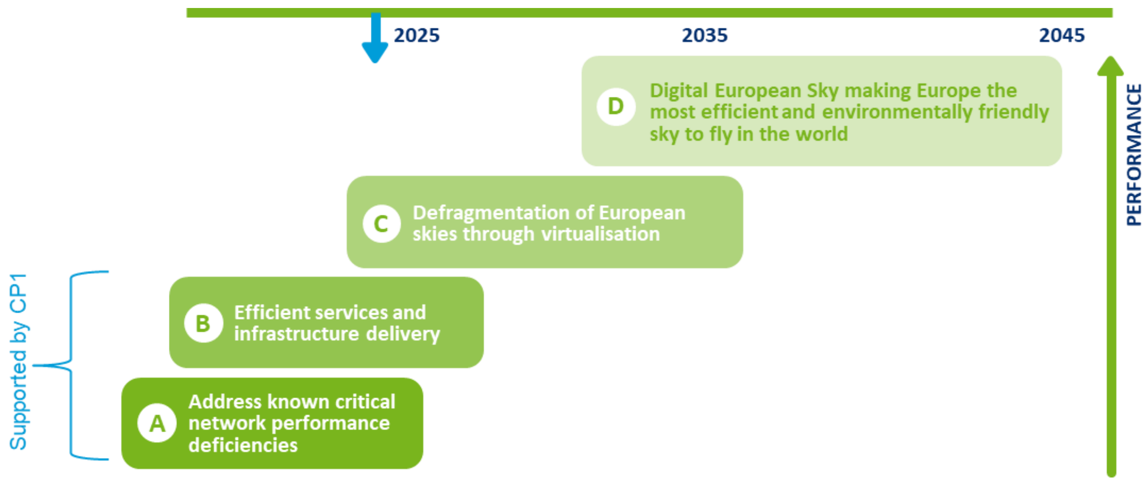


**Figure 7: Four-phased approach to roll-out**



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## 4.2 Current state of play

*Note to readers: This section is based on information reported to the SESAR JU Governing Board at the end of 2022; It will be updated in autumn 2024 with 2023 data from the latest SESAR strategic deployment and development monitoring reports.*

The ATM innovation life cycle covers SESAR definition (European ATM Master Plan), development (exploratory and industrial research) and deployment (industrialisation and implementation). This chapter provides today's state of play on the development and deployment activities plotted against the four phases of the roll-out.

### 4.2.1 Status of SESAR development

As illustrated in Figure 8 below, SESAR development has been completed for phases A and B. For phase C, 66% of development activities are complete and the remainder will be completed by 2026. Phase D activities have started.

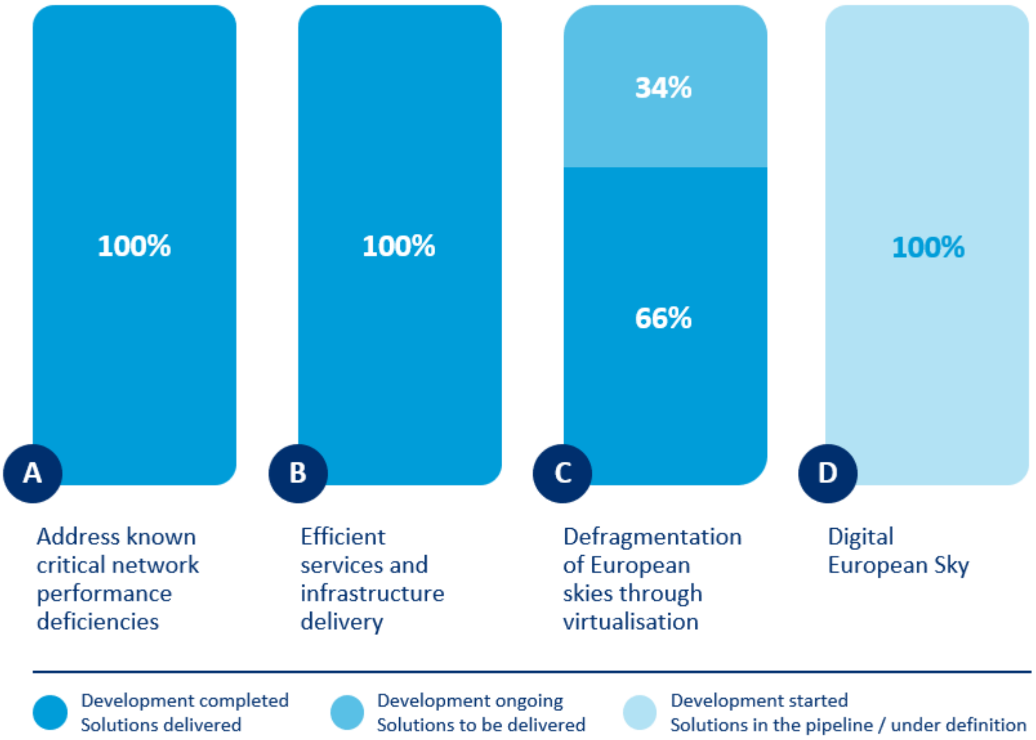


Figure 8: Status of SESAR development

### 4.2.2 Status of SESAR deployment

Out of the available SESAR Solutions for deployment, as illustrated in Figure 9 below, for phase A, 83% are being rolled out and standardisation work is underway for an additional 10%. For phase B, 58% are being rolled out and standardisation work is underway for an additional 27%. For phase C, 16% of available solutions are being rolled out and standardisation work is underway for an additional 68%. It should be noted that for all three phases, additional efforts are needed to encourage full market uptake of available solutions.

Deployment actions building on these solutions have been prioritised, thus constituting the next wave of deployments as reflected in Chapter 5. The strategic deployment objectives (SDOs) listed there will deliver phase C by 2035.

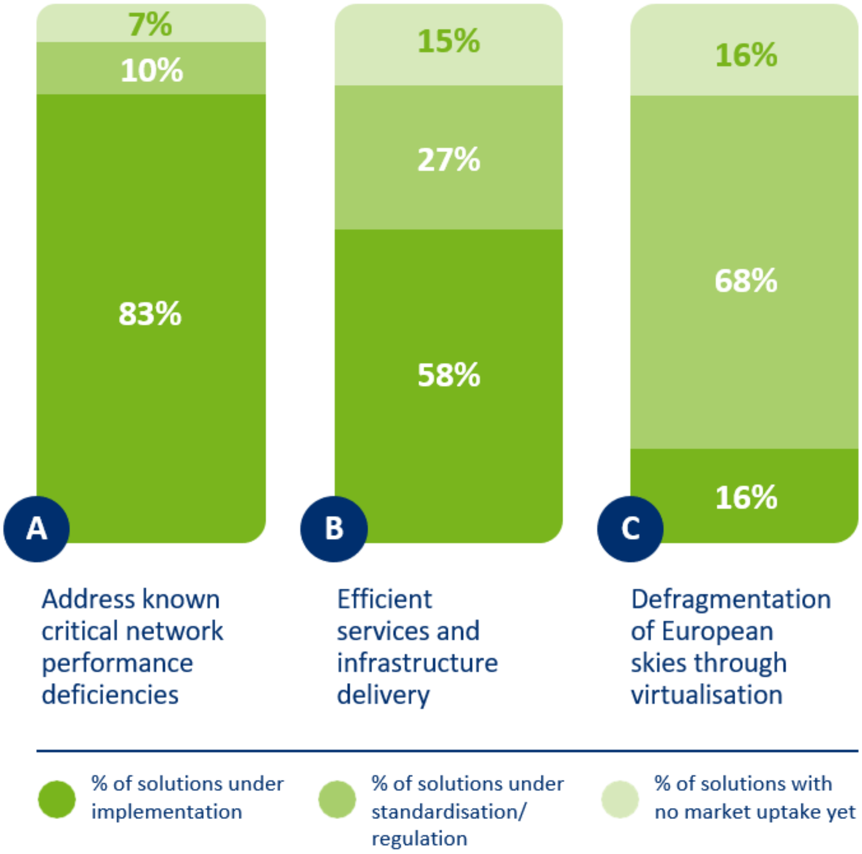


**Figure 9: Status of SESAR Deployment**

The expected contributions of the solutions (phases A-C) are estimated to deliver the following performance benefits relative to the 2012 baseline[25] :

- Punctuality: +19%
- Cost-efficiency: +30.3%
- Airport capacity: +23%
- En-route capacity: +59.7%
- Terminal manoeuvring area (TMA) capacity: +36%
- Reduction in CO2 emissions thanks to fuel-efficiency: -3.4%
- Reduction of additional flight time: -41%

## 4.3 Critical path and key milestones to roll out the vision by 2045

This section defines the critical path for establishing Europe as the most efficient and environmentally friendly sky to fly in the world by 2045. It puts the transformation of air traffic management into perspective with the planned introduction of sustainable aviation fuels (SAF)[26] and the next generation aircraft for zero-emission aviation[27].

The critical path is illustrated hereafter listing key transformations looking beyond completing Common Project 1 (CP1)[28] which is essential to secure the transition to TBO. Figure 10 lists these elements as well as their impact on the environment for each technology lever across phases C and D.

[25] 2012 was the baseline value for 2020 edition of the European Master Plan.

[26] ReFuelEU Aviation promotes the increased use of sustainable aviation fuels (SAF). The measure is part of the Fit for 55 package to meet the emissions reduction target of 55% by 2030. It sets requirements for aviation fuel suppliers to gradually increase the share of SAF blended into the conventional aviation fuel supplied at EU airports.

[27] Alliance for Zero-Emission Aviation (AZEA) vision on enabling hydrogen and electricity-powered flights in Europe: the vision sets the ambitious objective of having 36 to 68% of intra-EU flights operated by hydrogen- and electricity-powered aircrafts by 2050 and describes how they would progressively enter and expand in the market from 2035.

[28] Implementing Regulation (EU) No 2021/116


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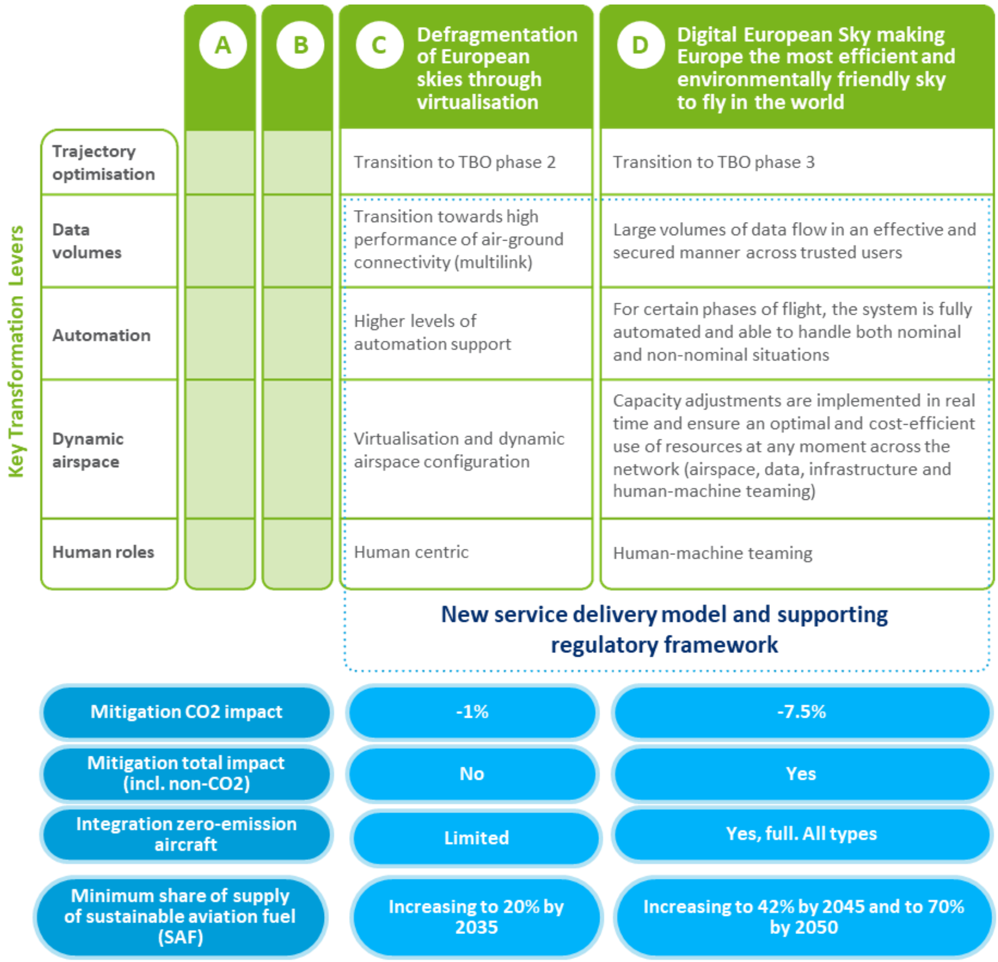


**Figure 10: Critical path for roll-out by 2045**

Focusing on this critical path will be key to eliminating environmental inefficiencies through enhanced capacity, flight efficiency, and predictability, allowing airspace users to fly optimal routes. Interdependencies between performance areas show that inadequate capacity leads to non-optimal aircraft routing and increased environmental impact.

The transition to trajectory-based operations will result in a progressive reduction of CO2 emissions. This will be achieved through a more precise and systematic optimisation of each flight's CO2 footprint, provided by advanced automation and greater air-ground connectivity. Figure 11 illustrates what these transformational changes will mean in real terms, namely CO2 emissions reduced by a further -1 % by phase C and -7.5% by phase D.

Reducing the total climate impact, including non-CO2 emissions, will be addressed in phase D through coordinated strategies and a revision of environmental performance metrics. This will include the definition of precision eco-sensitive areas supported by advanced prediction tools. In addition, other solutions will improve local air quality and noise mitigation at airports.

In parallel, phase D will also support the integration of zero-emission aircraft, accommodating the specific needs and flight profiles of a new generation of vehicles like battery-electric vehicles for short flights and hydrogen-powered aircraft, which are expected to enter service from 2035[29].

Any delays in the deployment of these elements will delay the overall roll-out of the vision and reduce Europe's ability to deliver the most efficient and environmentally friendly sky to fly in the world.

To achieve this ambition by 2045, the innovation cycle in ATM must be significantly shortened, impacting both development (time to market) and deployment (market uptake) of SESAR Solutions as illustrated below. Key milestones include advancing significantly phase D development by 2030, completing phase C deployment by 2035, and ultimately, completing phase D deployment by 2045.

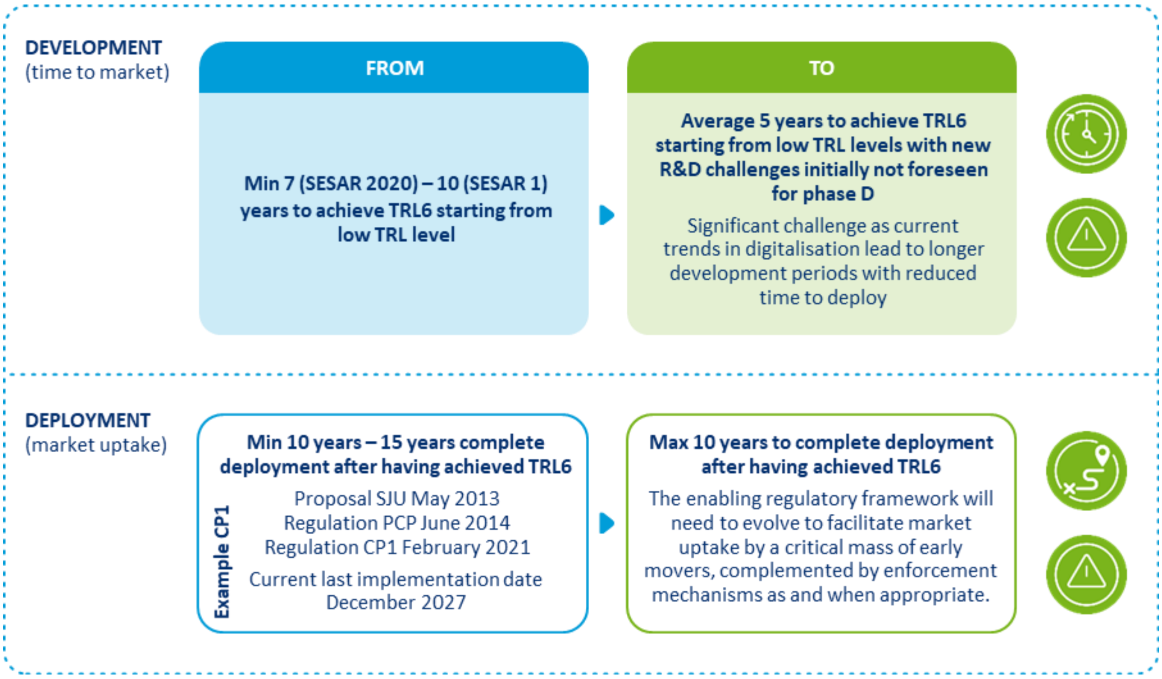


**Figure 11: Development and deployment cycle challenges**

To set this transition in motion in the period 2025 to 2030, key activities include: completing CP1 implementation, mobilising resources and investments towards phase C and D priorities, updating the European Plan for Aviation Safety (EPAS) according to the SDOs, launching Common Project 2, securing air-ground connectivity transitions, and ensuring continued SESAR funding beyond the EU's current multiannual financial framework (MFF), which ends in 2027.

## 4.4 Conditions for a successful roll-out

Achieving the key milestones (i.e. 2030, 2035, 2045) requires meeting several conditions that are listed hereafter.

- **Economic regulatory framework**: SES instruments work hand-in-hand from RP4[30] to promote investments in strategic deployment objectives (*see Chapter 5*).
- **EASA regulatory framework**: the EPAS published by EASA, and its supporting standardisation framework, are fully aligned with the timelines of the Master Plan.
- **Continued support for early movers**: Digital European Sky demonstrators[31] are expanded to cover the full scope of strategic deployment objectives, becoming also the 'regulatory sandboxes' for the Digital European Sky. EU funds (Connecting Europe Facility, Innovation Fund and their successors under the EU's next multiannual financial framework – MFF) are available for supporting deployment objectives under the next MFF as from 2028.
- **Future Common Projects:** regulate the deployment of those strategic deployment objectives that require a synchronised and harmonised roll-out at European level.
- **Research resources focused on development priorities:** all research resources are mobilised to deliver on strategic development objectives by 2030; the aviation community embraces the approach to develop next generation platforms. EU (research) funds are available to support further SESAR research under the next MFF as from 2028.
- **Involvement of the ATM workforce is secured:** professional staff organisations support development and deployment activities, training, and engagement to gain social acceptance of the changes envisaged by the vision.
- **Monitoring of progress:** to maintain the momentum generated by this edition of the Master Plan, the relevant EU bodies work together, and the SESAR JU reports annually to the SESAR JU Governing Board on progress made in relation to deployment and development, taking into account civil-military coordination needs.

[30] RP4 refers to the fourth reference period of performance and charging scheme,
[31] SESAR Innovation Pipeline

# 5 Deployment priorities

This chapter focuses on deployment priorities for Europe, introducing the strategic deployment objectives (SDOs). SDOs are prioritised actions (also referred to as essential operational changes[32]), covering ATM functionalities that need to be rolled out between 2025 and 2035. These actions are critical for achieving the vision and performance ambitions and are based on SESAR Solutions, delivered or in the pipeline.

The SDOs are the result of a prioritisation exercise and were selected according to four criteria, namely the critical role they can play in addressing climate-neutral aviation, capacity and scalability, safety-criticality, and the uptake of innovative air mobility.

For ATM stakeholders wishing to make local investment decisions on other delivered SESAR Solutions, the full list is available at: www.sesarju.eu/catalogue

As a result, the 10 SDOs described in Figure 12 provide the basis to trigger accelerated market uptake of SESAR Solutions by a critical mass of early movers and to support the evolution of the regulatory framework[33]. They look beyond the ATM functionalities already covered by CP1[34]. Completing the implementation of CP1 is essential to secure the transformation to trajectory-based operations (TBO) covered by SDO #5.


**Figure 12: Strategic deployment objectives looking beyond CP1**

[32] ''Essential operational change' means an air traffic management (ATM) operational change that provides significant network performance improvements to the operational stakeholders, as referred to in the ATM Master Plan.' (Commission Implementing Regulation (EU) No 409/2013)

[33] European Plan for Aviation Safety

[34] Commission Implementing Regulation (EU) No 2021/116

In the following sections, each SDO is defined with the corresponding required deployment actions (the 'what'), targeted stakeholders (the 'who'[35]) and operating environments (the 'where').

ATM modernisation is a global effort and requires continued cooperation with ICAO and other regions of the world. Appendix A.8 maps alignment with the global air navigation plan (GANP) and flags those activities with a global interoperability dimension that may require ICAO adaptations. Further details on roadmaps are given in the appendices (1 to 6). Details on the content of each SDO (e.g. supporting SESAR Solutions, reference period for starting investment, and link to essential operational changes (EOCs) in the previous edition of the Master Plan) are published on the SESAR JU website: https://sesarju.eu/MP2024proposal

## 5.1 SDO #01 - Alerts for reduction of collision risks on taxiways and runways

This strategic deployment objective aims to prevent collisions on the airport surface under increasing traffic in all weather conditions. It also aims to mitigate the safety issue assessed according to EASA with an elevated priority category 'undetected occupied runway (SI-2006)', to prevent runway incursion by an aircraft[36].

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 1.1 | Adapt airport ground safety nets to extend conflicting ATC clearances (CATC) to the entire aerodrome movement area, to enlarge the set of conformance monitoring (CMAC) alerting functions and to provide integrated occupancy/conflict status of a runway. | ANSP | Airport |

Table 1: SDO #01 - Alerts for reduction of collision risks on taxiways and runways

## 5.2 SDO #02 - Optimising airport and TMA environmental footprint

This strategic deployment objective aims to optimise the continuity of capacity delivery at airports and in TMAs, meeting also military needs and avoiding network-wide delays, while reducing environmental impact. It also aims to mitigate the safety issue assessed by EASA with an elevated priority category 'mass diversions (SI-2032)'[37] due to airspace and/or airport closure, where a large amount of displaced traffic leads to an overload for ATC and increased workload for the flight crew.

[35] Targeted stakeholders: air navigation service providers (ANSP), airspace users (AU), airport operators (AO), network manager (NM), U-space service provider (USSP), information service provider (CISP), Drone/UAS operators, vertiport operators, military (MIL)
[36] European Plan for Aviation Safety, 2024 edition
[37] European Plan for Aviation Safety, 2024 edition

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 2.1 | Implement collaborative management of regional airports and their integration with Network Manager (NM) by sharing departure planning information (also shared between NM and airspace users). | ANSP, AU, AU MIL, AO, NM | Airport TMA En-route Network |
| 2.2 | Implement solutions to better integrate large/very large airports and the network via an enhanced AOPs-NOP tactical, pre-tactical and strategic planning and AOP to AOP collaborative planning process. | ANSP, AU AO, NM | Airport Network |
| 2.3 | Implement environmental performance management at airports and solutions to reduce the airport impact on emissions (single engine taxiing, engine-off taxiing though use of sustainable taxiing vehicles). | ANSP, AU, AO | Airport |
| 2.4 | Implement capabilities to better manage arrival constraints between various extended arrival management (E-AMAN) units in cross-border environments and to better integrate the out-of-area inbound flights. | ANSP, AU | Airport TMA En-route Network |
| 2.5 | Implement optimised descent operations using merge to point and advanced approach procedures[38] (i.e. second runway-aiming point (SRAP), increased second glide slope (ISGS), increased glide slope to a second runway aiming point (IGS-to-SRAP)), which aim to reduce the environmental impact (e.g. noise, fuel consumption, CO2 emissions, etc.) on the airport's neighbouring communities. | ANSP, AU, AU MIL, AO | Airport TMA En-route |
| 2.6 | Implement new capabilities to increase airport runway capacity both on arrivals and departures using wake turbulence separations based on static aircraft characteristics, required surveillance performance (RSP) and runway occupancy time (ROT) characterisation of the leader aircraft. | ANSP, AU, AO | Airport TMA |

**Table 2: SDO #02 - Optimising airport and TMA environmental footprint**

[38] These advanced procedures can be implemented at airports with different type of approach means supporting vertical guidance (e.g., GLS (GBAS) or RNP APCH procedures (RNAV APV-Baro or LPV SBAS) as per ((EU) 2018/1048 (PBN Regulation)).

## 5.3 SDO #03 - Dynamic airspace configuration

This strategic deployment objective aims to enable the dynamic adaptation of air traffic service (ATS) capacity to changes in demand, increasing the flexibility of airspace capacity for civil and military users and maximising the productivity of controller teams. It also mitigates the safety issue assessed by EASA with an elevated priority category 'mass diversions' (SI-2032)[39], due to airspace and/or airport closure, where a large volume of displaced traffic leads to an overload for ATC and increased workload for the flight crew.

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 3.1 | Implement higher levels of granularity and dynamicity in airspace configurations, adjusted to traffic demand and military needs for airspace reservations, enabling cross-border coordination between all civil and military actors. | ANSP, ANSP MIL, AU, AU MIL, NM | En-route Network |
| 3.2 | Implement mission trajectory and dynamic mobile areas (DMAs) of type 1 and type 2 using the improved operational air traffic flight plan (iOAT FPL) into dynamic airspace configuration processes in the medium to short-term ATM planning phase to support military airspace requirements. | ANSP, ANSP MIL, AU AU MIL, NM | En-route Network |

**Table 3: SDO #03 - Dynamic airspace configuration**

[39] European Plan for Aviation Safety, 2024 edition

## 5.4 SDO #04 - Increased automation support

This strategic deployment objective aims to pave the way for trajectory-based operations by allowing controllers to focus on complex tasks rather than on routine activities.

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 4.1 | Implement sector team configurations, which in specific airspace configurations include the combination of one planning ATCO with two tactical/executive ATCOs in an en-route/eTMA environment. | ANSP | En-route |
| 4.2 | Implement automatic speech recognition (ASR), user profile management system (UPMS) and attention guidance (AG) to provide a higher automation environment to support the ATCO role. | ANSP | TMA<br>En-route |

**Table 4: SDO #04 - Increased automation support**

## 5.5 SDO #05 - Transformation to trajectory-based operations (TBO)

This strategic deployment objective aims at delivering a fully collaborative environment where all flight trajectory data is shared, maintained, and used by all the concerned actors during all phases of flight. Advanced automation tools assist in detecting, analysing and resolving potential conflicts, as well as in monitoring adherence to agreed and optimised trajectories, while securing a safe, cost-efficient and environmentally optimised trajectory for the whole flight.

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 5.1 | Implement enhanced conflict detection and resolution (CD&R) support tools by using aircraft-derived data (i.e. extended projected profile (EPP)) supported by the full implementation of ATS-B2 and high-resolution wind models. | ANSP, AU | TMA<br>En-route |
| 5.2 | Implement multi-element clearances using controller pilot datalink communications (CPDLC) with lateral and vertical datalink clearances and increased ground automation tools (e.g. CD&R tools) and trajectory prediction supporting the earlier detection and resolution of potential conflicts. | ANSP, ANSP MIL, AU, AU MIL | TMA<br>En-route |
| 5.3 | Implement a dynamic route availability document (RAD) to allow the dynamic management of restrictions based on traffic evolutions, better integration of letters of agreement (LoAs) between ATC centres and NM and the provision of preliminary flight plans by airspace users. This will feed dynamic network | ANSP, AU, NM | TMA<br>En-route<br>Network |

| | | | |
|---|---|---|---|
| | constraints publications initiated the day before operations, to optimise the environmental performance of the network. | | |
| 5.4 | Implement airspace user capabilities to provide, through the user-driven prioritisation process (UDPP), their preferences and priorities and influence ATFM arrival regulations. | AO, AU, NM | Airport<br>Network |
| 5.5 | Implement interaction tools supporting the full integration of the flight operations centre (FOC) into the ATM network process, and the flight delay criticality concept, to better integrate airspace user priorities in flow management decisions. | ANSP, AU, NM | TMA<br>En-route<br>Network |
| 5.6 | Exploit new FF-ICE/R1 trajectory services beyond the CP1 services (which are just the filing, data request, notification, publication and trial services) to improve the completeness and accuracy of traffic load calculation and advanced network performance capabilities. | ANSP, ANSP MIL, AU, AU MIL, AO, NM | Airport<br>TMA<br>En-route<br>Network |
| 5.7 | Implement seamless ATC-ATC coordination and sharing with NM of the ATC-ATC exchanges[40], encompassing more complex coordination dialogues implying negotiation between controllers across ACC boundaries. | ANSP, ANSP MIL, NM | TMA<br>En-route<br>Network |

**Table 5: SDO #05 - Transformation to trajectory-based operations (TBO)**

[40] Note the SESAR Deployment Manager's action to build consensus on ATC/ATC TBO Interoperability is on-going.

## 5.6 SDO #06 - Virtualisation of operations

This strategic deployment objective aims to make more efficient and flexible use of resources, without being constrained by the geographical, and ultimately organisational, location of the air traffic service units (ATSUs). It also mitigates the safety issue assessed by EASA with an elevated priority category 'mass diversions (SI-2032)'[41], due to airspace and/or airport closure, where a large volume of displaced traffic leads to an overload for ATC and increased workload for the flight crew.

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 6.1 | Implement virtual centres to enable decoupling of the ATM data service provider (ADSP) and ATSU through service interfaces that support new ways of dynamic ATS delegation (e.g. contingency delegation, night delegation (scheduled), fixed time delegation (scheduled), or 'on-demand'). | ANSP, ANSP MIL | TMA En-route |
| 6.2 | Implement multiple remote tower module (MRTM) flexible and dynamic allocation of different MRTMs accommodated within a remote tower centre (RTC) that allows the ATCO to maintain situational awareness for two or more small airports. It includes the implementation of a low-cost surveillance service for supporting remote tower operations. | ANSP, ANSP MIL, AO, AO MIL | Airport |

Table 6: SDO #06 - Virtualisation of operations

## 5.7 SDO #07 - Transition towards high performance of air-ground connectivity (multilink)

This strategic deployment objective aims to improve air-ground datalink performance, accelerate technology adoption, and achieve economies of scale while reducing the fragmentation that characterises current datalink implementation.

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 7.1 | Implement future air-ground communications network infrastructure, which supports multilink capability and complete mobility between different datalinks. | ANSP, ANSP MIL, AU, AU MIL | Airport TMA En-route Network |

[41] European Plan for Aviation Safety, 2024 edition



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| | | | |
|---|---|---|---|
| 7.2 | Implement SatCom class B, which enables data and voice communication services using existing satellite technology systems in oceanic, remote, polar, and progressively continental airspace. | ANSP, AU, ANSP MIL | TMA<br>En-route |
| 7.3 | Implement VDL2 successor (e.g. terrestrial datalink system L-band-digital aeronautical communication system (LDACS), datalink for ATM and AOC operations over commercial communication systems (hyper-connected ATM), and satellite communications for both continental and remote/oceanic regions. | ANSP, AO, AU, AU MIL | Airport<br>TMA<br>En-route<br>Network |

**Table 7: SDO #07 - Transition towards high performance of air-ground connectivity (multilink)**

## 5.8 SDO #08 - Service-oriented delivery model (data-driven and cloud-based)

This strategic deployment objective aims to implement the new service-oriented delivery model as defined in section 3.4, making it possible to decouple service provision from local infrastructure.

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 8.1 | Implement the new service-oriented delivery model (data-driven and cloud-based) covering all phases of flight and enabling:<br>• open ATM patterns enabling integration of components provided by various system providers to facilitate multi-vendor solutions using open platforms and interfaces;<br>• decoupling of service and infrastructure layers through cloud computing (including the various system components);<br>• a cloud-native architecture of components with standardised and open interfaces that can be deployed on commodity cloud technologies. | ANSP, NM, ANSP MIL | Airport<br>TMA<br>En-route<br>Network |

**Table 8: SDO #08 - Service-oriented delivery model (data-driven and cloud-based)**





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## 5.9 SDO #09 - CNS optimisation, modernisation and resilience

This strategic deployment objective aims to optimise, modernise, and increase the resilience of CNS infrastructure in Europe.

| What | | Who | Where |
|---|---|---|---|
| ID | Deployment action | | |
| 9.1 | Implement GBAS to support Cat II/III precision approach, landing, and departure procedures in all-weather operations conditions. | ANSP, AU, AO | Airport<br>TMA |
| 9.2 | Implement a secured surveillance functionality that enables detection and, when possible, mitigation of security threats that could affect the surveillance chain. | ANSP | Airport<br>TMA<br>En-route |
| 9.3 | Implement minimum operational network (MON). | ANSP,<br>ANSP MIL,<br>NM | TMA<br>En-route<br>Network |
| 9.4 | Rationalise instrument landing systems (ILS) and implement efficiency measures/methods for more cost-effective maintenance of ILS, providing a link between ICAO Doc. 8071 and national CNS provision. | ANSP,<br>NM | TMA<br>Network |
| 9.5 | Optimise surveillance, leveraging terrestrial and space-based information. | ANSP,<br>NM | TMA<br>En-route<br>Network |

**Table 9: SDO #09 - CNS optimisation, modernisation and resilience**

## 5.10 SDO #10 - Enable innovative air mobility (IAM) and drone operations

This strategic deployment objective addresses the safe, secure and sustainable air mobility of passengers and cargo enabled by new-generation technologies integrated into a multimodal transportation system. It also helps to mitigate the safety issue assessed by EASA with an elevated priority category 'airborne conflict with an uncrewed aircraft system (SI-2014)'[42].

| What | | Who | Where |
|---|---|---|---|
| ID | Description | | |
| 10.1 | Implement system support and procedures to integrate instrument flight rules (IFR) RPAS and IAM in airspaces A to C, which are required to have detect and avoid (DAA) systems that perform at least as well as TCAS II (traffic alert and collision avoidance system) and see and avoid. | ANSP, ANSP MIL, AU, AU MIL, Drone/UAS, Operator<br><br>Drone/UAS Operator, MIL | TMA En-route |
| 10.2 | Implement foundational (U1) and initial (U2) U-space services as established by the regulatory framework for U-space (Commission IR 2021/664). | USSP, CISP, Drone/UAS Operator | Very low-level airspace |
| 10.3 | Implement a common ATM-U-space interface and dynamic airspace reconfiguration service to help ATC actors in charge of airspace reconfigurations to increase safety, keeping crewed and uncrewed aircraft segregated within the designated U-space airspace. | ANSP, ANSP MIL, AU, AU MIL, AO, AO MIL, USSP CISP, Drone/UAS Operator | Airport, Vertiport, TMA, En-route |
| 10.4 | Implement simultaneous non-interfering (SNI) operations (e.g. parallel or convergent point in-space (PinS) procedures) and capabilities (i.e. GNSS and the RNP navigation specification) allowing airspace users (e.g. rotorcraft, VTOL capable aircraft, etc.) to operate to and from airports, vertiports and TMAs without conflicting with other traffic or requiring runway slots. | ANSP, AU, AO, Vertiport Operator, Drone/UAS Operator | Airport, Vertiport, TMA |

**Table 10: SDO #10 - Enable innovative air mobility (IAM) & drone operations**

[42] European Plan for Aviation Safety, 2024 edition

# 6 Development priorities

This chapter presents strategic development priorities (DPs), which cover the prioritised actions needed to develop future ATM functionalities and roll out phase D. They take into consideration the human dimension of the transformative changes ahead and also the SESAR Strategic Research and Innovation Agenda (SRIA)[43]. The priorities address new development challenges and expectations for phase D, which were not foreseen earlier, such as but not limited to:

- the vision to make Europe the most efficient and environmentally friendly sky to fly in the world;
- integration of innovative air mobility (IAM);
- higher airspace operations;
- integration of the next generation aircraft for zero/low emission aviation by 2035;
- a new security context for ATM in Europe.

The priorities are categorised in accordance with the SESAR innovation pipeline[44], the process used to transform promising ideas and concepts into tangible solutions for industrialisation and acceleration of market uptake. These include exploratory research covering fundamental research (FR TRL[45] 0-1) and applied research (AR TRL 1-2), as well as industrial research (IR TRL 2-6) including fast-track (up to TRL 7). Each DP details specific actions to be taken and links these with the relevant flagship[46] in the current SESAR Digital European Sky programme.

Table 11 lists the 12 DPs for future development activities in ATM from 2025.

[43] Strategic Research and Innovation Agenda, 2020
[44] SESAR innovation pipeline
[45] Technology readiness levels (TRLs) are a method for understanding the technical maturity of a technology during its acquisition phase.
[46] SESAR JU Flagships

| IR | Strategic development priorities | |
|---|---|---|
| IR-01 | Transformation to trajectory-based operations | Industrial research |
| IR-02 | Transition towards high performance of air-ground connectivity (multilink) | |
| IR-03 | Future en-route and TMA ground platforms | |
| IR-04 | Future airport platform | |
| IR-05 | Autonomy and digital assistants for the flight deck | |
| IR-06 | U3 U-space advanced services, IAM and vertiports | |
| AR-01 | Research to help shape the future regulatory framework for a Digital European Sky | Exploratory research |
| AR-02 | Definition of U4 U-space full services | |
| AR-03 | Integration of the next generation aircraft for zero/low emission aviation | |
| FR-01 | ATM impact on climate change | |
| FR-02 | Digital flight rules | |
| FR-03 | Investigate quantum sensing and computing applied to ATM | |

**Table 11: Strategic development priorities (DPs)**

In the following sections, each DP is defined with the corresponding required development actions (the 'what').

## 6.1 Industrial research priorities

These six DPs and supporting development actions define the priorities for industrial research (IR TRL 2-6) including fast-track (up to TRL 7) from 2025.

| Development priority | Description | Development action |
|---|---|---|
| **IR-1: Transformation to trajectory-based operations** | This development priority focuses on completing the industrial research needs that are identified in the TBO roadmap. | IR-1-01: Integrated air/ground trajectory management based on ATS-B2, including the extension for lower airspace and airport surface.<br><br>IR-1-02: Development of FF-ICE, including FF-ICE pre-departure enhancement and FF-ICE/R2.<br><br>IR-1-03: Advanced network trajectory synchronisation in the execution phase.<br><br>IR-1-04: Connected and integrated flight management system (FMS), electronic flight bag (EFB) and flight operations centre (FOC) functionalities for trajectory optimisation.<br><br>IR-1-05: Dynamic route availability document (RAD) towards a RAD by exception environment. |
| **IR-2: Transition towards high performance of air-ground connectivity (multilink)** | Covers the integration of non-safety, commercial links into a hybrid communication infrastructure for ATM safety communication needs, the complete development of the new terrestrial link LDACS, and innovative ways to support intelligent data pre-processing and integration, both on ground and on board the aircraft for air/ground exchange of data (e.g. meteorological data, etc.). | IR-2-01: Complete development of successor(s) to VHF datalink mode 2 (VDL2): L-band digital aeronautical communications system (LDACS), hyper-connected ATM, and satellite communications (SatCom class A) covering civil-military dual use.<br><br>IR-2-02: Aircraft as a sensor, including transmission of humidity information to ground, etc. |
| **IR-3: Future en-route and TMA ground platforms** | Targets the transformation of both cruise and climb/descent flight phases into highly automated environments | IR-3-1: Addresses the next generation ATC platform, fully leveraging aircraft capabilities. This includes supporting a data-sharing service delivery model, resilient integrated CNS/MET as a service, traffic synchronisation, etc., accommodating the |

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| | enabled by full air/ground integration. The aim is to implement a service-oriented, cloud-based model that allows dynamic capacity adjustment to meet airspace user demands. Focus areas include enhancing cyber-resilience, leveraging artificial intelligence for flight path optimisation, and promoting civil-military collaboration for seamless airspace management. | specific needs of the military, innovative air mobility (IAM), higher airspace operations (HAO), and U-space, etc.<br><br>IR-3-2: AI capabilities enabling the next generation platforms.<br><br>IR-3-3: Cyber-resilience and cyber-security capabilities enabling the next generation platforms.<br><br>IR-3-4: Separation management for high levels of automation.<br><br>IR-3-5: Demand capacity balancing (DCB) and airspace configuration concepts for high levels of automation.<br><br>IR-3-6: Future human–machine teaming.<br><br>IR-3-7: Ground capabilities for reducing the ATM environmental footprint. This includes climate-optimised trajectories including non-CO2 effects (e.g. contrails), environmentally optimised climb and descent operation, advanced required navigation performance green approaches, dynamic allocation of arrival and departure routes considering noise and local air quality, green ATC capacity concept, flexible eco-friendly clearances, wake energy retrieval (WER), integration of sustainable aviation fuels (SAF) and zero emissions aircraft, environmental performance dashboards, etc.<br><br>IR-3-8: Geometric altimetry.<br><br>IR-3-9: CNS capabilities to increase ATM system robustness (e.g. satellite-based multilateration (MLAT)). |
| **IR-4 Future airport platform** | Targets the evolution of airside operations, including aircraft turnaround, taxi, and take-off and landing clearances, into a highly automated environment. The aim is to develop a future platform incorporating advanced | IR-4-01: Addresses the next generation airport platform fully leveraging aircraft capabilities. This includes supporting the data-sharing service delivery model, interconnected with other airports and their 3rd parties (e.g. ground handlers), ANSPs, NM, CNS/MET as a service, etc., facilitating the accommodation of IAM, the interface with U-space as well as specific needs from the military. |





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| | technologies and a service-oriented, cloud-based model. This model allows dynamic capacity adjustment to meet the demands of all airspace users while improving safety and environmental sustainability. Key areas of focus include enhancing cyber-resilience, leveraging artificial intelligence and fostering civil-military collaboration for airport operations management. | IR-4-02: AI capabilities enabling the next generation of airport platforms.<br><br>IR-4-03: Cyber-resilience and cyber-security capabilities enabling the next generation of airport platforms.<br><br>IR-4-04: Airport solutions for reducing environmental impact operations. This includes green-taxiing related concepts, environmental performance dashboards, etc.<br><br>IR-4-05: Future human-machine teaming.<br><br>IR-4-06: Optimisation of runway throughput.<br><br>IR-4-07: Smart airports, airports as multimodal nodes and passenger experience. |
| **IR-5 Autonomy and digital assistants for the flight deck** | Focuses on increasing airborne automation and autonomy and the collaboration between air and ground for the integration of all airspace users. Development of onboard capabilities and advanced digital technologies (e.g. digital assistance to the flight crew) supports the flight crew during complex scenarios, reducing workload while improving safety and efficiency. The transition to single pilot operations (SiPO) is being explored, balancing societal expectations for human cockpit presence with increased automation for automatic flight phases. | IR-5-01: Single pilot operations (SiPO). This includes new sensors and aircraft architectures for the evolution towards SiPO/highly automated operations.<br><br>IR-5-02: Increased automation assistance for the pilot for ATM tasks. This includes improved flight-deck HMI and procedures for CPDLC, voice-less technology, etc.<br><br>IR-5-03: Highly automated ATM for all airspace users. This includes performance-based CNS enablers (assured navigation for robust ATM/CNS environment for all phases of flight, alternative positioning, navigation and timing (A-PNT), electronic conspicuity, sense and avoid, enhanced distance measuring equipment (eDME), etc.) to facilitate the integration of advanced airborne automation and future ATC platforms, as well as accommodating IAM and interfacing with U-space.<br><br>IR-5-04: Airborne capabilities for reducing ATM's environmental footprint. This includes wake energy retrieval (WER), energy-based operations, and environment driven trajectory optimisation, etc. |

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| **IR-6 U3 U-space advanced services, IAM and vertiports** | Focuses on enabling IAM operations with VTOL-capable aircraft (VCA) and UAS in complex environments and congested areas, including vertiport integration as an inherent component of an efficient and sustainable multimodal transportation system. This will be supported by the development of U3 U-space advanced services, which build on U1 and U2 U-space services under implementation (following Commission IR 2021/664), IAM integration into all types of airspace and vertiports under both instrument meteorological conditions (IMC) and visual meteorological conditions (VMC), etc. | IR-6-01: U3 U-space advanced services addressing aspects such as common altitude reference, collaborative interface with ATC, tactical conflict detection and resolution, fairness in strategic deconfliction, etc.<br><br>IR-6-02: CNS capabilities for U-space, which includes detect and avoid and collision avoidance for UAS, and the use of mobile networks by U-space (including performance-based communication and surveillance services using a mobile network infrastructure).<br><br>IR-6-03: Extending the U-space ecosystem. This includes the use of U-space services by commercial aircraft, general aviation, crewed VCA, etc., and the use of U-space services outside U-space airspace.<br><br>IR-6-04: Enabling IAM/VCA (crewed and uncrewed) operations, including in complex environments, congested areas and vertiports. This includes IAM operational procedures enabling access to all types of airspace and vertiports (both VMC and IMC) and IAM automation including simplified vehicle operations, automatic take-off and landing (TOL), resilient navigation, energy management, etc. |

**Table 12: Industrial research priorities**

## 6.2 Exploratory research priorities

These six DPs define the priorities from 2025 for exploratory research (TRL 0-2) split between applied research (AR) and fundamental research (FR). Unlike for industrial research, they do not contain specific development actions, as these activities address the exploration of science and knowledge that will help to define future development activities in ATM.

| Development priority | Description |
|---|---|
| **AR-1: Research to help shape the future regulatory framework for a Digital European Sky** | Focuses on supporting the evolution of the future regulatory framework to facilitate the implementation of the ATM Master Plan as well as the supporting actions identified in the EPAS For example: methods to evaluate performance of ATM/ANS ground equipment and determine appropriate assurance levels, the application of airspace classification in Single European Sky airspace, impact of automation on the air traffic controller role (evolution of the ATCO role from executor to supervisor), AI assurance, human factors, and safety risk mitigation. |
| **AR-2: Definition of U4 U-space full services** | Aims to explore the range of U-space services beyond U3, enabling the full potential of innovative air mobility (IAM) at scale. |
| **AR-3: Integration of the next generation aircraft for zero/low emission aviation** | Explores the ATM aspects of the integration of next generation aircraft for zero/low emission aviation as foreseen in the AZEA CONOPS[47] and the Clean Aviation JU programme[48]. |
| **FR-1: ATM impact on climate change** | Aviation contributes significantly to greenhouse gas emissions and other pollutants that impact climate change. Understanding the exact magnitude of this impact, as well as the mechanisms involved, is essential for developing effective ATM optimisation strategies that consider the total climate impact of each flight and that can be automated. Accurate scientific data is necessary to develop evidence-based optimisation algorithms and rules aimed at reducing the environmental impact of aviation. Without comprehensive research, it's challenging to implement measures that effectively balance, for example, the CO2 vs non-CO2 impacts. |
| **FR-2: Digital flight rules** | Focuses on the exploration and implementation of digital flight rules, a proposed new set of rules for an ATM system that would operate with significantly higher levels of automation for ground systems as well as autonomy for airborne systems. Indeed, higher levels of automation, |

[47] Alliance for Zero-Emission Aviation
[48] Clean Aviation JU





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| | autonomy and new data services may prompt the need for adjustments to rules such as PANS-OPS to ensure that new technologies support an increase in safety, compatibility, operational efficiency, and international harmonisation. |
| **FR-3: Investigate quantum sensing and computing applied to ATM** | Focuses on exploring the potential applications of quantum sensing and computing within ATM (e.g. cybersecurity, queue management, etc.). Quantum computing is a rapidly emerging technology and promises to revolutionise the computing landscape with its potential for high-speed and high-capacity data processing. In the context of ATM, quantum computing could significantly enhance the service-oriented architecture, improving efficiency and accuracy in air traffic control and management. This priority aims to position ATM to leverage advancements in quantum technology, ensuring that the sector stays at the forefront of technological innovation. It will involve studying the potential benefits and challenges of integrating quantum sensing and computing into ATM and developing strategies to implement this technology effectively. |

**Table 13: Exploratory research priorities**





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# 7 Benefits, investment needs and risks

This chapter outlines the expected impact in terms of benefits and investment needs associated with the planned roll-out of the vision by 2045. The chapter also identifies key risks and proposes corresponding mitigation actions.

## 7.1 Expected benefits and impact

Achieving the performance ambitions set out in the vision (Chapter 3, section 3.2) is essential for the aviation sector, as they represent one of the few viable short to medium-term technological pathways toward net-zero European aviation, as already identified by the Destination 2050 report[49]. Beyond climate protection, these advancements promise substantial direct benefits for all stakeholders in the aviation value chain. Importantly, they also serve citizens by enabling aviation to connect people and transport goods, while supporting a wide range of applications beyond transport such as in defence and security and in the digital economy (e.g. drone-enabled services). This adds value by ensuring speed, predictability, reliability, and resilience within a global network, over any distance, while minimising the impact on the environment.

This benefit assessment therefore covers the period from 2025 to 2050[50], using 2023 performance levels as a baseline, which reflect near pre-COVID traffic levels. To adopt a conservative approach, the actual performance inefficiencies observed in 2023 were considered to represent the maximum benefit pool achievable through the implementation of SESAR, even though it is widely recognised that system performance would deteriorate further without SESAR. The projected increase in benefits over time is consistent with the planned roll-out of CP1 and phases C and D.

For CP1, the benefits are well documented[51] . The benefits for phase C are calculated based on SESAR validation exercises and are enhanced by a network impact assessment performed by the Network Manager to provide the most accurate future benefit projections. For phase D, which is still in its early development stages, benefits have been assessed top-down based on expert judgement.

### Monetised benefits

Table 14 provides an overview of the performance improvements that can be monetised, using as reference the STATFOR Long Term Traffic Forecast (April 2022)[52] with a base traffic scenario of +57% and a high traffic scenario of +92% by 2050, compared to 2023. The ambitions for phase D are set to provide optimal performance, aiming for an en-route ATFM delay of 0.35 minutes per flight and eliminating any fuel inefficiency. These ambitions surpass the current regulatory target of 0.5 minutes of en-route ATFM delay per flight[53]. These values consider trade-offs and interdependencies, which

[49] Destination 2050: A Route to Net Zero European Aviation, 2021
[50] The year 2050 has been chosen to measure the benefits of the full deployment of the Digital European Sky by 2045, which coincides also with the policy goal to decarbonise aviation.
[51] Reference for full CP1 benefits is 'CBA update 2024' draft (release 1.01)'
[52] STATFOR interactive dashboard
[53] Targets used in reporting period 3 & 4 applicable until 2029.

limit the possibility of achieving maximum efficiency in all performance areas, as documented by the Performance Review Body and PRR 2023 reports. The ranges provided for airspace and airport capacity indicate potential fluctuations in line with uncertainties in long-term traffic demand and the need to maintain current safety and security levels, especially with the introduction of commercial drone flights. The analysis assumes that there will be no increase in accidents involving ATM/ANS contributions and that security incidents causing critical disruptions to service provision will be prevented.

| Performance impact (KPA) | Unit | Reference year 2023 | CP1 (up to 2030) | CP1 + Phase C | Phase D | Expected impact by 2050 |
|---|---|---|---|---|---|---|
| Airspace capacity (en-route & TMA) | % | 8.5 million flights* | *+34%* | +60% | +40% +80% | +100% +140% |
| Airport capacity | % | 17.9 million movements** | - | +15% | +1% +5% | +16% +20% |
| Environment (fuel reduction) | Kg/flight | 6,400 | *-22* | -109 | -491 | -600 |
| | % | | *-0.3%* | -1.6% | -7.7% | -9.3% |
| Passenger time saving (departure punctuality) | Min/flight | 18 | - | -0.9 | -8.1 | -9.0 |
| Cost-efficiency (air navigation services (ANS) cost reduction) | EUR/flight | 1,077 | *-26* | -164 | -45 | -209 |

*10.1 million actual flights generating an average delay of 1.82 min/flight (SOURCE: Performance Review Report (PRR) 2023). 8.5 million flights refers to the number of flights that the network could handle, offering a quality of service of 0.5 minutes of en-route ATFM delay per flight. This estimation is based on the PRR 2001 formula to convert traffic into capacity.
** IFR movements (arrivals and departures) at ECAC airports in 2023 (SOURCE PRR 2023)

**Table 14: Expected performance impact by 2050 compared with 2023**





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Table 15 shows the direct benefits in euro. Although the benefits associated with phase D are more uncertain compared to those quantified for CP1 and SDOs, they are expected to be substantial. The primary drivers of these benefits are anticipated to be savings related to the environment and passenger time.

| SESAR benefits (EUR billion) by 2050 | CP1* (up to 2040) | Phase C | Phase D | Total |
|---|---|---|---|---|
| **Airspace capacity** (en-route & TMA) | 23.4 | 54 | 13.3 | **90.7** |
| **Airport capacity** | 1.8 | 15.8 | 2.5 | **20.1** |
| **Environment** (fuel and CO2) | 10.1 | 14.2 | 62.9 | **87.2** |
| **Passenger time saving** (departure punctuality) | *Counted in airspace and airport capacity* | 14.3 | 66.4 | **80.7** |
| **Cost-efficiency** (air navigation services (ANS) cost reduction) | 5.8 | 27.5 | 6.4 | **39.7** |
| **Total cumulative benefits** | **41.1** | **125.8** | **151.5** | **318.4** |

*Reference for full CP1 benefits is 'CBA update 2024' draft (release 1.01)

**Table 15: SESAR benefits that can be monetised by 2050**

### Benefits for the environment

In 2023, the total $CO_2$ emissions from aviation in Europe were approximately 150 million tonnes. This figure represents a significant increase from the reduced levels during the COVID-19 pandemic. This increase in emissions highlights the need for the aviation sector to intensify efforts to achieve ambitious environmental targets, including the transition to sustainable aviation fuels and the introduction of low-emission aircraft.

In the period up to 2050, SESAR will play a key role in reducing the environmental impact of aviation in Europe, addressing both $CO_2$ and non-$CO_2$ emissions. This effort will be complemented by initiatives such as the transition to SAF and the gradual entry into service from 2035 of low-emission aircraft.

As illustrated in Figure 13 it is estimated that 400 million tonnes of $CO_2$ could be saved with the roll-out of the vision by 2050, in addition to the savings achieved from the introduction of sustainable aviation fuels as mandated by EU Regulation[54]. This amount is close to three years' worth of total CO2 emissions from aviation in the European Union.

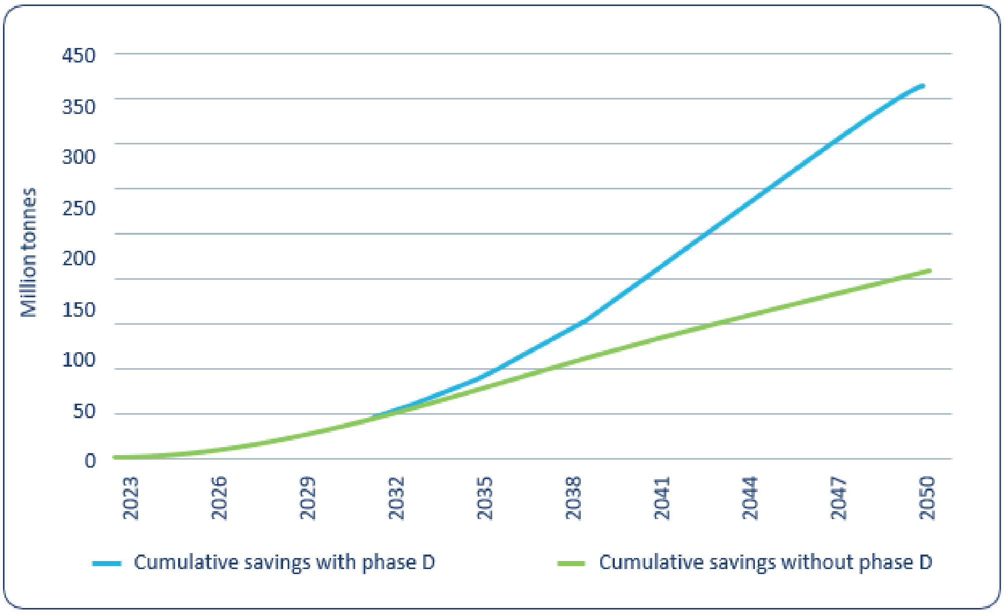


**Figure 13: Contribution to CO2 emissions reduction**

## 7.2 Investment needs

The investments calculated in this section represent the deployment of the vision across the ECAC region, excluding research and operational expenditure (OPEX). Figure 14 indicates an aggregated investment of EUR 25.8 billion between 2025 and 2045 by all stakeholders (i.e. crewed and uncrewed, civil and military, Network Manager). Minor residual investments are expected between 2046 and 2050, mainly addressing aircraft modifications. In addition, the roll-out of phase C by 2035 also includes one-off costs (write-offs) linked to reallocating resources to help secure the timely implementation of the new service delivery approach (SDO #08) and CNS optimisation (SDO #09), which in the long run will allow a reduction of the overall cost of rolling-out SESAR.

[54] Regulation (EU) 2023/2405 on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation)

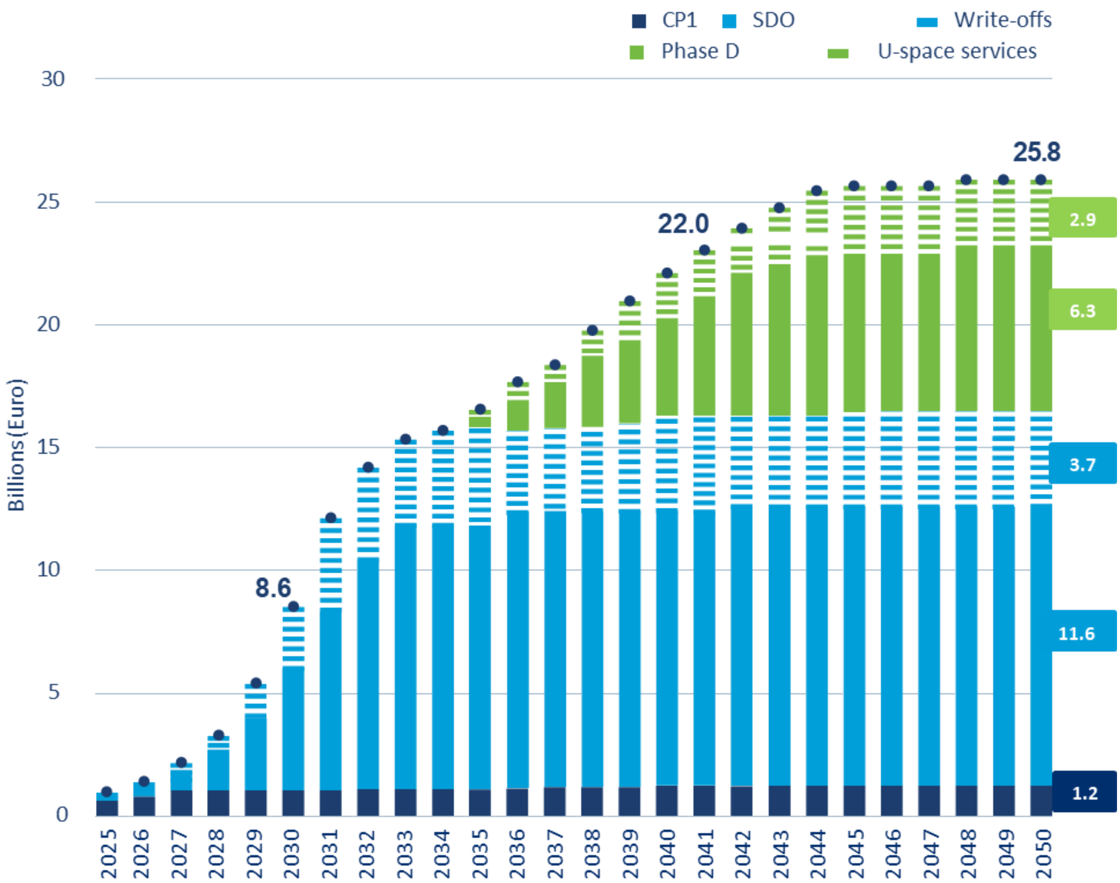


**Figure 14: Cumulative investment needs to deploy SESAR**

### Phases A-B (CP1)

The remaining investment needed for fully deploying CP1 (phases A-B) is estimated at up to EUR 1.2 billion (a quarter of the total CP1 investment). An estimated 90% of these investments (EUR 1.1 billion) are required to finalise the ground deployment by the end of 2027. The remaining 10% (EUR 100 million) is allocated to airspace user fleet equipage between 2028 and 2045.

### Phase C (SDOs)

The investment effort needed for the deployment of SDOs covering phase C is estimated at EUR 11.6 billion between 2025 and 2035. In addition, EUR 3.7 billion are estimated as write-offs to accelerate the transition to the new service delivery model and CNS optimisation.

ANSPs play a pivotal role in accelerating the market uptake of SDO-related solutions. As illustrated in Figure 15, their investments in this phase correspond to the investment planning in the context of the SES performance and charging scheme, starting in reference period 4 (RP4) with a total of EUR 4.0 billion investment for SDOs. The bulk of ANSP investments are expected to occur in the next reference period (RP5), requiring an estimated EUR 8.3 billion. Despite the lower level of investment foreseen for other major stakeholders, their contribution will be key to increasing the overall performance benefits. These CAPEX volumes are broadly speaking in line with historic CAPEX volumes for ANSPs[55]; however, SESAR investment needs may put pressure on other CAPEX-intensive investments not related to the Master Plan (e.g. towers, buildings, and facilities).

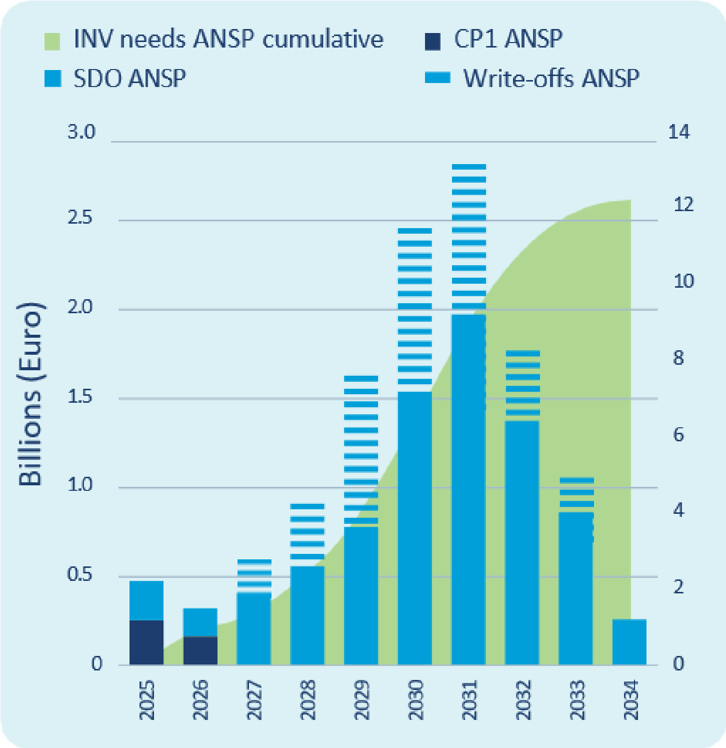


**Figure 15: ANSP investments**

### Phase D

The investment effort for the deployment of phase D between 2035 and 2045 is estimated at one-third of all the cumulative investment needs (i.e. EUR 9.2 billion), in line with the assumptions made in the Master Plan 2020 edition. Approximately EUR 2.9 billion will be dedicated to U3 and U4 services; U-space service providers and drone operators are expected to be the major investors.

[55] According to the PRB Annual Monitoring Report 2022 which covers the SES area (comprising EU Member States, Norway, and Switzerland - not the whole ECAC geographical scope covered by the Master Plan) the total Union-wide en route and terminal RP3 determined CAPEX allocated to ANS included in the performance plans amounted to 5.2B€.

## 7.3 Return on investment

As illustrated in Figure 16, the potential operational benefits for investors in SESAR Solutions significantly outweigh the required investments. By 2050, the combined benefits associated with SESAR deployment across airport and airspace capacity, fuel efficiency, CO2 emissions reductions, passenger time savings and cost efficiency for ANS is estimated at approximately EUR 318 billion.

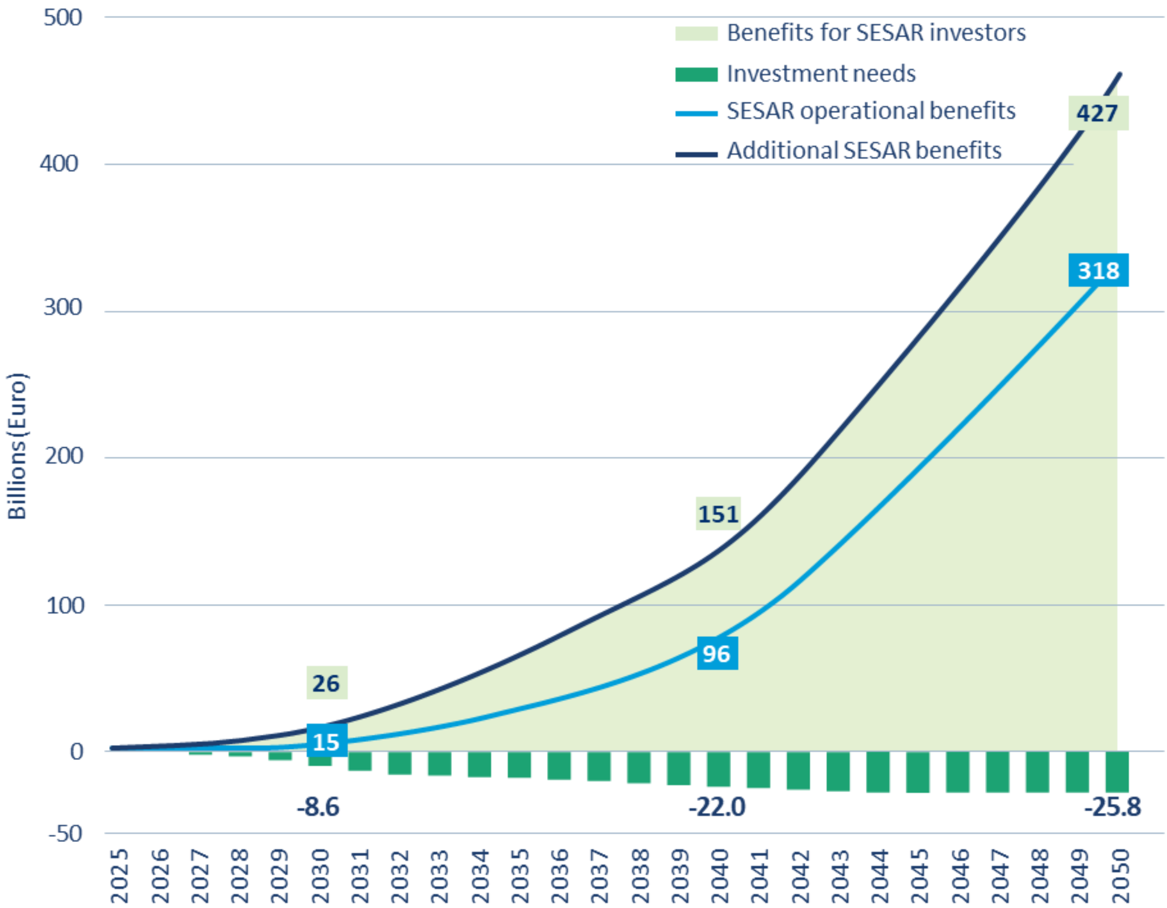


**Figure 16: Cumulative performance benefits and investments**[56]

Activities directly enabled by SESAR investments (e.g. value of additional flights) will generate additional value, expected to amount to EUR 109 billion (see Figure 16). The projected overall benefits for SESAR investors is estimated at EUR 427 billion by 2050.

[56] The figure takes into account investments in both crewed and uncrewed aviation but excludes benefits for U-space and RPAS.

The return on investment for investors (excluding U-space) is projected to be at least EUR 7 for every euro invested in SESAR by 2040, increasing to EUR 17 by 2050.

Direct benefits for the European economy and society (see Figure 17) will be substantial, totalling approximately EUR 1 375 billion, which account for roughly 40% of the overall socio-economic benefits delivered by SESAR. Every EUR 1 invested in SESAR, results in EUR 53 in socio-economic benefits.

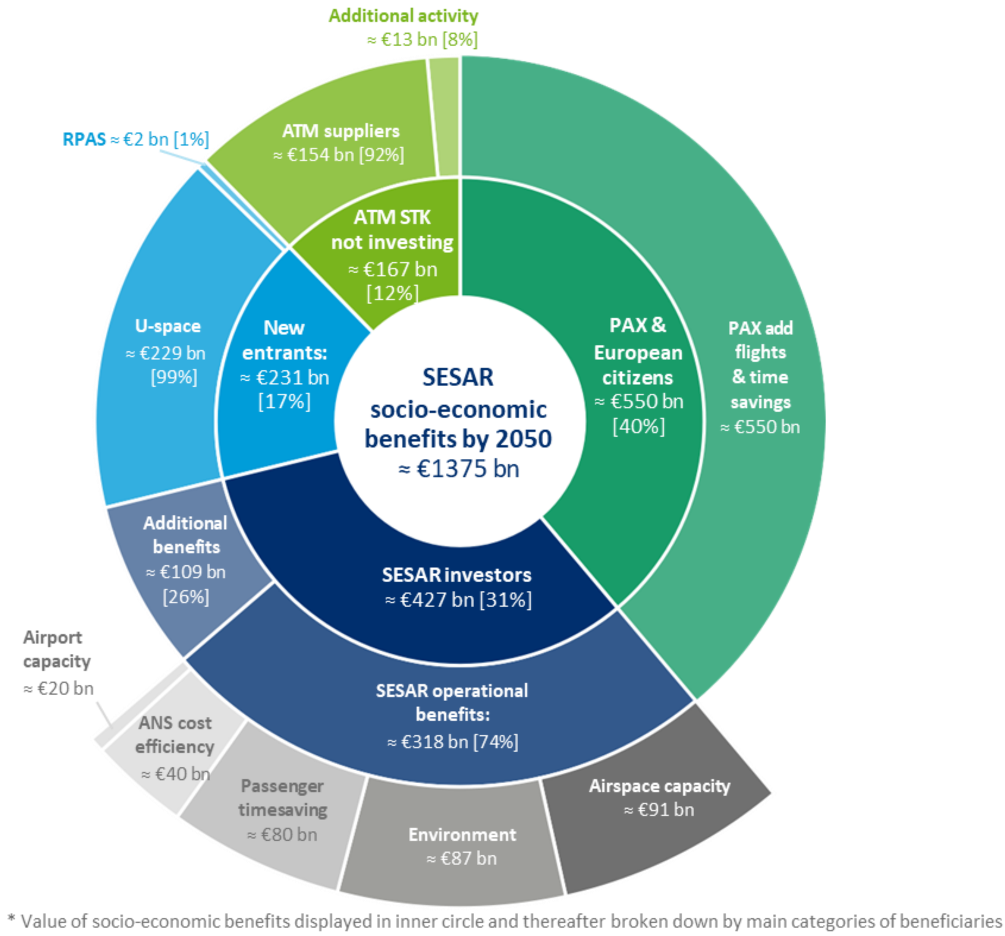


**Figure 17: Socio-economic benefits by 2050**

## 7.4 Sensitivity analysis

A sensitivity analysis confirms that the benefits of implementing SESAR greatly exceed its costs for all operational actors in ATM, even under scenarios of 0% growth, significant cost overruns, delays in deployment or if any of the projected benefits are substantially overestimated.

| Sensitivity drivers | Value | Range | Net benefits* by 2050 (EUR 293 bn) |
|---|---|---|---|
| Deployment of phase D | 2035-2045 | +/- 5 years | -36 / +67 |
| Traffic growth | STATFOR base + 57% | 0% to 92% | -18 / +89 |
| Fuel efficiency potential for phase D | 491 kg/flight | -20% to +20% | -12 / +12 |
| Fuel price | STATFOR base (EUR/kg) | -50% to + 50% | -25 / +25 |
| Passenger time saving potential for phase D | 8.1 min/flight | -50% to +50% | -34 / +34 |
| Investments | € 25.8 bn | -30% to +20% | -2 / +3 |

* Net benefits = monetised benefits minus investment needs

**Figure 18: Sensitivity analysis**

Reductions in fuel efficiency and fuel prices have a relatively minor effect on the benefits. On the contrary, the benefits are more positively influenced by an accelerated deployment and higher traffic forecasts, particularly compared to a zero-growth scenario after the year 2040 (i.e. pessimistic scenario). In this regard, changes in benefits are not symmetric, highlighting a higher positive elasticity. This indicates the need to significantly shorten the innovation cycle in ATM, impacting both development (time to market) and deployment (market uptake) of SESAR Solutions as already highlighted in Section 4.3.

## 7.5 Associated risks

The Master Plan addresses the most significant risks associated with the delivery of the vision and the associated performance ambitions. Identifying risks does not imply that they will actually materialise; rather, it means that these risks have been identified and are to be adequately managed so that they do not affect the execution of the Master Plan.

| Risk | Impact | Mitigation |
|---|---|---|
| Investments on deployment priorities identified in the Master Plan are not supported. | Phase C deployment milestone (by 2035) is not met. | SES instruments work hand-in-hand (as from RP4) to promote investments on SDOs. |
| Delay in CP1 implementation | Phase C deployment milestone (by 2035) is not met. | Yearly monitoring of CP1 implementation progress by the SESAR Deployment Manager (SESAR DM) |
| Delay in delivering the last SESAR solution for Phase C | Phase C deployment milestone (by 2035) is not met. | Yearly monitoring of development progress by SESAR 3 JU. |
| The EASA regulatory framework is not sufficiently supportive for a critical mass of early movers to deploy the priorities identified in the Master Plan. | Phase C deployment milestone (by 2035) is not met. | The European Plan for Aviation Safety (EPAS) of European Union Aviation Safety Agency (EASA) and its supporting standardisation framework is fully aligned with timelines of the Master Plan |
| There is no incentive for early movers to deploy ahead of everyone else. | Phase C deployment milestone (by 2035) is not met. | The Digital European Sky demonstrators are expanded to cover the full scope of strategic deployment priorities, becoming also regulatory sandboxes for the Digital European Sky. EU funds (e.g. Connecting Europe Facility, Innovation Fund and their successors under the next multiannual financial framework - MFF) should be made available to support the deployment of SDOs under the next MFF from 2028 |
| Insufficient level of coordination and harmonisation of SDO deployment. | Phase C deployment milestone (by 2035) is not met. | Future Common Project regulations support the deployment of those SDO elements that require a synchronised and harmonised roll-out at European level. Preparation of the next Common Project starts in 2025 for adoption in 2027, supporting the roll-out of the SDOs by end of 2035.<br><br>Appropriate coordination, harmonisation and monitoring by the relevant European actors. |

| | | |
|---|---|---|
| Insufficient level of global harmonisation | Phase C deployment milestone (by 2035) is not met | ATM functionalities within the scope of SDOs requiring global harmonisation are recognised in the ICAO Global Air Navigation Plan as priorities for global harmonisation fostering the necessary adaptation of the global regulatory framework |
| Failure to manage human performance issues properly (human factors, competency and change management). | Delays in the deployment of phases C and D | Involvement of ATM workforce through their professional staff organisations in the development and deployment activities, training and engagement to gain social acceptance of the changes envisaged by the vision. |
| Lack of resources and time to complete development of phase D by 2030 due to increased ambition in scope for phase D | Phase D development milestone (by 2030) is not met. | All research resources in the ATM innovation pipeline are mobilised to significantly advance development priorities by 2030, the R&D community embraces the approach to develop next generation platforms.<br><br>EU funds (research) should be made available for supporting further SESAR research under the next MFF from 2028. |

**Table 16: Key risks and associated mitigation measures**

# Appendix A

## A.1 TBO roadmap

This roadmap provides a timeline for the development and deployment activities addressing network, air traffic control, and intra-regional trajectory-based operations (TBO), from the 2025 deployment baseline towards the 2045 vision.

The roadmap is grouped into three areas based on the stakeholders involved.

- **Network TBO** are trajectory management processes involving the flight operations centre (FOC) and network manager (NM) supported by the local air traffic flow management (ATFM) units at the air navigation service providers (ANSPs) during the pre-departure and post-departure phases.

- **ATC TBO:** trajectory management processes involving the flight deck and the air traffic control (ATC) units at the ANSPs during the post-departure phase.

- **Regional TBO** concepts are trajectory management processes involving NM, ANSPs and airports during the pre-departure and post-departure phases. Neither the FOC nor the flight deck are involved in regional TBO concepts.

As illustrated in the roadmap, global harmonisation efforts are required and already underway in ICAO.

While the roadmap describes the envisaged European implementation of TBO, it should be noted that the TBO concepts are globally applicable.

**Vision and key milestones for TBO**

**Phase 1 (by 2030):** implementation of Common Project 1 (CP1), including notably a first giant step towards TBO with the integration of the airport operations plan (AOP) and iAOP airports into the network (as defined in CP1-AF2 and AF4), deployment of the first set of FF-ICE services (as defined in CP1-AF5) and initial trajectory information sharing (as defined in CP1-AF6). Significant progress will also have been made in advancing and completing the development priorities for TBO identified in the Master Plan.

**Phase 2 (by 2035):** implementation of the strategic deployment objectives (SDOs) covering TBO. This phase covers: conflict detection and resolution tools enhanced with ADS-C data downlinked from the aircraft; initial set of CPDLCv2 clearances in en-route (addressing complex lateral trajectory revision clearances and simple vertical clearances); dynamic route availability document (RAD); increased provision of trajectory updates by ANSPs and airports to NM; Network Trajectory service for airspace users (AU) and ANSPs; incorporation of departure and arrival user priorities, including flight delay criticality concept; full deployment of the iOAT flight plan; full FF-ICE/R1 (beyond the CP1 services); and seamless cross-border ATC-ATC coordination.

**Phase 3 (by 2045):** SESAR development activities covering advanced TBO functionalities will have been rolled out and every flight will be optimised both in the planning and execution phase of the flight. This covers: full development of the FF-ICE potential; development of advanced ATS B2, incorporating more complex clearances and extension to the lower airspace and airport surface, the network-wide STAR uplink service and flexible eco-efficient clearances; advanced network trajectory synchronisation in the execution phase; connected aircraft with full integration of the flight management system (FMS), electronic flight bag (EFB) and AOC functionalities with the ATM system for trajectory optimisation during the execution of the flight; digitalisation of Letters of Agreement (LOA); and dynamic RAD evolution towards a RAD by exception environment.

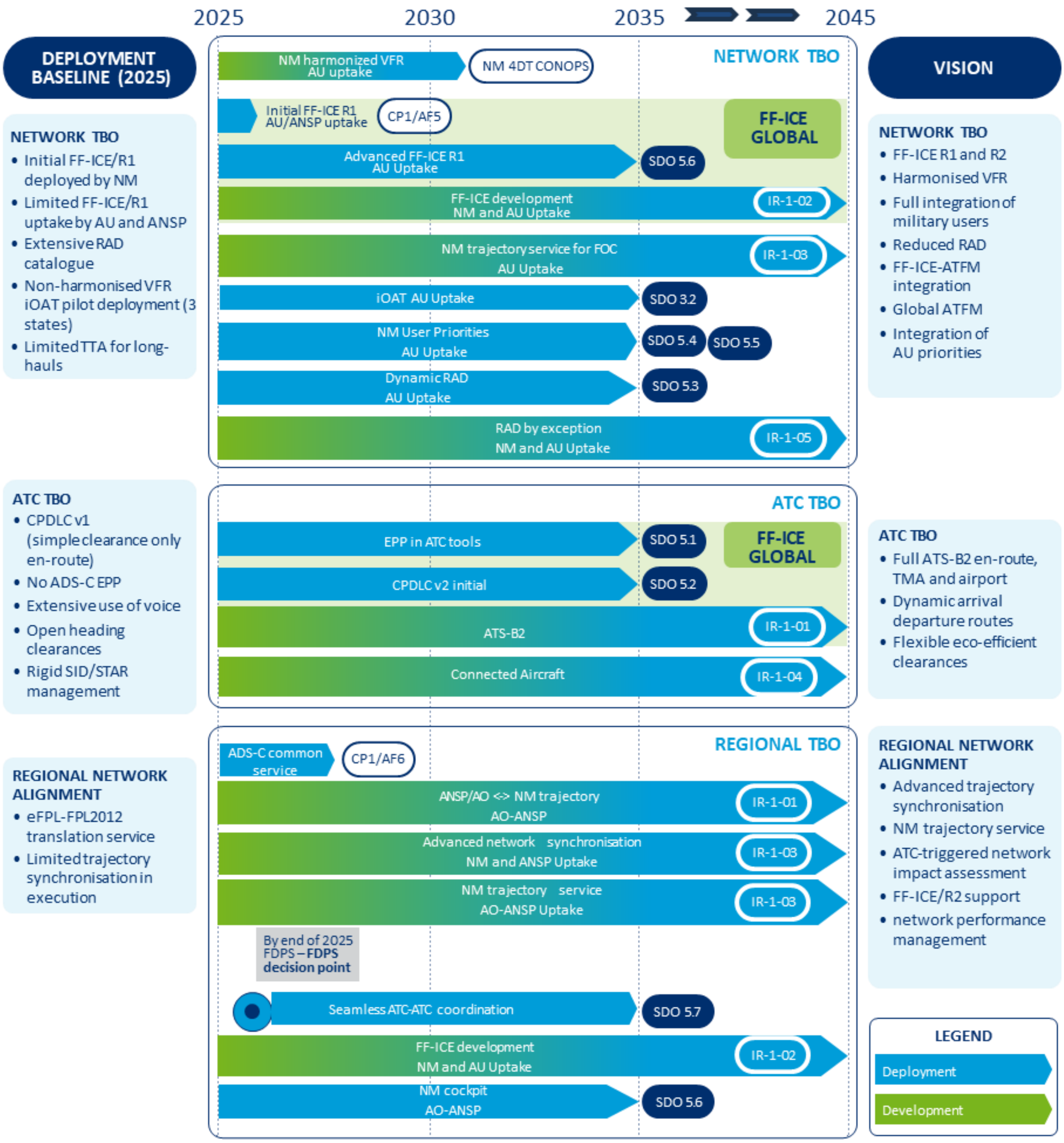


**Figure 19: Integrated TBO roadmap**



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## A.2 CNS roadmap

This roadmap covers communication, navigation, surveillance (CNS) functionalities that need to be developed and deployed to implement the vision, wherein the ATM system will gradually evolve towards one lean and efficient CNS infrastructure with start-of-the-art technology. The roadmap considers the target architecture and service delivery model which seeks to enable much higher levels of connectivity and automation of systems on the ground and in the air compared to today. It also outlines, where possible, opportunities for convergence of the ATM and U-space environments, as well as rationalisation that should be captured during the transition between the current and future CNS infrastructure. Finally, the roadmap integrates and refines the recent work of the CNS Advisory Group[57], civil-military synergies, as well as the white paper on future connectivity for aviation[58].

This roadmap will be complemented by a CNS Evolution Plan, which is under development by the CNS Programme Manager function executed by the Network Manager. It will provide more details for the modernisation of European CNS infrastructure, addressing how best to deploy strategic priorities defined in the ATM Master Plan. It will detail the rationale and timelines for the deployment of new ground infrastructure, on which the synchronised evolution of the relevant ground and airborne certification specifications and EU deployment mandates can be based, as well as options for decommissioning and removal of equipment assessed as surplus to resilience principles still to be defined at network level. The CNS Programme Manager may make recommendations to be considered for regulatory or policy intervention, which will remain subject to the relevant institutional regulatory and rule-making process.

**Vision and key milestones for CNS**

By **2030**: the number of required navigation performance (RNP) approaches and precision approach procedures will be significantly increased and the transition towards high-performance air-ground connectivity (successor of VDL2) will be underway. Significant progress will have been made on development priorities impacting CNS, such as the use by future ground platforms of CNS data as a service.

By **2035**: GBAS will serve CAT II/III operations relying currently on ILS, and GNSS capabilities will be fully leveraged to allow innovative air mobility (IAM) users to operate effectively. A minimum operational network (MON) will have been implemented in Europe to fully optimise the infrastructure where possible and address vulnerabilities such as system failures, electromagnetic interferences, jamming, spoofing and ionospheric propagation disturbances.

By **2045**: voice communication will no longer be the primary means of communication as most routine tasks will be managed through machine-to-machine applications. Infrastructure on the ground, in the air or in space will be used in an effective way to deliver CNS as a service. The latter will be contracted between customers and providers with a clearly established European-wide set of harmonised services

[57] Composed of experts from the European Commission, EASA, EUROCONTROL, SESAR Joint Undertaking, SESAR Deployment Manager, European Defence Agency and EUROCAE, CANSO, IATA/EBAA representing airspace users, ACI, Expert Group of the Human Dimension of SES, Industry Consultation Body

[58] Future Connectivity for Aviation, White Paper, 2022

and level of quality that enables the optimisation of trajectories for all users of the sky (civil and military).

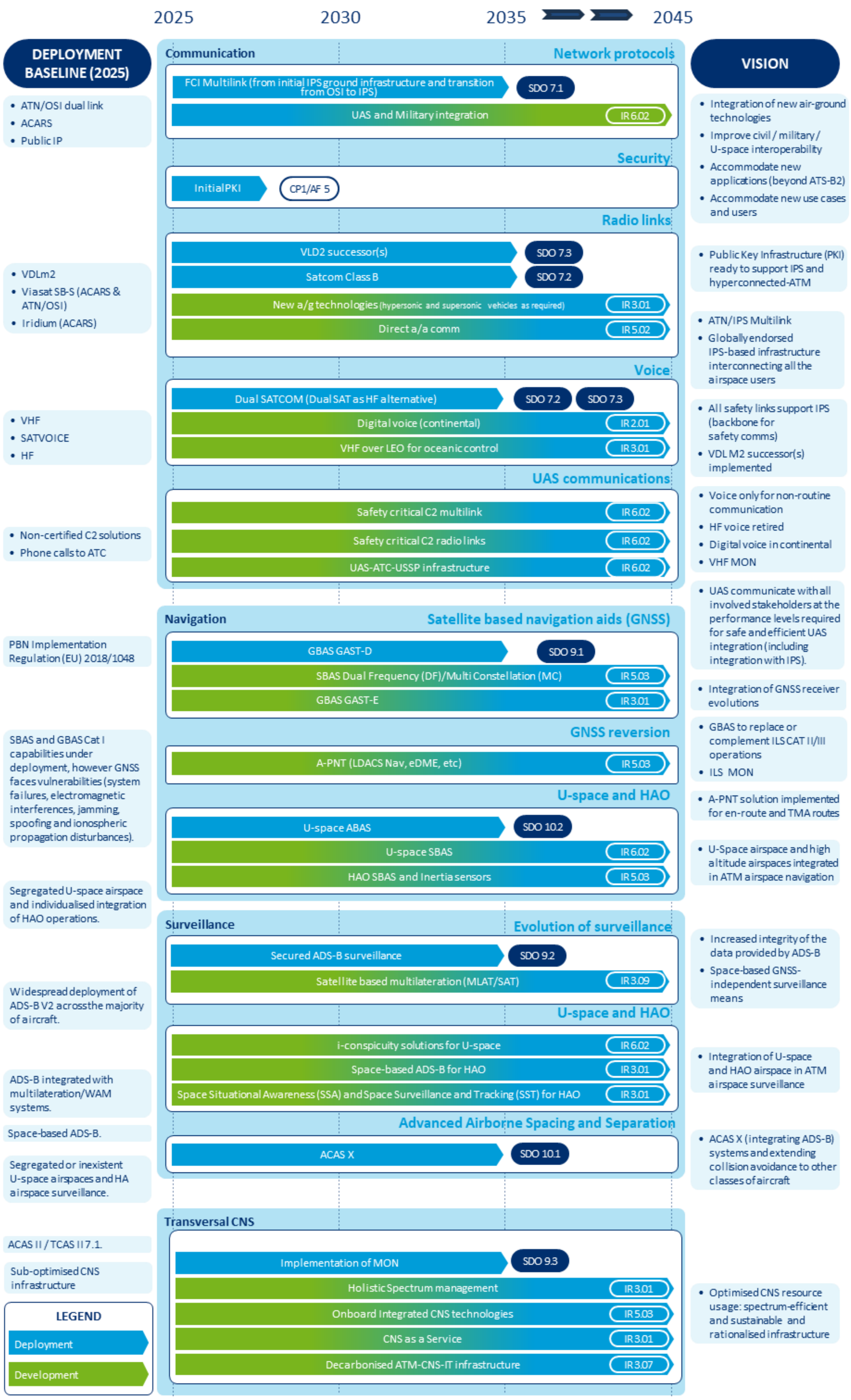


Figure 20: CNS roadmap

## A.3 Automation roadmap

This roadmap covers automation functionalities that need to be developed and deployed to enable human-machine teaming, as outlined in the vision. The aim is that operations in certain phases of flight will be fully automated, whereby automation is capable of managing both nominal and non-nominal situations. In this new paradigm, the human role evolves significantly, focusing on tasks too complex for automation. Voice is no longer the primary means of communication, as routine tasks are managed through machine-to-machine applications.

For simple tasks, high levels of automation are achievable without AI, while it is expected that the automation of more complex tasks will require AI. The EASA AI Roadmap 2.0 provides an AI trustworthiness framework for enabling readiness for use of AI in aviation, defining six levels of AI based on the level of human agency and oversight of the AI-based application.

The targeted automation levels for ATM are expressed as future system capabilities, which should gradually enable air traffic service providers to handle flights in automated ways within a predefined scope. Outside of this scope (when a task becomes too complex for automation to handle) automation will request the human operator to supervise its operation as illustrated in Figure 21. For each automation level, the table indicates the EASA AI level applicable, where the automation level is achieved using AI.



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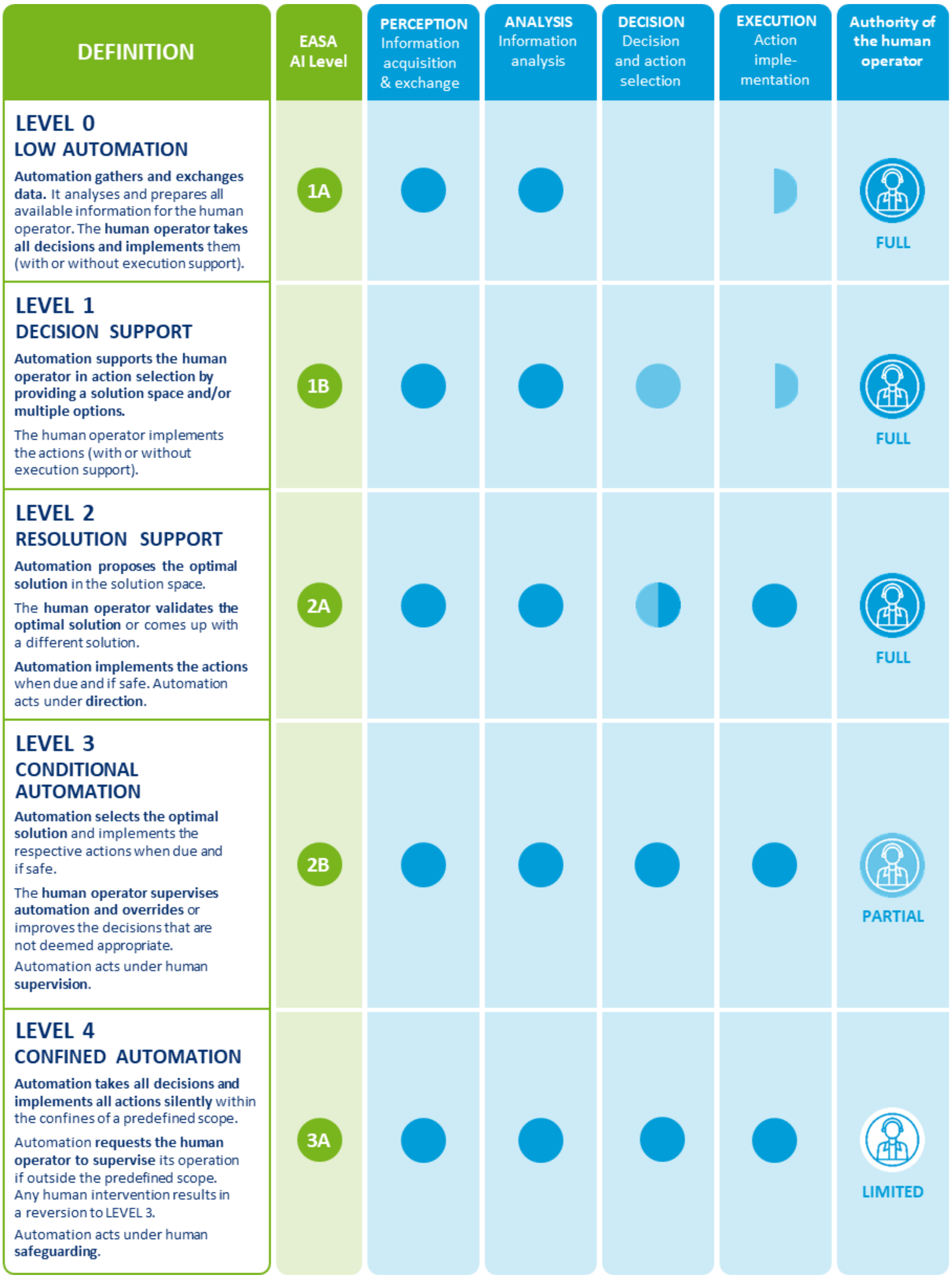


**Figure 21: Levels of automation taxonomy and correspondence to EASA AI Levels**

The human actors in the roles and functions of the ATM system will evolve in line with the paradigm shift envisaged by the implementation of the vision. New roles and functions will emerge; existing roles and functions may or will change, in some cases radically, whereby humans become 'system components' in joint and distributed cognitive systems, and humans and automation share responsibility for safety and efficiency. Automation support will also make it possible for controllers to provide services across a wider geographical area than was previously possible, with controller competence being linked to the ability to operate the system efficiently rather than to specific sectors . The controller licensing schemes, and the ATM system certification framework will evolve to support this new way of operating. Automation will be developed to the extent that situations can be handled as well or better than when the human is involved, including full decision-making and action implementation.

The following describes the different levels of human roles:

**Enhanced decision-maker** (Level 1): the human makes all decisions based on appropriate overviews of all feasible options (e.g. solution space) provided by automation.

**Director** (Level 2): the human evaluates the optimal solution provided by automation and improves it where necessary. The human has the final say, while automation performs all necessary calculations to support the decision-making.

**Supervisor** (Level 3): the human decides which tasks/situations are to be managed by the automation and by themselves. For instance, the human air traffic controller decides which aircraft should be guided by automation. The human controller oversees and can override automation once a system decision is not deemed appropriate due to a particular operational understanding that is not known to automation.

**Safeguard** (Level 4): the system operates fully autonomously under the supervision of the human. When the system identifies that it is at risk of operating outside of its allocated operational design parameters it suggests moving back to Level 3 or lower.

The design of the next generation of ATM systems in this highly automated environment will aim at achieving a human-machine teaming. The trade-off between augmentation and assistance will be carefully balanced to avoid information overload. Technology-specific and operational metrics will be used to track system performance both in the short and long term, with particular attention being paid to the early detection of degradation modes via leading indicators.

The ATM workforce will be involved in the design of the new ATM platforms from the early stages. The system development will incorporate the well-established SESAR methodology to include iterative verification and validation, in which systems are tested by end-users in isolation as well as in an integrated setting, and all relevant human performance metrics are carefully monitored. Service orientation principles will be applied at all levels to facilitate the update of the system both in its development and operational phases, allowing the incorporation of user feedback and providing flexibility to address emerging operational needs. Human performance expectations and responsibilities will be clearly identified and commensurate with human capabilities and limitations. The integration of AI in ATM systems will be designed to be interpretable to operators. Human competence schemes will evolve to ensure that controllers and air traffic safety electronics personnel (ATSEPs) gain and retain the appropriate skills, including relevant expert-user-level understanding of AI methodologies.

**Vision and key milestones for automation**

- **By 2030**: ATM in Europe will operate at automation level 0, and AI will be only marginally used in machine learning applications for supporting ATFM or airport landside processes.

Significant progress will have been achieved on the development of the future platforms for en-route, TMA and airports designed for automation level 4.

- **By 2035**: ATM in Europe will operate at automation level 2 thanks to the implementation of increased automation support tools and the transition to trajectory-based operations phase 2. This will have been achieved with the implementation of sector team configurations, automatic speech recognition, user profile management, attention guidance and trajectory prediction tools supporting the earlier detection and resolution of potential conflicts.

- **By 2045**: for certain phases of flight, ATM in Europe will operate at automation level 4 (or when needed at lower levels when outside of a pre-defined scope for level 4) thanks to the implementation of new platforms designed for human-machine teaming. Voice communication will no longer be the primary means of communication as most routine tasks will be managed through machine-to-machine applications.

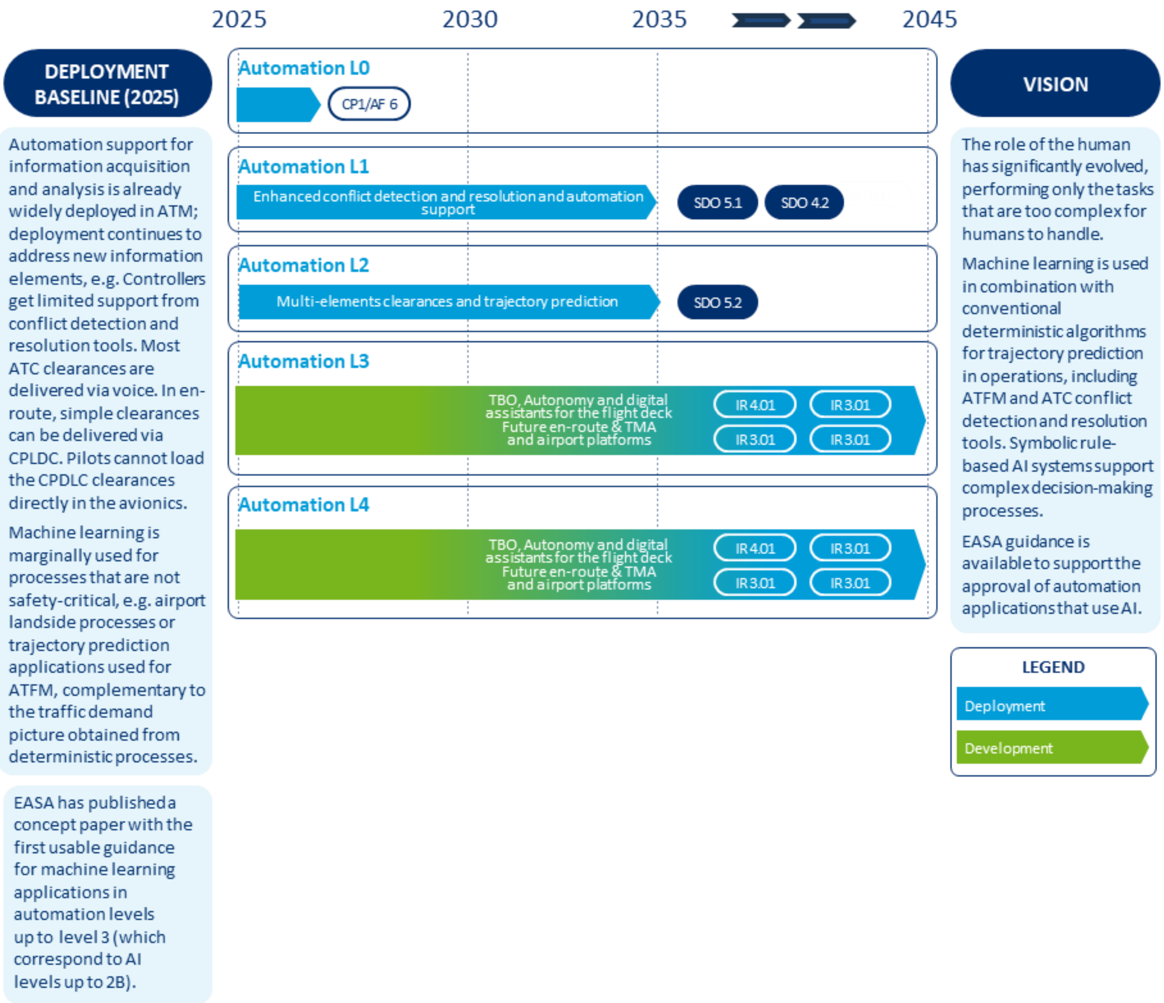


**Figure 22: Automation roadmap**

## A.4 U-space 2.0 roadmap

This roadmap covers U-space 2.0 functionalities, which need to be developed and deployed to implement the vision where the ATM system gradually evolves to cater for the uptake of innovative air mobility (IAM). The roadmap includes an overall refinement of the U-space concept to better reflect latest developments and insights that impact the definition and roll-out of U1 and U2 services. It also reflects the latest developments and needs of IAM that impact the definition and roll-out of U3 and U4 services. Where feasible, the roadmap also takes into account the specific needs of general aviation (GA) and rotorcraft that could be addressed through U-space services.

**Vision and key milestones for U-space 2.0**

By **2030**: U-space U1 and U2 services will be implemented in Europe and the first IAM/VTOL capable aircraft (VCA) operations will be accommodated like any other rotorcraft operation. Significant progress will have been made on development priorities related to U3 and U4 services, such as enabling IAM/VCA (crewed and uncrewed) operations at scale, including in complex environments, congested portions of airspace and vertiports.

By **2035**: a common ATM/U-space interface, dynamic airspace reconfiguration service and new GNSS-enabled procedures will be implemented allowing IAM users to operate to and from airports/vertiports and TMAs without conflicting with other traffic.

By **2045**: thanks to the implementation of U-space U3 and U4 services, as well as future platforms for en-route, TMA and airports, ATM and U-space will enable the seamless integration of crewed and uncrewed vehicles in all classes of airspace.

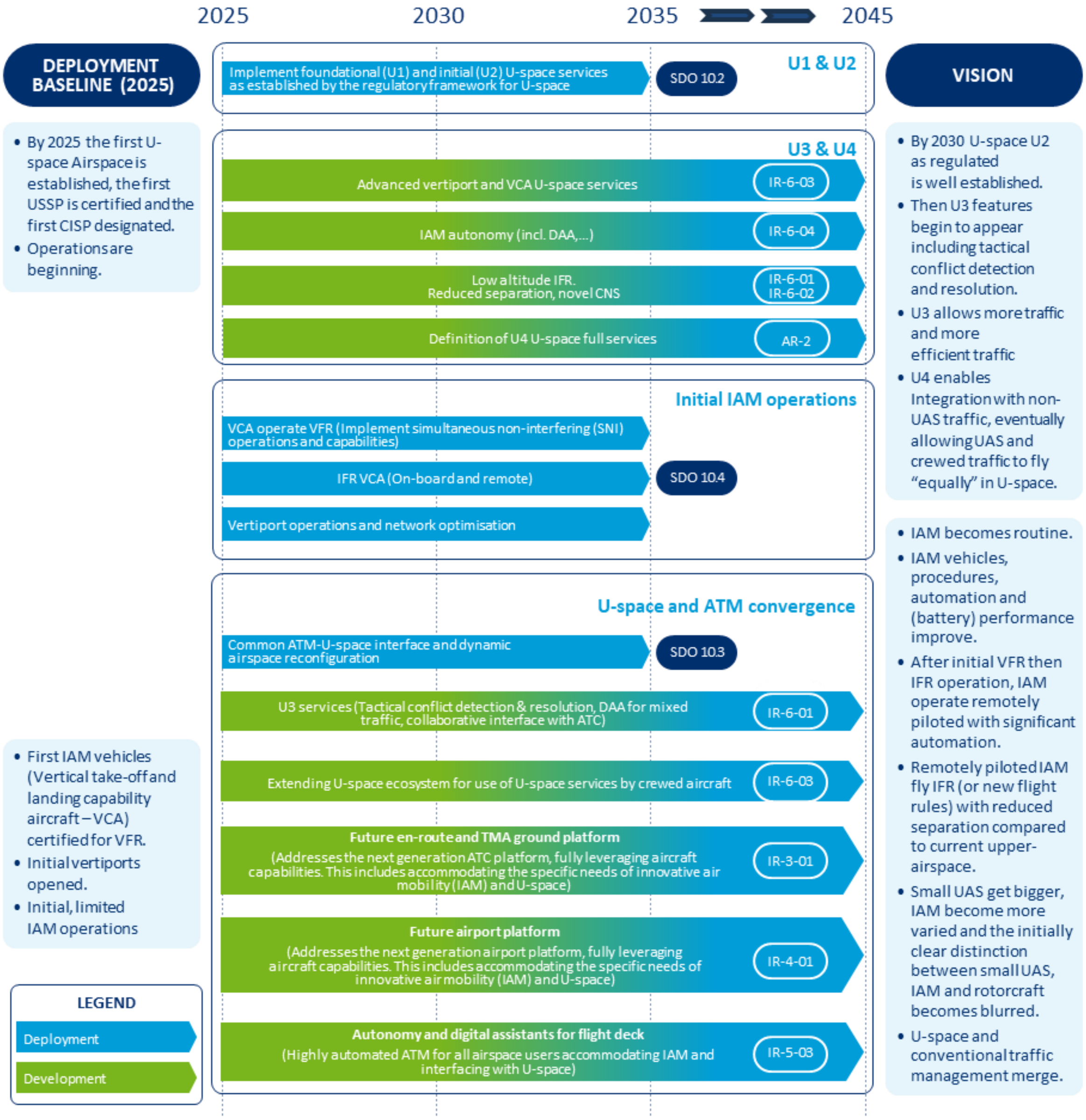


**Figure 23: U-space 2.0 roadmap**





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## A.5 Civil-Military roadmap

This roadmap identifies priority civil-military capabilities (i.e. airspace, technology, data), which need to be developed and deployed to ensure the progressive airspace integration of envisaged future combat systems, including remotely piloted air systems (RPAS), in an interoperable manner and with additional efforts on cybersecurity robustness and resilience. The air domain is critical to securing EU territories and its population, as well as for international trade and travel. Effective civil-military cooperation, as reflected in this roadmap, is key to enhancing flight efficiency, optimising airspace capacity, and safeguarding military operational efficiency, as well as military mission effectiveness (i.e. planning versus activation). This cooperation is also critical for facilitating access to airspace for new military aerial vehicles (e.g. fifth generation fighters, RPAS, high altitude pseudo satellites, balloons, etc.) in a sustainable, safe and secure aviation environment.

**Vision and key milestones for civil-military capabilities**

**By 2030**: Enhanced data sharing will be facilitated by pre-defined airspace structures, enabling more dynamic airspace management and free route airspace (FRA). This process necessitates higher levels of coordination between civil and military air navigation service providers (ANSPs), supported by dynamic civil-military collaborative decision-making (CDM).

Significant progress will have been made on development priorities impacting air-ground connectivity (including CNS dual-use) and the level of automation for future en-route, TMA and airport platforms (includes fully dynamic management of scalable airspace configuration to meet the needs of military users).

**By 2035**: the implementation of mission trajectory and dynamic mobile areas (DMAs) of type 1 and 2 will be completed, using the improved operational air traffic flight plan (iOAT) in dynamic airspace configuration processes, together with integration of IFR RPAS into airspace classes A to C.

**By 2045**: all missions (crewed or uncrewed) - including those by supersonic, hypersonic and suborbital vehicles – will operate in a way that maximises, to the fullest extent, aircraft capabilities to reduce the overall climate impact of aviation. Airspace will be designed and managed to deliver the right capacity at the right time in a fully dynamic manner, including cross-border management. A single and seamless rolling ATM process will be in place from planning to execution, providing an accurate picture of an integrated civil-military predicted situation in ATS-controlled airspace. Civil-military collaborative decision-making will be in place at network level throughout the various ATM phases, based on information maturity rather than time bound.

With these developments, civil ANSPs in collaboration with the military can dynamically scale capacity up or down in line with demand also taking into account military users. These capacity adjustments are implemented in real time and ensure an optimal and cost-efficient use of resources at any moment across the network (airspace, data, infrastructure and human-machine teaming). The continuous optimisation of every mission trajectory will also improve the civil use of released and available airspace (CURA) thanks to high connectivity between air/ground and ground/ground components.





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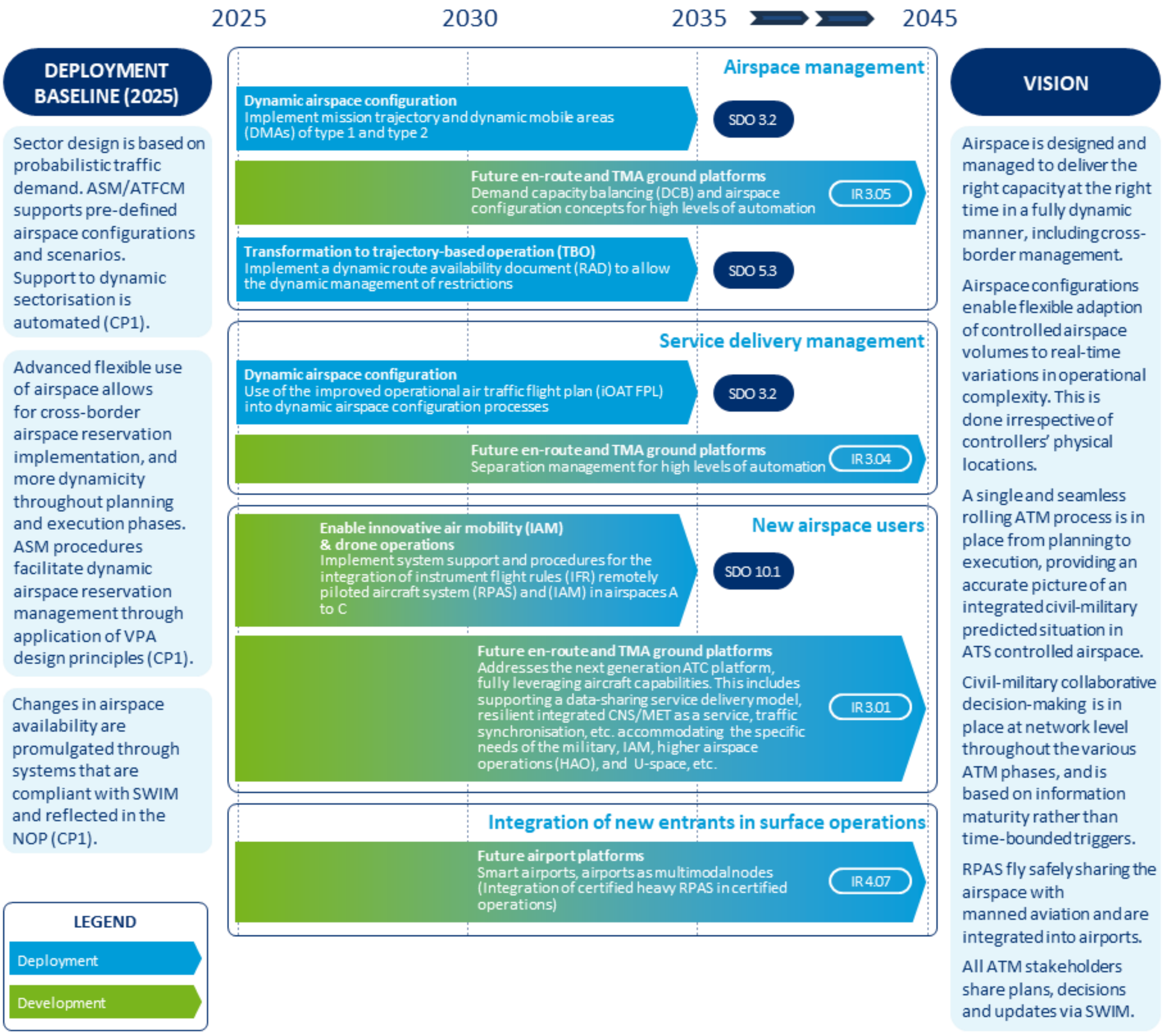


**Figure 24: Civil-Military roadmap**

## A.6 Cybersecurity capabilities roadmap

This roadmap defines priority cybersecurity capabilities, which need to be developed and deployed to enhance the cybersecurity posture of ATM systems, protecting critical infrastructure, data, and operations from cyber threats.

As described by the vision, future ATM will rely on increased information flows between more stakeholders and higher levels of automation, all against a backdrop of an increasingly hostile environment prone to cyber-attacks. A homogeneous and holistic approach to **security risk management** will be critical to tackling increased exposure to cyber threats and ensuring cyber-resilience. This will allow interconnected components to trust the information flow they receive. Effective and efficient risk management, using the latest updated security risk assessment methodology (SECRAM) and threat catalogue, will be based on identifying the risks associated with any compromise of key security attributes: confidentiality, integrity, availability, authenticity, and non-repudiation.

An oversight mechanism will be implemented, enabling the evaluation of Security Risk Assessments, applied consistently among SESAR Solutions.

Once the appropriate risk level is established for each security attribute, specific security requirements can be identified. For example, a strong digital signature mechanism might be necessary for high integrity requirements, while a simple checksum might suffice for low integrity needs. Similarly, for confidentiality, a medium level of risk might require encryption with a standard algorithm, while a high level of risk would necessitate using advanced encryption methods and stricter access controls. In this way, a secure and trusted communication infrastructure will be available.

**Vision and key milestones for cybersecurity capabilities**

**By 2030**: the European aviation ecosystem will be **resilient** to cyber threats. It will maintain its ability to always deliver the intended outcome continuously, even when regular delivery mechanisms are under cyber-attack.

**By 2035**: the European aviation ecosystem will transition from resilience to a state of **anti-fragility**, where its cybersecurity infrastructure actively learns from attacks and becomes stronger in the face of new threats, ensuring a safer and adaptive aviation ecosystem. This approach relies on proactive systems that not only withstand attacks and disruptions but also evolve to anticipate and neutralize future cyber risks, thereby enhancing the overall security and reliability of European aviation.

**By 2045**: European aviation cybersecurity reaches the **enlightened** state, a fully predictive model where advanced AI algorithms analyse extensive data and emerging cyber trends to forecast and pre-emptively counteract potential cyber-attacks before they occur, establishing an unparalleled level of proactive digital security.


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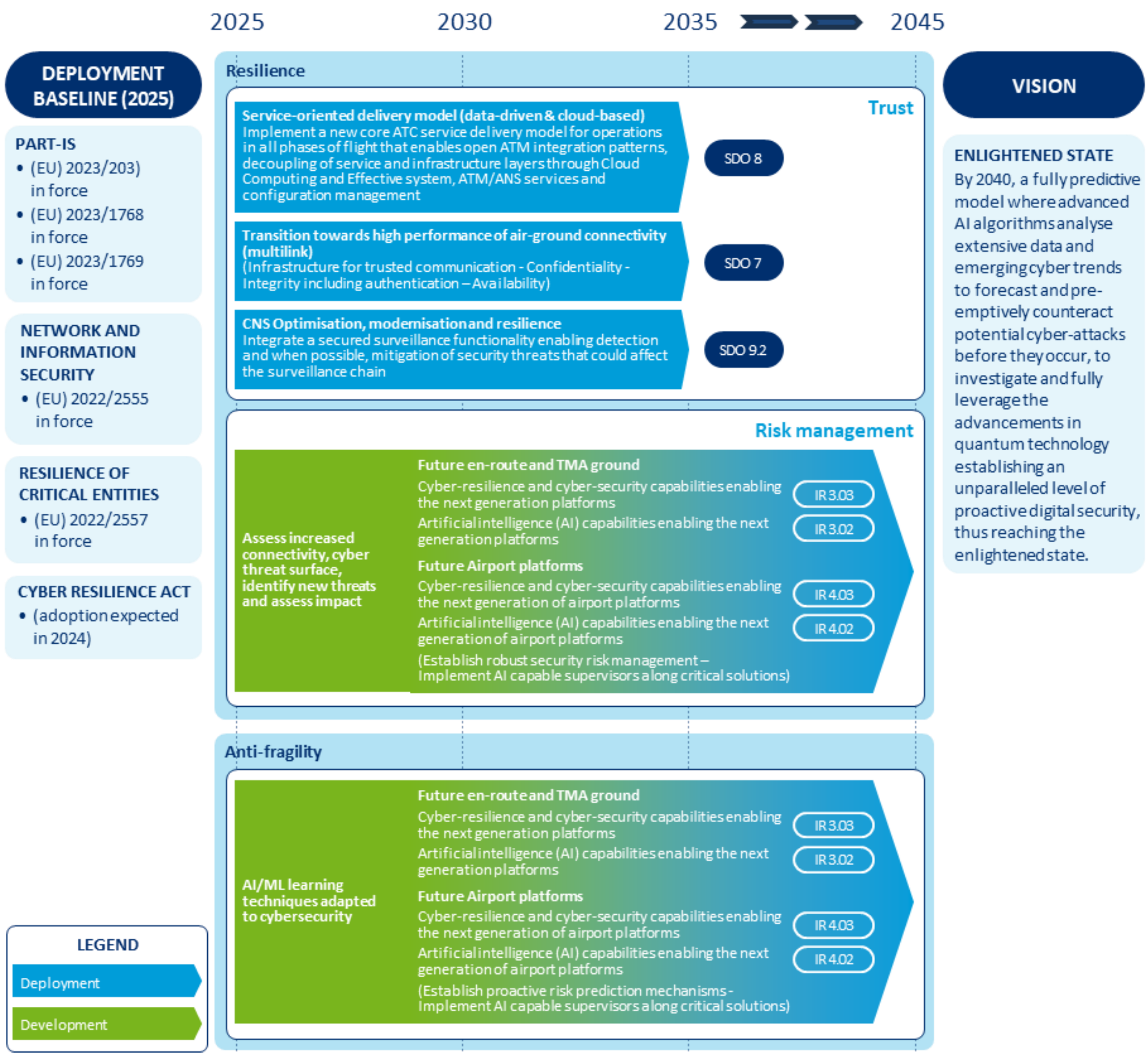


**Figure 25: Cybersecurity capabilities roadmap**

## A.7 New service delivery model – Business services

This appendix presents the list of business services for a typical area control centre (ACC).

| Business service | Examples of functions covered by the business service<br><br>*Indicative only – this list of examples may not be complete and may be subject to change.* |
|---|---|
| HMI | Air situation display, alerts, flight editing and dialog, attention & fatigue, speech recognition. |
| Flight data/trajectory management | 4D trajectory prediction, ATC-ATC exchanges, ATC-NM exchanges, flight correlation, SSR code management, flight plan correction, performance management. |
| Sequencing | Arrival management, departure management, integrated AMAN-DMAN, time-based separation. |
| Separation management | Tactical controller tools, conflict detection, conflict resolution and assistance, what if - what else probing, adherence monitoring (CLAM, RAM, …), merging and spacing. |
| Local ATFCM | Local demand and capacity balancing (DCB), complexity management. |
| Safety nets | Short term conflict alert (STCA), minimum safe altitude warning (MSAW), area proximity warning (APW), approach path monitoring (APM), ground safety nets. |
| Navigation | Navigation signal, performance monitoring. |
| Communication | Ground-ground voice communication, air-ground voice communication, voice control distribution, voice control management, performance monitoring. |
| Surveillance | Surveillance data fusion, tracking, surveillance data distribution, surveillance sensors, performance monitoring. |
| Datalink | Controller pilot datalink communication (CPDLC), automatic dependent surveillance – contract (ADS-C) including extended projected profile (EPP), context management, downlinked aircraft parameters (DAP) including humidity. |
| Environment (CO2/Non-CO2) | CO2, non-CO2 including contrail management, noise. |
| CIV/MIL Airspace management | Airspace reservation management (ARES), booking management, airspace configuration and distribution, airspace status distribution. |

| | |
|---|---|
| Operational supervision | Sector configuration, configuration of parameters, operational supervision distribution. |
| CNS infrastructure and basic services | Deployment, recording, time synchronisation, metrics & reports, logging, voice over internet protocol (VoIP), monitoring, billing. |
| Network services | Pan European network service (PENS), ATS common datalink services (ACDLS), future communications infrastructure (FCI), system-wide information management (SWIM) yellow profile. |
| Simulation, training & analysis services | Traffic generator, preparation and execution, pseudo-pilots, replay. |
| Meteorology | OPMET, local weather, convection, winds, clear air turbulence, icing, space weather. |
| Aeronautical information management (AIM) | Aeronautical information publication (AIP), aeronautical information circular (AIC), NOTAM, D-NOTAM, AIM on request, charting, charting on request. |

**Table 17: Business services for a typical ACC**

## A.8 Mapping with the global air navigation plan (GANP)

This appendix presents the mapping between the European ATM Master Plan and the seventh edition of the ICAO global air navigation plan (GANP). The Master Plan and the GANP are complementary, with the Master Plan focussing on the European context, while the GANP provides a global framework, ensuring consistency and collaboration across regions. It is therefore important to demonstrate that the European ATM Master Plan aligns with the global objectives set by the GANP.

As the content of the GANP is organised into a multilayer structure with each layer tailored to different audiences, the mapping relates the deployment actions of the SDOs to the global technical level (i.e. level 2) of the GANP. The global technical level supports technical managers in planning the implementation of basic services and new operational improvements in a cost-effective manner and according to specific needs, while ensuring interoperability of systems and harmonisation of procedures. One of the key building blocks of the global technical level are aviation system block upgrade (ASBU) elements that describe specific operational improvements. ASBU elements are organised in ASBU threads that correspond to key features of the air navigation system. In the figure below, for every SDO a one-to-many mapping was established between DAs and ASBU elements, where available.

The ICAO ASBU panel project team is currently preparing the 8th edition of the GANP, to which this master plan brings significant input.

| Deployment Action | ICAO ASBU Element |
|---|---|
| **SDO 1: Alerts for reduction of collision risks on taxiways and runways** | |
| **Deployment Action 1.1**<br>Adapt airport ground safety nets to extend conflicting ATC clearances (CATC) to the entire Aerodrome Movement Area, to enlarge the set of Conformance monitoring (CMAC) alerting functions and to provide integrated occupancy/conflict status of a runway. | SURF-B1/3 |
| **SDO 2: Optimising airport and TMA environmental footprint** | |
| **Deployment Action 2.1**<br>Implement collaborative management of regional airports and their integration with Network Manager (NM) by sharing departure planning information (also shared between NM and airspace users). | ACDM-B2/2<br>ACDM-B2/3<br>NOPS-B2/5 |
| **Deployment Action 2.2**<br>Implement solutions to better integrate large / very large airports and the network via enhanced AOPs-NOP tactical, pre-tactical and strategic planning and AOP to AOP collaborative planning process. | NOPS-B2/5<br>ACDM-B3/1 |
| **Deployment Action 2.3**<br>Implement environmental performance management at airports and solutions to reduce the airport impact on emissions (single engine taxiing, engine-off taxiing though use of sustainable taxiing vehicles). | ACDM-B3/1 |
| **Deployment Action 2.4**<br>Implement capabilities to better manage arrival constraints between different E-AMAN units in cross-border environments and to better integrate the out-of-area inbound flights. | ACDM-B3/1 |
| **Deployment Action 2.5**<br>Implement optimised descent operations using merge to point and advanced approach procedures (i.e. second runway-aiming point (SRAP), increased second glide slope (ISGS), increased glide slope to a second runway aiming point (IGS-to-SRAP)), which aim to reduce the environmental impact (e.g. noise, fuel consumption, CO2 emissions, etc.) on the airport's neighbouring communities.* | APTA – B1/4 |
| **Deployment Action 2.6**<br>Implement new capabilities to increase airport runway capacity both on arrivals and departures based on Wake Turbulence Separations based on static aircraft characteristics, Required Surveillance Performance (RSP) and Runway Occupancy Time (ROT) characterisation of the leader aircraft.** | WAKE-B3/3<br>WAKE-B3/6 |

*No ICAO Element yet for increase secondary glide slope (ISGS), second further runway aiming point (SRAP), increased glide slope to a second runway aiming point (IGS-to-SRAP) – possibility to be in next version of the GANP

**An ASBU APTA-B3/X related to DA 2.6 will possibly be included in next version of the GANP





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SDO 3: Dynamic airspace configuration

ICAO ASBU Element

**Deployment Action 3.1**
Implement higher granularity and flexibility in the airspace configurations, dynamically adjusting them in response to changes on demand, and refining airspace management within and across ANSPs' areas of responsibilities.

FRTO-B2/1
FRTO-B2/2
NOPS-B2/2

**Deployment Action 3.2**
Implement mission trajectory and dynamic mobile areas (DMAs) of type 1 and type 2 using the improved Operational Air Traffic Flight Plan (iOAT FPL) into dynamic airspace configuration processes in medium to short-term ATM planning phase supporting military airspace requirements.

FRTO-B1/3
FRTO-B2/2

SDO 4: Increased automation support

**Deployment Action 4.1**
Implement sector team configurations which, in specific airspace configuration, include the combination of one planning ATCO to two tactical/executive ATCOs in en-route/eTMA environment.

FRTO-B1/6

**Deployment Action 4.2***
Implement automatic speech recognition (ASR), user profile management system (UPMS) and attention guidance (AG) to provide a higher automation environment to support the ATCO role.

*No ICAO Element yet – will be in next version of the GANP

| SDO 5: Transformation to Trajectory-Based Operations (TBO) | ICAO ASBU Element |
|---|---|
| **Deployment Action 5.1**<br>Implement enhanced conflict detection and resolution (CD&R) support tools by using aircraft derived data (i.e., extended projected profile (EPP)) supported by the full implementation of ATN B2 and high-resolution wind models. | FRTO-B1/5<br>FRTO-B2/4 |
| **Deployment Action 5.2**<br>Implement multi-element clearances using controller pilot datalink communications (CPDLC) with lateral and vertical datalink clearances and increased ground automation tools (e.g., CD&R tools) and trajectory prediction supporting the earlier detection and resolution of potential conflicts. | FRTO-B1/5<br>COMS-B3/1 |
| **Deployment Action 5.3**<br>Implement a dynamic route availability document (RAD) to allow the dynamic management of restrictions based on traffic evolutions, better integration of Letters of Agreement (LoAs) between ATC centres and NM and the provision of preliminary flight plans by airspace users, ahead of dynamic network constraints publications initiated the day before operations.* | |
| **Deployment Action 5.4**<br>Implement airspace user capabilities to provide, through the user-driven prioritisation process (UDPP), their preferences and priorities and influence arrival ATFM arrival regulations. | NOPS-B2/4 |
| **Deployment Action 5.5**<br>Implement interaction tools supporting the full integration of the flight operations centre (FOC) into the ATM network process and the flight delay criticality concept, to better integrate airspace user priorities in flow management decisions looking at short term implementation step. | NOPS-B2/4 |
| **Deployment Action 5.6**<br>Exploit new FF-ICE/R1 trajectory services beyond the CP1 services, which are just the filing, data request, notification, publication and trial services, to improve completeness and precision of traffic load calculation and advanced network performance capabilities. | FICE-B2/1<br>FRTO-B2/4 |
| **Deployment Action 5.7**<br>Implement seamless ATC-ATC coordination and sharing with NM of the ATC-ATC exchanges, encompassing more complex coordination dialogues implying negotiation between controllers across ACC boundaries. (Note that SDM action plan to build consensus on IOP is ongoing). | FICE-B3/1 |

*N/A - Dynamic RAD and LoA Management are not part of ICAO ASBUs

| Deployment Action | ICAO ASBU Element |
|---|---|
| **SDO 6: Virtualisation of operations** | |
| **Deployment Action 6.1*** Implement virtual centre to allow decoupling of the ATM data service provider (ADSP) and air traffic service unit (ATSU) through service interfaces that support new ways of dynamic ATS delegation (e.g. contingency delegation, night delegation (scheduled), fixed time delegation (scheduled ), ('on-demand'). | |
| **Deployment Action 6.2** Implement multiple remote tower module (MRTM) flexible and dynamic allocation of different MRTMs accommodated within a Remote Tower Centre (RTC) that allows the ATCO to maintain situational awareness for two or more small airports. It covers the implementation of a low-cost surveillance service for supporting remote tower operations. | DATS-B1/1 |
| **SDO 7: Transition towards high performance of air-ground connectivity (multilink)** | |
| **Deployment Action 7.1** Implement future ground communications network infrastructure, which supports ATN/IPS multilink capability and complete mobility between different datalinks. | COMS-B2/1, COMS-B2/2, COMI-B2/1 |
| **Deployment Action 7.2** Implement SatCom class B, which enables data and voice communication services using existing satellite technology systems in oceanic, remote, polar, and gradually continental airspace. | COMI-B1/3 |
| **Deployment Action 7.3** Implement VDL2 successor (e.g. terrestrial datalink system L-band-digital aeronautical communication system (LDACS), datalink for ATM and AOC operations over commercial communication systems (hyper-connected ATM), and satellite communications for both the continental and remote/oceanic regions). | COMI-B2/1, COMI-B2/3, COMI-B3/2, COMI-B3/3, COMI-B3/4 |

*No ICAO Element yet – will be in next version of the GANP

**SDO 8: Service-oriented delivery model (data-driven and cloud-based)**

**Deployment Action 8.1**

Implement Phase C target architecture and a service-oriented delivery model (data-driven and cloud-based). By 2035, a new core ATC service delivery model for operations in all phases of flight should be in place that enables:

- Open ATM integration patterns enabling participation of third-party system providers;
- Enables decoupling of service and infrastructure layers as defined in the Master Plan through cloud computing (including flight data processing (FDP), human machine interface (HMI) and the relation between FDP and HMI);
- New service agreements governing the delivery of core services (common to all ANSP in Europe) vs additional services (specific to one ANSP).

ICAO ASBU Element: DAIM-B2/1, DAIM-B2/2, DAIM-B2/5, SWIM-B2/1, SWIM-B2/2

**SDO 9: CNS optimisation, modernisation and resilience**

**Deployment Action 9.1**

Implement ground-based augmentation system (GBAS) based on single frequency signals to support Cat II/III precision approach, landing, and departure procedures in all-weather operations conditions.

ICAO ASBU Element: APTA-B2/1, NAVS-B1/1

**Deployment Action 9.2**

Implement data fusion for en-route and TMA surveillance chain integrating secured surveillance functionality enabling detection and when possible, mitigation of security threats that could affect the surveillance chain.

ICAO ASBU Element: ASUR-B4/1

**Deployment Action 9.3**

Implement minimum operational network (MON)

**Deployment Action 9.4**

Rationalise instrument landing system (ILS) and implement efficiency measures/methods for more cost-effective maintenance of ILS, providing a link between ICAO Doc. 8071 and national CNS provision.

**Deployment Action 9.5**

Optimise surveillance

ICAO ASBU Element (Deployment Actions 9.3, 9.4, 9.5): NAVS-B0/4





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| SDO 10: Enable Innovative Air Mobility (IAM) & Drone Operations | ICAO ASBU Element |
|---|---|
| **Deployment Action 10.1**<br>Implement system support and procedures to integrate instrument flight rules (IFR) RPAS and IAM in airspaces A to C, which are required to have detect and avoid (DAA) systems that perform at least as well as TCAS II (traffic alert and collision avoidance system) and See and Avoid. | ACAS-B2/2<br>CSEP-B3/2<br>FICE-B2/8 |
| **Deployment Action 10.2***<br>Implement foundational (U1) and initial (U2) U-space services as defined by the Regulatory Framework for U-space (Commission IR 2021/664). | |
| **Deployment Action 10.3**<br>Implement a common ATM-U-space interface and dynamic airspace reconfiguration service to help ATC actors in charge of airspace reconfigurations to increase safety, keeping crewed and uncrewed aircraft segregated within the designated U-space airspace. | NOPS-B2/7 |
| **Deployment Action 10.4**<br>Implement simultaneous non-interfering (SNI) operations (e.g., parallel, or convergent Point-in-Space (PinS) procedures) and capabilities (i.e., GNSS and the RNP navigation specification) allowing IAM users (e.g., rotorcraft, eVTOL) to operate to and from airports and TMAs without conflicting with other traffic or requiring runway slots. | APTA-B0/6<br>APTA-B1/1<br>OPFL-B3/1 |

*No ICAO Element yet – will be in next version of the GANP

**Table 18: Mapping to GANP**

# A.9 Mapping strategic deployment objectives, essential operational changes, development priorities and flagships

This appendix presents the mapping between the new essential operational changes (EOC) within the scope of the strategic development objectives (SDOs) and those essential operational changes previously defined in the 2020 edition of the European ATM Master Plan, as well as a mapping between the development priorities (DP) and the flagships identified in the Strategic Research and Innovation Agenda (SRIA)[59] for the Digital European Sky and the Multiannual Work Programme 2022 – 2031 of the SESAR Joint Undertaking[60].

## A.9.1 Mapping of new essential operational changes compared to the Master Plan 2020 edition

| SDO ID | New | Master Plan 2020 edition |
|---|---|---|
| SDO #01 | Alert for reduction of collision risks on taxiways and runways | • Airport and TMA performance |
| SDO #02 | Optimising airport and TMA environmental footprint | • Airport and TMA performance<br>• ATM interconnected network |
| SDO #03 | Dynamic airspace configuration | • Fully dynamic and optimised airspace |
| SDO #04 | Increased automation support | • Fully dynamic and optimised airspace<br>• Virtualisation of service provision |
| SDO #05 | Transformation to trajectory-based operations (TBO) | • ATM interconnected network trajectory-based operations |
| SDO #06 | Virtualisation of operations | • Virtualisation of service provision<br>• Fully dynamic and optimised airspace |
| SDO #07 | Transition towards high performance of air-ground connectivity (multilink) | • CNS infrastructure and services |
| SDO #08 | Service-oriented delivery model (data-driven and cloud-based) | • ATM interconnected network<br>• Digital AIM and MET services |
| SDO #09 | CNS optimisation, modernisation and resilience | • CNS infrastructure and services |
| SDO #10 | Implement innovative air mobility (IAM) | • CNS infrastructure and services<br>• U-space services<br>• Multimodal mobility and integration of all airspace users |

Table 19: EOC mapping

## A.9.2 Mapping development priorities to SRIA flagships

| Development priority ID | Development action name | SRIA flagship |
|---|---|---|
| | | |
| IR-1 | Transformation to trajectory-based operations | |
| IR-1-01 | Integrated air/ground trajectory management based on ATS-B2 including the extension for lower airspace and airport surface | Air-ground integration and autonomy<br>Connected and automated ATM |
| IR-1-02 | Development of FF-ICE, including FF-ICE pre-departure enhancement and FF-ICE/R2 | Connected and automated ATM |

[59] Strategic Research and Innovation Agenda, 2020
[60] Multiannual Work Programme 2022 – 2031 of the SESAR Joint Undertaking



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| | | |
|---|---|---|
| **IR-1-03** | Advanced network trajectory synchronisation in the execution phase | Connected and automated ATM |
| **IR-1-04** | Connected and integrated FMS, EFB and FOC functionalities for trajectory optimisation | Air-ground integration and autonomy |
| **IR-1-05** | Dynamic route availability document (RAD) towards a RAD by exception environment | Connected and automated ATM |
| **IR-2** | **Transition towards high performance of air-ground connectivity (multilink)** | |
| **IR-2-01** | Complete development of successor of VHF data link mode 2 (VDL2) (L-band digital aeronautical communications system (LDACS), Hyper-connected ATM, satellite communications (SatCom) class A), covering civil military dual utilisation. | Connected and automated ATM<br>Civil/military interoperability and coordination |
| **IR-2-02** | Aircraft as a sensor, including transmission of humidity information to ground, etc. | Air-ground integration and autonomy |
| **IR-3** | **Future en-route and TMA ground platforms** | |
| **IR-3-01** | Next generation ATC platform fully leveraging aircraft capabilities. This includes supporting data-sharing service delivery model, communication, navigation and surveillance (CNS)/Meteo (MET) as a service, traffic synchronisation, etc. facilitating the accommodation of innovative air mobility (IAM), higher airspace operations (HAO), and interface with U-space, etc. | Connected and automated ATM<br>Virtualisation and cyber-secure data sharing<br>AI for Aviation |
| **IR-3-02** | Artificial intelligence (AI) capabilities enabling the next generation platforms. | AI for Aviation |
| **IR-3-03** | Cyber-resilience and cyber-security capabilities enabling the next generation platforms. | Virtualisation and cyber-secure data sharing<br>Civil/military interoperability and coordination |
| **IR-3-04** | Separation management for high levels of automation. | Connected and automated ATM |
| **IR-3-05** | Demand capacity balancing (DCB) and airspace configuration concepts for high levels of automation. | Capacity on-demand and dynamic airspace<br>Civil/military interoperability and coordination |
| **IR-3-06** | Future human–machine teaming. | Connected and automated ATM<br>Capacity on-demand and dynamic airspace<br>AI for Aviation |
| **IR-3-07** | Ground capabilities for reducing ATM environmental footprint. This includes climate-optimised trajectories including non-CO2 effects (e.g. contrails), environmentally optimised climb and descent operation, advanced required navigation performance green approaches, dynamic allocation of arrival and departure routes considering noise and local air quality, green ATC capacity concept, flexible eco-friendly clearances, wake energy retrieval (WER), integration of sustainable aviation fuel (SAF) and zero emissions aircraft, environmental performance dashboards, etc. | Connected and automated ATM<br>Aviation Green Deal |
| **IR-3-08** | Geometric altimetry | Connected and automated ATM |
| **IR-3-09** | CNS capabilities to increase ATM system robustness (e.g. satellite-based multilateration (MLAT)). | Connected and automated ATM |

| | | |
|---|---|---|
| **IR-4** | **Future airport platform** | |
| **IR-4-01** | Next generation airport platform fully leveraging aircraft capabilities. This includes supporting the data-sharing service delivery model, interconnected with other airports and their 3rd parties (e.g. ground handlers), air navigation service providers (ANSPs), network manager (NM), CNS/MET as a service, etc. facilitating the accommodation of IAM and interface with U-space. | Connected and automated ATM<br>Virtualisation and cyber-secure data sharing |
| **IR-4-02** | AI capabilities enabling the next generation of airport platforms. | AI for aviation |
| **IR-4-03** | Cyber-resilience and cyber-security capabilities enabling the next generation of airport platforms. | Virtualisation and cyber-secure data sharing<br>Civil/military interoperability and coordination |
| **IR-4-04** | Airport solutions for reducing environmental impact of operations. This includes green-taxiing related concepts, environmental performance dashboards, etc. | Connected and automated ATM<br>Aviation green deal |
| **IR-4-05** | Future human–machine teaming. | Connected and automated ATM<br>Capacity on-demand and dynamic airspace<br>AI for Aviation |
| **IR-4-06** | Optimisation of runway throughput. | Connected and automated ATM |
| **IR-4-07** | Smart airports, airports as multimodal nodes and passenger experience. | Multimodality and passenger experience |
| **IR-5** | **Autonomy and digital assistants for the flight deck** | |
| **IR-5-01** | Single pilot operations (SiPO). This includes new sensors and aircraft architectures for the evolution towards SiPO/highly automated operations. | Air-ground integration and autonomy |
| **IR-5-02** | Increased automation assistance for the pilot for ATM tasks. This includes Improved flight-deck human machine interface (HMI) and procedures for controller pilot datalink communications (CPDLC), voice-less technology, etc | Air-ground integration and autonomy<br>AI for aviation |
| **IR-5-03** | Highly automated ATM for all airspace users. This includes required performance-based CNS enablers (assured navigation for robust ATM/CNS environment for all phases of flight, alternative position, navigation and timing (A-PNT), electronic conspicuity, sense and avoid, etc.), to facilitate the integration between advanced airborne automation and future ATC platforms and the accommodation of IAM and interface with U-space. | Air-ground integration and autonomy |
| **IR-5-04** | Airborne capabilities for reducing ATM's environmental footprint. This includes wake energy retrieval (WER), energy-based operations, environment-driven trajectory optimisation, etc. | Air-ground integration and autonomy<br>Aviation Green Deal |
| **IR-6** | **U3 U-space services, IAM and vertiports** | |
| **IR-6-01** | U-space U3 advanced services:<br>• common altitude reference | U-space and urban air mobility |

| | | |
|---|---|---|
| | • collaborative interface with ATC<br>• tactical conflict detection and resolution<br>• fairness in strategic deconfliction. | |
| **IR-6-02** | CNS capabilities for U-space:<br><br>• detect and avoid and c/ Collision avoidance for UAS<br>• use of mobile networks by U-space: includes performance-based communication and surveillance services using mobile network infrastructure. | U-space and urban air mobility |
| **IR-6-03** | Extending U-space ecosystem:<br><br>• use of U-space services by commercial aircraft, general aviation, crewed VCA, etc.<br>Use of U-space services outside U-space airspace. | U-space and urban air mobility |
| **IR-6-04** | Enabling IAM/crewed and uncrewed electric vertical take-off and landing (eVTOL) (crewed and uncrewed) operations, incl. in complex environment, congested areas and vertiports:<br><br>• IAM operational procedures enabling access to all types of airspace and vertiports (both VMC and IMC).<br>• IAM automation including simplified vehicle operations, automatic take-off and landing (TOL), resilient navigation, energy management, etc. | U-space and urban air mobility |
| **Exploratory research** | | |
| **Applied research** | | |
| **AR-1** | Research to help shape the future regulatory framework for a Digital European Sky | Connected and automated ATM<br>AI for Aviation |
| **AR-2** | Definition of advanced U4 U-space services | U-space and urban air mobility |
| **AR-3** | Integration of the next generation aircraft for zero/low emission aviation | Air-ground integrations and autonomy<br>Aviation Green Deal |
| **Fundamental research** | | |
| **FR-1** | ATM impact on climate change | Aviation Green Deal |
| **FR-2** | Digital Flight Rules | Connected and automated ATM |
| **FR-3** | Investigate quantum sensing and computing applied to ATM | Connected and automated ATM |

**Table 20: Mapping development priority to SRIA flagships**

## A.10 Acronyms

| Acronym | Full term |
|---|---|
| ACAS | Airborne collision avoidance system |
| A/G | Air/Ground |
| ACARS | Aircraft communications addressing and reporting system |
| ACAS | Airborne collision avoidance system |
| ACAS Xa | ACAS extended area |
| ACAS Xu | ACAS experimental upgrade |
| ACC | Area control centre |
| ACDLS | ATS common datalink services |
| ADS-B | Automatic Dependent surveillance–broadcast |
| ADS-B-SBA | ADS-B space-based augmentation |
| ADSP | ATM Data service provider |
| AG | Attention guidance |
| AGL | Airfield ground lighting |
| AI | Artificial intelligence |
| AIM | Aeronautical information management |
| AMAN | Arrivals management |
| ANS | Air navigation services |
| ANSP | Air navigation service provider |
| AOC | Air operator certificate |
| AOP | Airport operations plan |
| A-PNT | Alternative positioning, navigation, and timing |
| ASM | Airspace management |
| ASR | Automatic speech recognition |
| ATC | Air traffic control |
| ATCO | Air traffic control officer |
| ATFCM | Air traffic flow and capacity management |





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|---|---|
| ATFM | Air traffic flow management |
| ATM | Air traffic management |
| ATN | Aeronautical telecommunications network |
| ATS | Air traffic service |
| ATSEP | Air traffic safety electronics personnel (ATSEPs) |
| ATSU | Air traffic service unit |
| AU | Airspace user |
| CAI | Continuity availability and integrity |
| CAT | Category |
| CATC | Conflicting ATC clearances |
| CD | Clearance delivery |
| CD& R | Conflict detection & resolution |
| CDM | Collaborative decision making |
| CISP | Common information service providers |
| CMAC | Conformance monitoring alerts for controllers |
| CNS | Communication, navigation & surveillance |
| CNS-PM | CNS Programme Manager |
| CP1 | Common Project 1 |
| CPDLC | Controller pilot datalink communications |
| DAA | Detect and avoid |
| DAC | Dynamic airspace configuration |
| DCB | Demand capacity balancing |
| DDA | Detect and avoid |
| DES | Digital European Sky |
| DFMC | Dual-frequency multi-constellation |
| DFR | Digital flight rules |
| DMA | Dynamic mobile areas |
| DME | Distance measuring equipment |
| DP | Development priority |

| | |
|---|---|
| **DPI** | Departure planning information |
| **DSD** | Digital Sky Demonstrator |
| **EAER** | European Aviation Environmental Report |
| **EASA** | European Union Aviation Safety Agency |
| **EDA** | European Defence Agency |
| **EFB** | Electronic flight bag |
| **ENV** | Environment |
| **EOC** | Essential operational changes |
| **EPAS** | European Plan for Aviation Safety |
| **EPP** | Extended projected profile |
| **ER** | Exploratory research |
| **ETS** | Emissions trading system |
| **EU** | Europe Union |
| **EU IR** | Europe Union instrument rating |
| **EUROCAE** | European Organisation for Civil Aviation Equipment |
| **EVS** | Enhanced vision system |
| **eVTOL** | Electric vertical take-off and landing |
| **FCA** | Non-geographical flight centric |
| **FCI** | Future communications infrastructure |
| **FF ICE** | Flight and flow Information for a collaborative environment |
| **FMS** | Flight management system |
| **FOC** | Flight operations centre |
| **FPL** | Flight plan |
| **GA** | General aviation |
| **GANP** | Global air navigation plan |
| **GBAS** | Ground based augmentation system |
| **GBAS DF/MC** | GBAS dual frequency/Multi-constellation |
| **GBAS- GAST SF/SC** | GBAS GAST special authorisation/ Special category |
| **GBAS-GAST** | GBAS approach service type |





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| | |
|---|---|
| **GNSS** | Global navigation satellite system |
| **HA** | High altitude |
| **HAO** | Higher airspace operations |
| **HAPS** | High altitude pseudo satellites |
| **HCATM** | Hyper-connected air traffic management |
| **HF** | High frequency |
| **HMI** | Human machine interface |
| **IA** | Intelligent automation |
| **IAM** | Innovation Air Mobility |
| **ICAO** | International Civil Aviation Organisation |
| **IFR** | Instrument flight rules |
| **ILS** | Instrument landing system |
| **IPS** | Internet protocol suite |
| **IR** | Implementing rule |
| **ISGS** | Increased second glide slope |
| **IT** | Information technology |
| **JU** | Joint undertaking |
| **KPA** | Key performance areas |
| **LDACS** | L-band digital aeronautical communication system |
| **LEO** | Low earth orbit satellites |
| **LVC** | Low visibility conditions |
| **MASPS** | Minimum aviation system performance standards |
| **MET** | Meteorology |
| **MIL** | Military |
| **ML** | Machine learning |
| **MLAT** | Multilateration |
| **MON** | Minimum operational network |
| **MOPS** | Minimum operational performance standards |
| **MP** | Master Plan |

| | |
|---|---|
| **MRTM** | Multiple remote tower module |
| **NAV** | Navigation |
| **NDB** | Non-direction beacon |
| **NM** | Network Manager |
| **NOP** | Network operations plan |
| **OP** | Operation |
| **OSI** | Open systems interconnection |
| **PANS-ATM** | Procedures for air navigation services – Air traffic management |
| **PANS-OPS** | Procedures for air navigation services – Aircraft operations |
| **PBCS** | Performance-based communication and surveillance |
| **PBN** | Performance-based navigation |
| **PKI** | Public key infrastructure |
| **PUE** | Power usage effectiveness |
| **R&D** | Research and development |
| **R&I** | Research and innovation |
| **RAD** | Route availability document |
| **RFI** | Radio frequency interface |
| **RNP** | Required navigation performance |
| **ROT** | Runway occupancy time |
| **RP4** | Reference period 4 |
| **RPAS** | Remotely piloted aircraft systems |
| **RPAS C2** | RPAS command and control |
| **RSP** | Runway surveillance performance |
| **RTC** | Remote tower centre |
| **SAF** | Sustainable aviation fuel |
| **SAT** | Satellite |
| **SatCom** | Satellite communications |
| **SATVOICE** | Satellite voice communications |
| **SBAS** | Satellite-based augmentation system |

| | |
|---|---|
| **SBAS DF/MC** | SBAS dual frequency/Multi-constellation |
| **SB-S** | Secure broadband-satellite |
| **SDO** | Strategic deployment objective |
| **SES** | Single European Sky |
| **SESAR** | Single European Sky ATM Research |
| **SESAR DM** | SESAR Deployment Manager |
| **SESAR JU** | SESAR Joint Undertaking |
| **SLA** | Service level agreement |
| **SNI** | Simultaneous non-interfering |
| **SiPO** | Single pilot operations |
| **SOA** | Service-oriented architecture |
| **SRIA** | Strategic research and innovation agenda |
| **SSA** | Space situational awareness |
| **SSR** | Secondary surveillance radar (SSR) |
| **SST** | Space surveillance and tracking |
| **STK** | Stakeholder |
| **STM** | Space traffic management |
| **SVS** | Synthetic vision system |
| **SWIM** | System-wide information management |
| **TBO** | Trajectory-based operations |
| **TCAS** | Traffic collision avoidance system |
| **TCG** | Technical coordination group |
| **TMA** | Terminal manoeuvring area |
| **TRA** | Temporary restricted areas |
| **TRL** | Technical readiness level |
| **TSA** | Temporary segregated Areas |
| **UAM** | Urban air mobility |
| **UAS** | Uncrewed aircraft system |
| **UDPP** | User-driven prioritisation process |





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| | |
|---|---|
| **UPMS** | User profile Management system |
| **UPR** | User preferred Route |
| **USSP** | U-space service providers |
| **UTM** | Uncrewed aircraft system traffic management |
| **VCA** | VTOL-capable aircraft |
| **VDL** | VHF digital link |
| **VFR** | Visual flight rules |
| **VHF** | Very high frequency |
| **VOR** | VHF omni-directional ranging |
| **VPA** | Vertical prohibited areas |
| **WAM** | Wide area multilateration |
| **WER** | Wake energy retrieval |

**Table 21: Acronyms**



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